Boulder Creek and St. Vrain Creek Coordinated Watershed Monitoring Framework

Prepared for
Keep It Clean Partnership

Prepared by
Wright Water Engineers, Inc.

Version 1.1, September 2015

Table of Contents

Tables

Appendices

Materials adapted directly from others:
[1]City of Boulder Water Quality Monitoring Program (last updated 2014)
[2] Standard Operating Procedures for Northern Water's Water Quality Monitoring Programs Northern Colorado Water Conservancy District (last updated 2014)
[3]Regulation 85 Sampling and Analysis Plan (SAP) Template (Colorado Monitoring Framework 2013)

1.0 Introduction

The overall St. Vrain Creek watershed (8-digit hydrologic unit code [HUC] = 10190005) covers approximately 980 square miles and includes many governmental jurisdictions and water-related organizations (e.g., conservancy districts). Streams in the watershed include Boulder Creek, South Boulder Creek, Coal Creek, Rock Creek, Lefthand Creek, St. Vrain Creek and many smaller tributaries. Multiple local governments and organizations conduct instream water quality, biological and flow monitoring in various parts of the watershed. The purposes of this Monitoring Plan are to:

- Provide better coordination of existing multi-jurisdictional monitoring efforts.
- Provide consolidated documentation of the monitoring that is occurring in the watershed.
- Provide guidance for standardized field procedures and analytical methods.
- Identify and recommend additional monitoring to fill data gaps to support progress toward attainment of stream standards.

Due to the size of the watershed, the remote nature of the upper basin locations, and varying levels of participation among governmental jurisdictions, this Monitoring Plan cannot practically address all stream reaches; however, it is designed to address water quality, flow and biological conditions at key locations in the watershed where supported by local jurisdictions. The plan is organized to provide basic information common to the overall watershed in the main body of the plan, supplemented by more detailed appendices that can be updated as individual monitoring programs are modified.

The scope of this Monitoring Plan is limited to flowing streams. Where lake monitoring is conducted in the watershed by Monitoring Plan participants as part of individual monitoring programs, sampling locations are provided in Appendix J, but are not discussed in detail. Additionally, biological monitoring is conducted on Boulder Creek, South Boulder Creek, Coal Creek, Rock Creek, Lefthand Creek and St. Vrain Creek in accordance with sampling and analysis procedures developed by Timberline Aquatics. Detailed biological monitoring guidance is not included in this plan; however, key metrics calculated as part of the biological monitoring program are briefly described in Appendix K and benthic macroinvertebrate sampling locations are shown on figures in Appendix A and in Table B-3 of Appendix B.

Appendix B provides the Keep It Clean Partnership (KICP) Coordinated Monitoring Program locations and analytes, which are the primary focus of this coordinated monitoring framework. However, a significant amount of additional monitoring is conducted in the watershed as summarized in Appendix J; these data sets will be integrated with the KICP data set, when appropriate and as budget constraints allow.

2.0 Sampling Project Management

PROGRAM PARTNERS

Table 1 provides contact information for partners and collaborators participating in the Monitoring Plan. These contacts are generally categorized as participating KICP partners and collaborators (non-KICP partners who conduct monitoring in the watershed). Contacts will be reviewed annually, and updated as needed. Geographic boundaries of program partners are currently generally limited to Boulder County, although a significant portion of the lower watershed is located in Weld County.

Table 1. Program Partner Contacts

Participating KICP Partner	Lead Contact	Phone	Monitoring Focus
Keep It Clean Partners/ Boulder County	Janice Lopitz	303-441-1439	Overall Coordination
City of Boulder	Bret Linenfelser Michelle Wind	303-413-7355 303-413-7405	Boulder Creek: upper tribs., main stem to below conf. with Coal Creek; Coal Creek at conf. with Boulder Creek; South Boulder Creek above Boulder Creek; Barker Res., Boulder Res. & tribs.
Town of Superior	Alex Ariniello	303-499-3675	Rock Creek above and below Superior WWTP discharge.
City of Louisville	Cameron Fowlkes	303-335-4611	Coal Creek above and below Louisville WWTP discharge.
City of Lafayette	Mick Forrester	303-665-5506 ext. 3571	Coal Creek above and below Lafayette WWTP discharge.
Town of Erie	Wendi Palmer	303-926-2875	Coal Creek & Boulder Creek above and below Erie WWTP discharge.
City of Longmont	Cal Youngberg & Kathryne Marko	303-651-8399 303-651-8906	St. Vrain Creek: through urbanized area to the conf. of Boulder Creek. Lefthand Creek: near conf. of St.Vrain Creek.

Collaborating Partner	Lead Contact	Phone	Monitoring Focus
St. Vrain/ Lefthand Water Conservancy District	Sean Cronin Glenn Patterson	303-772-4060	Riverwatch sites in Lefthand Creek, St. Vrain Creek and Upper Tributaries to St. Vrain Creek.
Northern Colorado Water Conservancy District	Esther Vincent Jan Stephenson Judy Billica	970-622-2356	Water supply canals and associated streams at selected locations: Lefthand Creek, St. Vrain Creek, Boulder Creek, Boulder Res.
Denver Water	Bruce Hale	303-628-5991	South Boulder Creek near Gross Reservoir.
River Watch (Colorado Parks and Wildlife)	Barb Horn	970-382-6667	Various locations in both Boulder Creek and St. Vrain Watersheds; vary depending on volunteers and priorities.
Boulder County	Erin Dodge	303-441-1241	Not currently monitoring, but jurisdiction includes major streams and tributaries in Boulder Creek and St. Vrain watersheds.
Weld County	Lindsay Massey	970-304-6496 Ext. 3788	Not currently monitoring, but jurisdiction includes St. Vrain Creek from Weld County line to confluence with the South Platte River.
Xcel Energy[1]	Christine Johnston	303-294-2224	Confluence of St. Vrain River and South Platte (temperature only).

[1] Xcel Energy is a potential future collaborator near the confluence with the South Platte River, but currently only monitors temperature instream.

MONITORING PROGRAM ORGANIZATION

This Monitoring Plan and future updates are being coordinated by KICP; however, each local government jurisdiction retains authority over the monitoring program within its own jurisdiction. Data sharing is voluntary.

Table 2 provides brief descriptions of the existing active monitoring programs in the Boulder Creek and St. Vrain Watershed by waterbody and references existing monitoring plans in place associated with the entities identified in Table 1. Appendix J contains more detailed information about each monitoring program. Due to the year-to-year variability in the Riverwatch monitoring program, it is not included in this table.

Table 2. Brief List of Existing Active Instream Monitoring Programs in the St. Vrain Watershed

General Waterbody	Program Description	Primary Monitoring Plan
Boulder Creek and Tributaries (from headwaters to below Coal Creek); Reservoirs—upper source water sites, Barker Reservoir, Boulder Reservoir; Dry Creek/Little Dry Creek	Extensive program including nutrients, fecal indicator bacteria, metals, and other physical constituents; flow, and biological monitoring. Sampling frequencies vary by waterbody. Main stem monitoring conducted monthly.	City of Boulder, Boulder Creek Monitoring Program, Prepared by the City of Boulder Department of Public Works Utilities Division Water Quality and Environmental Services. May 2012. Updated June 2014.
Rock Creek/Coal Creek	Monthly monitoring for TP, TKN, NO3/NO2, TN, TP and Flow. Also pH, temp., hardnesss, *E. coli*/total coliforms. Biological monitoring.	Regulation 85 Nutrient Sampling and Analysis Plan (separate plans for Lafayette, Superior, Louisville, Erie), 2013.
St. Vrain Creek (vicinity of Longmont) Lefthand Creek (@ conf. w/ St. Vrain) Selected ditches: Dry Creek, Spring Gulch #1, Spring Gulch #2, Oligarchy	Extensive program including nutrients, fecal indicator bacteria, metals, and other physical constituents; flow, and biological monitoring. Sampling frequencies vary by waterbody. Monthly monitoring for TP, TKN, NO3/NO2, TN, TP and flow.	Regulation 85 Nutrient Sampling and Analysis Plan, City of Longmont, Public Works and Natural Resources Division of Environmental Services, CDPS Permit No. CO-0026671, February, 2013.
Boulder Creek abv/blw Boulder Supply Canal; Lefthand Creek abv/blw Boulder Feeder Canal; St. Vrain Creek abv/blw St. Vrain Supply Canal(+other ditches/reservoirs)	Extensive program including nutrients, metals, and other physical constituents; flow, and biological monitoring. Sampling frequencies vary by waterbody.	Standard Operating Procedures for Northern Water's Water Quality Monitoring Programs. Northern Water, June 2014.
South Boulder Creek Near Gross Res.	South Boulder Creek sites near Gross Reservoir. Primary site is at South Boulder Diversion Canal.	Denver Water Quality Laboratory Project Plan, 2012 Watershed Monitoring, Updated 11/30/2013.

PROBLEM DEFINITION / BACKGROUND – SAMPLING NEEDS

Problem Statement

The Keep It Clean Partners recognize a need for better coordinated water quality monitoring in the Boulder Creek and St. Vrain watersheds and routine data sharing to develop a better understanding of water quality conditions so that the partners can achieve these objectives:

- attain water quality and aquatic life standards by targeting stream reaches where improvements are needed,
- identify changes in water quality in a timely manner, and
- evaluate return on investment for capital improvements affecting instream water quality.

Intended Use of Data

The intended use of data collected, shared and interpreted under this Monitoring Plan is to provide a sound scientific understanding of baseline water quality conditions, identify reaches of streams in need of water quality and aquatic life improvements, and to support prioritization of improvements expected to improve water quality and aquatic life.

SAMPLING PROGRAM DESCRIPTION

General Overview of Project

The overall basin monitoring program includes these general components:

- **Water quality monitoring:** Water quality monitoring includes instream sample collection during ambient conditions. This includes voluntary programs as well as samples collected to meet Regulation 85 requirements. Appendix J provides specific monitoring program information, including frequencies, parameters, locations and methods.
- **Flow measurements**: Two types of flow measurements are conducted (or retrieved) as part of this monitoring program. The first includes continuous daily flow measurements conducted at fixed, long-term gages shown on figures in Appendix A. These gauges and associated data are maintained by the U.S. Geological Survey (USGS) (see http://waterdata.usgs.gov/usa/nwis/sw) or the Colorado Division of Water Resources (DWR) (see http://cdss.state.co.us/onlineTools/Pages/StreamflowStations.aspx). Additionally, One-Rain gauge sites used in early alert flood warning systems may be used to supplement flow data; however, data downloads are restricted to subscribers. The second type of flow monitoring includes instantaneous flow monitoring with hand-held monitoring equipment, which is used to supplement fixed gauge data in key areas,

including some instream monitoring locations associated with Regulation 85 sampling. Manual flow monitoring is conducted only when it is safe for field staff to enter the stream.

- **Biological Monitoring**: Biological monitoring is conducted in the spring and fall on an annual basis for portions of Boulder Creek, South Boulder Creek, Coal Creek, Rock Creek St. Vrain Creek, and Lefthand Creek as summarized in Table B-3 of Appendix B and briefly described in Appendix K.

Appendix B provides a summary of active monitoring sites and constituents that will be the focus of the coordinated monitoring framework. Appendix B represents a subset of key monitoring locations and constituents of interest to the overall watershed. The list of monitoring locations and analytes will be reviewed on an annual basis and modified, if needed, according to the priorities of the participants. Monitoring locations identified in Appendix B correspond to figures in Appendix A. Additional active monitoring locations and analytes are described in Appendix J. These locations and analytes may not be included in annual reports prepared by KICP, but are important information sources in the watershed that will be reviewed and integrated on an as-needed basis and as budget constraints allow.

Sampling Project Timeline

This monitoring program is designed to be an on-going, voluntary, ambient-based program. The Monitoring Plan will be reviewed annually by the participating organizations to identify needed changes in sampling frequencies and water quality parameters monitored.

The initial release of this Monitoring Plan is focused on developing a coordinated baseline for the overall watershed. In the future, monitoring objectives and activities may be added to assess measureable results from implementation of structural or non-structural best management practices (BMPs) in the watershed.

DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

The monitoring program is designed to provide data to support these objectives:

1. Evaluate impacts from various activities in the watershed, such as major outfalls, diversions, land uses, mines, etc.
2. Assess compliance with state water quality standards.
3. Support appropriate stream standards and use classifications.
4. Support investigations into the causes of potential impairments (e.g., TMDLs).
5. Document existing conditions (baseline and naturally occurring).
6. Evaluate attainability and effects of new federal or state standards, classifications, and goals.
7. Monitor trends and changes in water quality in flowing streams.

Data must be of sufficient quality to support these objectives. The quality of data collected under the monitoring programs is assessed in terms of accuracy, bias, precision, analytical sensitivity, and comparability, as described below (Northern Water 2014[2]):

Accuracy and Bias: Accuracy is how close a measurement is to its true or expected value. Accuracy is a combination of precision (random error) and bias (systematic error) and the goal is to achieve high accuracy through high precision (low random error) and low bias. Bias can be introduced through poor equipment calibration, unrepresentative sampling, analyte degradation prior to analysis, and sample contamination (Cavanagh et al. 1998). Bias is minimized through regular calibration of instruments according to the manufacturers' specifications, using appropriate, known calibration solutions, and by strict adherence to the documented sample collection, handling and processing protocols. Laboratories use matrix spike samples and laboratory control samples to evaluate analytical accuracy/bias.

Bias due to sample contamination: Field blanks and laboratory method blanks are used to measure bias due to sample contamination. Samples can be contaminated by many sources including the field staff (dirty hands, etc.), from improperly cleaned sampling devices or laboratory equipment, from contaminated preservatives, reagents or sample bottles, and/or from dust particles or atmospheric deposition during filtering and preserving (Cavanagh et al. 1998). However, the strict adherence to the protocols presented in this document minimizes these sources of sample contamination. Blank samples are used to demonstrate that contamination of the environmental samples has not occurred or, if it did, where in the sampling/analysis process it occurred. Generally, analyte results for blanks should be below detection limits.

Precision: Precision is a measure of how well repeated measurements agree, and how consistent and reproducible the field and lab measurements are. Imprecise data are primarily the result of inconsistent field techniques and lab analysis (Cavanagh et al. 1998). Precision is monitored through replicate samples or measurements, including split field samples, concurrent field replicate samples, sequential field replicates, laboratory duplicate analysis, and matrix spike duplicate analysis. The relative percent difference (RPD) between two duplicate determinations is used to assess the precision of the sampling and analytical methods and is calculated using the following equation:

$$RPD = 100 \times (Xs - Xd) [(Xs + Xd)/2]$$

where:

RPD = relative percent difference, expressed in percent

[2] Northern Colorado Water Conservancy District (2014) developed the discussion of accuracy, bias, precision, sensitivity and comparability in this section, as originally published in Standard Operating Procedures for Northern Water's Water Quality Monitoring Programs (2014).

Xs = analytical result obtained for the sample
Xd = analytical result obtained for the duplicate sample

A low RPD reflects high precision. The acceptance criteria for replicate samples depend on the parameter and the measurement type, and are discussed in individual monitoring plans. Generally, RPD values should generally not exceed 25%. RPD values exceeding 25% should be further reviewed to determine the cause of sample result differences. (Note: it is not unusual for fecal indicator bacteria to exceed 25% RPD).

Analytical Sensitivity: Sensitivity refers to the minimum concentration that can be measured by a method (i.e., the method detection limit [MDL]) or by a laboratory. The laboratories and analytical methods must be selected so that the detection limits are appropriate for meeting the program objectives. Because of low background levels of many metals and nutrients, laboratories capable of low-level nutrient and metals analyses are needed for portions of the watershed. Laboratories analyze low-level quality control (QC) standards to verify MDLs and demonstrate the ability to recover at the MDL.

Comparability: Comparability refers to the degree to which data can be compared directly to similar studies. The use of standard, accepted sampling, analytical, and data management procedures helps to ensure that data will be comparable to other similar programs. One of the data quality objectives of this program is to collect data that are comparable throughout the watershed, although collected by different entities.

Completeness: Completeness refers to whether the collected data comply with the sampling program design in terms of numbers of samples collected during key time periods. Because some constituent results vary seasonally and/or with flow conditions, it is important that samples are collected at frequencies that do not bias results. Monthly sampling is a common practice for ambient sampling programs; however, metals may be conducted on a quarterly basis for cost-control.

Training Requirements and Certification

The active instream monitoring programs described in this plan are conducted by qualified professionals, including either city/county/agency staff with appropriate training or specialty consultants, as is the case for the biological monitoring program.

(Note: The Riverwatch Program is conducted by volunteers trained in the Riverwatch Program.)

Documentation and Records

Documentation shall include the following information:

- Completed chain of custody.

- Field observations for the sampling event (e.g., weather conditions, runoff conditions).
- Field observations for the sampling location (e.g., localized erosion, cattle in stream, dog activity/waste).
- Laboratory analysis results and associated meta data (e.g., MDLs, qualifiers).

Each partner shall maintain such documentation, as well as submit copies to the KICP if data sets are included in the annual water quality analysis. Although not currently required as part of this monitoring framework, it is highly recommended that basic field notes be entered electronically along with the water quality data. In lieu of electronic entry, field notebooks should be kept in a reasonably accessible location for easy reference in the event that anomalous or rare results can be explained due to field conditions at the time of sampling (e.g., cattle in stream, bank erosion, construction activity, storm event).

3.0 Measurement / Data Generation and Acquisition

SAMPLING PROCESS DESIGN

Rationale for Selection of Sampling Sites

Sampling sites included in this Monitoring Plan have been selected to meet source water, wastewater, and stormwater objectives, depending on the issues present for a particular stream segment and the objectives of the individual monitoring entity. Instream sampling for nutrients is currently required under Regulation 85 on Boulder Creek, Rock Creek, Coal Creek and St. Vrain Creek. Additional voluntary monitoring is also conducted, depending on the unique objectives of each monitoring program. Appendix B, Table B-1 summarizes the primary sampling sites of interest to the KICP for purposes of annual water quality analysis, focusing primarily on nutrients and fecal indicator bacteria. These sites have been selected primarily to bracket influences of urbanization, WWTP discharges, and water quality variations in the vicinity of tributary confluences with main stem locations. Several monitoring locations on Boulder Creek are also included in the agricultural area.

Appendix J documents additional information on location selection rationale for individual sampling programs, which differs by data provider.

Sample Design Logistics

Because of the size of the watershed, staff from multiple cities are needed to conduct the individual sampling programs. Within each subwatershed, efforts are made to collect samples on the same date to enable spatial trend analysis.

Sample collection may be restricted during certain times of the year due to frozen stream conditions, drought, dangerous high water conditions and/or high winds (lake sampling). Safety of sampling staff is the highest priority and sample collection should be delayed until conditions enable safe sample collection.

SAMPLING METHODS

Sampling Needs

Sampling needs depend on the objectives of the individual monitoring programs, as summarized in Appendix J.

Equipment Needs

Appendix D provides a summary of equipment needs for sampling. This equipment includes safety-related equipment for sampling staff and an equipment checklist.

Field Notes, Sample Labeling, and Chain of Custody

Field notes are taken for all sample sites and recorded in a field notebook. Information recorded includes: identification of the monitoring site; date and time of sampling, identity of the sampler(s); description of the type of samples taken; method of sampling; results of any field analyses; description of the weather, including percent cloud cover and air temperature; description of the site appearance ; and any unusual conditions observed. If weather conditions are consistent for the overall sampling event, these can be entered once for the field day; however, in some cases, field conditions may change during long sample days (e.g., afternoon thunderstorms).

Collected samples are designated by sample location using the location name assigned by the entity responsible for monitoring, as identified in Appendix B and Appendix J. Each sample container is individually labeled, with the label affixed directly to the bottle or bag itself with the preservative and analysis to be performed printed on the label.

A Chain of Custody (COC) will be filled out for each sampling event, with records maintained for all water quality sampling conducted in conjunction with this Monitoring Plan. The purpose of maintaining COCs is to provide documentation that samples are collected and delivered to the laboratories within an acceptable time frame, are properly preserved, are analyzed within the allowable holding time, and to record any conditions that might help to explain anomalous results. A significant deviation from required protocols requires that results be flagged or discarded.

All sample documents are completed in indelible ink. Correction or revisions are made by lining out the original entry with a single line. The person making or approving the change must initial and date the change. Copies of all COCs are retained by the party responsible for the sampling and should be retained for the project record.

Sampling Containers

The laboratory conducting the analysis provides the sampling containers and any shipping materials necessary to maintain sample integrity from the time of collection through analysis. Table II of 40 CFR section 136.3 defines specific materials, preservation techniques, and holding times. Appendix J provides specific information on sample containers for each individual sampling program.

General Sampling Recommendations

General recommendations for instream water quality sampling (as provided by the Colorado Monitoring Framework in the Regulation 85 SAP) include:

- Since sampling is taking place year round, it is possible that instream sampling may not be safe at certain times. If alternative methods of sample collection are not possible, it is up to the discretion of the individual sampling personnel whether sampling will take place during high flows. The turbidity of the stream, visual flow, and previous rain events may also affect sampling schedule.
- When wading, collect samples upstream from the body and avoid disturbing sediments in the immediate area of sample collection.
- Sampling at or near structures (e.g., dams, weirs, or bridges) may not provide representative data because of unnatural flow patterns. If you have to collect from a bridge, sample on the upstream side in the center of the main flow.
- Collect grab samples within the top 12 inches of the water column, but avoid skimming the surface of the water during collection.
- Where practical, use the actual sample container as the collection device (direct grab). If a direct grab sample cannot be collected, ensure that the intermediate sample container is well rinsed with site water before sample collection.

Grab Sample Technique

The grab sample technique is summarized as follows:

- Use an unpreserved sample container to collect the sample. Rinse with sample site water.
- If using pre-preserved sample bottles, collect sample water (in same manner described below) in a clean carboy/sample collection container that is rinsed with sample site water. Fill the bottles from that carboy.
- Take sample from area representative of the flow conditions at that site.
- Remove the container cap and slowly submerge the container, opening first, into the water.
- Invert the bottle so the opening is facing toward the water and parallel to water flow. Allow water to run slowly into the container until filled.
- Return the filled container quickly to the surface.
- Pour out a small volume of sample away from and downstream of the sampling location. This procedure allows for addition of preservatives (if using) and sample expansion.
- Add preservatives (provided by the analytical laboratory), if required, securely cap container, label, and complete field notes and COC.
- If preservatives have been added, invert the container several times to ensure sufficient mixing of sample and preservatives.

Flow Determination

Flow is an important tool in assessing water quality. Measurements will be recorded to help understand flow regimes within the watershed and to determine constituent loading. Daily average flow from a USGS, DWR, or One-Rain gauge at the time of sample collection is the first preference for flow measurements.

Where fixed flow gauge data are not available, alternative flow calculations using the “six-tenths” method, as described in Appendix G may be used. Proper calibration and use of flow equipment is important when such measurements are conducted.

SAMPLE HANDLING AND CUSTODY[3]

Sample handling will be conducted in accordance with the hold time and preservation requirements identified in Appendix J, with appropriate chain of custody documentation meeting at least the minimum requirements in Appendix C.

Samples are shipped or delivered to the labs as soon as possible after collection, with particular attention given to those parameters that have short maximum holding times (e.g., *E. coli*).

Samples to be hand-delivered are kept at 4°C until relinquished to laboratories responsible for analyses.

Chain of custody (COC) forms are prepared for all samples and laboratories. COC forms provide documentation that the samples were not tampered with and that the samples were under appropriate possession at all times. The COC forms are placed in zip lock bags and placed into the coolers with the samples for shipping or hand delivery.

Samples that will be shipped are packaged so that melting ice will not contaminate the samples or leak from the cooler they are being shipped in. Coolers are taped closed, and it is assumed that samples in tape-sealed ice chests are secure until received by the laboratory.

ANALYTICAL METHODS REQUIREMENTS

Analytical methods used in this monitoring program are approved by EPA for use in wastewater or ambient waters and are listed in 40 CFR §136.3. Appendix J provides a summary of analytical methods, detection limits, container volumes, holding times, preservation requirements and method detection limits suitable for monitoring conducted by individual programs in the watershed. Appendix B provides a summary of minimum MDLs for the subset of sites and constituents focused on under this Coordinated Monitoring Framework.

QUALITY CONTROL REQUIREMENTS

Field QC Checks

Field QC includes thorough cleaning of sampling equipment, use of appropriate sample containers, and maintaining COC procedures.

[3] Discussion adapted from Northern (2014).

Field duplicates and field blanks should be collected. Generally, one each for every 20 samples is recommended. Table 3 provides recommended field control samples frequencies; however, frequencies may vary by individual sample program. (Appendix B, Table B-2 summarized the minimum QC expected for the KICP Coordinated Monitoring Framework locations.) Field replicates and blanks are labeled as separate samples to avoid confusion and to provide an unbiased blind evaluation.

Table 3. Recommended Field Quality Control Samples
(adapted/modified from Northern [2014])

QC Sample	Data Quality Indicator	Collection Frequency (recommended)[1]	Acceptance Criteria	Corrective Action
Field Blank Sample	Bias Due to Sample Contamination	5% of samples (1 per 20 samples)	< Reporting Limit	Investigate and eliminate sources of contamination; flag suspect data (e.g., "B" qualifier)
Field Replicate Sample	Precision	5% of samples (1 per 20 samples)	For concentrations > Reporting Limit, <25% Relative Percent Difference[2]	Investigate and eliminate cause (e.g., inconsistent field techniques and sample processing, lab error); request re-analysis of sample; flag suspect data

[1]If the recommended frequency is infeasible, it is highly recommend that, at a minimum, one set of field duplicates and one set of field blanks should be collected by each sampling program per year.
[2]*E. coli* may be an exception to this acceptance criterion. In such cases, the RPD should be discussed as part of the data analysis report.

Laboratory QC Checks

Analytical QA/QC measures are also followed by the laboratories and include equipment blanks and spikes. Analytical QA/QC results are provided by the laboratory. Laboratory QC procedures and acceptance criteria for each laboratory are not described in this plan due to the multiple laboratories involved in the analysis in the watershed.

Data Analysis QC Checks

Data analysis QC checks will be accomplished by review of the draft data analysis report by KICP members and incorporation of recommended edits following a meeting to discuss findings. Use of both tabular and graphical statistical methods to characterized data will help facilitate QC of data analysis.

LABORATORY QUALIFICATIONS/INSTRUMENTATION

Laboratories responsible for water quality analysis shall have a quality assurance plan that assures the reliability of the data produced. Laboratories shall meet appropriate standards for quality control; instrument/equipment testing, inspection, maintenance, and calibration; quality of supplies; corrective management procedures; and other standard industry practices. Analytical laboratories are selected based on analytical capabilities and cost.

Commercial laboratories should provide documentation of qualifications and certifications appropriate for the analyses being conducted. Non-commercial laboratories (e.g., local government labs) should be either certified by the CDPHE Laboratory Services Division or participate successfully in Proficiency Testing (PT) studies in which unknown samples are analyzed for each constituent. Results must meet the acceptance limits established by the U.S. Environmental Protection Agency (EPA).

DATA ACQUISITION REQUIREMENTS

Data measurements and sample acquisition are conducted by municipal staff at frequencies appropriate to the objectives of each sampling program. The sample frequencies vary for each waterbody and parameter based on consideration such seasonal factors, cost of analyses, regulatory sampling requirements (e.g., nutrients) and other considerations. As part of this sampling plan, efforts are being made to coordinate sampling frequencies among various cities to improve comparability of data in the watershed. Appendix B, Table B-2, summarizes the minimum sampling frequencies for sampling conducted at the locations in Table B-1 as part of the KICP Coordinated Monitoring Framework. Efforts are made to adhere to the sampling schedule in Table B-2; however, if the safety of the samplers is in question, the sampling date will be adjusted.

Appendix J provides a broader summary of routine water quality sampling frequency by constituent, based on local government objectives. These sample frequencies may be monthly, oriented to the irrigation season (April to October), or quarterly.

DATA MANAGEMENT

A primary objective of this Monitoring Plan is to provide guidance for coordinated watershed-scale data management and analysis. Under the direction of the KICP, a centralized watershed database in Microsoft Access 2010 will be developed to store data for the overall St. Vrain and Boulder Creek watersheds.[4] The database shall be structured following the Colorado Data Sharing Network (CDSN) schema for physical and chemical data (See Appendix I). The data format for monitoring results should be provided to the laboratory conducting analysis so that electronic data deliverables from the laboratory data management systems (e.g., TRIBAL) can be exported in a readily compatible electronic format, eliminating the need for hand-entry or

[4] In support of the 319 Watershed Plan, an initial database has been developed with existing and historic data. This initial database can be mapped (transitioned) to a formal database structure agreed upon by the KICP.

transposition of the data. (A centralized biological data storage tool may be added in the future, but is not included in this initial Monitoring Plan.)

Additionally, this data structure provides for efficient data storage and queries that can be exported to Excel, CSV files or other commonly used formats. The basic structure includes these three tables:

- Project Information
- Monitoring Location Information
- Monitoring Results

Once the database is established, the monitoring results table is the primary focus of annual updates, unless monitoring locations are added or changed. Data can be uploaded to the master database from each data provider either through Excel spreadsheets, Access tables or other common data format, provided that the data set is properly structured. Data providers using TRIBAL or other similar laboratory management system should be able to export data in a reasonably comparable format without additional hand-entry of data.

Tips:

- Each result for each analyte is stored as a separate record (row). In other words, analytes are not used as column headers; instead, one column is used for recording the analyte name (with a separate column for sample fraction, where required) rather than listing each analyte in a separate column.
- Non-detects should be clearly identified with associated detection limit and associated data qualifier ("U" for non-detects).
- Monitoring location must be entered EXACTLY as defined in the monitoring location table in Appendix B to avoid time-consuming data cleanup prior to upload to the master database.
- Analyte must be entered using the pick-list of analytes provide in EPA's Water Quality Exchange (WQX) nomenclature, including appropriate identification of sample fraction (e.g., total, dissolved).
- Selecting uniform measurement units can help to reduce unit conversion errors. For example, most analytes are reported as mg/L, and metals are commonly reported in ug/L.

Appendix I contains additional information on the CDSN format.

To be included in the annual water quality analysis sponsored by the KICP, monitoring data from each partner should be provided to KICP by March 15 to enable timely analysis of the previous calendar year's data set.

4.0 Assessment and Oversight

Assessment and Response Actions

Monitoring data will be shared on a voluntary basis with the KICP, which will coordinate upload of data from each monitoring program into the watershed database. The compiled data set will be reviewed and synthesized into a format enabling meaningful assessment of findings and recommendations for additional monitoring or restoration/mitigation activities. The data set uploaded will ideally include the broader monitoring program described in Appendix J; however, the primary assessment focus will be the parameters in Appendix B.

A routine annual schedule for data submittal, assessment and reporting is recommended so that timely completion of analysis occurs annually. The recommended schedule is:

a. Submit electronic data to KICP– March 15

b. Provide draft report for review by May 15

c. Complete annual report and post to KICP website – June 30

Reports

Data reports can range from simple data tabulations to more comprehensive trend analysis once a robust data set is compiled. The extent of the report is typically controlled by available funding, size of the data set and number of sampling locations. Development of an initial report template requires some initial upfront investment, but once properly established can be easily updated on an annual (or biennial) basis. An annual data report will be completed, with more detailed data analyses on a periodic basis. The recommended approach and report contents for consideration each year depend on budget constraints. At a minimum, constituents of concern for each stream segment as summarized in Appendix B will be analyzed, if budget constraints preclude a comprehensive analysis on an annual basis. Commercially-available statistical software can be used to efficiently generate statistical analyses using “batch” analysis (e.g., create hundreds of graphs and tabular statistics in a few steps).

Although annual reports will typically be limited to constituents of concern, the overall data sets will be uploaded to the KICP database so that more in depth analysis can be completed on a periodic basis, based on the needs and objectives of the entities participating in the monitoring program.

The minimum annual report will include the following components:

1. Executive Summary

2. Overview of Monitoring Program and Scope of Analysis
    a. Monitoring locations (See Appendix B)
    b. Constituents analyzed (See Appendix B)
3. Summary of Annual Flow Data and Pertinent Field Conditions
4. Water Quality Analysis
    a. Rock Creek/Coal Creek (upstream of urbanized area to confluence with Boulder Creek)
    b. Boulder Creek (Canyon to Confluence with St. Vrain)
    c. South Boulder Creek (Open Space)
    d. St. Vrain River (upstream of Longmont to below confluence with Boulder Creek)
    e. Lefthand Creek (above confluence with St. Vrain Creek)
5. Summary of Biological Monitoring
6. QA/QC Analysis
7. Current and Future Regulatory Issues
8. Recommendations
    a. Modifications to Monitoring Plan
    b. Special Studies
    c. Water Quality Improvements/Habitat Enhancements
9. Conclusions

Appendices[5]

Appendix A. Monitoring Location Maps

Appendix B. Tabular Summary Statistics

Appendix C. Boxplots

Appendix D. Time Series Plots

[5]Depending on the number of water quality constituents analyzed, appendices may not be necessary if analyses are presented in the body of the report.

OVERVIEW OF STATISTICAL METHODS[6]

To complete statistical analysis, a commercially-available statistical package is recommended that is robust, user-friendly and capable of "batch" analysis of multiple analyte-location combinations. (As one example, XLSTAT is an Excel plug-in that enables the user to calculate statistics in a familiar software environment and edit the formatting of graphs and tables using Excel tools.) Table 4 summarizes recommended statistical methods for data collected under the watershed monitoring programs, followed by additional description of key statistical techniques. Additional descriptions of these analysis approaches follow.

Table 4. Water Quality Analysis Report Recommendations

Analysis Type	Frequency	Comment
Tabular Summary Statistics (Analyte-Monitoring Location)	Annual (targeted analytes)	Generate using batch processing tools in a commercially available software package.
Graphical Summaries • Boxplots • Time Series Plots	Annual (targeted analytes)	Generate using batch processing tools in a commercially available software package.
Comparison to Stream Standards	Annual (targeted pollutants)	Ideally, a five-year data set is included in this analysis; however, annual data comparisons can be conducted as well.
Trend Analysis and Targeted Hypothesis Testing (example tools) • Seasonal Mann Kendall • Mann-Whitney • Wilcoxon Signed Rank • Kruskal-Wallis with multiple pairwise comparisons using Dunn's Procedure • Probability plots (graphical data representation)	Budget-dependent; Biennial (targeted pollutants)	The examples listed include several non-parametric approaches that do not require assumptions of normally distributed data. Other statistical tests may be used.
Hydrologic Conditions Summary	Annual	Summarize data from stream gauges in Appendix B

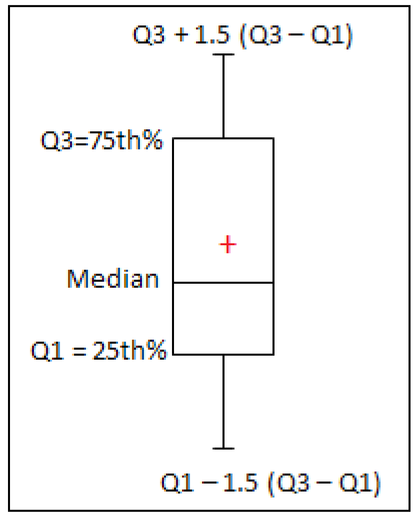
[6] Discussion adapted from City of Boulder Baseline and Annual Water Quality Report for 2011 (City of Boulder and WWE 2012).

Basic Descriptive Statistics

Basic summary statistic tabulations provide an overview of the characteristics of the data set, including measures of central tendency and range of the data, along with several other statistical parameters, as described in Table 5. For purposes of descriptive statistics, trend analysis, and hypothesis testing, a simple substitution approach using one-half of the detection limit will be used to represent non-detects. (Note: advanced substitution approaches could be considered on an as-needed basis.)

Graphical Methods

Boxplots: Boxplots provide a graphical representation of the 1st quartile (Q1 or 25th percentile), median (50th percentile), mean and 3rd quartile (Q3 or 75th percentile) displayed together with limits (i.e., the ends of the "whiskers") beyond which values are considered anomalous (or rare). The mean is displayed with a red +, and a black line through the box corresponds to the median. The ends of the whiskers represent the following: a) lower limit: = Q1 – 1.5 (Q3 – Q1) and 2) upper limit: Q3 + 1.5 (Q3 – Q1).



Time Series Plots (line charts): Time series plots provide a graphical representation of data over time. The x-axis identifies sample dates and the y-axis provides quantitative values for those sample dates. Time series plots are particularly useful for identifying potential repeating seasonal patterns over time, or identifying whether multiple sample locations behave similarly or differently over time.

Table 5. Overview of Representative Descriptive Statistics

Parameter	Brief Description
Number of observations	The number of values analyzed (n). Statistics based on few samples should be used with caution.
Minimum	The minimum of the series analyzed.
Maximum	The maximum of the series analyzed.
1st quartile	The first quartile (Q1) is defined as the value for which 25% of the values are less. Corresponds to the "floor" of a boxplot.
Median	The median (Q2) is the 50th percentile value for the data set that corresponds to the mid-line of a boxplot. This is a non-parametric estimate of central tendency that does not require the assumption of normally distributed data.
3rd quartile	The third quartile (Q3) is defined as the value for which 75% of the values are less. Corresponds to the "roof" of a boxplot.
Mean	The mean of the sample is the arithmetic average. This is a parametric estimate of central tendency that requires the assumption of normally distributed data.
Variance	Calculated variance of the sample population.
Standard deviation	Calculated standard deviation of the sample population.
Variation coefficient	This coefficient measures the dispersion of a sample relative to its mean.
Skewness (Fisher)	This coefficient gives an indication of the shape of the distribution of the sample. If the value is negative (or positive, respectively), the distribution is concentrated on the left (or right, respectively) of the mean. This test does not require an assumption of normally distributed data.
Kurtosis (Fisher)	This coefficient gives an indication of the shape of the distribution of the sample. If the value is negative, the peak of the distribution of the sample is more flattened out than that of a normal distribution. This test does not require an assumption of normally distributed data.
Geometric mean	A type of average, defined as the nth root of the product of n values. (Used for assessment of *E. coli* standard compliance.)
Percentiles (various)	Various percentiles such as the 15th and 85th percentile are used for purposes of regulatory assessments for certain constituents (in addition to the 25th, 50th, and 75th percentiles previously described).

Stacked Area Charts (in Excel): Stacked area charts are useful for showing the magnitude of change over time, and can be used to draw attention to the total value across a period of time. Stacked area charts are used to graphically display inflows to the reservoirs when daily flow data are available.

Stacked Bar Charts (in Excel): Stacked bar charts show the relationship of individual items to the whole. For example, the monthly loading to a reservoir can be shown by stacking the load from each source to show both the overall monthly load and the relative contribution of each source to the overall load.

Correlation Analysis

Correlation Coefficients: Correlation coefficients provide information regarding the correlation between two variables. The Pearson correlation method measures the strength of the linear relationship between normally distributed variables. The Spearman rank correlation method makes no assumptions about the distribution of the data. It may therefore be more appropriate for data with large outliers that hide meaningful relationships between series or for series that are not normally distributed. Correlation coefficients range from 0 to 1 and can be positive or negative (if an inverse relationship is present.

Hypothesis Testing

Seasonal Mann-Kendall Test for Trend: This is a non-parametric test that can be used to determine whether a trend is present in a time-series of data, taking into account seasonality of the data. This means that for monthly data with seasonality of 12 months, the hypothesis test does not try to determine if there is a trend in the overall series, but if there is a trend from one month of January to another, and from one month February and another, and so on. Data sets must be carefully reviewed and formatted in equal time steps to properly run this test. For this reason, the seasonal Mann-Kendall was only run for certain data sets in this report. For data sets where seasonality is not expected to be a significant factor, then the Mann-Kendall test for trend can be run, without the additional data formatting requirements.

Kruskal-Wallis Test for Differences among Sample Populations: The Kruskal-Wallis test is a non-parametric hypothesis test used to evaluate whether two or more sample populations come from the same populations. For example, this test can be used to evaluate whether there are statistically significant differences between monitoring locations on Boulder Creek. The assumption of normally distributed data is not required to use this test. (It is equivalent to the Mann-Whitney test if only two sample populations are being compared.) XLSTAT allows various methods for calculating this test. Multiple pairwise comparisons using Dunn's procedure can be used to identify which sample populations are different. Commonly, alpha is set at 0.05 as the threshold to reject the null hypothesis that the data are from the same sample population; however, higher alpha values can also be justified, depending on analysis objectives and parameter.

Additional Statistical Methods

Additional statistical analysis is beyond the scope of this report; however, a variety of additional statistical analysis techniques are available to characterize data, conduct hypothesis testing, develop regression equations, and conduct other types of statistical tests.

5.0 Data Validation and Usability

Data Review, Validation and Verification

Data review, validation and verification should occur at several stages of the monitoring program. These include:

- Laboratory Analyst Review: At the time of data analysis, the laboratory analyst will flag data with appropriate qualifiers such as in cases where the analyte is detected in the method blank, samples exceed hold time, or other conditions affecting the validity of the result.

- Data Entry Check by Original Data Provider: Prior to submittal of data to the watershed database, the original data provider will review the compiled data set for common errors such as decimal point shifts, units errors, incorrect dates, and other common data entry errors. These errors will be corrected prior to submitting data to the watershed database.

- KICP Review of Overall Database: After annual data upload to the watershed database is completed, draft tabular and graphical summary statistics will be distributed to KICP stakeholders for review to identify questionable data that should be checked prior to data analysis.

The data review procedure recommended by the CDPHE for Regulation 85 instream monitoring program includes these steps:

Step 1

1. Review the data set for completeness. Confirm that all sample sites and constituents are reported or that there is an explanation for each missing data point.
2. Review the data report. Confirm that all titles, labels, column headings, and footnotes are accurate and complete. Confirm that all constituents are reported in proper units.
3. Review the date and time documentation. Confirm that the sample dates and times are consistent with the date and time received in the laboratory. Confirm that the dates and time for analysis are consistent with the dates and times of the analysis. Confirm that the holding times were not violated, based on a comparison of sampling and analysis date and times.

Step 2

1. Review all values that are reported as “None Detected.” Confirm that the analytical detection limits are low enough to accomplish project goals and meet the [monitoring program] requirements. Confirm that all values are either reported as values or less

than the detection limit (i.e., zeroes should not be used for non-detects). Confirm that the detection limit is used consistently on all samples.

Step 3

1. Review data for internal consistency. Confirm that values have a logical relationship to one another. Confirm that values are within the historical range of data for a given site and constituent. Confirm that values vary logically according to known conditions, such as seasonal temperature and presence or absence of dilution flows.
2. Review the internal and external quality control results. Confirm that spike recovery percentages on matrix spikes, relative percent difference on laboratory duplicates, and percent error on known laboratory standards were within acceptance limits. Confirm that digestion blanks, reagent blanks, and method blanks do not contain concentrations of analyte that interfere with interpretation of data.

Validation and Verification Methods

In addition to the steps described above, data validation and verification will rely on both quantitative and qualitative methods. Quantitative methods will include the following:

- Calculation and review of relative percent difference (RPD) results for duplicate samples.
- Review of field blanks (should be non-detect for most analytes).
- Reasonableness checks for well-established data relationships (e.g., comparison of dissolved versus total forms for metals).
- Review of graphical data representations for potential outliers (e.g., decimal point shifts, units errors).
- Review of field conditions that may provide context/verification for extreme, but valid, results (e.g., flood events, fires, etc.)

Reconciliation with Data Quality Objectives

A water quality data analysis report will be completed on an annual basis, enabling review of findings by watershed stakeholders. During this process, findings will be compared to data quality objectives. Recommended modifications to the Monitoring Plan will be provided in the annual report and integrated into the Monitoring Plan on an annual basis, if such updates are needed. Additionally, special monitoring may be needed to supplement the routine monitoring in the plan. (For example, additional source identification monitoring for *E. coli* was recommended in the St. Vrain Basin 319 Plan in 2015.)

References

Cavanagh, N., R.N. Nordin, L.W. Pommen and L.G. Swain, 1998. Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia, British Columbia Ministry of Environment, Lands and Parks, Pub. No. 7680000554.

City of Boulder and Wright Water Engineers. 2013. Baseline and Annual Water Quality Report for 2011.

City of Boulder, 2014. Boulder Creek Water Quality Monitoring Program.

City of Boulder. 2013. Regulation 85 Nutrient Sampling and Analysis Plan. CDPS Permit CO-0024147. March 1.

City of Lafayette. 2013. Regulation 85 Nutrient Sampling and Analysis Plan. CDPS Permit No. CO-0023124. February 6.

City of Longmont. 2013. Regulation 85 Nutrient Sampling and Analysis Plan, City of Longmont, Public Works and Natural Resources Division of Environmental Services, CDPS Permit No. CO-0026671, February, 2013.

City of Louisville. 2013. Regulation 85 Nutrient Sampling and Analysis Plan. CDPS Permit No. CO-0023078. February 8.

Colorado Data Sharing Network. 2014. CDSN Universal Minimum Data Elements Physical/Chemical Data. Accessible at www.coloradowaterdata.org.

Colorado Monitoring Framework, 2013. Regulation 85 Sampling and Analysis Plan Template. Prepared with funding from the South Platte Coalition for Urban River Evaluation (SP CURE).

Colorado Water Quality Control Commission, 2012. Regulation No. 85. Nutrients Management Control Regulation. 5 CCR 1002-85. Effective: September 30, 2012.

Colorado Division of Water Resources DWR website: http://cdss.state.co.us/onlineTools/Pages/StreamflowStations.aspx

Colorado River Watch. 2009. Colorado River Watch Water Quality Sampling Manual, version 5.09.

Denver Water. 2013. Denver Water Quality Laboratory Project Plan, 2012 Watershed Monitoring, Updated 11/30/2013.

Northern Colorado Water Conservancy District, 2014. Standard Operating Procedures for Northern Water’s Water Quality Monitoring Programs.

Northern Colorado Water Conservancy District website:
http://www.northernwater.org/WaterProjects/EastSlopeWaterData.aspx?WDType=S

Town of Erie. 2013. Regulation 85 Nutrient Sampling and Analysis Plan.

Town of Superior. 2013. Regulation 85 Nutrient Sampling and Analysis Plan.

U.S. Geological Survey (various dates). National Field Manual for the Collection of Water-Quality Data Techniques of Water-Resources Investigations, Book 9 Handbooks for Water-Resources Investigations, accessible online: http://water.usgs.gov/owq/FieldManual/.

U.S. Geological Survey National Water Information System (NWIS) website:
http://waterdata.usgs.gov/nwis

Additional Acknowledgement:

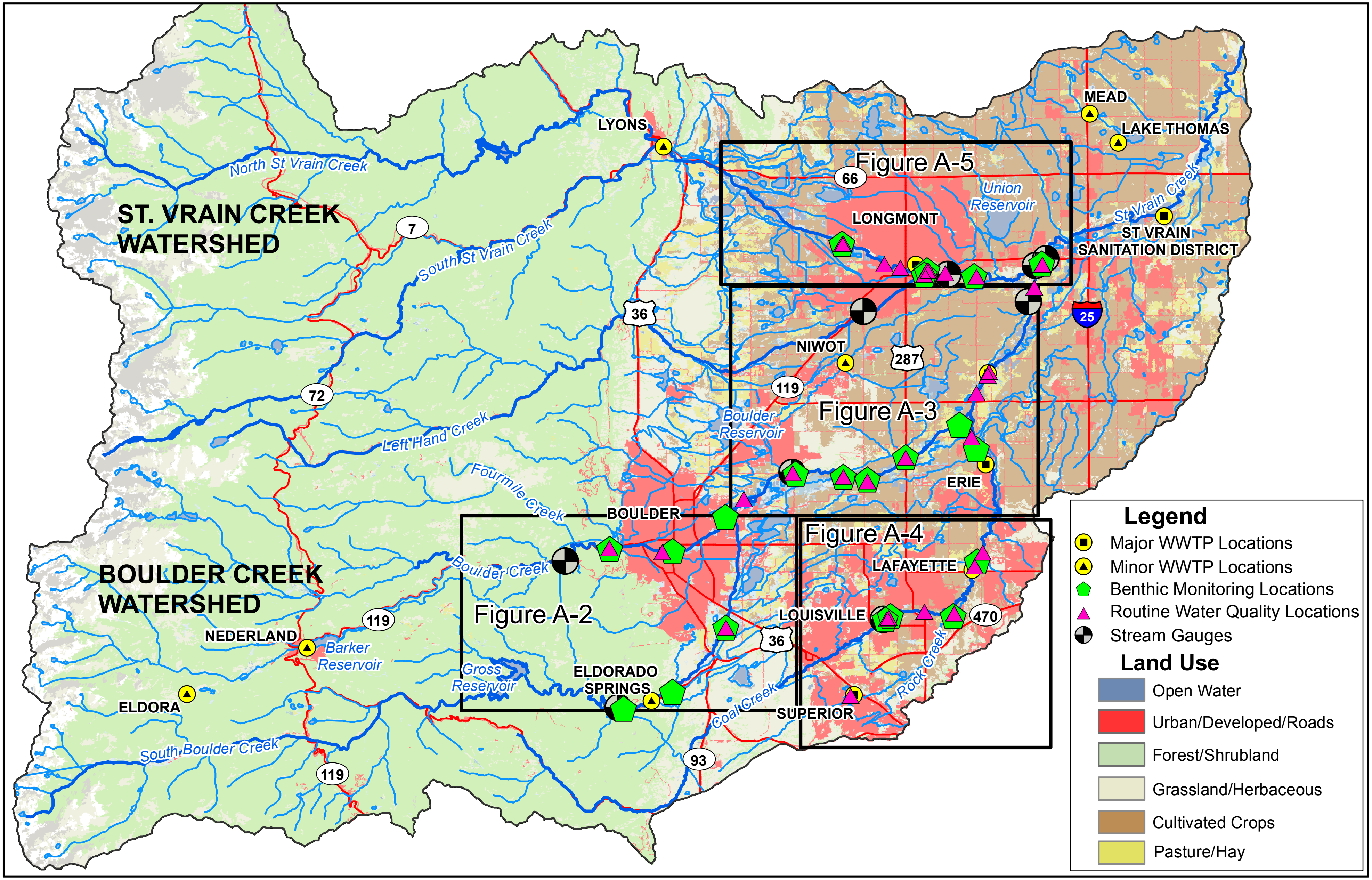
Big Dry Creek Watershed Association, 2013. Cooperative Sampling and Analysis plan for the Main Stem of Big Dry Creek. Prepared 2003 and updated February 2013. (*Note: used as a general reference in development of this sampling plan*.)

Z:\Project Files\12\121-002\121-002.010\Engineering\DRAFT Monitoring Plan\Active Draft Monitoring Plan\St Vrain Monitoring Plan_Version1.1_9-25-15.docx

This page intentionally left blank.

Appendix A Monitoring Location Maps

This page intentionally left blank.



Path: Z:\Project Files\12\121-002\121-002.010\CAD-GIS\GIS\Monitoring Plan Series\Figure 1_Boulder St Vrain Monitoring Locations.mxd

Base Map: National Land Cover Dataset

WWE
WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

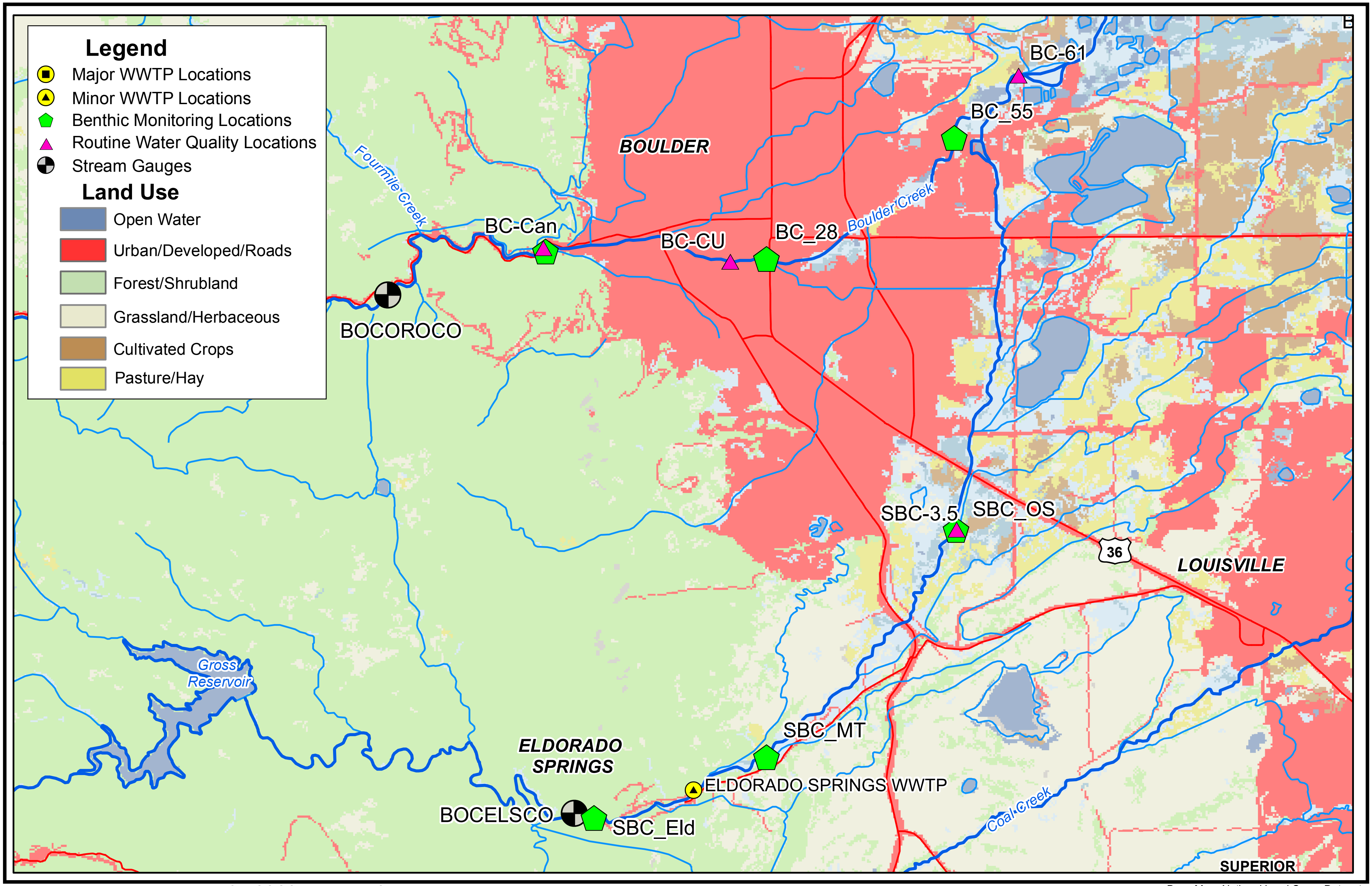
ST. VRAIN-BOULDER WATERSHED

JOINT MONITORING PLAN LOCATIONS

0 1.5 3 6
Miles

PROJECT NO. 121-002.010

FIGURE A-1



Path: Z:\Project Files\12\121-002\121-002.010\CAD-GIS\GIS\Monitoring Plan Series\Figure 2A_Boulder Monitoring Locations 62915.mxd

Base Map: National Land Cover Dataset

WWE
WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

BOULDER CREEK WATERSHED

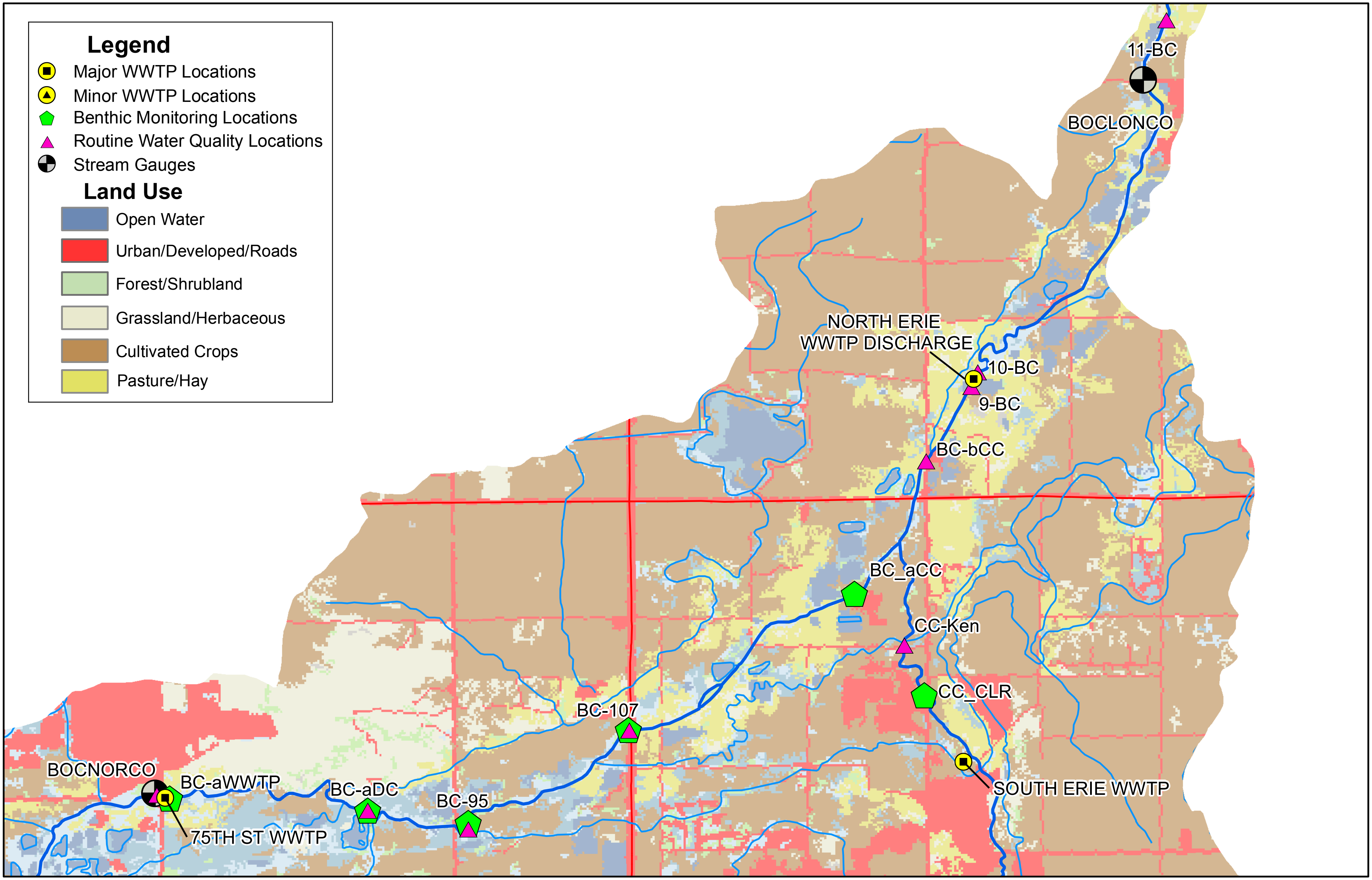
JOINT MONITORING PLAN LOCATIONS

N W E S

0 0.375 0.75 1.5
Miles

PROJECT NO. 121-002.010

FIGURE A-2



Path: Z:\Project Files\12\121-002\121-002.010\CAD-GIS\GIS\Monitoring Plan Series\Figure 2B_Boulder Monitoring Locations 62915.mxd

Base Map: National Land Cover Dataset

WWE
WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

BOULDER CREEK WATERSHED

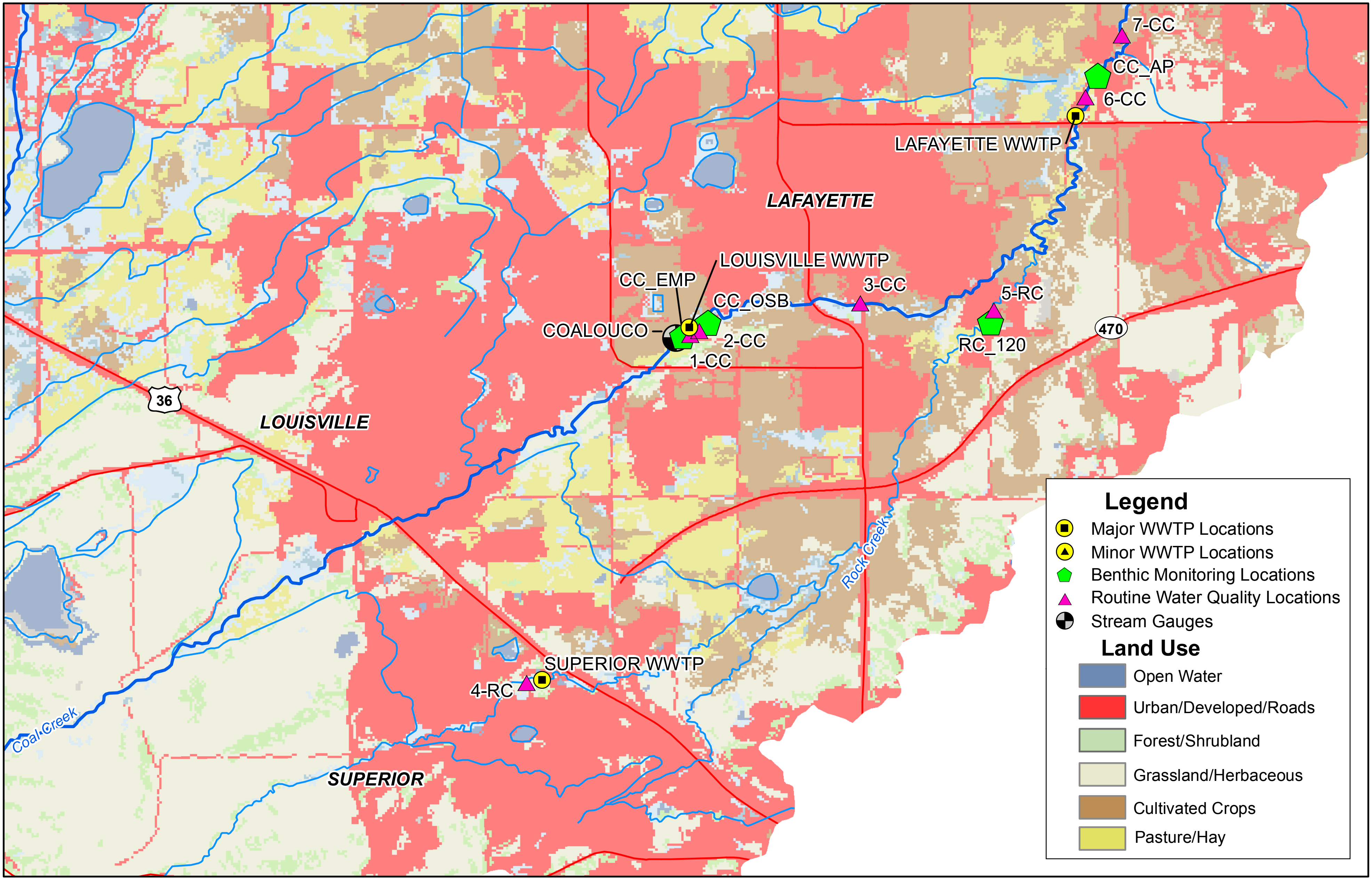
JOINT MONITORING PLAN LOCATIONS

N W E S

0 0.375 0.75 1.5
Miles

PROJECT NO.
121-002.010

FIGURE
A-3



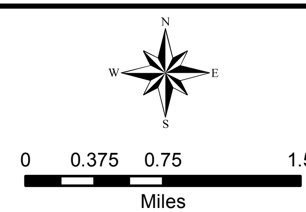
Path: Z:\Project Files\12\121-002\121-002.010\CAD-GIS\GIS\Monitoring Plan Series\Figure 2C_Boulder Monitoring Locations 62915.mxd

Base Map: National Land Cover Dataset

WWE
WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

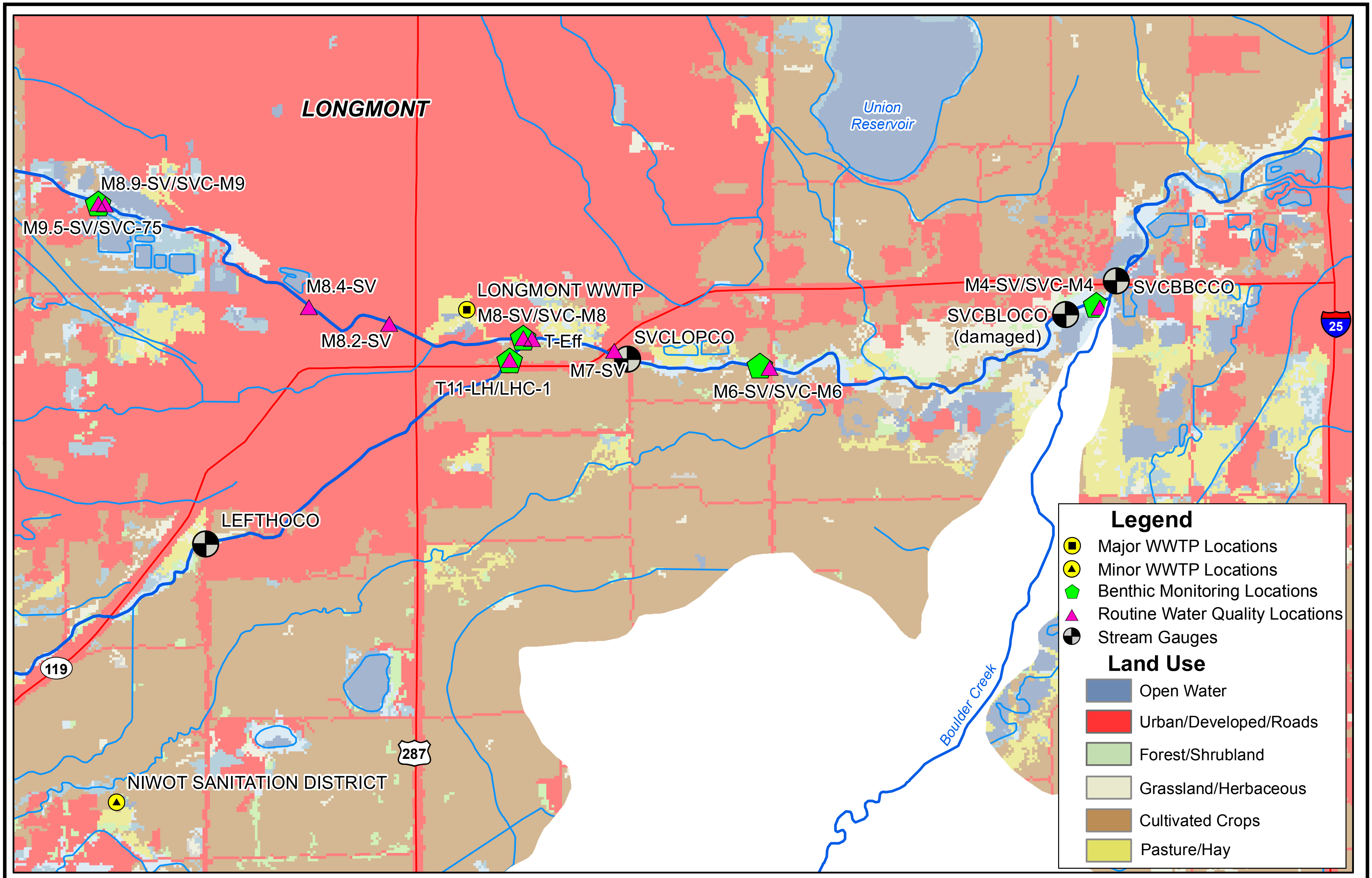
BOULDER CREEK WATERSHED

JOINT MONITORING PLAN LOCATIONS



PROJECT NO.
121-002.010

FIGURE
A-4



Path: Z:\Project Files\12\121-002\121-002.010\CAD-GIS\GIS\Monitoring Plan Series\Figure 3_St Vrain Monitoring Locations.mxd

Base Map: National Land Cover Dataset

WRIGHT WATER ENGINEERS, INC.
2490 W 26TH AVE 100A
DENVER, CO. 80211
(303) 480-1700

ST. VRAIN CREEK WATERSHED

JOINT MONITORING PLAN LOCATIONS

N S W E

0 0.25 0.5 1

Miles

PROJECT NO.

121-002.010

FIGURE

A-5

This page intentionally left blank.

Appendix B Keep It Clean Partnership Coordinated Monitoring Program Analytes and Locations

This page intentionally left blank.

Table B-1. 2014 KICP Cooperative Monitoring Program Locations

Plot_ID	Instream Monitoring Location Description	Stream Name	Data Provider	DD_Lat	DD_Long	Flow Monitoring Type (or closest gauge)	Anticipated Monthly Sample Date
BC-Can	Pool area at Anderson Ditch head gate	Boulder Creek	City of Boulder	40.0132	-105.3015	USGS 06727000 aka BOCOROCO; BOULDER CREEK NEAR ORODELL, CO	Second Tuesday of month
BC-CU	Under foot bridge connecting Folsom Field with dirt parking lot to the North	Boulder Creek	City of Boulder	40.0111	-105.2661		Second Tuesday of month
BC-61	Just West of 61st St. bridge	Boulder Creek	City of Boulder	40.0381	-105.2116		Second Tuesday of month
BC-aWWTP	Under bridge at 75th St. Western side	Boulder Creek	City of Boulder	40.0515	-105.178611	USGS 06730200 aka BOCNORCO; BOULDER CREEK AT NORTH 75TH ST. NEAR BOULDER, CO	Second Tuesday of month
BC-aDC	above Dry Creek	Boulder Creek	City of Boulder	40.0495	-105.14485	Flow Meter	Second Tuesday of month
BC-95	Downstream of Lower Boulder Ditch headgate 0.87 miles below BC-aDC sample site.	Boulder Creek	City of Boulder	40.0472	-105.1288		Second Tuesday of month
BC-107	Bridge at 107th Street	Boulder Creek	City of Boulder	40.0592	-105.1030		Second Tuesday of month
BC-bCC	Bridge where Boulder Creek goes under East County Line Road 2.13 miles below BC-Ken sample site.	Boulder Creek	City of Boulder	40.0921	-105.0553		Second Tuesday of month
SBC-3.5	Open Space at McGuinn Ditch gate	South Boulder Creek	City of Boulder	39.9722	-105.2236	USGS 06729500 aka BOCELSCO; SOUTH BOULDER CREEK NEAR ELDORADO SPRINGS, CO	Second Tuesday of month
CC-Ken	Bridge where Coal Creek goes under Kenosha Rd. 0.89 miles upstream from Boulder Creek confluence.	Coal Creek	City of Boulder	40.0695	-105.0590		Second Tuesday of month
9-BC	Boulder Creek above the North Erie WWTP discharge	Boulder Creek	Erie	40.1012	-105.0480		1st week of month
10-BC	Boulder Creek below the North Erie WWTP discharge	Boulder Creek	Erie	40.1030	-105.0470		1st week of month
11-BC	Boulder Creek Gage 06730500	Boulder Creek	Erie	40.1522	-105.0144	USGS 06730500 aka BOCLONCO; BOULDER CREEK AT MOUTH NEAR LONGMONT, CO	1st week of month
1-CC	Coal Creek above the Lousiville WWTP discharge	Coal Creek	Louisville	39.9761	-105.1164	USGS 06730400 aka COALOUCO; COAL CREEK NEAR LOUISVILLE, CO; aka COC-1	1st week of month
2-CC	Coal Creek below the Lousiville WWTP discharge	Coal Creek	Louisville	39.9765	-105.1160		1st week of month
3-CC	Coal Creek above the confluence with Rock Creek	Coal Creek	Lafayette	39.9799	-105.0909		1st week of month
6-CC	Coal Creek above the Lafayette WWTP discharge	Coal Creek	Lafayette	40.0032	-105.0574		1st week of month
7-CC	Coal Creek below the Lafayette WWTP	Coal Creek	Lafayette	40.0103	-105.0519		1st week of month
4-RC	Rock Creek above the Superior WWTP discharge	Rock Creek	Superior	39.9369	-105.1377		1st week of month
5-RC	Rock Creek above the confluence with Coal Creek	Rock Creek	Superior	39.9790	-105.0711		1st week of month
T11-LH	T-11, Lefthand Creek @ St Vrain	Left Hand Creek	Longmont	40.1551	-105.0874	Flow Meter	3rd Week of Month
M8.9-SV	M-8.9, St Vrain @ Golden Ponds	St. Vrain Creek	Longmont	40.1693	-105.1442	Flow Meter	3rd Week of Month
M8-SV	M-8, St Vrain @ Above Effluent	St. Vrain Creek	Longmont	40.1553	-105.0878	Flow Meter	3rd Week of Month
M7-SV	M-7, St Vrain @ 119	St. Vrain Creek	Longmont	40.1530	-105.0741	SAINT VRAIN CREEK BELOW KEN PRATT BLVD AT LONGMONT, CO (SVCLOPCO); also use flow meter	3rd Week of Month
M4-SV	M-4, St Vrain @ Above Boulder Creek Confluence	St. Vrain Creek	Longmont	40.1582	-105.0108	Flow Meter; (historic data from damaged gauge is USGS 06725450 ST. VRAIN CREEK BELOW LONGMONT, CO or SVBLOCO on the CDWR webpage)	3rd Week of Month
Planned Additions							
0-CC	Location above urbanized area	Coal Creek	Superior	39.94	-105.192778	No flow gauge. WQ site may be added in the future. Approximate location.	1st week of month
LH-HOV	Left Hand Creek at Hover Gauge	Left Hand Creek	Longmont	40.134278	-105.130819	USGS 06724970 aka LEFTHOCO; LEFT HAND CREEK AT HOVER ROAD NEAR LONGMONT, CO. WQ site may be added in the future. Approximate location.	3rd Week of Month

Notes:

Samples are also collected at WWTP discharges, ideally corresponding to instream sample date.

Additional routine monitoring is also conducted by others; this table is limited to KICP monitoring locations.

Table B-2. 2014 KICP Cooperative Monitoring Program Analytes and QC

Parameter	Type	Frequency	MDL	Comment
pH	Field	monthly	1 std.unit	
DO	Field	monthly	0.1 mg/L	
Temperature	Field	monthly	-15 C	At the time of sample collection. Also monitored more frequently below WWTPs.
Conductivity	Field	monthly	0.1 mmhos/cm	
Hardness, Total as CaCO3	Basic WQ Parameter (needed to calc. metals stds.)	monthly	1 mg/L	Use for stream standard evaluation. Highly recommended. (Calculate from Ca + Mg).
Alkalinity, Total	Basic WQ Parameter	monthly	1 mg/L	Monitored for Boulder Creek, South Boulder Creek, St. Vrain Creek, Lefthand Creek, recommend adding for Rock Creek, Coal Creek.
Flow	Field/Gauge	monthly (inst. Meters); daily @ gauges	Stream dependent	USGS/DWR gauge data used where available; instantaneous flow measurements at selected locations. Recommendation: add flow monitoring for Rock Creek above confluence
E. coli	Fecal Indicator Bacteria	monthly	1 MPN/100 mL	
TSS	Solids	monthly	2 mg/L	
NH3, as N	Nutrients	monthly	50 ug/L	To support potential future NH3 model.
NO3+NO2, as N	Nutrients	monthly	20 ug/L	
TKN, as N	Nutrients	monthly	100 ug/L	
TN, as N	Nutrients	monthly	100 ug/L	Calculated from NO2/NO3 + TKN.
TIN, as N	Nutrients	monthly	NA	Calculated from NO2/NO3 + NH3.
TP, as P	Nutrients	monthly	10 ug/L	Report as P.
Benthic monitoring	Aquatic Life	twice per year, Spring and Fall		See Table B-3.
Herbicides/ Pesticides	Herbicides/Pesticides	TBD	varies	KICP priority pollutant. May be discussed in future modification to the plan.
Hydrocarbons	Hydrocarbons	TBD	varies	KICP priority pollutant. May be discussed in future modification to the plan.
Metals: (1) As, (2) Se, (3) Metals w/stream stds.	Metals	TBD (min. quarterly)	varies	Metals are not a KICP priority pollutant (although relevant to individual cities). May be discussed in future modificiaton to the plan. Important in some locations given potential aquatic life impairments. Relevance varies by location.

Note: Instream monitoring is voluntary, with the exception of nutrients required at certain locations under Regulation 85.

Report both MDL and RDL with submitted data.

KICP QC/QA

Type	Frequency	Acceptance Criteria	Comment
Field Blank	5%; 1/20 samples	< RDL	Pour in field.
Field Replicate	5%; 1/20 samples	25% RPD	Sample collected right after the first sample.

Table B-3. 2014 KICP Cooperative Benthic Macroinvertebrate Monitoring Program Locations

Site ID	Description	Stream	Lat DD	Lon DD	Data Provider
SBC_Eld	above Eldorado Spr	South Boulder Creek	39.9305	-105.2921	City of Boulder
SBC_MT	at Mesa Trail	South Boulder Creek	39.9392	-105.2596	City of Boulder
SBC_OS	at Open Space	South Boulder Creek	39.9721	-105.2236	City of Boulder
BC_CAN	at Canyon	Boulder Creek	40.0127	-105.3011	City of Boulder
BC_28	at 28th Steet	Boulder Creek	40.0115	-105.2593	City of Boulder
BC_55	at 55th Steet	Boulder Creek	40.0290	-105.2238	City of Boulder
BC_aWTP	above WWTP	Boulder Creek	40.0511	-105.1766	City of Boulder
BC_aDC	above Dry Creek	Boulder Creek	40.0495	-105.1449	City of Boulder
BC_95	at 95th Street	Boulder Creek	40.0479	-105.1288	City of Boulder
BC_107	at 287	Boulder Creek	40.0593	-105.1032	City of Boulder
BC_aCC	above Coal Creek	Boulder Creek	40.0758	-105.0668	City of Boulder
SVC_M9	above Longmont	St Vrain Creek	40.1694	-105.1450	Longmont
SVC_M8	above WWTP	St Vrain Creek	40.1554	-105.0882	Longmont
LHC_1	above St Vrain	Lefthand Creek	40.1531	-105.0900	Longmont
SVC_M6	below WWTP	St Vrain Creek	40.1524	-105.0565	Longmont
SVC_M4	below Longmont	St Vrain Creek	40.1585	-105.0113	Longmont
SG_2	near Union Res	Spring Gulch #2	40.1718	-105.0502	Longmont
CC_EMP	at Empire Road	Coal Creek	39.9761	-105.1170	Coal Creek Cities
CC_OSB	at OS bridge	Coal Creek	39.9777	-105.1135	Coal Creek Cities
RC_120	at 120 Road	Rock Creek	39.9776	-105.0716	Coal Creek Cities
CC_AP	at Airport	Coal Creek	40.0056	-105.0555	Coal Creek Cities
CC_CLR	at county line	Coal Creek	40.0634	-105.0558	Coal Creek Cities

Table B-4. GIS Coordinates for Instream Monitoring with KICP Sample ID

Station Name	Data Type	Latitude	Longitude	Other Station ID
BOCOROCO	Gauge	40.0064	-105.3308	6727000
BOCNORCO	Gauge	40.0517	-105.1789	6730200
BOCLONCO	Gauge	40.1388	-105.0202	6730500
BOCELSCO	Gauge	39.9311	-105.2958	6729500
LEFTHOCO	Gauge	40.1343	-105.1308	6724970
SVCBLOCO	Gauge	40.1574	-105.0154	6725450
COALOUCO	Gauge	39.9761	-105.1172	6730400
SBC_Eld	Benthic	39.9305	-105.2921	
SBC_MT	Benthic	39.9392	-105.2596	
SBC_OS	Benthic	39.9721	-105.2236	
BC_CAN	Benthic	40.0127	-105.3011	
BC_28	Benthic	40.0115	-105.2593	
BC_55	Benthic	40.0290	-105.2238	
BC_aWTP	Benthic	40.0511	-105.1766	
BC_aDC	Benthic	40.0495	-105.1449	
BC_95	Benthic	40.0479	-105.1288	
BC_107	Benthic	40.0593	-105.1032	
BC_aCC	Benthic	40.0758	-105.0668	
SVC_M9	Benthic	40.1694	-105.1450	
SVC_M8	Benthic	40.1554	-105.0882	
LHC_1	Benthic	40.1531	-105.0900	
SVC_M6	Benthic	40.1524	-105.0565	
SVC_M4	Benthic	40.1585	-105.0113	
SG_2	Benthic	40.1718	-105.0502	
CC_EMP	Benthic	39.9761	-105.1170	
CC_OSB	Benthic	39.9777	-105.1135	
RC_120	Benthic	39.9776	-105.0716	
CC_AP	Benthic	40.0056	-105.0555	
CC_CLR	Benthic	40.0634	-105.0558	
BC-Can	WQ	40.0132	-105.3015	
BC-CU	WQ	40.0111	-105.2661	
BC-61	WQ	40.0381	-105.2116	
BC-aWWTP	WQ	40.0515	-105.1786	
BC-aDC	WQ	40.0495	-105.1449	
BC-95	WQ	40.0472	-105.1288	
BC-107	WQ	40.0592	-105.1030	
BC-bCC	WQ	40.0921	-105.0553	
SBC-3.5	WQ	39.9722	-105.2236	
CC-Ken	WQ	40.0695	-105.0590	
9-BC	WQ	40.1012	-105.0480	
10-BC	WQ	40.1030	-105.0470	
11-BC	WQ	40.1522	-105.0144	
1-CC	WQ	39.9761	-105.1164	
2-CC	WQ	39.9765	-105.1160	
3-CC	WQ	39.9799	-105.0909	
6-CC	WQ	40.0032	-105.0574	
7-CC	WQ	40.0103	-105.0519	
4-RC	WQ	39.9369	-105.1377	
5-RC	WQ	39.9790	-105.0711	
T11-LH	WQ	40.1551	-105.0874	
M8.9-SV	WQ	40.1693	-105.1442	
M8-SV	WQ	40.1553	-105.0878	
M7-SV	WQ	40.1530	-105.0741	
M4-SV	WQ	40.1582	-105.0108	

Table B-5. WWTP Discharge Locations Participating in KICP Monitoring Program

KICP Sample ID	KICP Sample Location Lat.	KICP Sample Location Long.	Facility Lat. (in ECHO)	Facility Long. (in ECHO)	Facility_Name	Facility_Street	Facility_ZIP_ Code	CDPS ProgramID#	Permit Type
A-CC	39.9801	-105.1221	39.9750	-105.1250	LOUISVILLE WWTF	1601 EMPIRE RD	80027	CO0023078	Major
B-RC	39.9368	-105.1403	39.9333	-105.1333	SUPERIOR METROPOLITAN DIST NO1	2025 HONEY CREEK LANE	80027	CO0043010	Major
C-CC	40.0038	-105.0579	40.0028	-105.0578	LAFAYETE WWTF	750 E COUNTY LINE RD	80026	CO0023124	Major
E-BC	40.1021	-105.0474	40.0552	-105.0495	ERIE WWTF	1000 BRIGGS ST	80516	CO0045926	Major
T-EFF	40.1557	-105.0862	40.1292	-105.1000	LONGMONT WWTF	501 E 1 AVE	80501	CO0026671	Major
WWTF Eff	40.0514	-105.1775	40.0511	-105.1772	75TH ST WWTP	4049 N 75 ST	80301	CO0024147	Major

This page intentionally left blank.

Appendix C Chain of Custody and Field Forms

This page intentionally left blank.

Agency: ______________________________

Agency Address: ______________________________

CHAIN OF CUSTODY RECORD

CDPS PERMIT #			SAMPLERS (SIGNATURE)			
LOCATION	DATE	TIME	SAMPLE TYPE (Grab/Composite)	SAMPLE TIME	# OF CONTAINERS	ANALYSIS REQUESTED
RELINQUISHED BY: (SIGNATURE)			RECEIVED BY: (SIGNATURE)			DATE/TIME
RELINQUISHED BY: (SIGNATURE)			RECEIVED BY: (SIGNATURE)			DATE/TIME
RELINQUISHED BY: (SIGNATURE)			RECEIVED BY: (SIGNATURE)			DATE/TIME
DISPATCHED BY: (SIGNATURE)		DATE/TIME	RECEIVED FOR LABORATORY BY:			DATE/TIME
METHOD OF SHIPMENT:						
RELINQUISHED BY: (SIGNATURE)			RECEIVED BY: (SIGNATURE)			DATE/TIME
RELINQUISHED BY: (SIGNATURE)			RECEIVED BY: (SIGNATURE)			DATE/TIME
DISTRIBUTION: ORIGINAL-ACCOMPANY SHIPMENT 1 COPY-COORDINATOR						

WQP Northern Water Water QualityProgram

Northern Water Flowing Sites Water Quality Notes

Station ID ________________________ Sample Time_________________ MST

Sample Date ______________________ QC Samples Concurrent Split Field Blank DOC

Sampling Team CH __________ DH _________ QC Sample Time ______________ MST

Laboratory Information

Bottle	Processing	S1 / S3	L1 / L3	N1 / CN	N2
		Analyte Group Codes			
500 ml HDPE	Raw	TSS, TDS, TKN, TP	TSS, TDS, TKN, TP	TSS, TDS, TKN, TP	
500 ml Amber	Raw	Chlorophyll	Chlorophyll	Chlorophyll	
125 ml HDPE	Raw, Preserved w/ HNO3	Fe	Fe, Mn, Cd, As		
125 ml Amber Glass	Raw, Preserved w/ H2SO4	TOC	TOC	TOC	
125 ml HDPE	Filtered, Acidified w/ HNO3	Fe, Mn, Cu, Ca, Mg, K, Na	Fe, Mn, Cu, Ag, Pb, Ni, Se, Zn, Ca, Mg, K, Na		
250 ml HDPE	Filtered	NH3, NO3/NO2, OrthoP	NH3, NO3/NO2, OrthoP	NH3, NO3/NO2, OrthoP	
125 ml HDPE	Filtered		Cl, SO4		
125 ml HDPE	Filtered, no headspace	Alkalinity	Alkalinity		
125 ml Amber Glass	Filtered, Acidified w/ H2SO4	DOC	DOC	DOC	

Sampling Information

Sampler Type DH-81 DH-95 Bottle VanDorn Pump **Nozzle** 1/4 5/16

Sampling Method EWI MPG SPG SV DIP Pump **YSI** 6600 6820

Sampling Location Wading Cableway Stream Bank Bridge Upstream Downstream ICE

Sampling Site pool riffle open channel braided backwater canal

Channel width _______ **ft** Left Bank _____ Right Bank _____ **Ice cover** _____%

Sampling Points _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Chlorophyll _____________ ml Filtered **Discharge** ____________ cfs

Bottom bedrock rock cobble gravel sand silt concrete **Gage Ht.** ____________ ft

Sky clear partly cloudy cloudy AC RS FT Init______

Precipitation none light medium heavy snow sleet rain mi: **Notes:**

Wind Calm Light breeze Breezy Windy

Quality Control Information

Preservation Lot Numbers

7.7N HNO3 _____________ 4.5N H2SO4 _____________

Filter Lot Numbers

Disposable Capsule Geotech _______________

Figure 2.14 - Flowing sites water quality field sheet.

WQP Northern Water Water QualityProgram

Northern Water Reservoir Water Quality Field Notes

Site ID	________	**Sample Date**	________	**Sample Team**	CH________ DH________

Laboratory Information

Bottle	**Processing**	Analyte Group Codes: **RS**	Analyte Group Codes: **RL**
500 ml HDPE	Raw	TSS, TDS, NVSS, TKN, TP	TSS
500ml Amber	Raw	Chlorophyll a	Chlorophyll a
125 ml HDPE	Raw, Preserved w/ HNO3		Fe, Mn, Cd, As
125ml Amber Glass	Raw, Preserved w/ H2SO4	TOC	TOC
250 ml HDPE	Raw	Zooplankton 0-5m, 5-10m	Zooplankton 0-5m, 5-10m
250 ml HDPE	Raw	Phytoplankton 0-5m,	Phytoplankton 0-5m,
125 ml HDPE	Filtered, Acidified w/ HNO3	Fe, Mn	Fe, Mn, Cu, Ag, Pb, Ni, Se, Zn, Cd, As, Ca, Mg, K, Na
250 ml HDPE Wide Mouth	Filtered	NH3, NO3/NO2, OrthoP	NH3, NO3/NO2, OrthoP
125 ml HDPE	Filtered		Cl^-, $SO_4^=$
125 ml HDPE	Filtered, no head space		Alkalinity
125 ml Amber Glass	Filtered, Preserved w/H2SO4	DOC	DOC
125 ml Amber Glass	Filtered	UV254	UV254

Sample Information

Sample Method Van Dorn Pump 3L bottle — **Process time** ________
YSI Sonde 6600 Other ________ — **Process location** boat truck other ________

Reservoir Depth ________
Top Sample Depth ________
Bottom Sample Depth ________
Lake Elevation ________
Chlorophyll ________ mL filtered

With View Scope

Secchi Disappear		**Secchi Reappear**			
1st	________	1st	________	Offset	________
2nd	________	2nd	________	Reader	________
Avg	________	Avg	________		________

Without View Scope

Secchi Disappear		**Seccchi Reappear**			
1st	________	1st	________	Offset	________
2nd	________	2nd	________	Reader	________
Avg	________	Avg	________		

Sample Times

Top	________	Zoo	0.5	________	Phyto	0.5	________		
Bottom	________	Zoo	5.10	________				EC-1	________
Chlorophyll	________	QA/QC:________					________	EC-	________
Hg-1	________	Hg-B ________						EC-B	________

Field Observations

Wind calm light breeze gusty windy — **Sky** clear party cloudy cloudy other________
Air Temp ________ ° C — **Pressure** ________mmHg
Precipitation none light medium heavy snow
sleet rain mist other________

Quality Control Information

Blank **Split Replicate** **Concurrent Replicate**

Preservation Lot Numbers
7.7N HNO3________ 4.5N H2SO4________
Filter Lot Numbers
Disposable Capsule 73050004
Blank Water Lot Numbers

FIGURE 2.20 - LAKE/RESERVOIR SITE WATER QUALITY FIELD SHEET.

This page intentionally left blank.

Appendix D Field Equipment and Supplies Checklist

This page intentionally left blank.

Factsheet 1

Field Equipment and Supplies Checklist

Equipment	Purpose
YSI 600 XL Multi probe (depth, pH, temp, specific conductivity, barometer and redox) with 650 Datalogger and 150 foot cable	Field parameter measurement for reservoirs and streams in the Upper Section and reservoirs in the Lower Section
Orion5-Star Series Multi probe (pH, temp, specific conductance, depth)	Field parameter for streams in the Lower Section
Flow meter Marsh-McBirney Flo-Mate 2000, 100 ft fiberglass reel tape	Field parameter measurement measurements (depth, velocity, stream width) for stream flow
Waders and boots	Stream sample and flow measurement collection
Peristaltic field pump and 5 ft. boom, 12 ft. piece of #15 silicone tubing/sample site	Access water at midstream throughout the year and minimize sample contamination at Lower Section monitoring locations
Sample bottle tray	Hold sample bottles upright and prevent contamination during bottle filling for Lower Section
4 Wheel drive vehicle	Good ground clearance required for vehicle
Cellular phone	Available for staff use in the event of emergency
Coolers with ice	Hold samples after collection and maintain sample temperature at 4 degrees C
Canoe, stabilizers and brackets, paddles and fold out double pointed anchor, 200 feet nylon rope	Reservoir sampling
Canoe rack and 4 Nylon hold down straps	Quick adjusting straps to hold down canoe on vehicle for reservoir sampling
CB Radio and 2 –way radios	Used by personnel on shore and boat during reservoir sampling for safety
Life vests and floatation seat cushions	Used by personnel in boats during reservoir sampling for safety
Wildco Horizontal Beta Bottle 4.2 liters Acrylic and 200 foot braided polyester line with messenger	Collect top and bottom reservoir composite samples
Secchi disk (200 mm diameter, white and black) with 50 ft of braided polyester line	Measure clarity of reservoir water,

This page intentionally left blank.

Appendix E Field Equipment Calibration

This page intentionally left blank.

Factsheet 4

Field Equipment Calibration

Field Parameter	Equipment	Resolution	Calibration Procedure
Depth	YSI 600XL multi probe (*Used for Upper Section*)	0.01 feet	Probe calibrated at the site prior to conducting a vertical profile of reservoir. The sensor is zeroed to the current barometric pressure by entering zero in the pressure-abs calibration menu.
Temperature	YSI 600XL multi probe (*Used for Upper Section*) Orion 5-Star Series multi e-probe (*Used for Lower Section*)	0.01° C 0.1 up to 99.9 º, 1.0 over 99.9 º C	The temperature probe is checked annually.
pH	YSI 600XL multi probe (*Used for Upper Section*) Orion 5-Star Series multi probe (*Used for Lower Section*)	0.01 unit Accuracy ± 0.002 S.U.	Calibrated with pH buffers 7 and 10 in the laboratory before each sample event. Probe has automatic temperature compensation for temperature-corrected buffer values. Buffers are replaced at least monthly. YSI 600XL probe is not automatically temperature compensated, so room temperature pH values are used when calibrating the 7 and 10 buffers.

Field Parameter	Equipment	Resolution	Calibration Procedure
Dissolved Oxygen	YSI 600XL multi probe (*Used for Upper Section*) Orion 5-Star Series multi e probe (*Used for Lower Section*)	0.01 mg/L Accuracy ± 0.01 mg/L, Precision ± 0.1 mg/L	Calibrations are conducted in the field at the sample site with a moist-air saturated bottle. A calibration sleeve is used to calibrate DO in the wastewater laboratory before each sample event. The instrument automatically measures and compensates for temperature and total atmospheric pressure.
Specific Conductance	YSI 600XL multi probe (*Used for Upper Section*) Orion 5-Star Series multi probe meter (*Used for Lower Section*)	Accuracy ± 1% or 0.1 µmhos/cm 4 significant digits down to 0.001 µS/cm	The conductivity probe is used for Specific Conductance (SC) and water temperature. The conductivity probe is calibrated in the laboratory with a potassium chloride (KCl) solution of 1413 µmhos/cm at 25° C. Standards are replaced at least monthly.
Clarity - Secchi Depth	**Secchi Disc**	Not applicable	None required
Flow	Marsh-McBirney Flo-Mate 2000	Accuracy: ±2% of reading + zero stability	Calibration is performed at the factory. The zero is checked periodically.

6. Sensor Calibration and Maintenance

The YSI multiparameter sondes are calibrated and maintained according to the manufacturer's instructions and specifications. The general procedures for calibration and maintenance are summarized in Section 6.0, while the step-by-step procedures used by Northern Water are included in Appendix J.

6.1 YSI 6820/6600/600 Sonde Calibration

Calibration of the D.O., pH, and specific conductance sensors is conducted at the beginning of each sampling day and checked at the end of the day as outlined on Table 6.1. The results of all calibration activities are recorded in a log book (Figure 6.1) that includes the information shown on the sample log sheet on Figure 6.2.

The temperature sensors are not calibrated. The temperature sensors require a quarterly check against a NIST-traceable thermometer to verify that they are still performing according to specifications. Temperature sensors that do not perform according to specifications are replaced.

The turbidity sensors undergo a monthly two-point calibration. Note that this frequency is per the manufacturer's recommendation, unless there is uncertainty about the field measurements.

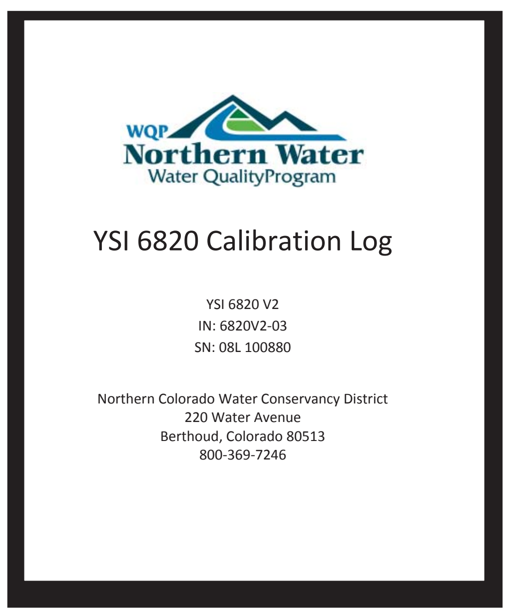


Figure 6.1 - Recording results of sonde calibration in log book.

TABLE 6.1 - YSI SENSOR CALIBRATION

Parameter	Sensor	Calibration Standard	Calibration Activity	Acceptance Criteria
Temperature (°C)	YSI 6560 Sensor: thermistor	NIST traceable thermometer	Quarterly check of endpoints of temperature range versus NIST thermometer.	± 0.15°C of true value at both endpoints (manufacturer's listed accuracy for the sensor)
Dissolved Oxygen, D.O. (mg/L)	YSI 6150 Sensor: ROX™ luminescent optical	D.O. Calibration Chamber (for use with YSI 6600 & 6820 sondes)	Calibration: daily, in camper lab, at first site; one-point calibration with air-saturated water (YSI 6660 & 6820), or one-point calibration with water-saturated air (YSI 600). Post-sampling (end of day) check: one-point check with air saturated water or water saturated air	Calibration: ± 0.1 mg/L of saturated value (100% saturation value obtained from table based on temp & atm pressure) Post-sampling check: ± 0.1 mg/L of saturated value
pH (units)	YSI 6561 Sensor (used with YSI 600XLM sondes) YSI 6589 Fast-Response Sensor (used with all other sondes)	Ricca Chemical (VWR) pH 7.00 Buffer & pH 10.00 Buffer	Calibration: daily, in camper lab, at first site; two-point calibration with pH 7.00 and pH 10.00 buffers. Post-sampling (end of day) check: Two-point check with pH 7 and pH 10 buffers	Calibration: Millivolts output after calibration pH 7 Buffer: 0± 50 mv pH 10 Buffer: -180±50 mv Millivolt span between the two calibration points: 165 to 180 mv. Post-sampling check: ± 0.2 pH units from buffer value
Specific Conductance (µS/cm at 25°C)	YSI 6560 Sensor	Ricca Chemical (VWR) 1000 µS/cm Potassium Chloride Conductivity Standard	Calibration: daily, in camper lab, at first site; one-point calibration with 1000 µS/cm standard. Post-sampling (end of day) check: One-point check with 1000 µS/cm standard	Calibration: Conductivity cell constant within 4.5 to 5.5 Post-sampling check: ± 0.5% + 1 µS/cm of true value for the 1000 µS/cm Standard
Turbidity (ntu)	YSI 6136 Sensor: optical, 90° scatter	YSI 126 NTU Turbidity Standard; 0 NTU standard prepared by filtering D.I. water through 0.45 micron disposable capsule filter.	Two-point calibration performed monthly (per manufacturer's recommendation) unless there is uncertainty about field measurements. After calibration, apply 0.5 NTU offset to 0 NTU standard to eliminate negative readings.	Calibration: ± 2% of reading or 0.3 ntu, whichever is greater
Depth (meters)			Calibrated at first lake/reservoir sample site of the day at depth of 1.0 meter; Check/verify 1.0 meter depth reading at other sites.	± 0.02 m

FIGURE 6.2 - YSI SONDE CALIBRATION SHEET.

Location ________________**Date** ______________**Time** _____________ **Initials** _______________

Specific Conductance Calibration						
Standard Value µS/cm	Ricca Lot No.	Standard Exp. Date	Standard Temp °C	Initial Reading µS/cm	Adjusted Reading µS/cm	6560 Conductivity Cell Constant
1000						
Accuracy: 0.5 % of reading + 1 µS/cm. Cell Constant range 5.0 ± .45						

pH Calibration									
pH Buffer	Ricca pH Buffer Lot No.	pH Buffer Exp. Date	pH Buffer Temp °C	pH Buffer Corrected for Temp	Initial pH	Adjusted pH	Millivolts	mv Range	Slope
7								**0 ± 50**	
10								**-180 ± 50**	
4								**+180 ± 50**	
Accuracy: ± 0.2 pH units. To determine the slope calculate the difference in the millivolt readings of the two calibration points. The slope should be within 165 to 180 millivolts.									

Dissolved Oxygen Calibration					
___ Air-Saturated Water ___ Water-Saturated Air					
Calibration Temp °C	Barometric Pressure mm Hg	100% Saturation from chart mg/L	Initial Reading mg/L	Adjusted Reading mg/L	ODO Gain
Accuracy: ± 1% of reading or 0.1 mg/L, whichever is greater. ODO gain range 0.25 to 1.25					

Turbidity ___ Calibration ___ Check						
Standard Value	Standard Brand	Standard Lot No.	Standard Expiration Date	Calibration Temp °C	Initial Reading NTU	Adjusted Reading NTU
0	Filtered DI	X	X			
0.5 NTU Offset	Filtered DI	X	X			
Accuracy: ±2 % of reading or 0.3 NTU, whichever is greater						

Post Sampling Calibration Check Time _________									
Specific Conductance			**pH**				**DO** BP _________mmHg		
Std Value µS/cm	Std Temp °C	SC Reading µS/cm	pH Buffer	Buffer Temp °C	Buffer pH Corrected for Temp	pH Reading	Temp °C	DO Table Reading mg/L	DO Reading mg/L
			7						
			10						
1000									

Notes:

6.2 YSI 6820/6600/600 Sonde Maintenance

Sonde maintenance, cleaning and storage is performed by Northern Water according to the manufacturer's specifications (https://www.ysi.com/media/pdfs/069300-YSI-6-Series-Manual-RevH.pdf).

A maintenance kit for YSI 6-series sondes (Figure 6.3) is taken into the field during all sampling events in order to address routine maintenance issues that might occur such as replacement of damaged o-rings.

Routine cleaning of the pH probe. Cleaning of the pH probe is required whenever deposits or contamination appear on the glass or when the response of the sensor becomes slow. Initially, clean water and a soft clean cloth, lens cleaning tissue, or cotton swab are used to remove all foreign material from the glass bulb. If the pH sensor response is still not restored, additional steps are followed as outlined in Appendix J.

Figure 6.3 - YSI 6-series sonde maintenance kit: o-rings, o-ring lubricant, cleaning brushes, probe installation tool, syringe for sensor port cleaning.

YSI 6600/6820 Short Term Storage. When a sonde will remain inactive for four weeks or less, the sonde is stored with all of the sensors left installed in the bulkhead. The sensors are kept hydrated by adding 1/8" of tap water to the bottom of the calibration cup. Deionized water is not used since it can shorten the life span of the pH sensor. It is important to have enough water in the cup so that the sensors stay hydrated, but the sensors should never be immersed in water during storage.

YSI 6600/6820/600 Long Term Storage. When a sonde will not be used for over 4 weeks, it is prepared for long term storage. All batteries are removed from the sonde (6600 and 600 sondes) as well as the 650 MDS. The cable is thoroughly cleaned using Simple Green. The pH sensor is removed from the bulkhead and placed back into the original storage bottle filled with 2M KCL. After the pH sensor is removed, the empty port is plugged. The remaining sensors can be left installed in the bulkhead, but they must be hydrated by adding 1/8" of tap water to the bottom of the calibration cup. The sonde is periodically checked to make sure that the sensors left in the bulkhead remain hydrated.

Annual Sensor Maintenance. The optical sensors (turbidity and dissolved oxygen) are sent to a YSI repair facility every other year for preventative maintenance as required to maintain the factory warranty. All o-rings and quad seals are serviced at this time to ensure proper operation and seal of the wiper assembly.

All dissolved oxygen ROX membranes must be replaced annually. Membrane assemblies are purchased from YSI and installed by Northern Water Field Services.

The YSI 6561 pH sensors are replaced on an annual basis. The YSI 6589 Fast-Response pH sensors usually perform per specifications for periods longer than a year, and are replaced as required.

Appendix F Sample Bottle Preparation

This page intentionally left blank.

Factsheet 5

Sample Bottle Preparation

Drinking Water Quality Laboratory
Upper Boulder Creek & Boulder Reservoir Watershed Sample Bottles

# of Bottles		Type of Bottle	Parameter(s)	Preservation	Holding Times
Field Bottles					
Upper Boulder Creek	Boulder Reservoir WS				
10	9	2 Liter PE	Hardness, Alkalinity, Turbidity	<4°C	24 hours
			Sodium[1]	<4°C	5days
2[2]	1[2]	1 Liter	NH_3-N; TKN	sulfuric acid <2 pH, <4°C	28 days
10	9	250 ml PE	TP	frozen	30 days
10	9	100 ml autoclaved PP	Total Coliform & *E. coli*	<4°C	6 hours
10	9	40 ml amber glass	Total Organic Carbon	<4°C	5 days
1[3]	1[3]	2 Liter amber PE	Chlorophyll *a*	filtered within 5 hours, then frozen	30 days
1[3]	1[3]	125 ml PE	Phytoplankton (count & bio-volume)	1 ml Lugol's Solution	30 days
10	9	2 Liter PE	Total Suspended Solids	<4°C	24 hours
Filtered Lab Bottles (not taken to the field)					
10	9	250 ml PE	NO_3-N, Cl, SO4, F, OP	filtered	5 hours
				frozen	30 days
10	9	250 ml PE	DP	frozen	30 days
10	9	500 ml PE	UV 254, True Color, Fe, Mn	<4°C	5 days
2[4]	2[4]	500 ml PE	NH_3 (low range)	frozen	30 days

[1]Boulder Reservoir Watershed only
[2]Nederland effluent & reservoir top sites only
[3]Reservoir top sites only
[4]Reservoir top & bottom sites only

This page intentionally left blank.

Appendix G Streamflow Measurement (Six-tenths method)

This page intentionally left blank.

Stream Channel Measurements from Regulation 85 Sampling and Analysis Plan Template (Prepared by Colorado Monitoring Framework 2013)

Stream channel flow is calculated by velocity and area measurements taken at instream sample locations. Stream width is determined with a tape measure across a sample transect perpendicular to the channel. Streams are generally waded to collect measurements of depth (staff gauge) and velocity (current velocity meter). Current velocity measurements may be obtained using an electromagnetic flow instrument (e.g., Global Flow Probe, Marsh McBurney). Where streams cannot be accessed by wading, flow can be measured from a bridge using a weighted line marked in feet for the depth with the flow meter attached.

Measurements of depth and velocity are taken on the same vertical line at even distances across the stream at the center of equally spaced intervals. Interval width is determined by how even and consistent the flow is across the channel, as well as the width of the channel. A stream strewn with boulders without a uniform channel would demand closer intervals than an even channel with a sandy bottom. Generally, velocity readings will be recorded at the center of intervals that are ten percent of the width of the stream along the cross-section transect at each sample site.

Flow for each section of the sample transect is calculated by multiplying the velocity by the area of the individual transect section. Flows for each transect section are then summed to determine an overall transect flow rate. This flow rate calculation method is shown schematically on Figure 3.

How to Calculate Flow

Calculating discharge from each of the width intervals:

$q_2 = v_2 d_2 (w_3 - w_1) / 2$

where:
- q_2 = discharge at width interval 2 (cfs)
- v_2 = velocity measure at width interval 2 (ft./sec.)
- d_2 = depth at interval 2 (feet)
- w_3 = distance from the bank or initial measuring point to the point following interval 2 (feet)
- w_1 = distance from the bank or initial measuring point to the point preceding interval 2 (feet)

Calculate the total discharge (flow) as the sum of each of the partial discharges.

$Q = q_1 + q_2 + q_3 + q_4 \ldots q_0$

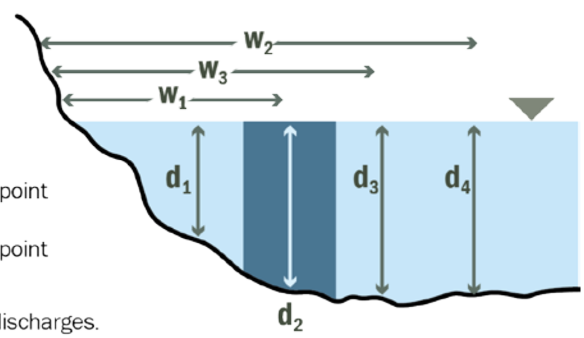


Figure 3. Stream Channel Flow Calculation

Another flow measurement option, the sixth-tenths depth method (0.6 method) is summarized below. The 0.6 method consists of measuring the velocity at 0.6 of the depth from the bottom of the stream, and is generally used for shallow flows where the water depth is less than 2 feet. A single velocity measurement is taken at each interval, at 0.6 of the depth from the bottom. It is essential that portable flow meter be in place long enough to get a reliable average of the velocity. Electromagnetic velocity meters are counted or observed for a minimum of 20 seconds. This standard operating procedure describes general use of an electromagnetic velocity meter. Instructions for steps 1, 5, and 9 may vary based on the specific manufacturer and model.

3. Adjust the time averaging interval with the up/down arrows until 20 seconds is displayed on the screen.
4. Measure the width of the stream leaving the tape suspended several feet above the water.
5. Beginning 6 inches from either bank, measure the depth.
6. Adjust the wading rod to the 0.6 tenth position.
7. Holding the rod in a steady upright position, push the START button on the meter. The movement screen will begin moving left to right measuring velocity for 20 seconds. At the end of 20 seconds, the average velocity will appear on the screen and the display will again begin another 20-second period.
8. Record the first velocity reading, ignoring the second displayed velocity.
9. Move the wading rod 1 foot into the stream and record the depth.
10. Adjust the wading rod to the 0.6 tenth position.
11. Push the START button on the display. A new 20-second interval period will begin. At the end of the 20-second period, the average velocity will again appear on the screen.
12. Record the second velocity reading, ignoring the display counting the third display period.
13. Repeat step 7-10 until you reach 6 inches from the far bank. The 6 inch reading will be your last reading.
14. Add all the velocities and divide by the number of readings to get the average.
15. Add all the depths and divide by the number of readings to get the average depth.
16. Multiply the width by the average depth and the average velocity to determine flow in cubic feet per second (cfs).

Estimating Flow Volumes. Excessive flow velocities and flow depth may impede the measurement of flow at some sample locations. In this case, flow will be estimated using an approximate velocity, water depth, and the known cross-sectional geometry from previous sampling events. It is critical that the field sheet is marked “estimated” using this method.

Appendix H Sample Collection for Dissolved Metals Clean Hands/Dirty Hands Technique

Factsheet 2

Sample Collection for Dissolved Metals
Clean Hands/Dirty Hands Technique

A quick reference guide on the City of Boulder's dissolved metals sampling procedures used in the field.

Metals sample collection method is based on techniques outlined in the USGS Handbooks for Water-Resources Investigations, Techniques of Water-Resources Investigations, Book 9, (http://water.usgs.gov/owq/FieldManual), and EPA Method 1669 Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels (July 1996). These "clean hands/dirty hands" methods are used to minimize the potential for low level metal contamination of samples collected in the field and maximize the consistency and reliability of sample collection. This **Factsheet 2** outlines the Clean Hands/ Dirty Hands sampling technique.

Preparation in the Laboratory

It is essential that the "clean hands" / "dirty hands" process starts as the sampling equipment is received. Each item used in the sampling process should be received and stored in a manner compliant with the described protocols.

- Filters, syringes, and sample vials should be stored separately in clean and washed Tupperware containers.
- These items should never be handled with bare hands or gloves that have come in contact with anything other then the filters, syringes, or sample vials.
- You should open the Tupperware and then transfer the sampling equipment by pouring them out of the bags they are received in.
- Tupperware should be routinely washed to ensure against contamination, and should never be left open longer than required to perform necessary tasks.

When preparing sample kits (a syringe, sample vial, and all needed filters) clean gloves should be worn. Nothing besides a zip lock bag and the above equipment should be touched.

- Kit's can be pre-assembled before the event.
- A large zip lock bag should be used to store the individual kits and a separate bag for extra gloves to take into the field. Check to insure that sufficient gloves will always be taken into the field.
- Once the larger bag of sample kits is complete, it can be stored with the rest of the sample containers and taken into the field.

Sampling in the Field

Designate one person as "clean hands" and one person as "dirty hands."

- The individual designated as "dirty hands" will have the responsibilities of touching the exterior of bags and will aid the individual designated as "clean hands" but will never come into contact with the sample or sampling equipment directly.
- "Dirty hands" will first manipulate the syringe using the exterior of the zip lock bag to allow "clean hands" easy access without touching the interior or exterior of the bag.
- The same method described above should then be used for the filter. "Clean hands" should take extra precaution to avoid touching either the dispensing tip or connecting tip of the filter and only grab by the edge of the filter disc.
- After the filter and syringe are removed "dirty hands" will manipulate the exterior of the bag as to make the lid of the sample vial accessible to "clean hands". The bag should be folder over slightly to allow a stable resting place for "clean hands" to rest the lid of the vial on.

Sampling steps are then taken by the sampling team.

- "Clean hands" will approach the sampling location and, using one hand to hold the filter, use the other hand to pull sample water into the syringe. Nothing should be touched by "clean hands" with the exception of the filter and syringe.
- "Clean hands" will attach the filter to the end of the syringe.
- "Clean hands" will remove the sample vial cap and rest it on the inside of the bag that should be slightly folded over.
- "Clean hands" will purge a few drops of sample through the filter to prime the filter. After this is done, the remaining sample will be filtered into the sample vial.
- "Clean hands" will return the lid to the sample vial and, using the same methods described above, return to collect a second sample. This is done to achieve the 50mL sample volume required by laboratory staff.
- "Dirty hands" will close the zip lock bag and place the bag with the rest of the samples collected at the site.
- The syringe and filter should be discarded to prevent second use.

Laboratory Analysis

The following steps should be taken at sample receiving to ensure against contamination of dissolved metals samples.

- Sample receiving and laboratory analysis of dissolved metals samples should complement the steps taken to produce the high quality samples collected in the field.
- Clean receiving and analytical environments should be maintained and mandatory to meet the criteria set forth in the "clean hands / dirty hands" protocols described in this document.
- These procedures will be described in this document as they are produced.

Appendix I Colorado Data Sharing Network Minimum Data Elements for Physical/Chemical Data

This page intentionally left blank.

COLORADO WATER QUALITY MONITORING COUNCIL
COLORADO DATA SHARING NETWORK
P.O. Box 2058 Ridgway, CO 81432 • 970-626-4045
cwqmc@coloradowaterquality.org • www.ColoradoWaterData.org

May 9, 2014

CDSN Universal Minimum Data Elements Physical/Chemical Data | 2014

CDSN AWQMS divides elements into 4 main categories which are uploaded separately, using specific templates:

1. **Organizational elements**
2. **Project elements**
3. **Monitoring Location elements (what Phil calls "metadata")**
4. **Activities/Results for the type of sampling such as Physical/Chemical Results**

Once 1-3 are uploaded, they do not need to be uploaded again unless changes are being made or unless there are additional Projects and/or Monitoring Locations to add to the system.

1. Organizational elements -- see CDSN New Organization form (download at http://www.coloradowaterdata.org/background_2013/fin/new_data_provider_materials/New_Org_Form_CDSN_Aug_2013.docx). CDSN uploads the information on this form for you, when you order your CDSN AWQMS-WQX Org ID.

Organizational Element	Notes
Organization ID	
Organization Name	For Reg85 WQCD requires including your Watershed Group and CO Discharge Number
Organization Description	
Mailing Address	
Physical Address (if different)	
Phone	Can be office, mobile or both (specify type)
Fax	Optional
Organization Web Site	
Primary Contact Name	
Primary Contact Email	

This is the "Universal" CDSN Organization form.

2. Project elements -- see CDSN Project form (download at http://www.coloradowaterdata.org/background_2013/fin/new_data_provider_materials/Projects_Form.xlsx). CDSN or you can upload this form into AWQMS.

Project Element	**Notes**
Project ID	
Project Name	
Project Description	
QAPP (SAP) Approved Indicator	For Reg85 say "Yes"
QAPP Approval Agency Name	Required for Reg85 and if the QAPP Approved Indicator is "Yes"; Typically use "USEPA" or "CDPHE WQCD"
Project Attachment File Name	For Reg85 Attach SAP, put full file name, ends with .zip
Project Attachment File Type	Required by AWQMS if file name specified, must be .zip

This is the "Universal" CDSN Project form. It has all of the info required by both CDSN and CDPHE WQCD (2013). Your SAP is attached and uploaded into AWQMS.

May 2014 Update:

For data that is required to be submitted to a third party such as WQCD for a regulation or program (Reg85, Non-Point Source), CDSN had previously co-developed a protocol to put a common "tag" into an Activity Group element to be able to quickly search for, analyze and/or export data across multiple organizations, projects, and monitoring locations. For example to search for "%85%" would produce all of the Reg85 data stored in the system as long as it had the Reg85 tag.

CDSN and the database programmers have realized technical limitations with this original approach. So the new 2014 protocol moving forward is that any data that will need to be submitted for Reg85 for example, will not only be associated with the original Project ID, commonly used by the data organization, but will also be associated with a CDSN "global" Project ID. Any result can be associated with up to 3 Project IDs. Thus, any Reg85 organization will need to upload the following CDSN Reg85 Project in addition to their Projects:

Project Element	Notes
Project ID	**WQCD_REG85**
Project Name	**WQCD_REG85**
Project Description	CDSN Project Name for all data to be submitted to Colorado Water Quality Control Division (WQCD) to fulfill Regulation 85 requirements.
QAPP (SAP) Approved Indicator	For Reg85 say "Yes"
QAPP Approval Agency Name	Required for Reg85 and if the QAPP Approved Indicator is "Yes"; Typically use "USEPA" or "CDPHE WQCD"
Project Attachment File Name	For Reg85 Attach SAP, put full file name, ends with .zip
Project Attachment File Type	Required by AWQMS if file name specified, must be .zip

Any organization with data that needs to be submitted to WQCD for Reg85 must also associate this Project ID with their Reg85 Activities/Results or else their data will not be included in the annual CDSN Reg85 data submittal to WQCD.

3. Monitoring Location elements --

DSN Essential Data Elements for CDSN SURFACE & GROUND WATER MONITORING LOCATIONS

(Pink Shaded is what CDSN and/or WQCD required in 2013; Gold Shaded is strongly recommended and/or conditionally required; Gray are available data elements that are not currently included in the "universal template" but can be added if desired.)

Column/Element	Notes
Organization ID	
Monitoring Location ID	
Monitoring Location Name	For Reg85 WQCD & CDSN requires including CO Discharge Number in the Name
Monitoring Location Type	
Monitoring Location Description	Many Reg85 organizations put their discharge permit number (again) here along with node details from their SAP.
HUC 8	Use the CDSN GIS application to find the HUC8 code (and HUC12)
HUC 12	Strongly recommended! Use the CDSN GIS application to find the HUC12 code (and

	HUC8)
Tribal Land Indicator (Y/N)	Allowable values are "Yes" or "No"
Tribal Land Name	Conditional if Tribal Land Indicator is "Yes"
Alternate Monitoring Location ID	Such as USGS Station/Gage station number…
Alternate Monitoring Location Context	Conditional, if Alt Monitoring Location ID populated
Latitude	Decimal Degrees; or Deg Min Sec
Longitude	Decimal Degrees; or Deg Min Sec
Source Map Scale	Conditional. Required when Horizontal Collection Method = "Interpolation-Map"
Horizontal Collection Method	
Horizontal Reference System (Datum)	
Vertical Measure (Elevation)	
Vertical Measure UoM (Unit)	Units in Feet ("Ft") recommended
Vertical Collection Method	
Vertical Reference System (Datum)	
State Code	CO (or NM)
County Name	
Country Code	US
Well Type	
Aquifer Name	
Well Formation Type	
Well Hole Depth Measure Value	
Well Hole Depth Measure Unit	
Comments	
Monitoring Location Attachment File Name	Could be a map or document, save as .pdf first and then zip it to a .zip file.
Monitoring Location Attachment Type	Required if file name given. Will always be a .zip.
Waterbody Name	If on Strm/River/Lake/Res; Ex: South Platte

Assessment Unit ID	
Assessment Unit Use ID	
Ecoregion Level 3 ID	
Ecoregion Level 4 ID	
Reach Code	
Township/Range/Section	
Watershed Management Unit	
Horizontal Accuracy	
Horizontal Accuracy UoM	
Date Established	

This is the "Universal" CDSN Monitoring Location form. It has all of the info required by both CDSN and CDPHE WQCD (2013).

4. Activity/Results --

DSN Essential Data Elements FOR PHYSICAL/CHEMICAL ACTIVITIES/RESULTS

* is required for AWQMS and/or WQCD, therefore required. For more detailed allowable values refer to green tabs on Activity/Results Excel template (spreadsheet). Pink rows are required. White rows are optional or may be required for Ground Water/Well activities. Yellow are conditionally required. See the CDSN Physical/Chemical Data Upload Template for more info.

Column/Element	WQCD EDD?	* CDSN Required?	Notes
Project ID	*	*	Matches exactly the ID in Project detail above
Project ID #2 (if sampling is for 2 different projects; Required to use CDSN Reg85 or NPS Project IDs for those programs)	*	*	**WQCD_REG85** [required in order for your data to be submitted by CDSN to WQCD for Reg85.] -or- **CO_NPS** [required in order for your data to be searchable as Non-Point Source data]
Project ID #3 (if sampling is for 2 different projects)			
Monitoring Location ID	*	*	Matches exactly the ID in Monitoring Location detail

			above
Activity ID	*	*	**Value:** Must be unique, see template for details; often use LABSAMPID on lab sheet or use [MLname][YYYYMMDD][Lab or Field] -- important to put Lab or Field (or L/F) at end.
Activity Type	*	*	**Value: Sample-Routine or Field Msr/Obs or Sample-Composite**
Activity Media Name	*	*	**Value: Water**
Activity Media Subdivision Name	*	*	**Values: Surface Water or Wastewater Treatment Plant Effluent**
Activity Start Date	*	*	
Activity Start Time	*	*	
Activity Start Time Zone	*	*	MST, MDT; Required by WQCD
Sample Collection Method ID	*	*	**Values: GRAB, FIELD METER, SECCHI DISK, STAFF GAGE …**
Activity Depth/Height Measure	Conditional	Conditional	Depth from surface; additional details can be mentioned in the Activity comment field
Activity Depth/Height Unit	Conditional	Conditional	Typically feet in Colorado
Activity Depth Altitude Reference Point			Can reference if below sea level or below grade or other reference point; recommended if Activity Depth/Height Measure populated
Activity Top Depth/Height Measure			
Activity Top Depth/Height Unit			
Activity Bottom Depth/Height Measure			
Activity Bottom Depth/Height Unit			
Sample Equipment Name (Type)	*	*	**Values: Water Bottle, Probe/Meter, Water Sampler (Other), Van Dorn Bottle …**
Sample Equipment Comment			
Characteristic Name	*	*	**Values: see lookup tables in template**
Method Speciation	Conditional	Conditional	Required for certain characteristics (as N; as P)
Result Detection Condition	Conditional	Conditional	Not Detected, see lookups on template for other values
Result Value	*	*	In AWQMS, required to leave blank if Not Detected in Result Detection Condition
Result Unit	*	*	
Result Measure Qualifier	Conditional	Conditional	J, B, D, U …
Result Sample Fraction	*	*	Dissolved, Total, …

Appendix J Individual Monitoring Program Summaries

This page intentionally left blank.

APPENDIX D

LONG TERM MONITORING STATIONS AND ASSOCIATED OBJECTIVES

OBJECTIVE					INSTREAM SAMPLE SITES				
Provide Drinking Water	Comply With WQ Standards	Manage NPS Pollutants	Manage Wastewater Pollutants	Protect Natural Systems	Stream Segment (Boulder Creek)	Sample Site Designation	Site Description	Notes on Site Selection	Personnel
Boulder Creek									
X					2a	NBC @ SLP	North Boulder Ck. @ the Silver Lake Pipe Diversion (north side)	Represents Silver Lake watershed	DW
	X	X		X	2b	BC-Can	Boulder Creek at base of Boulder Canyon, in pool area at Anderson Ditch head gate	Represents upper reference reach of segment and above urban runoff discharges	SW
	X	X			2b	BC-CU	Under foot bridge connecting Folsom Field with dirt parking lot to the north	Represents lower reach of segment, below urban runoff discharges	SW
					9	BC-61st	Just west of 61st St. bridge	Segment below urban area, above WWTP discharge	SW
		X	X	X	5	SBC-3.5	South Boulder Creek on Open Space at McGuinn Ditch gate	Major tributary, represents Segment 5, reference reach (same as bioassessment site)	SW
	X		X	X	9	a-WWTP	Boulder Creek above discharge from 75th St. WWTP	Above major discharge point	SW
		X	X		9	WWTP-Effluent	Effluent of 75th St. WWTP in outfall channel before entering Boulder Creek (0.0 river miles below WWTP	Represents WWTP discharge	SW
	X	X	X	X	9	BC-aDC	Boulder Creek at foot bridge above confluence with Dry Creek; (13,304 ft / 2.52 river miles below WWTP effluent)	Regulatory compliance in-stream sampling point below WWTP mixing zone	SW
			X	X	9	BC-95th	Downstream of Lower Boulder Ditch head gate (14,742 ft / 2.79 river miles below WWTP effluent)	Downstream of WWTP, agricultural land-use	SW
	X	X	X		9	BC-107th	Boulder Creek at 109th St. bridge (23,921 ft / 4.53 river miles below WWTP effluent)	Represents lower reach of Segment 9 above confluence with Coal Creek	SW
	X	X	X		10	CC-Ken	Coal Creek at bridge where Coal Creek goes under Kenosha Rd.; (0.89 miles abover confluence with BC which is 38,255 ft/7.25 river miles below WWTP)	Major tributary downstream of municipal WWTP and agricultural land use	SW
	X	X	X		10	BC-bCC	Bridge where Boulder Creek goes under East County Line Rd.; (42,701 / 8.09 river miles below WWTP effluent)	Downstream of Coal Creek tributary	SW
Lakewood Reservoir Tributaries									
X		X			2a	SLP @ LW	Silver Lake Pipe hydro tail water at Lakewood Reservoir	Tributary to reservoir	DW
X	X	X			2a	NBC @ LW	North Boulder Creek at Lakewood Reservoir	Tributary to reservoir	DW
X	X	X			2a	Como @ LW	Como Creek at Lakewood Reservoir	Tributary to reservoir	DW
Barker Tributaries									
X		X	X		3	Ned Eff @ Barker	Nederland WWTF effluent sampled from the manhole	Tributary to reservoir, WWTP discharge	DW
X		X			3	Beaver @ Barker	North Beaver Creek where it enters Middle Boulder Creek	Tributary to reservoir	DW
X	X	X			3	MBC @ Barker	Middle Boulder Creek above Nederland Weir (north side)	Tributary to reservoir	DW
Boulder Reservoir Tributaries (Saint Vrain Stream Segment)									
X		X			SV-6	Unknown Ditch @BR	Unknown ditch in SW corner of Boulder Reservoir, west of the County Rd 51 (@ flume)	Tributary to reservoir	DW
X	X	X			SV-6	Little Dry Creek @ BR	Little Dry Ck SW corner of Bldr Res, N of Unk Ditch, E of the county Rd 51 (@ flume)	Tributary to reservoir	DW
X	X	X			SV-6	Dry Creek @ BR	Dry Creek NW corner of Boulder Reservoir, west of County Rd 51 (@ flume)	Tributary to reservoir	DW
X		X			SV-6	BFC @ BR	Boulder Feeder Canal (above NCWCD Station 12)	Tributary to reservoir	DW
X		X			SV-6	Farmer's Ditch @ BR	Farmers Ditch flume, west of Boulder Reservoir, west of County Rd. 51	Tributary to reservoir	DW
					LAKE AND RESERVIOR SAMPLING SITES				
Barker Reservoir									
X	X				14	BT	Barker Res. 300 feet out from middle of the dam (epilimnion)	Representative sample point - epillimnion	DW
X					14	BB	Barker Res. 300 feet out from middle of the dam (0.5 meters off bottom)	Representative sample point - half meter	DW
X					14	Below Barker	Below Barker Reservoir Dam	Representative sample point - top of water column	DW
Boulder Reservoir (Saint Vrain Stream Segment)									
X					SV-7	BR SDT	Deep water 200 feet SW of WTF intake (epilimnion)	Representative sample point - epillimnion	DW
X					SV-7	BR SDB	Deep water 200 feet SW of WTF intake (0.5 meters off bottom)	Representative sample point - half meter	DW

APPENDIX F

MONITORING CONSTITUENTS

Updated June 30, 2014

Constituents Analyzed

Sample Site Designation[1]	Sample Frequency	Active Site?	Sample Type	Flow	DO	DO % Sat	pH	Water Temp	SpCond	Secchi	Profile	Air Temp	TSS	Turb	TDS	Alk	Hard	DOC	S2	SO4	Na	Cl	F	TP	DP	OP	NO2	NO3	TKN	NH3	Dis Fe	Dis Mn	Metals Suite	TOC	UV254	E.coli	Tot Coli	(VOC's) BTEX	Emerging Contaminants	Chl *a*	Phyto	Periphyton	Habitat
UPPER WATERSHED																																											
Silver Lake																																											
SLT	August	Y	Vertical comp secchi depth (Van Dorn-churn)		X	X	X	X	X	X	X		X	X	X	X	X			X		X	X	X	X	X		X	X	X	X	X	1/yr	X	X	X	X			X	X		
SLB	August	Y	Grab 0.5 m above bottom (Van Dorn-churn)		X	X	X	X	X		X		X	X	X	X	X			X		X	X	X	X	X		X	X	X	X	X	1/yr	X	X	X	X						
Silver Lake Watershed																																											
Albion @ Silver	August	Y	Grab		X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					1/yr	X	X	X	X						
NBC below Island	August	Y	Grab		X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					1/yr	X	X	X	X						
NBC below Goose	August	Y	Grab		X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					1/yr	X	X	X	X						
Albion below Green 2	August	Y	Grab		X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					1/yr	X	X	X	X						
NBC @ SLP	August	Y	Grab	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					1/yr	X	X	X	X						
Lakewood Reservoir Tributaries																																											
SLP @ LW	Monthly	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					4/yr	X	X	X	X						
NBC @ LW	Monthly	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					4/yr	X	X	X	X						
Como @ LW	Monthly	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X					4/yr	X	X	X	X						
Barker Tributaries																																											
Ned Eff @ Barker	Every 2 weeks (May-Oct), Monthly (Winter)	Y	Grab	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X	X	X			4/yr	X	X	X	X						
Beaver @ Barker	Every 2 weeks (May-Oct), Monthly (Winter)	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X	X	X			4/yr	X	X	X	X						
MBC @ Barker	Every 2 weeks (May-Oct), Monthly (Winter)	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X	X	X			4/yr	X	X	X	X						
MBC @ NedWTF	Every 2 weeks (May-Oct), Monthly (Winter)	N	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X		X	X	X	X			X					4/yr	X	X	X	X						
Barker Reservoir																																											
BT	Every 2 weeks (May-Oct)	Y	Vertical comp secchi depth (Van Dorn-churn)		X	X	X	X	X	X	X		X	X	X	X	X			X		X	X	X	X	X		X	X	X	X	X	4/yr	X	X	X	X			X	X		
BB	Every 2 weeks (May-Oct)	Y	Grab 0.5 m above bottom (Van Dorn-churn)		X	X	X	X	X		X		X	X	X	X	X			X		X	X	X	X	X		X	X	X	X	X	4/yr	X	X	X	X						
Below Barker	Monthly (Nov-May)	Y	Grab (Churn)		X	X	X	X	X				X	X	X	X	X			X		X	X	X	X	X		X	X	X	X	X	4/yr	X	X	X	X			X	X		
Betasso WTF Lakewood & Kossler	**Monthly**	**Y**	**Grab**		X	X	X	X	X					X	X	X	X			X		X	X	X	X	X		X					4/yr	X	X	X	X		**February, June & August**	X			
MIDDLE AND LOWER WATERSHED																																											
Boulder Reservoir Tributaries																																											
Unknown Ditch @BR	Monthly (If flowing)	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X	X	X	X	X	X	X		X	X		X	X	4/yr	X	X	X	X						
Little Dry Creek @ BR	Monthly	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X	X	X	X	X	X	X		X	X		X	X	4/yr	X	X	X	X						
Dry Creek @ BR	Monthly	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X	X	X	X	X	X	X		X	X		X	X	4/yr	X	X	X	X						
BFC @ BR	Monthly (If flowing)	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X	X	X	X	X	X	X		X	X		X	X	4/yr	X	X	X	X						
Farmer's Ditch @ BR	Monthly (If flowing)	Y	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X	X	X	X	X	X	X		X	X		X	X	4/yr	X	X	X	X						
Boulder Feeder Canal (BFC)																																											
BFC @ 654	Special	N	24hr autosampler																																X	X	X						
BFC @ Niwot Rd	Special	N	Grab																																X	X	X						
BFC @ Oxford Rd	Special	N	Grab																																X	X	X						
BFC @ ProspectRd	Special	N	Grab																																X	X	X						
BFC @ St.VrainRd	Special	N	Grab																																X	X	X						
BFC @ Lyons	Special	N	Grab																																X	X	X						
BFC @ Nelson Rd	Special	N	Grab																																X	X	X						
St.VrSupply R Mt	Special	N	Grab																																X	X	X						
Left Hand Creek																																											
LHC @ 49th St	Special	N	Grab (Churn)		X	X	X	X	X				X	X	X	X	X			X	X			X	X			X			X	X		X	X	X	X						
LHC @ BFC	Special	N	Grab (Churn)		X	X	X	X	X				X	X	X	X	X			X	X			X	X			X			X	X		X	X	X	X						

APPENDIX F

MONITORING CONSTITUENTS

Updated June 30, 2014

Constituents Analyzed

Sample Site Designation[1]	Sample Frequency	Active Site?	Sample Type	Flow	DO	DO % Sat	pH	Water Temp	SpCond	Secchi	Profile	Air Temp	TSS	Turb	TDS	Alk	Hard	DOC	S2	SO4	Na	Cl	F	TP	DP	OP	NO2	NO3	TKN	NH3	Dis Fe	Dis Mn	Metals Suite	TOC	UV254	E.coli	Tot Coli	(VOC's) BTEX	Emerging Contaminants	Chl *a*	Phyto	Periphyton	Habitat
LHVRes Out	Special	N	Grab (Churn)		X	X	X	X	X				X	X	X	X	X			X	X			X	X			X			X	X		X	X	X	X						
Boulder Reservoir																																											
BR SDT	Monthly or as necessary (March-Dec)	Y	Vertical comp secchi depth (Van Dorn-churn)		X	X	X	X	X	X	X		X	X	X	X	X			X	X	X	X	X	X	X		X	X	X	X	X	4/yr	X	X	X	X	5X Summer (2 high use)		X	X		
BR SDB	Monthly or as necessary (March-Dec)	Y	Grab 0.5 m above bottom (Van Dorn-churn)		X	X	X	X	X		X		X	X	X	X	X			X	X	X	X	X	X	X		X	X	X	X	X	4/yr	X	X	X	X						
BR Marina																																						Summer 2X high use					
63rd ST WTF BFC & Boulder Reservoir	**Monthly**	**Y**	**Grab**		X	X	X	X	X					X	X	X	X			X	X	X	X	X	X	X		X					4/yr	X	X	X	X		February, June & August				
BR DC In	Monthly	N	Comp (Van Dorn-churn)		X	X	X	X	X	X	X		X	X	X	X	X			X	X			X	X	X		X			X	X		X	X	X	X						
BR LDC In	Monthly	N	Comp (Van Dorn-churn)		X	X	X	X	X	X	X		X	X	X	X	X			X	X			X	X	X		X			X	X		X	X	X	X						
BR NDT	Monthly	N	Comp (Van Dorn-churn)		X	X	X	X	X	X	X		X	X	X	X	X			X	X			X	X	X		X			X	X		X	X	X	X						
BR NDB	Monthly	N	Comp (Van Dorn-churn)		X	X	X	X	X		X		X	X	X	X	X			X	X			X	X	X		X			X	X		X	X	X	X						
BRMT	Monthly	N	Comp (Van Dorn-churn)		X	X	X	X	X	X	X		X	X	X	X	X			X	X			X	X	X		X			X	X		X	X	X	X						
BRMB	Monthly	N	Comp (Van Dorn-churn)		X	X	X	X	X		X		X	X	X	X	X			X	X			X	X	X		X			X	X		X	X	X	X						
BCSC	Monthly	N	Grab (Churn)	X	X	X	X	X	X				X	X	X	X	X			X	X			X	X			X			X	X		X	X	X	X						
Boulder Creek																																											
BC-aNBC	Monthly	N	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
NBC-Falls	Monthly	N	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
BC-Oro	Monthly	N	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X						X							
BC-Can	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X						X	
BC-Lib	Monthly	N	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
BC-CU	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X					X			X							
BC-47th	Monthly	N	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
BC-61st	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
BC-aWWTP	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X						X	
O-WWTP	Monthly	N	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
WWTF- Eff Outfall	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
BC-aDC	Monthly	Y	Grab	X	X	X	X	X	X			X	X			X	X	X	X	X	X			X			X	X	X	X			X			X						X	
BC-95th	Monthly	Y	Grab		X	X	X	X	X			X												X			X	X	X	X													
BC-107th	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X						X	
BC-Ken	Monthly	N	Grab		X	X	X	X	X			X	X			X								X			X	X	X	X						X							
CC-Ken	Monthly	Y	Grab		X	X	X	X	X			X	X			X								X			X	X	X	X						X							
BC-bCC	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X	X	X			X			X							
SBC 3.5	Monthly	Y	Grab		X	X	X	X	X			X	X			X	X							X			X	X		X			X			X							
Macroinvertebrate Bioassessment																																											
SBC-A ELD	Spring and Fall	N	Quantitative	X	X	X	X	X	X			X																															
SBC-MT	Spring and Fall	N	Quantitative	X	X	X	X	X	X			X																															
SBC-OS	Spring and Fall	N	Quantitative	X	X	X	X	X	X			X																															
BC-Can	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														X	X
BC-28th	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														Pic	X
BC-55th	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														Pic	X
SBC 3.5	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														Pic	X
BC-aWWTP	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														X	X
BC-aDC	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														X	X
BC-95th	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														Pic	X
BC-107th	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														X	X
BC-aCC	Spring and Fall	Y	Quantitative	X	X	X	X	X	X			X																														Pic	X

APPENDIX F

Updated June 30, 2014

MONITORING CONSTITUENTS

Sample Site Designation[1]	Sample Frequency	Active Site?	Sample Type	Constituents Analyzed																																						
				Flow	DO	DO % Sat	pH	Water Temp	SpCond	Secchi	Profile	Air Temp	TSS	Turb	TDS	Alk	Hard	DOC	S2	SO4	Na	Cl	F	TP	DP	OP	NO2	NO3	TKN	NH3	Dis Fe	Dis Mn	Metals Suite	TOC	UV254	E.coli	Tot Coli	(VOC's) BTEX	Emerging Contaminants	Chl *a*	Phyto	Periphyton	Habitat

Note: Inactive sites are shaded grey.
Fecal coliform analysis replaced by *E. coli* analysis starting in 2004.

APPENDIX H

AQUATIC LIFE AND HABITAT MONITORING SITES

Stream Segment	Sample Site Designation	Site Description	Justification	Frequency	PT Longitude	PT Latitude	Elevation (ft)	Tribal Database Number
Macroinvertibrate Bioassessment								
2b	BC-Canyon	BC at mouth of Boulder Canyon in pool area at Anderson Ditch head gate	Baseline prior to urban impacts and monitor seasonal macroinvertibrate populations	Macroinvertebrates – spring and fall Habitat – Both Sessions	105 º 18' 03.84"W	40 º 00' 45.67"N	5,510	14
2b	BC-28th	BC at 28th Street - Pool area just east of 28th St. under bridge	Monitor urban impacts and seasonal macroinvertibrate populations	Macroinvertebrates – spring and fall Habitat – Both Sessions	105 º 15' 33.43"W	40 º 00' 41.25"N	5,317	10015
2b	BC-55th	BC at 55th Street - Under foot bridge north of location where boulder Creek goes under Valmont Rd. and upstream of WWTF	Assess recovery from upstream urban impacts and seasonal macroinvertibrate populations and serve as a baseline for WWTF impacts	Macroinvertebrates – spring and fall Habitat – Both Sessions	105 º 13' 25.16"W	40 º 01' 44.26"N	5,249	10146
2b	BC-aWWTP	Under bridge at 75th St. Western side	Background condition prior to 75th Street WWTF and monitor seasonal macroinvertibrate populations	Macroinvertebrates – spring and fall Habitat – Both Sessions	105 º 10' 39.71"W	40 º 03' 05.97"N	5118	25
9	BC-aDC	BC at foot bridge above the confluence with Dry Creek, 2.4 river miles (3.9 km) downstream of the WWTF	Evaluate impacts of 75th Street WWTF effluent and potential recovery downstream, and monitor seasonal macroinvertebrate populations	Macroinvertebrates – spring and fall Habitat – Both Sessions	105 º 08' 41.29"W	40 º 02' 57.73"N	5,071	28
9	BC-95th	BC at 95th Street, 3.2 river miles (5.1 km) below the WWTF and downstream of Lower Boulder Ditch head gate	Proive information on WWTF effluent influence and potential recovery downstream as well as monitor seasonal macroinvertibrate populations	Macroinvertebrates – spring and fall Habitat – Both Sessions	105 º 07' 43.81"W	40 º 02' 51.63"N	5,060	12
9	BC-107	Boulder Creek at 107th Street approximately 4.7 RM (7.5 km) downstream of the WWTF	Provides information on the influence of WWTF effluent and potential recovery downstream	Macroinvertebrates – spring and fall Habitat – Both Sessions	105° 06' 10.70 W	40° 03' 33.18 N	5,012	13
9	BC-aCC	Boulder Creek 1.07km upstream of Coal Creek confluence	Provides information on the influence of WWTF effluent and potential recovery downstream	Macroinvertebrates – spring and fall Habitat – Both Sessions	105° 4'2.32"W	40° 4'32.19"N	4,973	31
4b	SBC-3.5	South Boulder Creek on Boulder City Open Space at McGuinn Ditch gate.	"Reference" reach to provide information un-urbainzed major tributary of Boulder Creek and use as a comparision for relatively undeveloped basin	Macroinvertebrates – spring and fall Habitat – Both Sessions	105º 13' 15.75"W	39° 59' 08.48"N	5,400	10213
South Boulder Creek: Special Study								
4b	SBC 1	Inside Eldorado Park near concrete water tank	Background quality prior to Eldorado Springs community and WWTF	Special Study	105° 17' 01.45 W	39° 55' 50.38 N	5,860	10210
4b	SBC 1.5	Under pool access bridge	Eldorado Springs community impacts and background for WWTF	Special Study	105° 16' 48.75 W	39° 55' 57.15 N	5,770	10219
4b	SBC 2	Mesa Trailhead bridge	Monitor quality and effects of Eldorado Springs WWTF	Special Study	105° 15' 34.04 W	39° 56' 22.32 N	5,615	10211
4b	SBC 3	Behind old Lafayette water treatment facility	Monitor quality and effects of Eldorado Springs WWTF	Special Study	105° 14' 18.23 W	39° 57' 19.52 N	5,496	10212
4b	SBC 3.5	Open Space at McGuinn Ditch gate	Monitor quality and effects of Eldorado Springs WWTF	Special Study	105° 13' 24.90 W	39° 58' 19.75 N	5,400	10213

APPENDIX I

WATER QUALITY PARAMETERS, PRESERVATION, AND LABORATORY METHODS

Drinking Water Quality Laboratory (Located at the 63rd Street WTF)						
Parameter	**Container Type**	**Container Volume**	**Preservation**	**Holding Time**	**Method Detection Limit (PPM)**	**Method**
Alkalinity, total	Plastic	200 mL	Cool to ≤4C	24 hours	1	SM 2320 B**
Hardness	Plastic	200 mL	Cool to ≤4C	24 hours	1	SM 2340 C**
Chloride	Plastic	100 mL	Frozen	30 days	0.05	IC EPA 300.1
Sulfate	Plastic	100 mL	Frozen	30 days	0.05	IC EPA 300.1
Fluoride	Plastic	100 mL	Frozen	30 days	0.01	IC EPA 300.1
Sodium	Plastic	200 mL	Cool to ≤4C	5 days	1	Orion ISE Method
Iron, dissolved	Plastic	100 mL	Filtered 0.45 um within 4 hours, Cool to ≤4C	5 days	0.01	Hach FerroZine Method 8147
Manganese, dissolved	Plastic	100 mL	Filtered 0.45 um within 4 hours, Cool to ≤4C	5 days	0.01	Hach PAN Method 8149
E. coli	Autoclaved Plastic	100 mL	Cool to ≤4C	6 hours	1 cfu	SM 9223 B**
Total coliform	Autoclaved Plastic	100 mL	Cool to ≤4C	6 hours	1 cfu	SM 9223 B**
Bacteria, heterotrophic (discontinued 2010)	Autoclaved Plastic	100 mL	Cool to ≤4C	6 hours	1 cfu	SM 9215 D**
Chlorophyll *a*	Amber Plastic	1 L	Filtered 1.2 um within 4 hours, Filter Frozen	30 days		CU Ethanol Extraction Method
Total Organic Carbon	Amber Glass	40 mL	Cool to ≤4C	7 days	0.5	SM 5310 C
Color, true (discontinued 2010)	Plastic	100 mL	Filtered 0.45 um within 4 hours, Cool to ≤4C	5 days	0.0 abs	Hach Method 8025
UV-254	Plastic	100 mL	Filtered 0.45 um within 4 hours, Cool to ≤4C	5 days	0.0 abs	SM 5910 B
Ammonia (NH3)	Plastic	1 L	Sulfuric Acid/ Cool to ≤4C	30 days	0.1	Methods 4500-NH_3 B; 4500 NH_3C**
Nitrate (NO3)	Plastic	100 mL	Cool to ≤4C	48 hours	0.002	IC EPA 300.1
Total kjeldahl nitrogen (TKN)	Plastic	1 L	Sulfuric Acid/ Cool to ≤4C	30 days	0.1	4500 N_{org} B**
Ortho phosphate	Plastic	100 mL	Filtered 0.45 um within 4 hours, Frozen	30 days	0.002	IC EPA 300.1
Phosphorus, dissolved	Plastic	150 mL	Filtered 0.45 um within 4 hours, Frozen	30 days	0.002	Digestion SM4500-P B.5** Analysis SM4500-P E**
Phosphorus, total	Plastic	150 mL	Frozen	30 days	0.002	Digestion SM4500-P B.5** Analysis SM4500-P E**
Total dissolved solids	n/a	n/a	n/a	n/a	1	Estimated from specific conductance
Total suspended solids	Plastic	2 L	Cool to ≤4C	24 hours	0.1	SM 2540 D**
Turbidity	Plastic	200 mL	Cool to ≤4C	24 hours	0.01 ntu	SM 2130 B**

Wastewater and Environmental Laboratory (Located at the 75th St WWTF)						
Parameter	**Container Type**	**Container Volume**	**Preservation**	**Holding Time**	**Method Detection Limit (PPM)**	**Method**
Alkalinity, total	Plastic	1 L	Cool to ≤4C	14 days	1	Method 2320 B**
Hardness	Plastic	200 mL	Sulfuric acid and Cool to ≤4C	14 days	1	Method 2340 C**
Chloride	Plastic	200 mL	Cool to ≤4C	30 days	0.1	Hach Method 8113
Chemical oxygen demand	Plastic	200 mL	Sulfuric Acid/ Cool to ≤4C	30 days	3	Hach Method 8000
E. coli	Autoclaved Plastic	500 mL	Sodium Thiosulfate	4 hours	1	9221 F (proposed)**
Metals Suite (below)	*See below*	*See below*	*See below*	*See below*	*MDL as below (dissolved/ total)*	*See below*
Aluminum	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00022/ 0.0039	ICPMS EPA 200.8
Antimony	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000013/ 0.0025	ICPMS EPA 200.8
Arsenic	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000015/ 0.000033	ICPMS EPA 200.8
Barium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000005/ 0.000006	ICPMS EPA 200.8
Beryllium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000009/ 0.00002	ICPMS EPA 200.8
Cadmium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000005/ 0.000005	ICPMS EPA 200.8
Calcium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00307/ 0.0022	ICPMS EPA 200.8
Chromium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00002/ 0.00001	ICPMS EPA 200.8
Copper	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00001/ 0.000014	ICPMS EPA 200.8
Iron	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00023/ 0.0013	ICPMS EPA 200.8
Magnesium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00025/ 0.0002	ICPMS EPA 200.8
Manganese	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000006/ 0.00002	ICPMS EPA 200.8
Molybdenum	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000014/ 0.0000053	ICPMS EPA 200.8
Nickel	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00001/ 0.00003	ICPMS EPA 200.8
Lead	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.000008/ 0.00002	ICPMS EPA 200.8
Potassium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.0035/ 0.02	ICPMS EPA 200.8
Selenium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00036/ 0.00026	ICPMS EPA 200.8
Silver	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.00003/ 0.000015	ICPMS EPA 200.8
Uranium	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.0000005/ 0.000005	ICPMS EPA 200.8
Zinc	LDPE	500 mL	Trace metals grade nitric acid	6 months	0.0001/ 0.0013	ICPMS EPA 200.8
Ammonia (NH_3)	Plastic	1 L	Sulfuric Acid/cooled to 4C	30 days	0.1	Timberline 001
Nitrite (NO_2)	Plastic	500 mL	Cool to ≤4C	48 hours	0.001	Hach Method 10020
Nitrate (NO_3)	Plastic	100 mL	Cool to ≤4C	48 hours	0.3	Hach Method 10020

Parameter	Container Type	Container Volume	Preservation	Holding Time	Method Detection Limit (PPM)	Method
Total kjeldahl nitrogen (TKN)	Plastic	1 L	Sulfuric Acid/ Cool to ≤4C	30 days	0.1	Timberline 001
Ortho phosphate	Plastic	500 mL	Cool to ≤4C	48 hours	0.03	Hach Method 8048
Phosphorus, total	Plastic	200 mL	Cool to ≤4C	48 hours	0.06	Hach Method 8190
Total dissolved solids	Plastic	1 L	Cool to ≤4C	14 days	1	Method 2540 C**
Total suspended solids	Plastic	1 L	Cool to ≤4C	14 days	1	Method 2540 D**
Turbidity	Plastic	200 mL	Cool to ≤4C	24 hours	0.01	Method 2130 A **

* *Standard Methods for the Examination of Water and Wastewater 19th Ed.

City of Longmont Watershed Monitoring Locations and Frequency
6/5/15

Location	Short Name	Stormwater	River	Reservior	Benthic*	Reg 85*	Temperature	EC Program	Frequency
Button Rock Reservior	ButRck-T ButRck-M ButRck-B			x					3x per year, May, July, Sept. or October. Samples collected at the surface (ButRck-T) for e.coli only, 2x the sechi depth (ButRck-M), and 1 ft above the bottom (ButRck-B).
Button Rock Inlet	ButRck-I			x					
Union Reservoir	Union-T Union-M Union-B			x					1x per season – June Samples collected at the surface (Union-T), 2x the sechi depth (Union-M), and 1 ft above the bottom (Union-B).
NFWTP Forebay	NF-FB			x					Monthly April-October
M-9.5, St Vrain @ N. 75th St	M9.5-SV		x		x				Monthly All Year
M-8.9, St Vrain @ Golden Ponds**	M8.9-SV		x		x				Monthly All Year
M-8.4, St Vrain @ Below Boston Ave	M8.4-SV		x						Monthly All Year
M-8.2, St Vrain @ Pratt Parkway	M8.2-SV		x						Monthly All Year
M-8, St Vrain @ Above Effluent	M8-SV		x		x	x	x		Monthly All Year
M-7, St Vrain @ 119*	M7-SV		x			x	x		Monthy All Year
M-6, St Vrain @ County Line Rd	M6-SV		x		x				Monthly All Year
M-4, St Vrain @ Above Boulder Creek Confluence	M4-SV		x		x				Monthly All Year (Suspended except for Benthic until reevaluated for post flood conditions)
T-11, Lefthand Creek @ St Vrain	T11-LH		x		x	x	x		Monthly All Year
T-Eff, Longmont WWTP Effluent	T-EFF		x						Monthly All Year. Effluent Channel, which inlcudes ditch.
Effluent	WWTP					x	x		Monthy All Year. Actual WWTP Effluent.
Dry Creek (and Dry Creek-G)	DC1	x							Monthly April-October
Spring Gulch #1 (and Spring Gulch #1-G)	SG1	x							Monthly April-October
Spring Gulch #2 (and Spring Gulch #2-G)	SG2	x			x				Monthly April-October
Oligarchy Ditch (and Oligarchy Ditch-G)	Olig	x							Monthly April-October
CLCPL (sample tap in blending structure)	NFWTP-CL							x	February, June, August
North St. Vrain (sample tap in Blending Structure)	NFWTP-SV							x	February, June, August
South St. Vrain at Longmont's Diversion	SV-LD							x	February, June, August
Highland Ditch at NFWTP	NFWTP-HD							x	June & August
St. Vrain Supply Canal at Longmont's Diversion	SVSC-SV							x	June & August

* Benthic monitoring is done twice per year in spring and fall. Spring Gulch #2 started in 2012.

**At least since 2008 Airport road has not been active, any sample named M9 or Airport is actually Golden Ponds M8.9. In addition, benthic monitroing upstream label is SVC-M9, the actual location is golden ponds.

City of Longmont Watershed Monitoring Sample Parameters 3/25/15

Standard Sample Parameters	RDL	Comments
Metals		
Aluminum, Al	10 ug/L	
Antimony, Sb	2 ug/L	
Arsenic, As	2 ug/L	
Boron, B	10 ug/L	
Bromide	50 ug/L	Forebay and Buttonrock 2 x secchi only **(SUSPENDED)**
Calcium, Ca	1000 mg/L	
Cadmium, Cd	0.5 ug/L	
Chromium, Cr	2.0 ug/L	
Copper, Cu	3 ug/L	
Iron, Fe	100 ug/L	
Potassium, K	2000 ug/L	
Lead, Pb	0.5 ug/L	
Magnesium, Mg	1000 mg/L	
Manganese, Mn	3 ug/L	
Molybdenum, Mo	3 ug/L	
Nickel, Ni	3 ug/L	
Sodium, Na	1500 ug/L	
Selenium, Se	0.5 ug/L	
Silver, Ag	0.3 ug/L	WWTP RDL=0.2 ug/L
Thallium, Tl	0.5 ug/L	
Uranium, U	1.0 ug/L	
Zinc, Zn	10 ug/L	
Nutrients		
NH3	50 ug/L	
NO3+NO2	20 ug/L	
P as total, PO4	20 ug/L	RDL = 10 ug/L for Reg 85.
TKN	0.5 mg/L	Regulation 85 Samples only. MDL 0.1 mg/L
TIN-Calculated		Regulation 85 Samples only
TN-Calculated	0.5 mg/L	Regulation 85 Samples only. MDL 0.1 mg/L
Misc		
TOC	1 mg/L	
Chloride	1 mg/L	
Fluoride	0.5 mg/L	
Hardness, Total as CaCO3	10 mg/L	Calculated value.
Alkalinity	10 mg/L	
Conductivity	10 umhos/cm	
TSS	2 mg/L	
TVSS	2 mg/L	Storm only
SO4	10 mg/L	
Gross Alpha		Reservoirs only 1x per year
Gross Beta		Reservoirs only 1x per year
e. coli	1MPN/100mls	
Total Coliforms	1MPN/100mls	
Chlorophyll a		BSA Reservoirs only
BTEX		Union Reservoir only 1x per year
Field Parameters		
Chlorophyll a		Reservoirs only, work on calibrating with BSA counts
Conductivity	10 umhos/cm	
pH and Temp	range= 4-9 SU	
DO		
pH, Temp and DO Profile		Profile in reservoirs only
Secchi Depth		Reservoirs only
Flow	NA	Storm and River only

City of Longmont Watershed Monitoring Locations Coordinates 6/8/15					
Short Name	**Location**	**Description**	**Latitude**	**Longitude**	**Source**
ButRck	Buttonrock (Hypolimnion & Photic Zone)		40°12'58.44"N	105°22'17.93"W	Google Earth
Union	Union		40°10'51.49"N	105° 2'19.86"W	Google Earth
M9.5-SV	M-9.5, St Vrain @ N. 75th St		40°10'38.86"N	105°10'42.28"W	Google Earth
M8.9-SV	M-8.9, St Vrain @ Golden Ponds		40°10'9.40"N	105° 8'39.10"W	Google Earth
M8.4-SV	St Vrain @ Below Boston Ave, M-8.4		40° 9'30.98"N	105° 7'0.79"W	Google Earth
M8.2-SV	St Vrain @ Pratt Parkway, M-8.2		40° 9'24.74"N	105° 6'22.14"W	Google Earth
M8-SV	St Vrain @ Above Effluent M-8		40° 9'19.09"N	105° 5'16.17"W	Google Earth
M7-SV	St. Vrain @ 119th St M-7		40° 9'10.64"N	105° 4'26.81"W	Google Earth
M6-SV	St Vrain @ County Line Rd, M-6		40° 9'7.74"N	105° 3'18.42"W	Google Earth
M4-SV	St Vrain @ Above Confluence, M-4		40° 9'29.41"N	105° 0'38.99"W	Google Earth
T11-LH	Lefthand Creek@ St Vrain,T-11		40° 9'18.48"N	105° 5'14.53"W	Google Earth
T-EFF	WWTP Effluent	WWTP effluent channel where it enters the St. Vrain. This is combined with the roadside ditch flow.	40° 9'20.47"N	105° 5'10.30"W	Google Earth
WWTP	Effluent	Actual WWTP Effluent at parshall flume	40°09'26.643"N	105°05'10.218"W	Google Earth
Dry Crk	Dry Creek		40° 8'58.56"N	105° 7'19.44"W	Google Earth
SG1	Spring Gulch #1		40° 9'24.99"N	105° 5'36.11"W	Google Earth
SG2	Spring Gulch #2		40° 9'29.79"N	105° 2'30.96"W	Google Earth
Olig	Oligarchy Ditch		40° 9'32.51"N	105° 4'0.79"W	Google Earth
NFWTP-CL	CLCPL (sample tap in blending structure)		40°12'51.00"N	105°13'44.00"W	Google Earth
NFWTP-SV	North St. Vrain (sample tap in Blending Structure)		40°12'51.00"N	105°13'44.00"W	Google Earth
SV-LD	South St. Vrain at Longmont's Diversion		40° 12' 50" N	105° 16' 38" W	Google Earth
NFWTP-HD	Highland Ditch at NFWTP		40°12'52" N	105°13'42" W	Google Earth
SVSC-SV	St. Vrain Supply Canal at Longmont's Diversion		40°13'18.00"N	105°14'54.00"W	Google Earth
	Lykins Gulch (not active anymore)		40° 9'35.21"N	105° 9'16.78"W	Google Earth
	St Vrain @ Airport, M-9 (Not active since at least 2008) M-9 references are typically M8.9 Golden Ponds.		40°10'9.40"N	105° 8'39.10"W	Google Earth
Burch	Burch (not active)		40°12'3.00"N	105°11'21.00"W	Google Earth

City of Longmont Watershed Monitoring Program QC/QA
2/27/15

QC Sample	Data Quality Indicator	Description	Collection Frequency	Acceptance Criteria	Corrective Action
Field Blank	Bias Due to Sample Contamination	Sample collected in lab and carried with during sampling activity.	1 per sample event (week) This meets the Watershed commitment of 5% of samples (1 per 20 samples)	< Reporting Limit	Investigate and eliminate sources of contamination; flag suspect data (e.g., “B” qualifier)
Field Replicate	Precision	Samples collected at the same time.	1 per sample event (week) This meets the Watershed commitment of 5% of samples (1 per 20 samples)	For concentrations > Reporting Limit, <25% Relative Percent Difference	Investigate and eliminate cause (e.g., inconsistent field techniques and sample processing, lab error); request re-analysis of sample; flag suspect data

Summary of Coal Creek/Rock Creek Water Quality Sampling Locations under Regulation 85

Coal Creek/Rock Creek Regulation 85 Locations		**Decimal Degrees**	
Sample ID	Description	Latitude	Longitude
1-CC	Coal Creek above the Lousiville WWTP discharge	39.97611	-105.11639
A-CC	Louisville WWTP discharge (0.41 miles from stream)	39.98007	-105.12208
2-CC	Coal Creek below the Lousiville WWTP discharge	39.97650	-105.11595
3-CC	Coal Creek above the confluence with Rock Creek	39.97985	-105.09090
4-RC	Rock Creek above the Superior WWTP discharge	39.93685	-105.13773
B-RC	Superior WWTP discharge	39.93677	-105.14031
5-RC	Rock Creek above the confluence with Coal Creek	39.97897	-105.07110
6-CC	Coal Creek above the Lafayette WWTP discharge	40.00321	-105.05736
C-CC	Lafayette WWTP discharge	40.00375	-105.05788
7-CC	Coal Creek below the Lafayette WWTP	40.01025	-105.05190
8-CC	Coal Creek above the South Erie WWTP discharge	40.05544	-105.04796
D-CC	South Erie WWTP discharge (not currently in operation)	40.05570	-105.04831
9-BC	Boulder Creek above the North Erie WWTP discharge	40.10120	-105.04797
E-BC	North Erie WWTP discharge	40.10209	-105.04744
10-BC	Boulder Creek below the North Erie WWTP discharge	40.10209	-105.04744
11-BC	Boulder Creek Gage 06730500	40.15222	-105.01444

Note: Contact each discharger directly for a copy of the Regulation 85 Sampling Plan.
Sampling locations and nutrient analytes have been integrated into the KICP Routine Sampling Program.
City of Boulder and City of Longmont also submitted Regulation 85 Sampling Plans to CDPHE.

BASELINE MONITORING PROGRAM
Water Year 2014

The following describes Northern Water's Baseline Water Quality Monitoring Program.

The objectives of the Baseline Monitoring Program are to:

- Monitor current conditions
- Monitor trends and changes in water quality in lakes and reservoirs and flowing sites: streams, rivers and canals.
- Assess potential impact of introduction of Colorado-Big Thompson Project and Windy Gap Project water in streams
- Assess compliance with state water quality standards and potential inclusions on 303(d) List of impaired waters or Colorado's M&E List.
- Support development of TMDLs, if required
- Support water quality modeling efforts
- Support current and future permitting requirements
- Assess water quality impacts from adverse events such as floods, wildfires, and spills

Monitoring Locations

The Baseline Monitoring Program covers 55 monitoring sites in eight watersheds on both sides of the Continental Divide in Northern Colorado. There are 41 flowing sites (canals and streams) and 14 lake and reservoir sites. The flowing sites are located downstream of reservoirs, in the canals at points of release to the streams, and upstream and downstream of these release points.

Reservoir Monitoring Locations

Station	Description	Latitude	Longitude	Slope
GL-ATW	Grand Lake West Portal (USGS #401428105481601)	40.2411	-105.8044	West
GL-MID	Grand Lake Mid-Section (USGS #09013900)	40.2433	-105.8136	West
GR-DAM	Lake Granby Dam (USGS #09018500)	40.1497	-105.8614	West
GR-EAS	Lake Granby East Side (USGS #400806105474700)	40.135	-105.797	West
GR-WES	Lake Granby West Side (USGS #401030105521101)	40.175	-105.8697	West
SM-CHL	Shadow Mountain Channel in Grand Lake at mouth of Channel (USGS #09014000)	40.2447	-105.8258	West
SM-DAM	Shadow Mountain Dam (USGS #09014500)	40.2101	-105.8421	West
SM-MID	Shadow Mountain Mid-Section (USGS #401331105501401)	40.2252	-105.8378	West
WC-DAM	Willow Creek at Dam (USGS #400853105563701)	40.1481	-105.9436	West
WG-DAM	Windy Gap Reservoir at Dam (USGS #400631105585501)	40.1084	-105.9824	West
CL-DAM1	Carter Lake Dam #1 (USGS #06742500)	40.3253	-105.2152	East
HT-DIX	Horsetooth at Dixon Canyon (USGS #403317105090000)	40.5543	-105.1506	East
HT-SOL	Horsetooth at Soldier Canyon (USGS #06737500)	40.5888	-105.1649	East
HT-SPR	Horsetooth at Spring Canyon (USGS #403147105083800)	40.5292	-105.1456	East

Flowing Sites Monitoring Locations

Station	Description	Latitude	Longitude	Slope
AC-GRU	Arapahoe Creek at Monarch Lake outlet, upstream of Lake Granby (USGS #09016500)	40.1128	-105.7497	West
CR-GRD	Colorado River downstream of Lake Granby (USGS #9019500)	40.1444	-105.8672	West
CR-SMD	Colorado River downstream of Shadow Mountain Reservoir	40.2059	-105.838	West
CR-SMU	North Fork of Colorado River upstream of Shadow Mountain Reservoir	40.219	-105.8577	West
CR-WGD	Colorado River downstream of Windy Gap (USGS #09034250)	40.1082	-106.0037	West
CR-WGU	Colorado River above Windy Gap, upstream of confluence with Fraser River	40.1003	-105.9726	West
EI-GLU	East Inlet upstream of Grand Lake (USGS #090135000)	40.2369	-105.801	West
FR-WGU	Fraser River upstream of confluence with Colorado River	40.0984	-105.9727	West
GR-Pump	Granby Pump Canal at foot bridge on south side of Shadow Mountain (USGS #09018300)	40.2068	-105.8495	West
NI-GLU	North Inlet upstream of Grand Lake	40.2507	-105.8148	West
RF-GRU	Roaring Fork inlet upstream of Lake Granby	40.1308	-105.7671	West
ST-GRU	Stillwater Creek upstream of Lake Granby (USGS #09018000)	40.1829	-105.8892	West
WC-Pump	Willow Creek discharge chute to Lake Granby	40.143	-105.8888	West
WC-WCRD	Willow Creek directly downstream of Willow Creek Reservoir Dam	40.1456	-105.9404	West
WG-Pump	Windy Gap discharge chute to Lake Granby	40.1429	-105.8888	West
AT-EP	Adams Tunnel East Portal near Estes Park (USGS #09013000)	40.3278	-105.5782	East
BFC	Boulder Feeder Canal below cement plant at Hygiene Rd	40.1889	-105.2388	East
BFC-BR	Boulder Feeder Canal to Boulder Reservoir	40.0863	-105.2175	East
BFC-LH	Boulder Feeder Canal at Left Hand Creek	40.104	-105.227	East
BFC-LHD	Left Hand Creek downstream of BFC at golf cart bridge crossing with Left Hand Creek	40.1033	-105.217	East
BFC-LHU	Left Hand Creek diversion into Boulder Feeder Canal	40.1038	-105.2272	East
BSC-BC	Boulder Supply Canal feed to Boulder Creek at Jay Rd	40.053	-105.1877	East
BSC-BCD	Boulder Creek downstream of Boulder Supply Canal	40.0514	-105.179	East
BSC-BCU	Boulder Creek upstream Boulder Supply Canal	40.0507	-105.1874	East
BSC-BR	Boulder Reservoir at outlet to Boulder Supply Canal	40.0775	-105.2071	East
HFC-BT	Hansen Feeder Canal downstream of trifurcation at USGS gage	40.4234	-105.2265	East
HFC-BTD	Big Thompson River downstream of Hansen Feeder Canal and Trifurcation Plant	40.4258	-105.2167	East
HFC-BTU	Big Thompson upstream of Hansen Feeder Canal at canyon mouth by USGS station	40.422	-105.2269	East
HFC-FRD	Hansen Feeder Canal downstream of Flatiron Reservoir	40.3748	-105.2306	East
HFC-HT	Hansen Feeder Canal at Inlet to Horsetooth	40.5056	-105.197	East
HSC-PR	Hansen Supply Canal Release to the Cache La Poudre River	40.659	-105.2098	East
HSC-PRD	Cache La Poudre River downstream of Hansen Feeder Canal	40.6606	-105.2032	East
HSC-PRU	Cache La Poudre River upstream of Hansen Feeder Canal	40.6601	-105.2094	East
OLY	Olympus Tunnel at Lake Estes (USGS #06734900)	40.3764	-105.4858	East
SVSC-CL	Carter Lake outflow to Saint Vrain Supply Canal	40.3173	-105.2068	East
SVSC-LT	Saint Vrain Supply Canal feed to Little Thompson River	40.2615	-105.2083	East
SVSC-LTD	Little Thompson River downstream of St Vrain Supply Canal	40.2584	-105.1977	East
SVSC-LTU	Little Thompson River upstream of Saint Vrain Supply Canal	40.2584	-105.2074	East
SVSC-SV	Saint Vrain Supply Canal at Saint Vrain Creek	40.2182	-105.2582	East
SVSC-SVD	Saint Vrain Creek downstream of Saint Vrain Supply Canal	40.2166	-105.2596	East
SVSC-SVU	Saint Vrain Creek upstream of Saint Vrain Supply Canal	40.2173	-105.2595	East

Monitoring Frequency

Monitoring frequency varies from monthly to weekly depending on the site location. For a weekly breakdown of the anticipated monitoring schedule please see the 2014 Sampling Schedule.

Northern Water
Water Quality Program

Parameters

The baseline program includes monitoring of nutrients, metals, general chemistry, physical parameters, zooplankton, phytoplankton and chlorophyll. Different groups of parameters are looked at depending on the location of the site and the timing of the sampling. The groups are defined by codes as shown below. For a breakdown of what code is used when, please see the 2014 Sampling Schedule.

Parameter	L1	L2	L3	S1	S3	N1	CN	RL	RS
Temperature	X	X	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X
secchi depth								X	X
Calcium	X	X	X	X	X			X	X
Magnesium	X	X	X	X	X			X	X
Chloride	X	X	X					X	
Potassium	X	X	X					X	
Sodium	X	X	X					X	
Sulfate	X	X	X					X	
Dissolved Organic Carbon			X		X		X	X	X
Total Organic Carbon	X	X	X	X	X		X	X	X
UV254								X	X
Total Alkalinity	X	X	X	X	X			X	
Total Suspended Solids	X	X	X	X	X	X	X	X	X
Total Dissolved Solids	X	X	X	X	X	X	X	X	X
Arsenic, total	X	X	X					X	
Chromium, total	X	X	X					X	
Iron, total	X	X	X	X	X			X	
Arsenic, dissolved	X	X	X					X	
Boron, dissolved	X	X	X					X	
Cadmium, dissolved	X	X	X					X	
Chromium, dis	X	X	X					X	
Copper, dissolved	X	X	X	X	X			X	
Iron, dissolved	X	X	X	X	X			X	X
Lead, dissolved	X	X	X					X	
Manganese, dissolved	X	X	X	X	X			X	X
Nickel, dissolved	X	X	X					X	
Selenium, dissolved	X	X	X					X	
Silver, dissolved	X	X	X					X	
Uranium, dissolved	X	X	X					X	
Zinc, dissolved	X	X	X					X	
Mercury		X						X	
TKN	X	X	X	X	X	X	X	X	X
NH3 as N	X	X	X	X	X	X	X	X	X
NO3+NO2	X	X	X	X	X	X	X	X	X
Ortho P	X	X	X	X	X	X	X	X	X
P Total	X	X	X	X	X	X	X	X	X
chlorophyll a	X	X	X	X	X		X	X	X
phytoplankton								X	X
zooplankton								X	X

In the reservoirs, nutrient, metals and general chemistry samples are collected at a depth 1 meter below the surface and approximately 1 meter above the bottom. Profiles of the physical parameters are taken at one meter increments until a depth of 25 meters, then the increment increases to every 5 meters to the bottom of the water body. Chlorophyll samples are collected by sampling the water column from 0-5 meters. Phytoplankton samples are collected by sampling the water column from 0-5 meters. Zooplankton samples are collected from a 0-10 meter depth, except in Shadow Mountain where only 0-5 meters is sampled due to its shallow depth. Secchi depth is collected at all reservoir sampling events, with a viewscope on the east slope and both with and without a viewscope on the west slope.

Changes to the Baseline Program Parameter List June 2014

In April 2014, the US Bureau of Reclamation met with Northern Water staff to review Northern Water's water quality monitoring efforts that are cost-shared with Reclamation, discuss the connection of these water quality monitoring programs to C-BT operation and maintenance (O&M) funds, and explore opportunities for future cost savings. The details of this meeting, potential cost saving changes to the baseline program as determined by Reclamation and Northern's recommendations and actions are detailed in a memo from Judy Billica "Recommendations for potential cost savings for Baseline Monitoring Program".

Northern's recommendations and subsequent changes to the program only included elimination of some of the parameters that are monitored. The monitoring network has evolved and been optimized over the years; therefore no sites in the Baseline Program were eliminated. The sampling frequency for 2014 also remains unchanged. The table below shows which parameters were eliminated from each parameter group. The changes officially began in June 2014, although some of the parameters (such as chlorophyll at the flowing sites and TDS) were eliminated in mid-May. Mercury at Horsetooth Reservoir was eliminated after the June sampling event as part of the CSU mercury study.

Parameter	L1	L2	L3	S1	S3	N1	CN	RL	RS
Temperature	X	X	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X	X	X
Specific Conductance	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X
secchi depth								X	X
Calcium	X	X	X	~~X~~	~~X~~			X	~~X~~
Magnesium	X	X	X	~~X~~	~~X~~			X	~~X~~
Chloride	X	X	X					X	
Potassium	X	X	X					X	
Sodium	X	X	X					X	
Sulfate	X	X	X					X	
Dissolved Organic Carbon			X		X		X	X	X
Total Organic Carbon	X	X	X	X	X		X	X	X
UV254								X	X
Total Alkalinity	X	X	X	~~X~~	~~X~~			X	
Total Suspended Solids	X	X	X	X	X	X	X	X	X
Total Dissolved Solids	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Arsenic, total	X	X	X					X	
Chromium, total	X	X	X					X	
Iron, total	X	X	X	~~X~~	~~X~~			X	
Arsenic, dissolved	X	X	X					X	
Boron, dissolved	X	X	X					X	
Cadmium, dissolved	X	X	X					X	
Chromium, dis	X	X	X					X	
Copper, dissolved	X	X	X	X	X			X	
Iron, dissolved	X	X	X	X	X			X	X
Lead, dissolved	X	X	X					X	
Manganese, dissolved	X	X	X	X	X			X	X
Nickel, dissolved	X	X	X					X	
Selenium, dissolved	X	X	X					X	
Silver, dissolved	X	X	X					X	
Uranium, dissolved	X	X	X					X	
Zinc, dissolved	X	X	X					X	
Mercury		~~X~~						~~X~~	
TKN	X	X	X	X	X	X	X	X	X
NH3 as N	X	X	X	X	X	X	X	X	X
NO3+NO2	X	X	X	X	X	X	X	X	X
Ortho P	X	X	X	X	X	X	X	X	X
P Total	X	X	X	X	X	X	X	X	X
chlorophyll a	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		~~X~~	X	X
phytoplankton								X	X
zooplankton								X	X

~~X~~ = Parameters that were eliminated from the Baseline Monitoring Program

Sample Collection and Analysis

Northern Water primarily operates the Baseline Monitoring Program. The United States Geological Survey (USGS) assists with sampling at some sites and during the winter. All flowing sites, except AT-EP and OLY, are sampled by Northern Water Field Services (NWFS). Sampling on the lakes and reservoirs is conducted NWFS except during the winter months (December to March); this sampling is conducted by the USGS. All sampling is done utilizing protocols documented in Northern Water's SOP "Standard Operating Procedures (SOP's) for Northern Water's Water Quality Monitoring Programs".

Samples for nutrients, TSS and TDS are analyzed at High Sierra Water Lab; a USGS certified private laboratory whose analytical methods have low level detection limits. Samples for metals (except mercury) and general chemistry are analyzed at Huffman Laboratory; a USGS certified private laboratory whose analytical methods for metals have low level detection limits. Samples for mercury are analyzed at Accutest Laboratory; a USGS certified private laboratory whose analytical method for mercury has a low level detection limit. Chlorophyll samples are analyzed at the USRB Laboratory in Denver. Zooplankton and Phytoplankton samples are analyzed at BSA Environmental Services, Inc.

All samples are subject to thorough quality control to validate laboratory procedures and sampling protocols. Between 5% and 10% of the total number of samples are quality control blanks or replicate samples.

Data Processing

All data collected in the field and received from laboratories is subject to thorough QAQC and housed in Northern's SQL Access relational databases. The data are accessible at Northern's website, http://www.northernwater.org/WaterQuality/WaterQualityData.aspx.

Although QAQC protocols are not final at this time, the following steps are taken to ensure the data are accurate and high quality:

- ✓ Sample dates and times are verified.
- ✓ General 'rules' of the results are checked (i.e. the total fraction of a parameter should be greater than the dissolved fraction).
- ✓ Results are compared to typical concentrations specific to the site and time of year.
- ✓ Results are compared to other samples collected at the same time at locations with similar water quality (i.e. if samples are collected in Horsetooth Reservoir, the results are compare for the top depths at all three sites collected for that event in Horsetooth).
- ✓ Results are compared at sites in order from upstream to downstream (i.e. if samples are collected above and below a canal, the results are compared upstream of the canal to downstream of the canal with consideration of canal inputs by looking at the results in the canal).

- ✓ If any outliers are observed, steps are taken to determine why there are differences from the reported results and atypical results:
    - ~ Field notes are looked at to see if anything out of the ordinary was observed during sampling.
    - ~ Results of other parameters that correlate with the parameter in question are looked at to see there is a similar pattern.

- ~ Operation and maintenance activities of the C-BT system are noted if applicable.
- ~ The lab is contacted to make sure there was not a reporting error.

✓ Re-run analysis by the laboratories or QAQC documentation is requested in order to verify any result that may be suspect. In these cases, the data that is verified is flagged as such in the database.

After the QAQC and verification processes, if the data are still found to be suspect due to error in sample collection or error in analysis, the data are marked with a disqualifier in the database. The data that are 'disqualified' are not used internally or available on the database interface on the website.

In addition, the QAQC samples that are collected on a regular basis can help determine if there are problems that may not be apparent in the screening of the environmental samples:

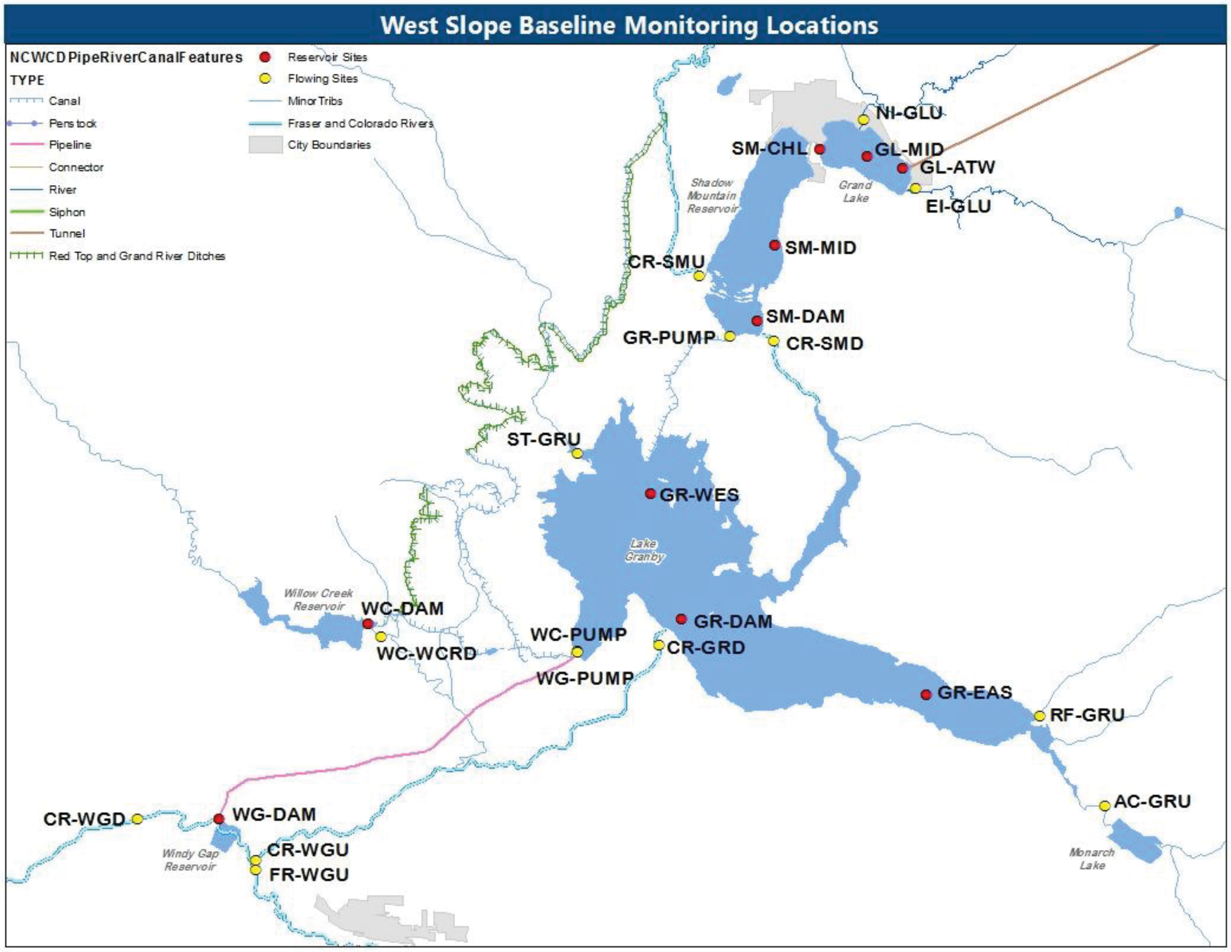
✓ Field and source water blanks are tracked in order to see if there are any reoccurring patterns of detections that need to be investigated.

✓ Replicates are tracked in order to see if there are any reoccurring differences between the environmental and replicate sample that need to be investigated. In general, the following criteria for acceptable replicates are:

- ~ For concentrations > 10 times the RL the RPD must be <25%
- ~ For concentrations < 10 times the RL the RPD must be < 50%.

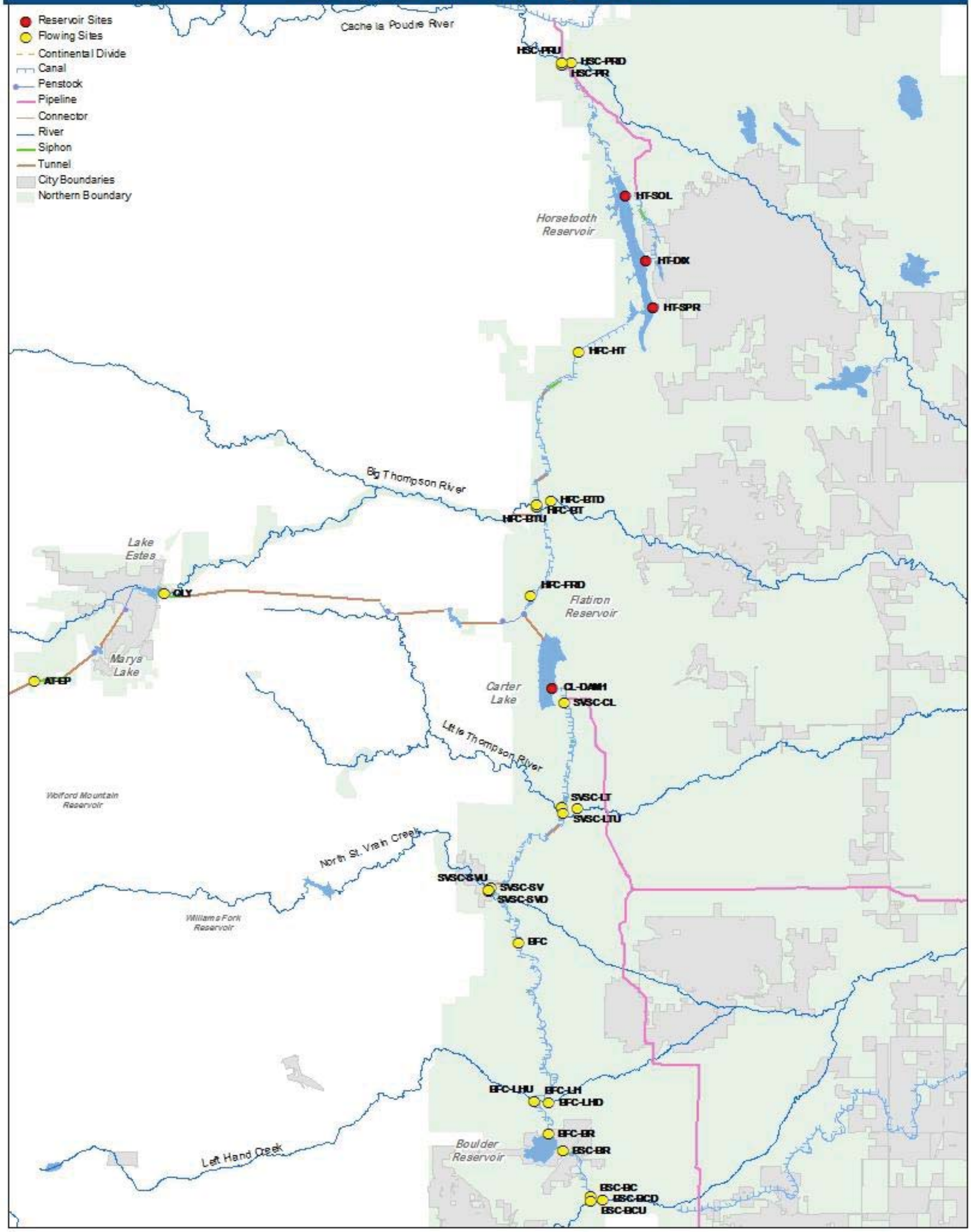
Problems with the QAQC samples may be attributed to several sources and can occur in the field and/or in the laboratory. If reoccurring problems occur with any of the QAQC samples, steps are taken to try to pinpoint the source of the problem.

Maps of Sampling Locations



Northern Water
Water Quality Program

East Slope Baseline Monitoring Locations



Sampling Schedule

Baseline Water Quality Monitoring - Flowing Sites

	Oct					Nov				Dec				Jan					Feb			
Station	Sep 29	Oct 06	Oct 13	Oct 20	Oct 27	Nov 03	Nov 10	Nov 17	Nov 24	Dec 01	Dec 08	Dec 15	Dec 22	Dec 29	Jan 05	Jan 12	Jan 19	Jan 26	Feb 02	Feb 09	Feb 16	Feb 23
AC-GRU		N1		N1		L3				N1				S3					N1			
ST-GRU		N1		N1		L3				N1				S3					N1			
RF-GRU		N1		N1		L3				N1				S3					N1			
EI-GLU	N1		N1		N1	L3				N1				S3					N1			
NI-GLU	N1		N1		N1	L3				N1				S3					N1			
CR-SMU	N1		N1		N1	L3				N1				S3					N1			
CR-SMD	N1		N1		N1	L3				N1				S3					N1			
GR-PUMP	S3	N1	N1	N1	N1	L3		N1		N1		N1		S3		N1		N1		N1		N1
CR-WGU	S1					L1				S1				S1					S1			
FR-WGU	S1					L1				S1				S1					S1			
CR-WGD	S1					L1				S1				S1					S1			
WC-PUMP	S1	S1	S1	S1	S1	L1	S1	S1	S1													
WC-WCRD	S1					L1				S1				S1					S1			
CR-GRD	S1					L1				S1				S1					S1			
WG-PUMP																						
BFC	S1																					
BFC-BR	S1																					
BFC-LH	S1																					
BFC-LHD	S1																					
BFC-LHU																						
BSC-BC	S1																					
BSC-BCD	S1																					
BSC-BCU																						
BSC-BR	S1																					
HFC-BT	S1					S1								L1								
HFC-BTD	S1					S1								L1								
HFC-BTU														L1								
HFC-FRD	S1					S1								L1								
HFC-HT	S1					S1								L1								
HSC-PR	S1																					
HSC-PRD	S1																					
HSC-PRU																						
SVSC-CL	S1																					
SVSC-LT	S1																					
SVSC-LTD	S1																					
SVSC-LTU																						
SVSC-SV	S1																					
SVSC-SVD	S1																					
SVSC-SVU																						
AT-EP	S1					S1								L2								
OLY	S1					S1								L2								

	Mar				Apr					May				Jun				Jul					Aug				Sep				
Station	Mar 02	Mar 09	Mar 16	Mar 23	Mar 30	Apr 06	Apr 13	Apr 20	Apr 27	May 04	May 11	May 18	May 25	Jun 01	Jun 08	Jun 15	Jun 22	Jun 29	Jul 06	Jul 13	Jul 20	Jul 27	Aug 03	Aug 10	Aug 17	Aug 24	Aug 31	Sep 07	Sep 14	Sep 21	Comment
AC-GRU	S3				S3	N1	N1		N1		L3		N1		S3		N1		L3		CN		S3		CN		S3		CN		Every other week Apr-Nov, Monthly otherwise
ST-GRU	S3				S3	N1	N1		N1		L3		N1		S3		N1		L3		CN		S3		CN		S3		CN		Every other week Apr-Nov, Monthly otherwise
RF-GRU	S3				S3	N1	N1		N1		L3		N1		S3		N1		L3		CN		S3		CN		S3		CN		Every other week Apr-Nov, Monthly otherwise
EI-GLU	S3				S3	N1	N1		N1		L3		N1		S3		N1		L3		CN		S3		CN		S3		CN		Every other week Apr-Nov, Monthly otherwise
NI-GLU	S3				S3	N1	N1		N1		L3		N1		S3		N1		L3		CN		S3		CN		S3		CN		Every other week Apr-Nov, Monthly otherwise
CR-SMU	S3				S3	N1	N1		N1		L3		N1		S3		N1		L3		CN		S3		CN		S3		CN		Every other week Apr-Nov, Monthly otherwise
CR-SMD	S3				S3		N1		N1		L3		N1		S3		N1		L3		CN		S3		CN		S3		CN		Every other week Apr-Nov, Monthly otherwise
GR-PUMP		S3		N1	S3	N1	N1	N1	N1	N1	L3	N1	N1	N1	S3	N1	N1	CN	L3	CN	CN	CN	S3	CN	CN	CN	S3	CN	CN	CN	When pumping weekly Apr-Oct and biweekly Nov-Mar
CR-WGU	S1				S1		S1		S1		L1		S1		S1		S1		L1		S1		S1				S1				Every other week when pumping
FR-WGU	S1				S1		S1		S1		L1		S1		S1		S1		L1		S1		S1				S1				Every other week when pumping
CR-WGD	S1				S1		S1		S1		L1		S1		S1		S1		L1		S1		S1				S1				Every other week when pumping
WC-PUMP	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	L1	S1	S1	S1	S1	S1	S1	S1	L1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1		Weekly when pumping
WC-WCRD	S1				S1						L1			S1					L1				S1				S1				
CR-GRD	S1				S1						L1			S1					L1				S1				S1				
WG-PUMP							S1	S1	S1	S1	L1	S1	S1	S1	S1	S1	S1	S1	L1	S1	S1	S1									Weekly when pumping
BFC										S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
BFC-BR										S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
BFC-LH										S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
BFC-LHD										S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
BFC-LHU										S1				L1													L1				
BSC-BC										S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
BSC-BCD										S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
BSC-BCU										S1				L1													L1				
BSC-BR										S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
HFC-BT	S1				S1					S1				L1				S1					S1				L1				
HFC-BTD					S1					S1				L1				S1					S1				L1				
HFC-BTU										S1				L1				S1					S1				L1				Jul and Aug sample collected only if Dille is running
HFC-FRD	S1				S1					S1				L1				S1					S1				L1				
HFC-HT	S1				S1					S1				L1				S1					S1				L1				
HSC-PR					S1					S1				L1				S1					S1				L1				
HSC-PRD					S1					S1				L1				S1					S1				L1				
HSC-PRU										S1				L1													L1				
SVSC-CL					S1					S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
SVSC-LT					S1					S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
SVSC-LTD					S1					S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
SVSC-LTU										S1				L1													L1				
SVSC-SV					S1					S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
SVSC-SVD					S1					S1				L1				S1					S1				L1				October scheduled event not sampled due to flooding
SVSC-SVU										S1				L1													L1				
AT-EP	S1				S1					S1				L2				S1					S1				L2				Samples collected by the USGS
OLY	S1				S1					S1				L2				S1					S1				L2				Samples collected by the USGS

Placeholder sampling event scheduled the week of Apr 6 to capture 1st flush event at the Three Lakes inflow sites: AC-GRU,ST-GRU,RF-GRU,EI-GLU,NI-GLU,CR-SMU

Baseline Water Quality Monitoring Lakes and Reservoirs

	Oct					Nov				Dec					Jan				Feb				Mar					Apr				May				Jun					Jul				Aug				Sep				
Station	Sep 29	Oct 06	Oct 13	Oct 20	Oct 27	Nov 03	Nov 10	Nov 17	Nov 24	Dec 01	Dec 08	Dec 15	Dec 22	Dec 29	Jan 05	Jan 12	Jan 19	Jan 26	Feb 02	Feb 09	Feb 16	Feb 23	Mar 02	Mar 09	Mar 16	Mar 23	Mar 30	Apr 06	Apr 13	Apr 20	Apr 27	May 04	May 11	May 18	May 25	Jun 01	Jun 08	Jun 15	Jun 22	Jun 29	Jul 06	Jul 13	Jul 20	Jul 27	Aug 03	Aug 10	Aug 17	Aug 24	Aug 31	Sep 07	Sep 14	Sep 21	Comment
GL-MID	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		Zooplankton collected at 0-5m and 5-10m
GL-ATW	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		Zooplankton collected at 0-5m and 5-10m
SM-MID	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		
SM-DAM	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		
SM-CHL	RL		N1		N1		N1			N1				RL					N1				RS				N1		N1		N1	RS		N1		RL		N1		RS		CN		CN	RS		RS		RS		RS		
GR-DAM	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		Zooplankton collected at 0-5m and 5-10m
GR-EAS	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		Zooplankton collected at 0-5m and 5-10m
GR-WES	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		Zooplankton collected at 0-5m and 5-10m
WC-DAM	RL													RL									RS									RS				RL				RS					RS		RS		RS		RS		
WG-DAM																																RS				RL				RS					RS		RS		RS		RS		
HT-SPR	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan floating event, sampled based upon ice conditions
HT-DIX	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan floating event, sampled based upon ice conditions
HT-SOL	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan floating event, sampled based upon ice conditions
CL-DAM1	RL					RS								RL													RS					RS				RL				RS					RS				RS				Jan floating event, sampled based upon ice conditions

This page intentionally left blank.

5. Analytical Methods, Laboratories and Lab QA/QC

The analytical methods, laboratories, and detection limits that apply to Northern Water's water quality monitoring programs are outlined on Tables 5.1 and 5.2. Northern Water currently uses seven different laboratories for the analysis of the various water quality samples and parameters:

- High Sierra Water Lab (Truckee, CA; http://hswaterlab.com/): Nutrients, TDS, TSS
- Huffman Laboratories (Golden, CO; http://www.huffmanlabs.com/): Metals, major ions, TOC, DOC, UV254
- Accutest Laboratory (Wheat Ridge, CO; http://www.accutest.com/): low level mercury
- USBR Denver Environmental Chemistry Lab (http://www.usbr.gov/pmts/eco_research/eco2.html): Chlorophyll
- BSA Environmental Services, Inc. (Beachwood, OH; http://www.bsaenv.com/): Phytoplankton & Zooplankton
- Timberline Aquatics (Fort Collins, CO; http://timberlineaquatics.com/index.html): Periphyton
- University of Colorado (Boulder) Center for Environmental Mass Spectrometry (CEMS; http://ceae.colorado.edu/cems/): Emerging Contaminants

Each of the laboratories that Northern Water uses is responsible for the accuracy of its data. Each laboratory has its own set of internal QA/QC procedures and conducts its own internal data review and verification prior to submitting data to Northern Water. The primary quality control procedures used by each of the laboratories are outlined on Table 5.3.

High Sierra Water Lab, Huffman Laboratories, and Accutest Laboratory are USGS-certified laboratories. USGS-certified laboratories undergo annual QC audits that include the analysis of blind samples submitted to them by the USGS. These laboratories also participate in the USGS "Round Robin" program, an inter-laboratory comparison study where Standard Reference Samples are submitted to approximately 150 laboratories (USGS and non-USGS labs) in the spring and fall to evaluate and compare analytical performance.

Note that there are some slight differences between the USGS methods and the corresponding Standard Method (SM) or EPA methods identified on Table 5.1. More information about the USGS and EPA analytical methods identified in Tables 5.1 and 5.2 can be found at https://www.nemi.gov/home/.

Also note that the low-level nutrient analysis conducted by High Sierra Water Lab has an associated holding time of ≤ 7 days. In regard to this holding time, Mark Palmer (High Sierra Water Lab) indicated the following in an email to Jen Stephenson (Jan 14, 2014): "*Since 1988 I have performed water chemistry for low-level nutrients including NO3/NO2 and Ortho-P. I have completed holding time studies for these analyses on samples from pristine lakes and streams. I ran the samples within the 48-hour holding time and then again five weeks later. The results were the same as long as the samples were kept refrigerated at 4 degrees C and kept in the dark. Additionally, clients have asked me to re-run samples two months after collection and results were the same or well within the 15% RPD*".

TABLE 5.1 - PARAMETERS, ANALYTICAL METHODS, AND METHOD DESCRIPTIONS.

Constituent	Method	Method Description
GENERAL PARAMETERS		
Alkalinity (mg/L)	SM 2320B (USGS I-2030-89)	Titration with acid to pH 4.5
Chlorophyll a, b & c (mg/m^3)	SM 10200 H.2	Spectrophotometric determination
Dis. Organic Carbon, DOC (mg/L)	SM 5310C (USGS O-3100-83)	Heated-Persulfate oxidation
Total Organic Carbon, TOC (mg/L)	SM 5310C (USGS O-3100-83)	Heated-Persulfate oxidation
Total Dissolved Solids, TDS (mg/L)	EPA 160.1	Filtrate evaporated to dryness at 180°C
Total Suspended Solids, TSS (mg/L)	EPA 160.2	Residue dried at 103 - 105°C
UVA 254 (cm^{-1})	SM 5910	Absorption at 253.7 nm using spectrophotometer
NUTRIENTS		
Ammonia as N, Dissolved (mg/L)	EPA 350.1 modified	Colorimetric with Indophenol, spectrophotometer
Total Kjeldahl Nitrogen (TKN) as N (mg/L)	EPA 351.2 modified	Digestion followed by colorimetric with Indophenol, spectrophotometer
Nitrate plus Nitrite as N (mg/L)	EPA 353.1 modified	Hydrazine reduction, colorimetric, spectrophotometer
Ortho Phosphate as P (mg/L)	SM 4500-P E	Colorimetric with ascorbic acid, spectrophotometer
Phosphorus, Total (mg/L)	EPA 365.3	Acid-persulfate digestion, colorimetric with molybdate & ascorbic acid, spectrophotometer
MAJOR IONS		
Cations: Calcium, Magnesium, Potassium, Sodium (mg/L)	EPA 200.7 (USGS I-4471-97)	Inductively Coupled Plasma – Atomic Emission Spectrometry (ICP-AES)
Anions: Chloride, Sulfate (mg/L)	EPA 300.1 (USGS I-2057-85)	Ion-exchange chromatography
METALS		
Arsenic, Dissolved (µg/L)	EPA 200.8 (USGS I-4472-97)	Inductively Coupled Plasma – Mass Spectrometry (ICP-MS)
Arsenic, Total Rec (µg /L)		
Boron, Dissolved (µg /L)		
Cadmium, Dissolved (µg/L)		
Copper, Dissolved (µg /L)		
Iron, Dissolved (µg /L)		
Iron, Total Rec (µg /L)		
Lead, Dissolved (µg /L)		
Manganese, Dissolved (µg /L)		
Nickel, Dissolved (µg /L)		
Selenium, Dissolved (µg /L)		
Silver, Dissolved (µg /L)		
Zinc, Dissolved (µg/L)		
Mercury, Total Rec (nanograms/L)	EPA 1631E	Mercury in water by cold-vapor atomic fluorescence spectrometry (CVAFS)
BIOLOGICAL	**Method Description**	
Phytoplankton: Species I.D., Density (cells/mL) & Biovolume ($\mu m^3/mL$)	Membrane Filtration (McNabb 1960)	
Zooplankton: Species I.D. & #/L	Utermohl Chamber Method	
Periphyton: Species I.D. & estimate % contribution to total biomass	Leitz inverted microscope, 125X &500X, with Whipple grid	

TABLE 5.2 - PARAMETERS, ANALYTICAL METHODS, LABORATORIES , METHOD DETECTION LIMITS (MDL) AND REPORTING LIMITS (RL) USED IN NORTHERN'S WATER QUALITY MONITORING PROGRAMS.

Constituent	Method	Lab Name	MDL	RL
GENERAL PARAMETERS				
Alkalinity (mg/L)	SM 2320B	Huffman Laboratories	1	5
Chlorophyll a, b & c (mg/m^3)	SM 10200 H.2	USBR Denver	0.1	0.1
Dis. Organic Carbon, DOC (mg/L)	SM 5310C	Huffman Laboratories	0.02	0.6
Total Organic Carbon, TOC (mg/L)	SM 5310C	Huffman Laboratories	0.02	0.6
Total Dissolved Solids, TDS (mg/L)	EPA 160.1	High Sierra Water Lab	10	10
Total Suspended Solids, TSS (mg/L)	EPA 160.2	High Sierra Water Lab	0.1	0.1
UVA 254 (cm^{-1})	SM 5910	Huffman Laboratories	0.001	0.002
NUTRIENTS				
Ammonia as N, Dissolved (mg/L)	EPA 350.1 modified	High Sierra Water Lab	0.001	0.004
Total Kjeldahl Nitrogen (TKN) as N (mg/L)	EPA 351.2 modified	High Sierra Water Lab	0.035	0.07
Nitrate plus Nitrite as N (mg/L)	EPA 353.1 modified	High Sierra Water Lab	0.001	0.004
Ortho Phosphate as P (mg/L)	SM 4500-PE	High Sierra Water Lab	0.001	0.002
Phosphorus, Total (mg/L)	EPA 365.3	High Sierra Water Lab	0.001	0.003
MAJOR IONS				
Calcium (mg/L)	EPA 200.7	Huffman Laboratories	0.003	0.02
Magnesium (mg/L)	EPA 200.7	Huffman Laboratories	0.001	0.012
Potassium (mg/L)	EPA 200.7	Huffman Laboratories	0.03	0.06
Sodium (mg/L)	EPA 200.7	Huffman Laboratories	0.01	0.12
Chloride (mg/L)	EPA 300.1	Huffman Laboratories	0.03	0.12
Sulfate (mg/L)	EPA 300.1	Huffman Laboratories	0.03	0.18
METALS				
Arsenic, Dissolved (µg/L)	EPA 200.8	Huffman Laboratories	0.03	0.06
Arsenic, Total Rec (µg /L)	EPA 200.8	Huffman Laboratories	0.4	0.8
Boron, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.01	0.05
Cadmium, Dissolved (µg/L)	EPA 200.8	Huffman Laboratories	0.01	0.02
Copper, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.02	1
Iron, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.06	4
Iron, Total Rec (µg /L)	EPA 200.8	Huffman Laboratories	1.8	14
Lead, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.003	0.03
Manganese, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.02	0.2
Nickel, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.02	0.12
Selenium, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.02	0.06
Silver, Dissolved (µg /L)	EPA 200.8	Huffman Laboratories	0.005	0.01
Zinc, Dissolved (µg/L)	EPA 200.8	Huffman Laboratories	0.1	1
Mercury, Total Rec (nanograms/L)	EPA 1631E	Accutest Laboratory	0.5	0.5
BIOLOGICAL				
Phytoplankton: Species I.D., Density (cells/mL) & Biovolume (µm^3/mL)	Membrane Filtration (McNabb 1960)	BSA Env. Services, Inc	--	--
Zooplankton: Species I.D. & #/L	Utermohl Chamber Method	BSA Env. Services, Inc	--	--
Periphyton: Species I.D. & estimate percent contribution to total biomass	Leitz inverted microscope, 125X &500X, with Whipple grid	Timberline Aquatics	--	---

TABLE 5.3 - QUALITY CONTROL REQUIREMENTS FOR LABORATORY ANALYSES.

NUTRIENTS: High Sierra Water Laboratory			
Quality Control Procedure/Sample Type	**Purpose**	**Frequency/Number**	**Acceptance Criteria**
Matrix Spike	Monitor matrix interferences & method accuracy	1/ 20 samples	NH_3, ortho-P, TP: 80 – 120% recovery NO_3/NO_2 & TKN: 75– 125% recovery
Lab Duplicates	Assess method precision	1/ 20 samples	RPD ≤ 15%
Method Blanks	Assess lab contamination	1/ 20 samples	TKN: < 0.035 mg/L Others: < 0.001 mg/L
Standard Curve Slope	Standard curve slope value should remain consistent from one assay to the next.	Statistics for standard curve of each assay recorded on Standard Curve Statistical Summary Form. Structural curve slope, Y-intercept, correlation coefficient & standard range are noted.	Assay slopes must fall within control limits; control limits defined as ±3sx from the average slope value.
Standard Reference Material	Check calibration using a Standard Reference Material.	1/ 20 samples	RPD ≤ 15% between the actual value & assay value

TDS, TSS: High Sierra Water Laboratory			
Quality Control Procedure/Sample Type	**Purpose**	**Frequency/Number**	**Acceptance Criteria**
Check analytical balance	Verify accuracy of balance	Before sample analysis	< 0.5 mg
Lab Duplicates	Assess method precision	1/ 20 samples	RPD ≤ 15%
Method Blanks	Assess lab contamination	1/ 20 samples	TDS: < 10 mg/L TSS: < 0.1 mg/L
Standard Reference Material	Assess accuracy	1/ 20 samples	RPD ≤ 15% between the actual value & assay value

PHYTOPLANKTON & ZOOPLANKTON: BSA Environmental Services, Inc.		
Quality Control Procedure	**Purpose**	**Acceptance Criteria**
Use of standard taxonomic reference materials	Ensure consistency in identification between other labs/programs; ensure use of most current taxa names	Keys and references widely available.
Verification of taxonomic composition by second phycologist or zooplankton taxonomist	Ensure taxonomic accuracy	Differences in taxonomy reconciled.
Selection of minimum acceptable tally for each analysis	Ensure counting precision & accuracy	**Phytoplankton**: min. 400 units identified & enumerated/sample **Zooplankton**: min. 200 zooplankters identified & enumerated/sample

TABLE 5.3 – QUALITY CONTROL REQUIREMENTS FOR LABORATORY ANALYSES (*CONTINUED*).

MAJOR IONS & METALS: Huffman Laboratories			
Quality Control Procedure/Sample Type	**Purpose**	**Frequency/Number**	**Acceptance Criteria**
Calibration Check (Continuing Calibration Verification)	Check instrument calibration after every 10 samples to confirm proper operation of the system.	1/10 samples	±10% of theory
Method Blank (Laboratory Reagent Blank)	Blank (analyte-free) water carried through entire analytical procedure to assess contamination associated with lab prep, solvents, glassware, reagents & analysis	1/10 samples	< 2x DL
Laboratory Control Sample (Laboratory Fortified Blank)	Samples prepared by lab using contaminant-free reagent water that is spiked with a known quantity of the analyte of interest and used to measure lab accuracy & precision.	1/10 samples	±15% recovery of theory
Matrix Spike (Laboratory Fortified Matrix Sample)	Environmental sample spiked with known quantity of analyte to determine if the sample matrix contributes bias to the analytical results.	1/10 samples	±20% recovery of theory
Matrix Spike Duplicate	A sample prepared simultaneously as a split with the matrix spike sample with each specimen being spiked with identical, known concentrations of targeted analyte. Assess precision associated with laboratory procedures	1/10 samples	RPD ≤ 10%, or ± the detection limit for a given element, whichever is greater.
Laboratory Duplicate	Two aliquots of the same environmental sample taken in the laboratory from a single sample bottle and analyzed separately with identical procedures. Analyses of LD1 and LD2 indicates precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.	1/10 samples	RPD ≤ 10%, or ± the detection limit for a given element, whichever is greater.

TABLE 5.3 – QUALITY CONTROL REQUIREMENTS FOR LABORATORY ANALYSES (*CONTINUED*).

EMERGING CONTAMINANTS: University of Colorado CEMS			
Quality Control Procedure/Sample Type	**Purpose**	**Frequency/Number**	**Acceptance Criteria**
Method Blank	Assess contamination associated with lab prep, solvents, glassware, reagents & analysis.	1/10 samples	Less than LOD for each compound
Laboratory Duplicates	Assess precision associated with laboratory procedures.	1/10 samples	Percent relative standard deviation < 10%
Matrix Spikes for LC-MS-MS samples (Environmental sample spiked with 40 ng/L of all analytes)	Determine if the sample matrix contributes bias to the analytical results.	One for each batch of samples	Accuracy: ±15% recovery of theory Percent relative standard deviation < 10%
Calibration Curves developed for all compounds for concentrations between 1 ng/L and 200 ng/L	Accurate quantitation of compounds	1 curve per compound per batch of samples	Correlation coefficients > 0.99
Intra-day (single day) Precision: assessed at two different concentration levels in spiked water extracts; analysis performed in five replicates at each level	Assess precision	Twice a year	Percent relative standard deviation < 5%
Inter-day (5-day) Precision: analyze spiked water extracts in five consecutive days	Assess precision	Twice a year	Percent relative standard deviation < 10%

TABLE 5.3 – QUALITY CONTROL REQUIREMENTS FOR LABORATORY ANALYSES (*CONTINUED*).

LOW LEVEL (ng/L) MERCURY: Accutest Laboratory			
Quality Control Procedure/Sample Type	**Purpose**	**Frequency/Number**	**Acceptance Criteria**
Calibration Blank	Demonstrate that flow injection systems are free from contamination	3/analytical batch	
Reagent Blank	Demonstrate that the reagents used to prepare the samples are free from contamination	Required whenever a new batch of reagent is prepared	Hg < 0.2 ng/L
Method Blank	Blank (analyte-free) water carried through entire analytical procedure to assess contamination associated with lab prep, solvents, labware, reagents & analysis	3/analytical batch	Hg < 0.5 ng/L
Laboratory Control Sample (Spike Blank)	Samples prepared by lab using contaminant-free reagent water that is spiked with a known quantity of the analyte of interest and used to measure lab accuracy & precision.	1/ 20 samples	77 – 123% recovery
Ongoing precision and recovery (OPR) standard (Calibration Check Standard, CCV)	Ability of lab to continue to generate acceptable precision and recovery data	Analyze the OPR solution (5 ng/L Hg) prior to each analytical batch, & end of analytical sequence or end of 12-hr shift	77 – 123% recovery
Quality Control Sample (QCS)	QCS from a source different from the Hg used to produce calibration standards; Independent check of system performance		77 – 123% recovery
Matrix Spike	Environmental sample spiked with known quantity of analyte to determine if the sample matrix contributes bias to the analytical results.	10% of each sample batch	71 – 125% recovery
Matrix Spike Duplicate	A sample prepared simultaneously as a split with the matrix spike sample with each specimen being spiked with identical, known concentrations of targeted analyte. Assess precision associated with laboratory procedures	10% of each sample batch	RPD ≤ 24%

This page intentionally left blank.

COLORADO RIVER WATCH

Colorado River Watch Water Quality Sampling Manual

Version 5.09

Sponsored By: *The Colorado Division of Wildlife*
&
Colorado Watershed Assembly

Written By: *River Watch Staff*

http://wildlife.state.co.us/riverwatch

Table of Contents

SAMPLING

OPTIONAL

TIPS TO BRING BACK TO YOUR COMMUNITY

INTRODUCTION TO RIVER WATCH

The "Colorado River Watch" program (River Watch) is a statewide volunteer water quality-monitoring program co-sponsored by the Colorado Division of Wildlife (CDOW) and the Colorado Watershed Assembly (CWA). River Watch brings together education with environmental protection in a meaningful, hands-on project for Colorado students and volunteers.

The mission of River Watch is to provide an educational opportunity for students, adults, and all citizens to understand the value and function of Colorado rivers, lakes and wetland ecosystems, along with providing CDOW, Water Quality Control Commission, water resource managers and all interested entities with high quality spatial and temporal water ecosystem data.

River Watch accomplishes this by working with voluntary stewards to monitor water quality and other indicators of watershed health, and utilize high quality data to inform decision makers and educate citizens about the condition of Colorado's waters along with providing a hands-on opportunity for citizens to understand the value and function of their river ecosystem. This program is unique in its statewide focus and frequency of data collection.

River Watch volunteers are primarily Middle and High School students, but also include citizen groups, individuals, colleges, youth programs, government agencies, and non-profit organizations. Each volunteer group receives the training, support and supplies needed to monitor their respective water bodies with the goal of providing consistent and accurate data. A Quality Assurance and Quality Control plan (QA/QC plan) is in place to ensure high quality data is collected. This includes a visit from a River Watch staff member once a year in order to provide quality control, one on one support and technical assistance.

Each volunteer group signs an annual agreement committing to sample a minimum of one station. Volunteers collect monthly field samples and analyze those samples for hardness, alkalinity, temperature, dissolved oxygen, and pH. Additional laboratory samples are collected monthly for analysis of total and dissolved metals, including Al, As, Ca, Cd, Cu, Fe, Mg, Mn, Pb, Na, K, Se and Zn. Twice a year volunteers collect nutrient samples for analysis of total phosphorous, nitrate+nitrite, ammonia, chloride, sulfate and total suspended solids. In addition to the chemical samples, a macroinvertebrate sample is collected on an annual basis and sent to an outside lab for identification. These macroinvertebrate collections are accompanied by an annual instream and reach physical habitat assessment.

New volunteers must attend a River Watch sponsored training prior to participating in the program. Additionally, existing groups with a new volunteer team leader are encouraged to attend, while others can attend as a refresher course if space and funding allows. The training consists of an introduction to stream ecology, basic watershed management, and the chemical, physical and biological metrics used in studying rivers. Each volunteer is instructed on how to collect water and macroinvertebrate samples, conduct physical habitat assessment, record field data, and how to analyze hardness, alkalinity, dissolved oxygen, pH, and temperature. Volunteers also receive training on QA/QC sample processing, data management and interpretation. Each group receives the supplies and equipment necessary to be a River Watch volunteer organization and keeps the equipment as long as a signed agreement is on file.

An essential part of the success of River Watch is the rigorous Quality Assurance and Quality Control Program. All methods are approved by the Environmental Protection Agency (EPA) Standard Methods 2002, or the Colorado Water Quality Control Division (CWQCD). River Watch has standardized equipment, chemicals and protocols that are used by all volunteers. For example, in the field, volunteers must collect a metal field blank and duplicate sample every fifth outing, and analyze unknown samples for pH, alkalinity and hardness tests twice a year. In the laboratory, analysis is validated through a series of special samples including laboratory blanks, duplicates, known standards and spikes, use of outside labs and documentation and reporting of QA/QC results. All data is validated by CDOW or River Watch staff before release. The Colorado River Watch Water Quality Sampling Manual, Operation Procedures Manual and Quality Assurance Project Plan are updated annually. The ecological foundation of River Watch is based on the River Continuum Concept (RCC). RCC illustrates that a river is a predictable continuum of chemical, physical and biological attributes. Station locations are determined each year based on data gaps, priorities, active volunteer groups and resources.

Federal, state, and local agencies make land use management, regulatory and non-regulatory decisions about Colorado's rivers and streams using data from the River Watch program. Many other local, private and public entities also use the data. This includes use of the River Watch data to help establish water-quality standards for Colorado waters in the Colorado Water Quality Control Commissions (CWQCC) Hearings. (The CWQCC is a politically appointed nine member commission that represents a diverse geographic and water use spectrum. This commission decides what uses will be protected and what level of protection will be afforded via Colorado's Clean Water Act.) River Watch data is available upon request, through the River Watch website and USEPA STORET (Storage and Retrieval database).

The ambitious and successful River Watch project is funded through the CDOW and operated by the Colorado Watershed Assembly. The program began in 1990 with 19 schools along the Arkansas, Eagle and Yampa rivers, and is still going strong. River Watch has worked with hundreds of volunteer groups to collect tens of thousands of water quality samples. We have trained over 400 adults, 1000 students directly; we have data for 800 stations and over 500 rivers in Colorado.

While this manual is used for sample collection of rivers, River Watch plans to include lake and wetland studies as the opportunities arise.

Benefits

- For the CDOW, water resource managers and other interested entities: accurate useable data on all rivers in the network. This data will aid in making reliable, consistent, and holistic, watershed management decisions regarding the rivers of Colorado. All data is carefully collected and analyzed according to state water quality standards, and made available to CDOW biologists, Water Quality Control Commissioners, EPA and other water resource managers.

- For participating citizens, watershed groups and students: an educational opportunity to understand and value our river ecosystems. Citizens and students (with supervision and support from their teachers) monitor a stretch of a river in their community; collect biological, physical and chemical data over time. Along with collection, individuals learn how these aspects interact to shape their river ecosystem.

- For local communities and the state of Colorado: healthier rivers and watersheds as a result of more accurate and consistent water quality information for every level of land use and water management decision making. Students, the future citizens and decision makers of Colorado, become stewards of the river that serve their community.

Data Objectives

River Watch's primary data objective is to collect long term baseline aquatic ecosystem data. Aquatic ecosystem data includes chemical, physical and biological components. River Watch's secondary data objective is to collect site or study specific aquatic ecosystem data for a short term purpose. River Watch's primary volunteer base consists of teachers and students however; individuals, citizen watershed groups and even industry groups participate.

Staff Members

River Watch Staff (Colorado Watershed Assembly Organization):

Michaela Taylor
River Watch Program Manager
303.291.7322
michaela@coloradowatershed.org

Curtis Hartenstine
River Watch Resource Specialist
303.291.7439
Curtis@coloradowatershed.org

Matt McIntyre
River Watch Analyst
970.472.4376
Matt@coloradowatershed.org

You can reach us any of us at riverwatch.wildlife@state.co.us as well.

For all River Watch related business, (samples, equipment, contract, data sheets, other paper work, etc.) please use this mailing address:

River Watch
c/o Colorado Division of Wildlife
6060 Broadway
Denver CO 80216

For **Colorado Watershed Assembly** related business, mailing address is:

PO Box 211729, Denver, Colorado 80221

Visit www.coloradowater.org for more information regarding the Assembly.

Colorado Division of Wildlife Staff

Barb Horn
CDOW Water Resource Specialist
151 East 16th Avenue
Durango, Colorado 81301

970.382.6667
barb.horn@state.co.us

This page intentionally left blank.

Appendix K Biological Monitoring (Overview)

This page intentionally left blank.

Biological Sampling Program Analysis Metrics Overview
(Extracted from Material Prepared by Timberline Aquatics 2014)

TRADITIONAL SAMPLING METHODS AND ANALYSIS

Three replicate quantitative samples are taken from each study site in a combined effort by Timberline Aquatics, Inc. and city staff. All samples are taken in similar habitat at each station using a Hess Sampler to provide quantitative benthic macroinvertebrate data. Substrate within each sample is thoroughly agitated and individual rocks are scrubbed by hand to dislodge benthic organisms. All macroinvertebrates are rinsed into sample jars and preserved in 70% ethanol solution. Each sample jar is labeled with the date, location, and sample ID number. Samples are transported to the lab at Timberline Aquatics, Inc. where benthic macroinvertebrates are sorted, identified, and enumerated. The sorting and identification process is conducted for each entire sample to avoid potential problems or controversy associated with subsampling.

The sorting process involves separating macroinvertebrates from debris in each sample. All macroinvertebrates are removed from each sample and placed into vials containing coarse taxonomic groups. Macroinvertebrates are identified to the "lowest practical taxonomic level" based primarily on Merritt et al. (2008) and Ward et al. (2002). The "lowest practical taxonomic level" means that all specimens are identified to a level that is permitted based on available physical characteristics and species keys using a dissecting microscope. This level of identification consisted of genus or species for mayflies, stoneflies, caddisflies, and many dipterans. The Family Chironomidae is identified to subfamily or tribe in the spring and to the genus level in the fall.

As part of the quality control protocols at Timberline Aquatics, Inc., all sorted macroinvertebrate samples are checked by an additional taxonomist, and Dr. Boris Kondratieff (Professor of Entomology at Colorado State University) checked identifications in approximately 10% of the samples. As an additional means of QA/QC, Dr. Kondratieff confirms identifications in all cases where the classification of a species is difficult or questionable.

Population densities and species lists are developed for each sampling site in the study area. Data are used in various indices (metrics) to provide information regarding aquatic conditions. The following sections provide a description of each metric that is used in this study:

Shannon Diversity (Diversity) and Evenness (Evenness): Diversity and Evenness values are used to detect changes in macroinvertebrate community structure. In unpolluted waters, Diversity values typically range from near 3.0 to 4.0. In polluted waters this value is generally less than 1.0. The Evenness value ranges between 0.0 and 1.0. Values lower than 0.3 are usually considered indicative of organic pollution (Ward et al. 2002).

Diversity and Taxa Index (DAT): The DAT is also used in this study to evaluate water quality based on benthic community diversity with taxa richness. This metric is unique because it incorporates components of community diversity along with taxa richness. Calculated DAT values fall within a range of numbers that are correlated to a scale describing stream condition (Mangum 1986). This index has been a valuable indicator of changes in water quality and/or habitat that have occurred in Boulder Creek since the onset of this study. The DAT scale is as follows:

DAT Value	SCALE
18-30	Excellent
11-17	Good
6-10	Fair
0-5	Poor

Hilsenhoff Biotic Index (HBI): The HBI is used in this study because it has been widely used and/or recommended in numerous regional biomonitoring studies (Paul et al. 2005). Most of its value lies in detection of nutrient enrichment, but it is also used to evaluate aquatic conditions in a variety of other circumstances. The HBI is originally developed using macroinvertebrate taxa from streams in Wisconsin; therefore, it may require regional modifications (Hilsenhoff 1988). Tolerance values for taxa occurring in this study area are taken from Barbour et al. (1999) which provides tolerance values for Idaho, or King (1993) who modified the HBI for Wyoming streams. Although the HBI value may naturally vary among regions, comparison of the values produced within the same system should provide information regarding locations with impact from nutrients or other disturbances. Values for the HBI range from 0.0 to 10.0, and increase as water quality decreases.

Ephemeroptera Plecoptera Trichoptera Richness (EPT): The design of this metric is based on the assumption that the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are generally more sensitive to pollution than other benthic macroinvertebrate orders (Lenat 1988). The EPT metric is currently an important and widely used metric in many regions of the United States (Barbour et al. 1999). The EPT value is simply given as the total number of distinguishable taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera found at each station. This number will naturally vary among river systems, but it can be an excellent indicator of disturbance within a specific drainage. The EPT score is expected to decrease in response to a variety of stressors including nutrients (Wang et al. 2007).

Ratio of EPT to Chironomidae abundance (EPT/Chironomidae Ratio): This ratio has been widely used in the U.S. to test for nutrient enrichment (Plafkin et al. 1989). Design of this metric incorporates the density of individuals in taxonomic Orders that are generally considered to be sensitive to pollution (EPT taxa) in a ratio with the density of individuals from a Family (Chironomidae) with taxa that are thought to be tolerant to most disturbances (Plafkin et al. 1989; King 1993). Limitations of this metric can result from variability in tolerances among EPT taxa, and certain species of Chironomidae that are relatively sensitive to pollutants. When aquatic conditions are favorable, values often range from 3.0 to 7.0 (but can be higher). Values usually decline to less than 1.0 when nutrient enrichment is a problem.

Taxa Richness: Taxa Richness is another metric often used as an indicator of habitat adequacy and water quality. The Taxa Richness measurement is reported as the total number of identifiable taxa collected from each sampling location. It is similar to the EPT index, except that it includes all aquatic macroinvertebrate taxa (including those thought to be tolerant to disturbance). Taxa Richness, or the total spectrum of taxa groups present at a given site, will generally decrease when exposed to decreasing water quality or habitat degradation (Weber 1973).

Multiple Index Score (MIS): The MIS is developed specifically for the Boulder Creek Biomonitoring Program using the combined relative values from the previously described metrics in a comparison to a reference site. The MIS provides a single score for each site that is based on these seven equally weighted metrics. For the purpose of this study, site BC-CAN has served as the reference site because it does not receive influence from potential impacts associated with the City of Boulder. It should be noted, however, that site BC-CAN is susceptible to other disturbances that may occur farther upstream in Boulder Canyon. During instances in which BC-CAN receives lower than expected metric scores, site SBC-OS could serve as an alternative reference site. The methodology for development of the MIS is based on EPA Rapid Bioassessment Protocols (Plafkin et al. 1989), and the "Wyoming Bioassessment Method" (King 1993). Metric values from the reference station are used in a relative comparison with metric values produced at other sites to obtain MIS values. Each metric value for non-reference sites is expressed as a percentage of the value obtained at the reference location. A mean relative percentage value is determined by combining the seven metric values produced at each of the non-reference sites. This number is then divided by 10 to produce a simplified single index score. Since much of the MIS is based on the multi-metric index produced by King (1993), the scale used to evaluate aquatic conditions in the Boulder Creek Biomonitoring Study is similar.

MIS SCALE	
8.0-10	Not Stressed
5.0-7.9	Slightly Stressed
2.1-4.9	Moderately Stressed
0.0-2.0	Severely Stressed

Density and Biomass: A measure of macroinvertebrate standing crop at each site is determined using density and biomass. Density is reported as the mean number of macroinvertebrates per m^2 and biomass is reported as the mean dry weight of macroinvertebrates per m^2 at each study site. Biomass values are obtained by drying macroinvertebrates from each sample in a scientific drying oven at 100° C for 24-hours or until all water content had evaporated (no decrease in weight could be detected). Biomass values provide production-related information in terms of weight of macroinvertebrates produced by each habitat. Density and biomass provide a means of measuring and comparing standing crop and provide an indication of productivity for the macroinvertebrate portion of the food web at each sampling location.

Functional Feeding Groups: Most of the previously described metrics use macroinvertebrate information that is related to community structure; however, macroinvertebrate taxa are also separated into functional guilds based on food acquisition to provide a measurement of community function. Aquatic macroinvertebrates are categorized according to feeding strategy to determine the relative proportion of various groups. Some representation of each group usually indicates good conditions; however, it is normal for certain groups (collector-gatherers) to be more abundant than others (Ward et al. 2002). Scrapers and shredders are often considered sensitive to disturbance because they are specialized feeders (Barbour et al. 1999). Consequently, these sensitive groups are expected to be well represented in healthy streams. Much of the value in this type of analysis comes from comparison of sites within a specific study area. Changes in the proportion of functional feeding groups can provide insight into various types of stress in river systems (Ward et al. 2002).

ADDITIONAL ANALYSIS USING CDPHE PROTOCOLS

The CDPHE developed a Multi-Metric Index (MMI) to assist in the evaluation of benthic macroinvertebrate data. This tool relies on specific methods and protocols for sample processing and analysis. The MMI tool is developed using data from the late summer and fall seasons, and therefore requires similar seasonal data to provide reliable results. For the purpose of this study, the CDPHE protocols for MMI analysis are applied and paired with the results from traditional analysis tools using data from each site in the Boulder Creek Biomonitoring Program during the fall of 2012.

Macroinvertebrates are identified to a taxonomic level that is consistent with the Operational Taxonomic Unit (OTU) established by the CDPHE. This level of identification is usually genus or species for mayflies, stoneflies, caddisflies, and many dipterans. Chironomidae are identified to the genus level. The MMI program randomly selects approximately 300 individual specimens to be used in the individual metric calculations. Any taxa that are both large and rare are also included in the data analysis used to generate MMI scores. The inclusion of rare taxa may provide important biological information because many rare taxa are also considered sensitive to disturbances (Fore et al. 1996).

The MMI is constructed similarly to the MIS that has been previously used (since 2005) for the Boulder Creek Biomonitoring Program. The MMI provides a single index score based on five or six equally weighted metrics. The group of metrics used in MMI calculations depends on the location of the site and corresponding Biotype (Mountains, Transitional, or Plains). Each of the metrics used in the MMI produces a value that is adjusted to a scale from 1 to 100 based on the range of metric scores found at "reference sites" in the state of Colorado.

The current study area for the Boulder Creek Biomonitoring Program is completely located within Biotype 1. Biotype 1 (Transition Zone) includes lower mountain areas of the Colorado Front Range downstream to the lower boundary of the "Front Range Fans" (near the confluence of Coal Creek and Boulder Creek). The thresholds for MMI scores that determine impairment for Biotype 1 are as follows:

Biotype	Attainment Threshold	Impairment Threshold
Transition (Biotype 1)	52	42

Metric scores that fall between the thresholds for attainment and impairment require further evaluation using two additional metrics (Diversity and HBI) in order to determine if the site is in attainment or impaired. Calculations for these metrics have been previously described; however, scores may vary slightly when using the OTU level of identification. Thresholds for these metrics are as follows:

Biotype	HBI	Diversity
Transition (Biotype 1)	5.4	2.4

Specific metrics used in the MMI are dependent on site location and corresponding Biotype. Metrics currently used for Biotype 1 include: Percent Non-insect Taxa, EP Taxa, Percent Chironomidae, Percent Sensitive Plains Families, Predator-Shredder Taxa, and Clinger Taxa. These metrics are employed to determine MMI scores and assist in data analysis during the fall of 2012. The CDPHE does not provide information regarding the mechanisms or types of stressors that influence each metric; however, the following section provides a limited description of each metric based on a literature review conducted by Timberline Aquatics, Inc.

Biotype 1 Metrics

Percent Non-Insect Taxa: Percent Non-Insect Taxa relies on community richness for detection of perturbations. When using metrics that rely on community richness, it is important that specimens are identified to a consistent taxonomic level in order to obtain comparable results among sites (Resh and Jackson 1993). Since many insect taxa are thought to be relatively sensitive to perturbations, the Percent Non-Insect Taxa value is expected to increase in response to impacts from metal toxicity (Chutter 1972) and other types of stress.

EP Taxa: Another metric that relies on community richness is the EP Taxa metric. This metric uses components (Ephemeroptera and Plecoptera) of the EPT metric, which is widely accepted as a good indicator of overall benthic community health (Resh and Jackson 1993). The "intolerant" classification of the three EPT orders is suggested in 1983 and gained support during the following years (Lenat 1988). Some research has suggested the Plecoptera component may be most important because many of these taxa are among the most sensitive to human disturbance (Fore et al. 1996), but Eaton and Lenat (1991) recommend using all components of the EPT metric to avoid restrictions in its applicability. The WQCD has opted to use only two of the EPT components (Ephemeroptera and Plecoptera) and has incorporated an elevation adjustment for the metric when evaluating steams in Biotype 1.

Percent Chironomidae: This metric is closely related to the EPT/Chironomid Ratio used to assist in data analysis since the onset of the Boulder Creek Biomonitoring Program. Chironomidae taxa are generally considered to be tolerant of environmental stress compared to other aquatic insect families (Plafkin et al. 1989). The Percent Chironomidae metric relies on the assumption that the proportion of Chironomidae will increase with decreasing water quality. Streams that are undisturbed often have a relatively even distribution of Ephemeroptera, Plecoptera, Trichoptera, and Chironomidae (Mandaville 2000); while the Chironomidae family often dominates (75% or more of the macroinvertebrate density) at sites degraded by metals or other pollutants (Barton and Metcalf-Smith 1992). One ecological reason why this group is used as an indicator of environmental stress involves the Chironomidae life cycle. Most species of Chironomidae tend to have a relatively short life cycle which enables them to continually re-colonize unstable or polluted habitats (Lenat 1983).

There is some debate regarding the consistency of the Chironomidae group as indicators of stress. Severe pollution has been found to cause a decrease in Chironomidae abundance (Lenat 1983), and there are detectable differences in tolerance to stress at the genus or species level. Although low to moderate levels of stress are expected to result in increased Chironomidae abundance, the number of taxa representing this Family has been documented as unchanging along a gradient of negative human impact (Lenat 1983, Fore et al. 1996). For these reasons, Rabeni & Wang (2001) have suggested that the Chironomidae group can be removed from some bioassessment evaluations without risking a loss of sensitivity.

Percent Sensitive Plains Families: This metric is specifically developed for the State of Colorado by the CDPHE and has not been previously used or tested in other benthic macroinvertebrate bioassessment studies. Macroinvertebrate data from “Plains” streams are evaluated to determine the presence and absence of taxa that may be influenced by disturbance from human activity. It is assumed the list of sensitive Families includes taxa that are intolerant to perturbations occurring in the Colorado plains and transition zone ecosystems. There is little evidence to support the accuracy of this metric, particularly when it is applied to higher elevations in the transition zone (Biotype 1).

Predator/Shredder Taxa: This biotic metric is based on the classification of benthic macroinvertebrates into functional feeding groups. Predators primarily rely on living animal tissue for food (often other aquatic insects), while shredders feed on coarse particulate organic matter (CPOM), often in the form of leaf packs (Merritt et al. 2008). The CDPHE has recommended that the number of taxa from both of these feeding groups be used as indicators of stress. The number of predator and shredder taxa is expected to decrease in response to stress in aquatic systems.

Although there has been some research suggesting that predator and shredder taxa are sensitive to environmental perturbations, there has also been some debate over the accuracy of functional feeding group metrics in multi-metric indices. The food source for shredders (CPOM) may contain toxins from the surrounding terrestrial environment which, if found in high enough concentrations, can produce a negative impact on shredder richness and abundance. However, it has been suggested that physical parameters such as stream size and canopy cover can also influence shredder taxa richness and abundance, making detection of human influences more difficult (Kerans & Karr 1994). Although the utility in pairing predators and shredders in this metric remains unclear, Kerans and Karr (1994) found that predator taxa in certain streams may be important indicators of changes in nutrient levels. While metrics that utilize functional feeding groups may provide information not readily obtainable from other taxonomic metrics, functional feeding group measures have also been found to produce variable responses when used in different ecoregions (Rawlier-Jost et al. 2000).

Clinger Taxa: This metric requires that benthic macroinvertebrates are organized into categories based on their habits or mode of locomotion. Clingers are benthic macroinvertebrates having behavioral and/or morphological adaptations that allow them to attach or "cling" to substrate surfaces, often in riffle habitat (Merritt et al. 2008). The Clinger Taxa metric is the only habit/mode of locomotion metric included in the MMI for Biotype 1. Clingers typically require clean substrate surfaces for attachment and are therefore influenced by stressors that result in habitat alterations. Clingers have often been used to evaluate the impacts from sedimentation because the deposition of fine sediment reduces the availability of their preferred habitat (Rinella 2003, Hughes and Brossett 2009). The Clinger Taxa metric may also respond negatively to increases in algal growth (that alters potential points of attachment) and rapid changes in discharge (because they are typically poor swimmers).