Chatfield ~~Watershed~~

Reservoir Reallocation Project and
Chatfield Watershed Authority~~:~~

~~Quality Assurance Project Plan (QAPP),~~
Coordinated Sampling and Analysis Plan (SAP) ~~and~~
~~Standard Operating Procedures (SOP)~~

~~Version 2008.01~~
~~November 2007~~
~~Updated January 2009~~

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Chatfield Reallocation Project
Water Providers
and
Chatfield Watershed Authority

Updated: June 2015

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Acceptance Page

The Chatfield Watershed Authority and the Chatfield Reallocation Project Water Providers approved this Sampling and Analysis Plan ~~and Quality Assurance Project Plan document on November~~ ___, ~~2007~~as indicated below:

Chatfield Reallocation Project

Chair Date

Chatfield Watershed Authority

Co-Chair Date

Co-Chair Date

Administrator ~~Date~~

~~**Water Quality Control Division**~~

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~~1.0 chatfield water quality monitoring program~~

1.0 Chatfield Water Quality Monitoring Program

The Chatfield Watershed Authority (~~Authority~~CWA) is the water quality management agency for the Chatfield Watershed ~~(Figure 1).~~(Figure 1). The Chatfield Watershed contains Plum~~-~~ Creek, Deer~~-~~ Creek, the portion of the South Platte River from the Strontia Springs Reservoir, and Chatfield Reservoir. The Chatfield Watershed includes those areas tributary to the Plum~~-~~ Creek drainage or directly connected to the Chatfield Reservoir. ~~The watershed tributary to the South Platte River upstream of the Strontia Springs Reservoir outfall is part of the Upper South Platte River Watershed.~~

~~The Authority~~The CWA implements the *Chatfield Reservoir Control Regulation* (Regulation #73), as adopted by the Colorado Water Quality Control Commission. ~~The control regulation assures watershed point and nonpoint source water quality compliance consistent with adopted stream standards and classifications. The Authority~~The CWA is responsible for water quality monitoring within the Chatfield Watershed. The monitoring stations are shown in ~~Figure 2.~~Figure 2. The Chatfield Reallocation Project (CRP) will store 20,600 acre-feet (AF) of water in Chatfield Reservoir to develop additional surface water supplies. The CRP Water Providers will satisfy water quality mitigation measures described in the CRP Record of Decision (ROD).

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Figure 1: Chatfield ~~Watershed~~Reservoir

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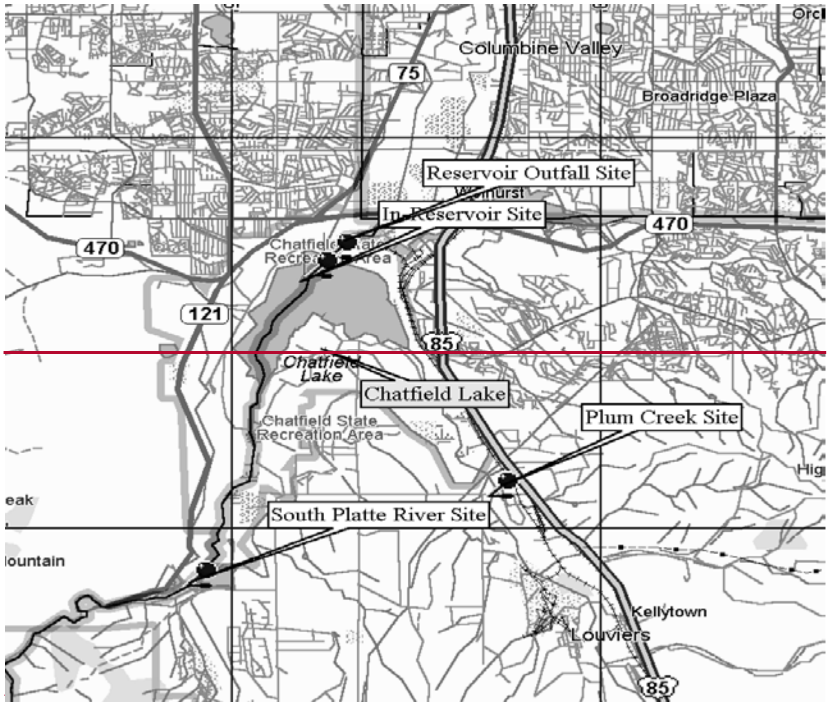
~~Figure 2 Sampling Sites~~



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The coordinated water quality~~-~~ monitoring program ~~samples~~will be used to characterize selected water quality parameters at two inflow locations (South Platte River and Plum~~-~~ Creek~~) and output~~), one outflow location (South Platte River~~) stations~~), and three locations within Chatfield Reservoir ~~Table 1).~~(Table 1 and Table 2) to address the needs of both the CRP and CWA.

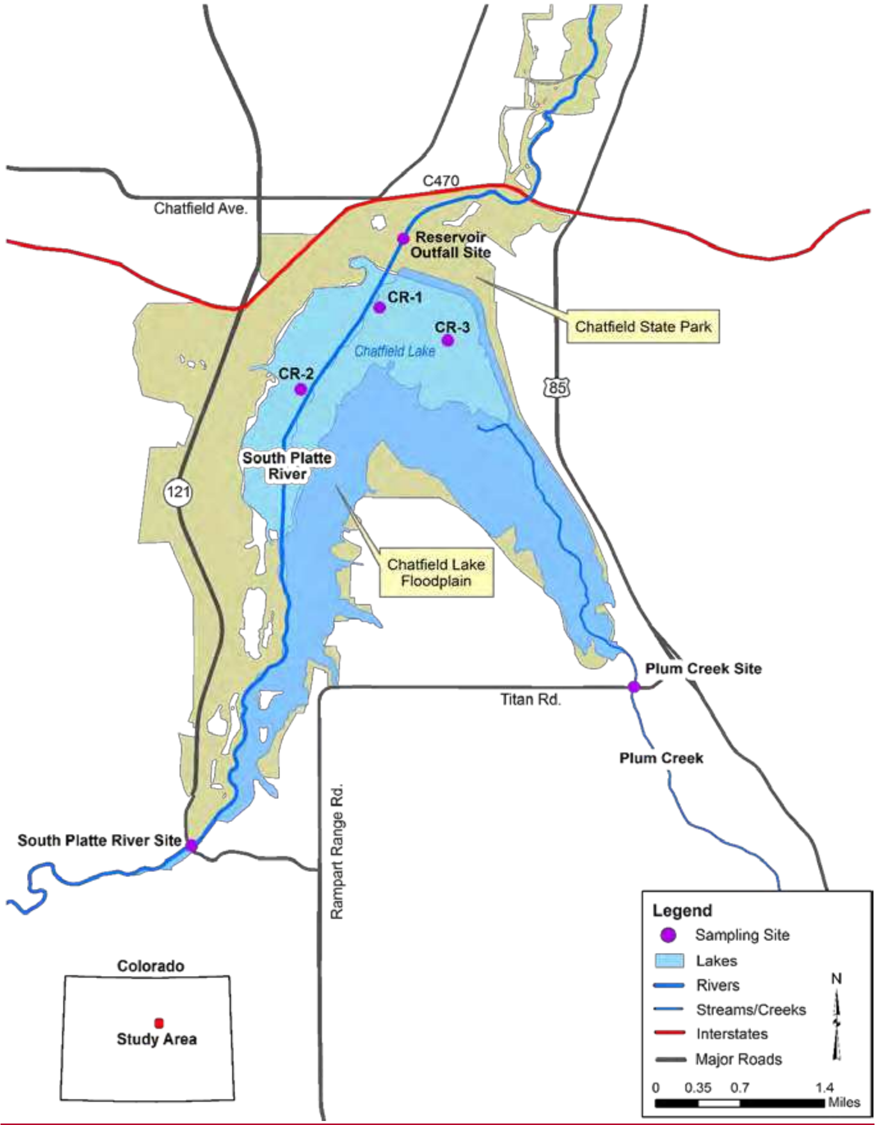

Figure 2 Sampling sites for the Chatfield Reallocation Project.

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Table 1: Reservoir Sampling Parameters

~~Field parameters~~	~~Temperature, pH, specific conductance, dissolved oxygen, instantaneous flow & Secchi depth~~
~~Miscellaneous analyses~~	~~Total suspended solids, E. coli & total organic carbon~~
~~Nutrient analyses~~	~~Phosphorous and nitrogen species~~
~~Biological analyses~~	~~Chlorophyll-a, phytoplankton & zooplankton~~
~~Metals analyses~~	~~16 metals including hardness (as resources allow)~~

Field Parameters	Temperature, pH, specific conductance, dissolved Oxygen (DO), oxidation reduction potential (ORP), Secchi depth, and Chlorophyll a
Miscellaneous Analyses	Total suspended solids (TSS), total dissolved solids (TDS), *Escherichia coli* (E. *coli*), total organic carbon (TOC), dissolved organic carbon (DOC), carbonaceous biochemical oxygen demand (CBOD), alkalinity (ALK), sulfate (SO_4), silica
Nutrient Analyses	Total phosphorous (TP), total dissolved phosphorous (TDP), ortho-phosphorous (SRP), nitrate+nitrite-nitrogen (NO_3+NO_2), total ammonia nitrogen (TAN), and Total Kjeldahl Nitrogen (TKN)
Biological Analyses	Chlorophyll *a*, phytoplankton, and zooplankton
Metals Analyses[1]	Arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silica (SiO_2), silver (Ag), zinc (Zn) and total hardness
Sediment Analyses	Total organic bound phosphorous, loosely bound and pore water phosphorous, iron-bound phosphorous, calcium-bound phosphorous, aluminum-bound phosphorous, percent solids, total organic carbon, total iron, total calcium, and total aluminum

[1] Analyses include total and dissolved fractions for the metals listed for both reservoir and stream sampling.

Table 2: Stream Sampling Parameters

Field Parameters	Temperature, pH, specific conductance, dissolved oxygen (DO), and instantaneous flow
Miscellaneous Analyses	Total suspended solids (TSS), total dissolved solids (TDS), *Escherichia coli* (E. *coli*), total organic carbon (TOC), dissolved organic carbon (DOC), carbonaceous biochemical oxygen demand (CBOD), alkalinity (ALK), and silica
Nutrient Analyses	Total phosphorous (TP), total dissolved phosphorous (TDP), ortho-phosphorous (SRP), nitrate+nitrite-nitrogen (NO_3+NO_2), and total ammonia nitrogen (TAN), and Total Kjeldahl Nitrogen (TKN)
Metals Analyses[1]	Arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silica (SiO_2), silver (Ag), zinc (Zn) and total hardness

2.0 Monitoring ~~program MANAGEMENT~~Program Management

2.1 Project/Task Organization

The project and task organization for the Chatfield Watershed water-quality monitoring program is shown in ~~Figure 3.~~Figure 3. The roles and responsibilities of each of the organizations identified in ~~Figure 3~~Figure 3 are summarized in sections 2.2 through 2.8. The existing external analytical laboratories are shown in ~~Figure 3~~Figure 3 as examples~~,~~; other laboratories could serve necessary analyses ~~needs.~~ as needed on a case by case basis.

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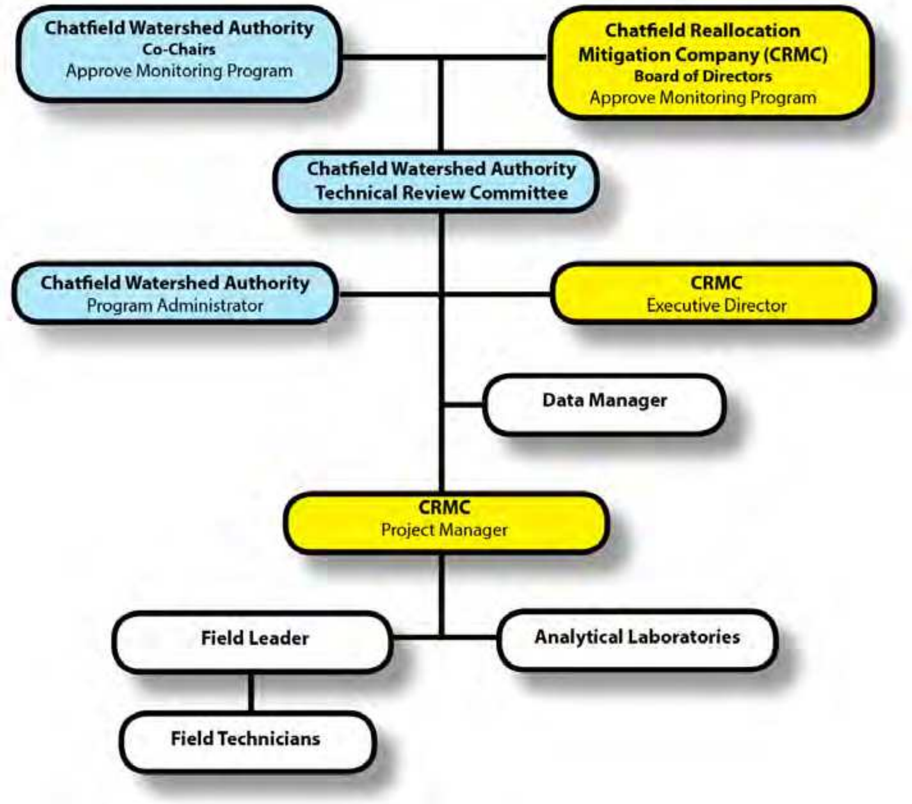

Figure 3~~—~~: Project Organization

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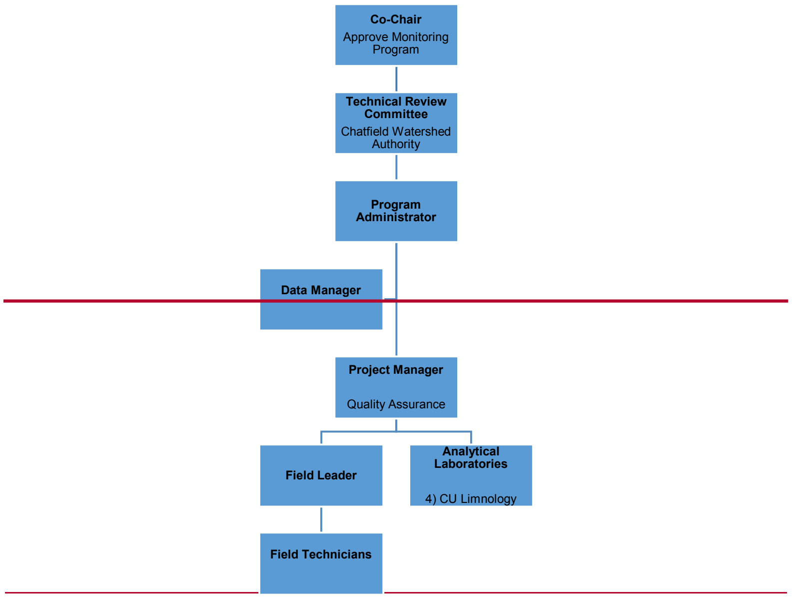

2.2 Chatfield Reallocation Project (CRP) and the Chatfield Watershed Authority (CWA)

The Chatfield Reallocation Project Providers have the ultimate responsibility for ensuring that the monitoring program is conducted to attain compliance with the Final Feasibility Report and Environmental Impact Statement and Adaptive Management Plan for the CRP. The CWA has the ultimate responsibility for ensuring that the watershed water-quality monitoring program is conducted in accordance with this ~~QAPP~~SAP and the Chatfield Reservoir Control Regulation (#73).

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2.3 Technical Review Committee (TRC)

The TRC is composed of members of the CWA. The TRC reviews all technical matters for the CWA including review of the water-quality monitoring program. The TRC is responsible for the review and approval of this QAPP and SAP and other monitoring program documents and periodically reviews the status of the monitoring program. The TRC determines the monitoring program compliance with the intent of the control regulation.

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2.4 Program ~~Administrator~~ Administrators

The Program ~~Administrator is~~Administrators are responsible for overseeing the performance of the water-quality monitoring program and acting on behalf of the CRP and CWA to ensure that the program is conducted in accordance with all requirements.

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2.5 Project Manager

The CRMC Project Manager is responsible for the implementation of this ~~QAPP~~SAP and the water-quality monitoring program. The CRMC Project Manager ensures that the program is staffed with the appropriate number of qualified and trained staff and performs periodic oversight of field teams. The CRMC Project Manager reviews field data sheets, verification/validation of analytical data, maintenance of the program database, and all required reporting. The CRMC Project Manager performs required quality assurance and quality control duties.

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2.6 Field ~~Leader~~ Teams

~~The~~Multiple entities (field teams) will conduct individual field components of the CRP/CWA water quality monitoring program. Each entity will ensure that their Field Team Leader ~~appoints~~is appropriately trained and qualified ~~field teams~~ to perform the monitoring activities. The Field Team Leader schedules laboratory and other required services and reviews ~~and approve all~~/approves the field data sheets prior to transmittal to the CRMC Project Manager.

~~2.7~~ In addition, the Field ~~Technicians~~

~~The field technicians are responsible for conducting~~Team Leader will ensure that all field activities conducted by technicians are performed in accordance with this ~~QAPP and SAP and the standard operating procedures (SOPs) adopted by the CWA~~SAP.

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~~2.8~~2.7 Analytical ~~Laboratory~~Laboratories

~~The analytical~~ Multiple analytical laboratories will be responsible for analyzing specific components of the monitoring program. Each laboratory ~~performs all analyses~~ will be responsible for performing the requested ~~by the Project Manager~~ analyses in accordance with established procedures and approved quality assurance plans.

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3.0 Monitoring Objectives and Data Evaluation

~~3.0~~ The water quality concerns for the Chatfield Reservoir reallocation focus on the potential change to water quality conditions (i.e., nutrients and chlorophyll *a*) based on the expansion of the hypolimnion and inundation of shoreline areas following the increased storage capacity (ERO 2013). There is uncertainty whether the expansion of the hypolimnion will increase the areal coverage of anaerobic sediment conditions and result in increased internal phosphorus loading that may impinge on the Total Maximum Annual Load (TMAL) for the reservoir. Furthermore, the inundated shoreline vegetation may also increase phosphorus loading to the reservoir. The following core objectives ~~AND DATA EVALUATION~~have provided the basis for the adaptive management plan and the CRP monitoring program (ERO 2013).

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~~The Authority determines the monitoring program in cooperation with the Colorado Water Quality Control Division (WQCD). Questions answered by the monitoring program are:~~

1. Internal loading from "new" anoxic sediments attributed to reallocation pool level increases will not cause water quality standards for chlorophyll and total phosphorus or the total phosphorus TMAL to be exceeded.
2. Internal loading from "newly" inundated vegetation attributed to reallocation pool level increases will not cause water quality standards for chlorophyll and total phosphorus or the total phosphorus TMAL to be exceeded.
3. Expansion of hypoxic conditions and potential release of reduced contaminants from anaerobic sediments will not cause other water quality standards (i.e., other than chlorophyll and total phosphorus) to be exceeded.

The CRP and CWA are coordinating their respective objectives to maximize efficiency and minimize costs. The increased spatial coverage of reservoir monitoring locations and the increased sampling frequency will provide a more complete data set to address the following water quality questions for the reservoir as well as the future water quality modeling effort of the CRP:

~~1)~~*1.* *Does Chatfield Reservoir meet the growing season total phosphorus and chlorophyll a standard annually?*

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~~2)~~*2.* *Are total phosphorus loads in compliance with the TMAL?*

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3. *Are the requirements of the CRP Record of Decision on water quality monitoring and analyses satisfied?*

Water~~-~~ quality data are used to characterize the trophic state of the reservoir, evaluate trends in the watershed and to assess compliance with ~~the adopted~~basic/site-specific water quality standards and the phosphorus TMAL identified in the control regulation. The in-reservoir total phosphorus data are used by the Colorado Water Quality Control Division to determine compliance with the total phosphorus standard of 0.030~~-~~ mg/L (30~~ ug~~ µg/L) and chlorophyll~~-~~ *a* standard of 10~~ ug~~ µg/L as a growing season average (July-September). The monitoring program characterizes inputs into the reservoir, the reservoir water column and outflow from the reservoir.

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~~3.1.0.~~*3.1.1 Evaluation of Data*

In addition to the routine compilation of the monitoring data collected, data evaluations include:

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1. Perform time-trend and spatial analyses for selected annual monitoring programs; ~~or~~
2. Evaluate historical data~~.~~ ; and
3. Verify and validate data, and conduct statistical evaluation for outliers.

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~~3.1.1.~~*3.1.2 Graphical Presentation of Data*

In addition to the compilation and presentation of tabular forms of the monitoring data collected, additional graphical presentations of the data at ~~TRC and Authority~~CWA meetings and in the two separate annual monitoring ~~report~~reports for the CWA and for the CRP will assist in data evaluation.

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3.2 Data Quality Objectives

The project ~~objective is~~objectives are to collect data in a manner that complies with WQCD ~~rules~~guidance for surface~~-~~-water quality monitoring programs, to support decisions related to ~~TMDL~~TMAL development, stream standards modifications, permit decisions, ~~and~~ water

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quality assessments and CRP ROD compliance. The following paragraphs define the measurement performance criteria necessary to support the project ~~objective~~objectives.

~~3.2.0. *Precision and Accuracy*~~

~~Accuracy and precision are crucial aspects of analytical data and this monitoring program. Accuracy is defined as "the degree of agreement of a measured value with the true or expected value." In other words, accuracy is hitting the *bullseye* on a target. Laboratory accuracy is measured in Percent Recoveries (PR). Precision is "the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions." In other words, precision is the relative size of a group of shots on a target. Laboratory precision is measured in Relative Percent Difference (RPD). PR and RPD are measured and reported by labs for every individual analysis. Table 2 illustrates the precision and accuracy for the Chatfield Watershed field and laboratory analyses. These represent worst cases estimates and data collection precision and accuracy measurements are well within these estimates.~~

~~Table 2 Data Precision and Accuracy Estimates~~

~~**Matrix**~~	~~**Parameter**~~	~~**Precision**~~	~~**Accuracy**~~
~~Water~~	~~pH~~	~~± 0.05~~	~~0.01 s.u.~~
~~Water~~	~~Temperature~~	~~± 0.3~~	~~0.1 C~~
~~Water~~	~~Specific Conductance~~	~~± 1%~~	~~0.01 mS/cm~~
~~Water~~	~~Dissolved Oxygen~~	~~± 0.1~~	~~0.01 mg/L~~
~~Water~~	~~Total Phosphorous (Field)~~	~~± 0.02~~	~~0.01 mg/L~~
~~Water~~	~~Secchi Depth~~	~~± 0.3~~	~~0.1 meter~~
~~Water~~	~~Nitrate-Nitrogen (Field)~~	~~± 0.8~~	~~0.1 mg/L~~
~~Water~~	~~Total Suspended Solids~~	~~± 20%~~	~~80-120~~
~~Water~~	~~E. Coli~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Total Organic Carbon~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Total Phosphorus~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Ortho Phosphorus~~	~~± 20%~~	~~80-120~~
~~Water~~	~~NO2+NO3 – Nitrogen~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Ammonia – Nitrogen~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Total Nitrogen~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Chlorophyll A~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Phytoplankton~~	~~± 20%~~	~~80-120~~

~~Matrix~~	~~Parameter~~	~~Precision~~	~~Accuracy~~
~~Water~~	~~Zooplankton~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Cadmium (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Copper (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Lead (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Mercury (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Selenium (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Iron (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Iron (Total Recoverable)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Arsenic (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Arsenic (Total)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Manganese (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Nickel (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Chromium III (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Chromium IV (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Zinc (Dissolved)~~	~~± 20%~~	~~80-120~~
~~Water~~	~~Cyanide - WAD~~	~~± 20%~~	~~80-120~~
~~Sediment~~	~~Cadmium (Total)~~	~~± 20%~~	~~80-120~~
~~Sediment~~	~~Copper (Total)~~	~~± 20%~~	~~80-120~~
~~Sediment~~	~~Lead (Total)~~	~~± 20%~~	~~80-120~~
~~Sediment~~	~~Mercury (Total)~~	~~± 20%~~	~~80-120~~
~~Sediment~~	~~Phosphorous (Total)~~	~~± 20%~~	~~80-120~~
~~Sediment~~	~~Selenium (Total)~~	~~± 20%~~	~~80-120~~
~~Sediment~~	~~Total Organic Carbon~~	~~± 20%~~	~~80-120~~

~~3.2.1.~~3.2.1 *Representative Sample Sites*

~~Due to fiscal constraints that have resulted in the reduction of the total number of sites that can be sampled, the~~The routine stream sampling locations selected are ~~those that are believed to be~~ representative of the inflows to and outflow from Chatfield Reservoir. Three stream sites were selected 1) on the South Platte River upstream of the reservoir, 2) on Plum Creek upstream of the reservoir and 3) immediately downstream of the reservoir outflow. In addition, ~~a single~~three monitoring ~~site~~sites within the reservoir ~~was selected based on analyses of previous data that show the single site to be spatially representative of the reservoir.~~were selected. These three sites were selected to represent 1) a deep water location near the dam, 2) a mid-reservoir location characteristic of the South Platte River arm, and 3) a mid-reservoir location characteristic of the Plum Creek arm of the reservoir. Vertical profile sampling will occur at ~~this site is still required due to seasonal vertical~~the three reservoir sites to document physicochemical stratification of the reservoir.

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~~3.2.2.~~3.2.2 *Comparability*

One of the ways that the ~~Chatfield Watershed~~ CRP monitoring program ~~ensures~~will ensure data comparability is to follow established ~~monitoring protocol~~analytical protocols for assessment and analysis. All ~~analytical~~laboratory analyses ~~are~~will be performed in accordance with established EPA analysis methods or other widely accepted methods (see Section 4.4). In addition, the lowest possible minimum detection limits (MDLs) should be used for all parameters.

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~~3.2.3.~~3.2.3 *Completeness*

Samples will be collected from at least 90% of the scheduled sites unless unanticipated weather conditions or lack of running water prevent sampling. Fluctuations of reservoir levels could prevent sampling at certain depths during monthly depth profile sampling.

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3.3 Documentation and Records

Each ~~Chatfield Watershed~~CRP/CWA field~~-~~-sampling sheet is completed on-site at the time sampling occurs. Field technicians record the site number, date and time the sample was collected, the name of each person present, weather conditions present at the time of sampling, and any other information pertinent to the collection of the sample. Field technicians also use standard forms for recording all field measurements (e.g., pH, temperature, conductivity, etc.) for each sampling location. The information is consistent with meta~~-~~-data requirements of STORET.

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4.0 ~~MEASUREMENT~~Measurement and ~~DATA ACQUISITION~~Data Acquisition

4.1 Sampling Process Design

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~~4.1.0.~~*4.1.1 Reservoir Sampling Sites*

The reservoir monitoring sites established by the CRP and CWA are shown in Section 1.0 (see Figure 2). These sites include 1) a deep water location near the dam, 2) a mid-reservoir location characteristic of the South Platte River arm, and 3) a mid-reservoir location characteristic of the Plum Creek arm of the reservoir.

4.1.2 Inflow/Outflow Stream Monitoring

The inflow/outflow and reservoir monitoring sites used by the ~~Authority are shown in section 1.0.~~ CRP and CWA are shown in Section 1.0 (Figure 2). These sites include 1) on the South Platte River upstream of the reservoir, 2) on Plum Creek upstream of the reservoir and 3) immediately downstream of the reservoir outflow.

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~~4.1.1.~~*4.1.3 Basic Monitoring Program*

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~~The basic monitoring program parameters are provided in Table 3, and the rationale for the selection of these parameters is provided in section 4.2.~~

~~Table 3 Basic Monitoring Program Parameters~~

The basic monitoring program parameters are provided in Tables 3a-3g, and were selected based on the monitoring objectives discussed in Section 3.2. The data sources are listed as either field or laboratory generated along with the entity responsible for the analytical result – Centennial Water and Sanitation District (CWSD), Colorado Parks and Wildlife (CPW), Denver Water (DW), GEI Consultants, Inc. (GEI), or Plum Creek Water Reclamation Authority (PCWRA). Denver Water will be responsible for collecting reservoir water samples with exception to the *E. coli* samples collected by CPW; CWSD will be responsible for collecting inflow/outflow water samples from the South Platte River and Plum Creek; PCWRA will be responsible for collecting water samples from the Plum Creek Reclamation Project upstream of the inflow site.

Table 2a: Depth Profile Samples in Reservoir

~~Parameter~~Constituent	Monthly Sampling Frequency (Apr-Oct)	Depth Profile Reservoir Locations	Notes	Data Source
	~~Monthly~~	~~Quarterly~~	~~Annually~~	
Standard Grab Samples				
Temperature, ~~Degrees~~ °C	X	CR-1 CR-2 CR-3	Sonde – Depth Profile - Collected at one meter intervals through entire water column	Field, DW
~~Field~~ pH ~~(~~ s.u. ~~)~~.	X	CR-1 CR-2 CR-3	Sonde – Depth Profile - Collected at one meter intervals through entire water column	Field, DW
Dissolved Oxygen, mg/L	X	CR-1 CR-2 CR-3	Sonde – Depth Profile - Collected at one meter intervals through entire water column	Field, DW
Specific Conductance ~~(uS,~~ µS/cm~~)~~	X	CR-1 CR-2 CR-3	Sonde – Depth Profile - Collected at one meter intervals through entire water column	Field, DW
~~Hardness, mg/L~~Oxidation – Reduction Potential mV	X	CR-1 CR-2 CR-3	Sonde – Depth Profile - Collected at one meter intervals through entire water column	Field, DW
~~Dissolved Oxygen, mg/L~~Chlorophyll *a* µg/L	X	CR-1 CR-2 CR-3	Sonde – Depth Profile - Collected at one meter intervals through entire water column	Field, DW
~~Total Suspended Solids, mg/L~~	~~X~~			
~~E. Coli, colonies/100 ml~~	~~X~~			
Total Phosphorus, mg/L as P	~~X (twice monthly during GS)~~X	CR-1 CR-2 CR-3	Collected at three meter intervals through entire water column	Lab, GEI
Ortho Phosphorus, mg/L as P	~~X (twice monthly during GS)~~X	CR-1 CR-2 CR-3	Collected at three meter intervals through entire water column	Lab, GEI
~~Nitrite + Nitrate-nitrogen, mg/L~~	~~X~~			
~~Ammonia Nitrogen, mg/L~~	~~X~~			
~~Total Nitrogen, mg/L~~		~~X~~		
~~Instantaneous Flow (Rivers & Streams), cfs~~	~~X~~			
~~Total Organic Carbon (Reservoir), mg/L~~	~~X~~			

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~~Parameter~~Constituent	Monthly Sampling Frequency (Apr-Oct)	Depth Profile Reservoir Locations	Notes	Data Source
	~~Monthly~~	~~Quarterly~~	~~Annually~~	
~~Chlorophyll a (Reservoir), ug/L~~	~~X (twice monthly during GS)~~			
~~Secchi Depth (Reservoir), meters~~	~~X~~			
~~Phytoplankton Biomass & Species (Reservoir)~~		~~X(GS)~~		
~~Zooplankton Species (Reservoir)~~		~~X(GS)~~		
~~Alkalinity (optional), mg/L~~		~~X~~		
~~Metals – As Dissolved [Soluble] Unless Otherwise Noted~~				
~~Cadmium, mg/L~~			~~X~~	
~~Copper, mg/L~~			~~X~~	
~~Lead, mg/L~~			~~X~~	
~~Mercury, mg/L~~			~~X~~	
~~Selenium, mg/L~~			~~X~~	
~~Iron, mg/L~~			~~X~~	
~~Iron, Total Recoverable, mg/L~~			~~X~~	
~~Silver, mg/L~~			~~X~~	
~~Manganese, mg/L~~			~~X~~	
~~Nickel, mg/L~~			~~X~~	
~~Chromium III – Cr VI, mg/L~~			~~X~~	
~~Cyanide, Weak Acid Dissociable, mg/L~~		~~X~~		
~~Arsenic, Total, mg/L~~			~~X~~	
~~Zinc, mg/L~~			~~X~~	

~~4.2 Parameter Rationale~~

~~The monitoring parameters for this program were selected to maximize the use of available financial resources while still meeting the objectives of the program. The rationale for the selection of the monitoring parameters is summarized below.~~

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~~4.2.0. *Important Trophic Indicators*~~

~~The ongoing trend-monitoring program characterizes Chatfield Reservoir chemical and biological quality, along with South Platte River and Plum Creek inputs and outflow from the reservoir. The reservoir trophic status evaluation determines overall water quality trends. The two trophic models (TSI) look at chemical and biological parameters to produce a growing season or annual estimate of water quality. Trophic state parameters include total phosphorus, nitrate-nitrogen, Secchi depth, chlorophyll-a, total suspended sediments, dissolved oxygen, phytoplankton species composition and density.~~

~~4.2.1. *Field Parameters*~~

~~The field parameters (temperature, pH, specific conductance, dissolved oxygen, instantaneous flow, and Secchi depth) measured in this program are standard parameters necessary for any water-quality monitoring program. Temperature and pH are necessary parameters for the evaluation of ammonia toxicity that currently is a concern of the Colorado Division of Wildlife for some stream segments within the watershed. Dissolved oxygen is an important parameter for assessing the health of a reservoir system and potential affect to aquatic life, primarily fisheries. Dissolved oxygen is a key trophic indicator. Secchi depth or water clarity is used as an indicator of the trophic status of the reservoir. The instantaneous flow measurements used for this program are obtained from other sources (i.e., the U.S. Geological Survey, U.S. Army Corps of Engineers, and the Colorado Division of Water Resources).~~

~~4.2.2. *Miscellaneous Notes*~~

~~The analysis of total suspended solids characterizes mass loading and deposition into the reservoir. Analysis for E. coli replaced the fecal coliform analyses performed previously for consistency with measurements performed by the Colorado State Parks for swim beaches at Chatfield Reservoir. Total organic carbon analysis was added to the program to gain information that may be required for potential future changes in water-quality standards for the South Platte River.~~

~~4.2.3. *Nutrient Analyses*~~

~~Analysis of nutrient species (phosphorous and nitrogen species) is necessary for the assessment of compliance with the total phosphorous standard for Chatfield Reservoir as specified in the Chatfield Control Regulation and to monitor the trophic status of the reservoir. In addition, these species are measured in samples from the watershed in order to assess the relative contributions of nutrients to the Reservoir from the inflowing streams and~~

~~rivers. Nutrient management is a critical objective of the long-range watershed and reservoir management program of the Authority.~~

~~4.2.4. *Biological Analyses*~~

~~Analysis of samples for chlorophyll a is required to assess attainment of the chlorophyll a goal for Chatfield Reservoir and is an indicator of the trophic status of the reservoir. Measurement of phytoplankton and zooplankton species provides useful information for assessing the overall health of the reservoir and trends in the numbers and types of species can be used to assess stability and changes in water quality within the reservoir on a seasonal, annual and long-term basis. In addition, because fishing is one of the principal recreational activities at Chatfield Reservoir, the biological data collected under this program can also provide insight into the status of fisheries. Additional correlation and evaluation of the biological data collected under this program will be performed as necessary.~~

~~4.2.5. Metals Analyses (Including Hardness)~~

~~Based on the analysis of metals data collected during 1997 through 1999, the frequency of analyses for metals in this program was reduced significantly in 2000 with one annual sample being collected. This same frequency will be employed during 2003-2005, or as resources allow, in order to continue to monitor potential changes in metals concentrations in the watershed and reservoir. Hardness data are required for assessment of compliance with water-quality standards for metals. Collected water quality metal data doesn't indicate that metals are degrading water quality within the reservoir. Consequently, a single annual data set can be used to determine major changes in input concentrations.~~

~~4.3 Watershed Monitoring~~

~~Monthly water-quality sampling is done at two major inputs to Chatfield Reservoir (Plum Creek and the South Platte River) and at the reservoir outfall for the basic water-quality parameters.~~

1. ~~Monitoring locations at existing gauging stations include the South Platte River at Waterton (Colorado State Engineer, historically reported stream flows at USGS station 06708000, Field Code SP), for Plum Creek at Titan Road near Louviers (USGS station 06709530, Field Code PC), and for the South Platte River just downstream from Chatfield Reservoir (Field Code SO).~~

2. ~~No direct flow measurements are made at inflow/outflow sites; rather, discharge values are obtained from the appropriate data sources (U.S. Army Corps of Engineers, Colorado Water Resources Division, or the USGS, respectively) for the three-inflow/outflow sites.~~

3. ~~Only total (unfiltered) nutrient concentrations are analyzed.~~

4. ~~Sampling frequency - Inflow and reservoir-outflow samples are collected monthly with doubled up (bi-monthly) sampling during the growing season months of July, August, and September. Thus, the total annual inflow and outflow sampling surveys equals 15.~~

5. ~~Approximately 15 percent of the water-quality laboratory analyses are duplicate or spike samples for quality-control/quality-assurance (QC/QA) purposes.~~

~~4.4 Reservoir Monitoring~~

1. ~~The in-reservoir monitoring is done at one reservoir location (Field Code RM) for both depth-specific samples and vertical profiles for the basic water-quality parameters. The single reservoir monitoring location has been shown through previous data analyses to be spatially representative of the reservoir. Vertical sampling is still required due to seasonal vertical stratification of the reservoir.~~

2. ~~The water column samples are taken from the top to bottom one meter of the water column.~~

3. ~~Nutrients and total suspended solids are collected throughout the water column.~~

4. ~~Chlorophyll is sampled only from the top 1 meter of the water column in an integrated sample. This sampling procedure is consistent with the method recommended previously by the Colorado Water Quality Division for Chatfield Reservoir.~~

5. ~~Sampling scheduling requires monthly surveys with doubled up (bi-monthly) sampling during the growing season months of July, August, and September.~~

6. ~~In-reservoir sampling is conducted from a boat during open water conditions. No samples are collected during winter ice-cover conditions. The boat does not need to anchor when sampling, but drift will be minimized. The Chatfield State Parks has historically provided the boat for monitoring, although coordination and scheduling with parks staff in advance is needed.~~

7. ~~Approximately 15 percent of the water-quality laboratory analyses are duplicate or spike samples for quality-control/quality-assurance (QC/QA) purposes.~~

8. ~~The depth profile is field monitored for temperature (degrees C), pH, dissolved oxygen (mg/L) and specific conductance (uS/cm). These profiles include the entire water-column with a measurement increment of one meter.~~

~~9. A total of six phytoplankton surveys are done at the reservoir site for cell-counts and species identification. Biological samples collected quarterly (spring, fall, winter) and three times during the growing season (July, August and September). Samples are taken from the mid-euphotic zone using standard collection and identification procedures.~~

~~10. Zooplankton species identification will be done one time during growing season using standard collection and identification procedures.~~

~~11. An annual reservoir bottom sediment characterization is done on a one-time basis during the growing season.~~

~~12. A sediment box core sample of surface sediments will be obtained at the profile monitoring station (The contractor needs to specify the SOP for this sampling requirement).~~

~~13. Sediment analyses will include five indicator metals.~~

~~14. Sediment analyses include total organic carbon, percent silts and clays, and total phosphorus.~~

Table 2b: Near Surface and Bottom Layer Samples in Reservoir

Constituent	Monthly Sampling Frequency (Apr-Oct)	Near Surface and Near Bottom Sampling Locations	Monthly Sampling Frequency (Apr-Oct)	Near Surface and Near Bottom Sampling Locations	Twice Monthly Sampling Frequency (Jul-Sep)	Near Surface and Near Bottom Sampling Locations	Data Source
Phosphorus (dissolved), mg/L as P	X	CR-1					Lab, GEI
Total Phosphorus, mg/L as P	X	CR-1	X	CR-2 CR-3	X	CR-1 CR-2 CR-3	Lab, GEI
Ortho-phosphorus, mg/L as P	X	CR-1	X	CR-2 CR-3	X	CR-1 CR-2 CR-3	Lab, GEI
Chlorophyll *a*, µg/L Lab[1]	X	CR-1 (top meter only)	X	CR-2 (top meter only) CR-3 (top meter only)	X	CR-1 (top meter only)	Lab, GEI
Nitrate+Nitrite- Nitrogen, mg/L as N	X	CR-1	X	CR-2 CR-3	X	CR-1 CR-2 CR-3	Lab, GEI
Ammonia Nitrogen, mg/L as N	X	CR-1	X	CR-2 CR-3	X	CR-1 CR-2 CR-3	Lab, GEI
Total Kjeldahl Nitrogen, mg/L as N	X	CR-1					Lab, Test America
Total Organic Carbon, mg/L	X	CR-1					Lab, CWSD
Dissolved Organic Carbon, mg/L	X	CR-1					Lab, CWSD

Constituent	**Monthly Sampling Frequency (Apr-Oct)**	**Near Surface and Near Bottom Sampling Locations**	**Monthly Sampling Frequency (Apr-Oct)**	**Near Surface and Near Bottom Sampling Locations**	**Twice Monthly Sampling Frequency (Jul-Sep)**	**Near Surface and Near Bottom Sampling Locations**	**Data Source**
Carbonaceous Biochemical Oxygen Demand, mg/L	X	CR-1					Lab, CWSD
Alkalinity, mg/L as CaCO3	X	CR-1	X	CR-2 CR-3	X	CR-1 CR-2 CR-3	Lab, CWSD
Total Dissolved Solids, mg/L	X	CR-1					Lab, CWSD
Total Suspended Solids, mg/L	X	CR-1					Lab, CWSD
Sulfate, mg/L as SO4	X	CR-1					Lab, CWSD
Silica, mg/L	X	CR-1					Lab, DW
Phytoplankton Identification and Enumeration[1] #/mL	X	CR-1	X	CR-2 CR-3	X	CR-1	Lab, GEI
Zooplankton, Identification and Enumeration #/L	X	CR-1					Lab, GEI
Secchi Depth meters	X	CR-1	X	CR-2 CR-3	X	CR-1 CR-2 CR-3	Field, DW

[1] Sample collected from the near surface only (i.e., one meter layer).

Table 2c: Metals Monitoring in Reservoir

Constituent	**Sampling Frequency (May, July and Sep)**	**Near Surface and Near Bottom Reservoir Sampling Locations**	**Data Source**
Arsenic, dissolved and total, µg/L	X	CR-1	Lab, DW
Cadmium, dissolved and total, µg/L	X	CR-1	Lab, DW
Chromium, total and dissolved, mg/L	X	CR-1	Lab, DW
Copper, dissolved and total, µg/L	X	CR-1	Lab, DW
Iron, dissolved and total, µg/L	X	CR-1	Lab, DW
Lead, dissolved and total, µg/L	X	CR-1	Lab, DW
Manganese, dissolved and total, µg/L	X	CR-1	Lab, DW
Mercury, total, µg/L	X	CR-1	Lab, DW
Nickel, dissolved and total, µg/L	X	CR-1	Lab, DW
Selenium, dissolved and total, µg/L	X	CR-1	Lab, DW

Silver, dissolved and total, µg/L	X	CR-1	Lab, DW
Zinc, dissolved and total, µg/L	X	CR-1	Lab, DW
Total Hardness (calculated), mg/L	X	CR-1	Lab, DW

Table 2d: Swim Beach Monitoring

Constituent	Sampling Frequency Weekly, May-September	Sampling Locations	Date Source
E. coli, #/100 mls	X	North and South Area of Swim Beach	Lab, CWSD

Note: All samples taken by Colorado Parks and Wildlife.

Table 2e: Reservoir Bottom Sediments

Matrix	Constituent	Sampling Locations	Data Source
Sediment	Total organic bound phosphorous	CR-1, 2, & 3	Lab, GEI
Sediment	Loosely bound and pore water phosphorus	CR-1, 2, & 3	Lab, GEI
Sediment	Iron-bound phosphorous	CR-1, 2, & 3	Lab, GEI
Sediment	Calcium-bound phosphorous	CR-1, 2, & 3	Lab, GEI
Sediment	Aluminum-bound phosphorous	CR-1, 2, & 3	Lab, GEI
Sediment	Percent Solids	CR-1, 2, & 3	Lab, GEI
Sediment	Total Organic Carbon	CR-1, 2, & 3	Lab, GEI
Sediment	Iron, Total	CR-1, 2, & 3	Lab, GEI
Sediment	Calcium, Total	CR-1, 2, & 3	Lab, GEI
Sediment	Aluminum, Total	CR-1, 2, & 3	Lab, GEI
Sediment	Phosphorous flux under anoxic conditions	CR-1, 2, & 3	Lab, GEI

Note: All samples taken by GEI Consultants: 2 cores per location, once a year (core or benthic grab depending on sediment conditions.

Table 2f: South Platte River, Plum Creek and Outflow Monitoring

Constituent	Sampling Frequency				Sampling Locations All at So. Platte @ Waterton, Plum Creek @ Titan Rd. and Outflow**	Data Source
	Year Round, Near-Real Time	Biweekly, Apr-Sep	Monthly, Oct-Mar	Storm Events, Apr-Sep*		
Temperature, °C***	X	X	X	X	X	Field, CWSD
DO, mg/L		X	X	X	X	Field, CWSD
pH s.u.		X	X	X	X	Field, CWSD
Specific Conductance, µS/cm		X	X	X	X	Field, CWSD
Total Organic Carbon, mg/L		X	X	X	X	Lab, CWSD
Dissolved Organic Carbon, mg/L		X	X	X	X	Lab, CWSD

	Sampling Frequency					
Constituent	Year Round, Near-Real Time	Biweekly, Apr-Sep	Monthly, Oct-Mar	Storm Events, Apr-Sep*	Sampling Locations All at So. Platte @ Waterton, Plum Creek @ Titan Rd. and Outflow**	Data Source
Carbonaceous biochemical oxygen demand mg/L	-	X	X	X	X	Lab, CWSD
Phosphorus, Total, mg/L as P	-	X	X	X	X	Lab, GEI
Phosphorus dissolved, mg/L as P	-	X	X	X	X	Lab, GEI
Ortho-Phosphorous, mg/L as P	-	X	X	X	X	Lab, GEI
Nitrate+Nitrite-nitrogen, mg/L as N	-	X	X	X	X	Lab, GEI
Ammonia Nitrogen, mg/L as N	-	X	X	X	X	Lab, GEI
Total Kjeldahl Nitrogen, mg/L as N	-	X	X	X	X	Lab, Test America
Alkalinity, mg/L as CaCO3	-	X	X	X	X	Lab, CWSD
TDS, mg/L	-	X	X	X	X	Lab, CWSD
TSS, mg/L	-	X	X	X	X	Lab, CWSD
Silica, dissolved mg/L	-	X	X	X	X	Lab, DW

* Estimated as 2-4 events per year

** No storm sampling at outflow site

***Add continuous temperature monitoring to gaging station

Table 2g: Sampling on Plum Creek Related to Plum Creek Restoration Project

Constituent	Sampling Frequency Monthly (Jan-Dec)	Location PC-0.25 (1/4 mile above reservoir)	Data Source
pH, s.u.	X	X	Field, PCWRA
Specific Conductance, µs/cm	X	-	Field, PCWRA
Temperature, °C	X	X	Field, PCWRA
Dissolved Oxygen, mg/L	X	X	Field, PCWRA
E. coli, #/100 mls	X	X	Lab, PCWRA

Constituent	Sampling Frequency Monthly (Jan-Dec)	Location PC-0.25 (1/4 mile above reservoir)	Data Source
Alkalinity, mg/L as CaCO3	X	X	Lab, PCWRA
Phosphorus, Total mg/L as P	X	X	Lab, PCWRA
Ortho-phosphorous mg/L as P	X	X	Lab, PCWRA
Nitrate+Nitrite-nitrogen, mg/L as N	X	X	Lab, PCWRA
Ammonia Nitrogen, mg/L as N	X	X	Lab, PCWRA
Total Suspended Solids TSS, mg/L	X	X	Lab, PCWRA

Note: All samples taken by Plum Creek Water Reclamation Authority (PCWRA)

~~4.4.0.~~*4.1.4 Unsafe Reservoir Conditions*

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The ~~Project Manager is~~Field Teams are not expected to sample the reservoir ~~under~~when unsafe boating conditions~~, which can include~~ exist (i.e., high winds, ~~storms~~lightning, or storm events) or when unsafe ice~~. When the field leader determines reservoir~~ cover conditions exist during winter. Other stream sampling ~~can't~~may occur ~~due to unsafe conditions, inlet and outlet~~during weather related events, especially storm event sampling~~ can still occur. ~~; however, safety measures need to be implemented when sampling under these conditions. The reservoir sample taken within 3-~~ ~~days is considered as representative of the same sample set as the inlet and outlet sample.

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~~4.5 Sampling Methods Requirements~~

~~The Chatfield Watershed Authority SOPs contain information on sampling protocols and equipment. Table 5 summarizes this information.~~

~~Table 4 Sampling Methods~~

~~Matrix~~	~~Parameter~~	~~Sampling Equipment~~	~~Sample Container~~	~~Sample Preservative~~	~~Holding Time~~
~~Water~~	~~pH~~	~~Horiba U-10~~	~~In situ~~	none	~~immediately~~
~~Water~~	~~Temperature~~	~~Horiba U-10~~	~~In situ~~	~~none~~	~~immediately~~
~~Water~~	~~Specific Conductance~~	~~Horiba U-10~~	~~In situ~~	~~none~~	~~immediately~~
~~Water~~	~~Dissolved Oxygen~~	~~Horiba U-10~~	~~In situ~~	~~none~~	~~immediately~~
~~Water~~	~~Total Phosphorous (Field)~~	~~Hach DR2010~~	~~100ml poly~~	~~none~~	~~immediately~~
~~Water~~	~~Nitrate-Nitrogen (Field)~~	~~Hach DR2010~~	~~100ml poly~~	~~none~~	~~immediately~~
~~Water~~	~~Total Suspended Solids~~	~~SS dipper~~	~~250ml poly~~	~~4°±2°C~~	~~7 days~~

~~Matrix~~	~~Parameter~~	~~Sampling Equipment~~	~~Sample Container~~	~~Sample Preservative~~	~~Holding Time~~
~~Water~~	~~E. Coli~~	~~Container immersion~~	~~250ml sterile~~	~~4°±2°C~~	~~6 hours~~
~~Water~~	~~Total Organic Carbon~~	~~SS dipper~~	~~250ml glass~~	~~H_2SO_4 4°±2°C~~	~~28 days~~
~~Water~~	~~Total Phosphorous~~	~~SS dipper~~	~~250ml glass~~	~~H_2SO_4 4°±2°C~~	~~28 days~~
~~Water~~	~~Ortho Phosphorous~~	~~SS dipper~~	~~500ml poly~~	~~4°±2°C~~	~~48 hours~~
~~Water~~	~~NO2-NO3 – Nitrogen~~	~~SS dipper~~	~~500ml poly~~	~~4°±2°C filtered~~	~~48 hours~~
~~Water~~	~~ammonia – nitrogen~~	~~SS dipper~~	~~250ml glass~~	~~H_2SO_4 4°±2°C~~	~~28 days~~
~~Water~~	~~Total Nitrogen~~	~~SS dipper~~	~~250ml glass~~	~~H_2SO_4 4°±2°C~~	~~28 days~~
~~Water~~	~~Chlorophyll A~~	~~SS dipper~~	~~1 liter amber~~	~~4°±2°C~~	~~24 hours~~
~~Water~~	~~Phytoplankton~~	~~SS dipper~~	~~60ml glass~~	~~Lugos 4°±2°C~~	~~28 days~~
~~Water~~	~~Zooplankton~~	~~Plankton net~~	~~250ml glass~~	~~Iso-alcohol 4°±2°C~~	~~28 days~~
~~Water~~	~~Hardness~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Cadmium (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Copper (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Lead (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Mercury (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~28 days~~
~~Water~~	~~Selenium (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Iron (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Iron (Total Recoverable)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Arsenic (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Arsenic (Total)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Manganese (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Nickel (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Chromium III (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Chromium VI (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Zinc (Dissolved)~~	~~SS dipper~~	~~125ml poly~~	~~HNO_3 4°±2°C~~	~~6 months~~
~~Water~~	~~Cyanide - WAD~~	~~SS dipper~~	~~500ml poly~~	~~NaOH 4°±2°C~~	~~14 days~~
~~Sediment~~	~~Cadmium (Total)~~	~~SS dredge~~	~~500ml glass~~	~~4°±2°C~~	~~6 months~~
~~Sediment~~	~~Copper (Total)~~	~~SS dredge~~	~~500ml glass~~	~~4°±2°C~~	~~6 months~~
~~Sediment~~	~~Lead (Total)~~	~~SS dredge~~	~~500ml glass~~	~~4°±2°C~~	~~6 months~~
~~Sediment~~	~~Mercury (Total)~~	~~SS dredge~~	~~500ml glass~~	~~4°±2°C~~	~~28 days~~
~~Sediment~~	~~Phosphorous (Total)~~	~~SS dredge~~	~~500ml glass~~	~~4°±2°C~~	~~28 days~~
~~Sediment~~	~~Selenium (Total)~~	~~SS dredge~~	~~500ml glass~~	~~4°±2°C~~	~~6 months~~
~~Sediment~~	~~Total Organic Carbon~~	~~SS dredge~~	~~500ml glass~~	~~4°±2°C~~	~~14 days~~

~~4.6~~4.2 Sample Handling and Custody Requirements

The CRP/CWA SAP contains information on sampling protocols and equipment. Table 3 summarizes this information.

~~4.6.0.~~*4.2.1 Chain-of-Custody*

Proper sample handling and custody procedures ensure the custody and integrity of samples ~~beginning at~~is maintained from the time of sampling and ~~continue~~continues through transport, sample receipt, preparation, and analysis. A sample is in custody when it is in actual physical possession or in a secured area that is restricted to authorized personnel. The Chain of Custody (COC) form is used to document sample handling during transfer from the field to the laboratory. The following information concerning the sample is recorded on the COC form (See CWA SOPs): 1) date and time of collection; 2) sample identification; 3) sample matrix; 4) number of containers; 3)~~ Preservative~~ preservative used or when the sample was filtered; 4) analyses required; 5) name of collector; 6) custody transfer signatures and dates and time of transfer; and 7) bill of lading (when applicable).

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~~4.6.1.~~*4.2.2* *Sample Labeling*

~~Samples are labeled~~Sample information is recorded on ~~the container (~~each sample bottle or ~~*on a*~~bottle label~~)~~ with an indelible marker. Label information includes the sample identification, the date and time of sampling, the sample collector and the preservative added when applicable.

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Table 3: Acceptable Analytical Methods for Determining Constituent Concentrations Note – this table contains information for 4 different sampling groups. For example the VanDorn is not used for stream sampling. Could we delete Sampling Equipment column as the sampling is described later and talks about the methods and equipment in detail.

Matrix	Constituent	Sampling Equipment	Sample Container	Sample Preservative	Hold Time	Analytical Method
Water	pH	Field Meter	In situ	none	immediately	Field
Water	Temperature	Field Meter	In situ	none	immediately	Field
Water	Specific Conductance	Field Meter	In situ	none	immediately	Field
Water	Chlorophyll a	Field Meter	In situ	none	immediately	Field
Water	Oxidation Reduction Potential	Field Meter	In situ	none	immediately	Field
Water	Dissolved Oxygen	Field Meter	In situ	none	immediately	Field
Water	Total Alkalinity	VanDorn Sampler	100ml poly	4°±2°C	14 days	SM2320 B
Water	C-BOD-5	VanDorn Sampler	1000ml poly	4°±2°C	48 hours	SM5210 B
Water	Total Suspended Solids	VanDorn Sampler	1000ml poly	4°±2°C	7 days	SM2540 D
Water	Total Dissolved Solids	VanDorn Sampler	1000ml poly	4°±2°C	7 days	SM2540 C
Water	E. *coli*	Container immersion	250ml sterile	4°±2°C	6 hours	SM9223 B
Water	Dissolved Organic Carbon	VanDorn Sampler	250ml glass	H_2SO_4 4°±2°C	28 days	SM5310 C
Water	Total Organic Carbon	VanDorn Sampler	250ml glass	H_2SO_4 4°±2°C	28 days	SM5310 C
Water	Phosphorous, Total	VanDorn Sampler	250ml glass	H_2SO_4 4°±2°C	28 days	M365.1
Water	Phosphorous, Ortho	VanDorn Sampler	500ml poly	4°±2°C	48 hours	M365.1
Water	Phosphorus, Dissolved	VanDorn Sampler	250ml glass	H_2SO_4 4°±2°C	28 days	M365.1
Water	Nitrite+Nitrate – Nitrogen	VanDorn Sampler	500ml poly	4°±2°C	48 hours	M353.2
Water	Ammonia – Nitrogen	VanDorn Sampler	250ml glass	H_2SO_4 4°±2°C	28 days	M350.1
Water	Total Kjeldahl Nitrogen	VanDorn Sampler	500 ml glass	H_2SO_4 4°±2°C	28 days	EPA351.2
Water	Sulfate	VanDorn Sampler	250 poly	4°±2°C	28 days	EPA375.4 equivalent
Water	Chlorophyll *a*	VanDorn Sampler	1 liter amber	4°±2°C	24 hours	APHA 10200 H (Modified)
Water	Phytoplankton	VanDorn Sampler	60ml amber	Lugol's 4°±2°C	28 days	HPMA (Crumpton 1987)
Water	Zooplankton	Plankton net	250ml amber	Iso-alcohol 4°±2°C	28 days	APHA 10200 G
Water	Total Hardness (calculated)	VanDorn Sampler	125ml poly	HNO_3 4°±2°C	6 months	SM2340B
Water	Cadmium, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4°±2°C	6 months	M200.7
Water	Copper, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4°±2°C	6 months	M200.7
Water	Lead, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4°±2°C	6 months	M200.7
Water	Mercury, Total	VanDorn Sampler	125ml poly	HNO_3 4°±2°C	28 days	M245.1
Water	Selenium, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4°±2°C	6 months	SM3500

Matrix	Constituent	Sampling Equipment	Sample Container	Sample Preservative	Hold Time	Analytical Method
Water	Iron, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M200.7
Water	Arsenic, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M206.2
Water	Chromium, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M200.7
Water	Manganese, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M200.7
Water	Nickel, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M200.7
Water	Silica, Dissolved	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M200.7
Water	Silver, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M200.7
Water	Zinc, Dissolved and Total	VanDorn Sampler	125ml poly	HNO_3 4º±2°C	6 months	M200.7
Sediment	Total Organic Bound Phosphorus	Corer/Dredge	125ml poly	4º±2°C	28 days	M365.1, Lukkari et al. 2007)
Sediment	Loosely Bound and Pore Water Phosphorus	Corer/Dredge	125ml poly	4º±2°C	28 days	M365.1, Lukkari et al. 2007)
Sediment	Iron - Bound Phosphorus	Corer/Dredge	125ml poly	4º±2°C	28 days	M365.1, Lukkari et al. 2007)
Sediment	Calcium - Bound Phosphorus	Corer/Dredge	125ml poly	4º±2°C	28 days	M365.1, Lukkari et al. 2007)
Sediment	Aluminum - Bound Phosphorus	Corer/Dredge	125ml poly	4º±2°C	28 days	M365.1, Lukkari et al. 2007)
Sediment	Percent Solids	Corer/Dredge	125ml poly	4º±2°C	7 days	CLPSOW390, PART F, D-98
Sediment	Total Organic Carbon	Corer/Dredge	250ml glass	4º±2°C	28 days	ASA No. 9 29-2,2,4 IC Combustion
Sediment	Iron, Total	Corer/Dredge	125ml poly	4º±2°C	28 days	CLPSOW390
Sediment	Calcium, Total	Corer/Dredge	125ml poly	4º±2°C	6 months	M7742 Modified
Sediment	Aluminum, Total	Corer/Dredge	125ml poly	4º±2°C	14 days	ASA No. 9 29-2.2.4

~~4.6.2.~~4.2.3 *Sample Handling*

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All samples submitted to the laboratory for analyses must have proper documentation as to its source, method of collection, and maintenance of integrity during transport and delivery. Field personnel maintain custody of the samples until they are either relinquished directly to a laboratory or to a common carrier (e.g.,~~-~~ Federal Express) for shipment to a laboratory.

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The samples are received in the laboratory by the sample custodian or assigned alternate. After checking the COC form for completeness, the sample custodian records the date, time, and signs the form. The sample custodian also verifies that all custody seals are intact and immediately notifies the consultant when it appears that the custody of the samples may have been compromised. The sample custodian also verifies the temperature of the samples and notifies the consultant when the temperature is not within prescribed limits (for samples that are directly delivered to the laboratory, the chilling process must be initiated, but it is recognized that the samples may not have reached the prescribed limits). Each analytical laboratory used for this program maintains an internal quality control system for handling samples before, during, and after analyses.

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~~4.6.3.~~4.2.4 *Failed Chain-of-Custody and Corrective Action*

All issues associated with chain-of-custody procedures are immediately reported to the ~~consultant~~CRMC Project Manager. These include such items as delays in transfer, resulting in holding time violations; violations of sample preservation requirements; incomplete documentation, including signatures; possible tampering of samples; broken or spilled samples, etc. The ~~consultant~~CRMC Project Manager, in consultation with the Project Administrator will determine when the procedural violation may have compromised the validity of the resulting data. The ~~consultant~~CRMC Project Manager in consultation with the CRP Project Administrator will decide how the issue will be resolved based on best professional judgment and inform the TRC and ~~Authority~~CWA. Possible courses of action include, document and proceed; redo the entire sampling event~~ (At no cost to the Authority);~~; or selectively analyze samples. The resolution of the situation will be reported to the TRC and ~~Authority~~CWA at the next regularly scheduled meeting.

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~~4.7~~4.3 Analytical Method Requirements

The current accepted analytical methods, associated matrices, and performing laboratories are listed in ~~the following table.~~Table 3. The laboratory analyses cited in ~~Table 5~~Table 3 are EPA approved or other widely accepted standard methods, except where otherwise noted.

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Alternative analytical methods can be proposed and used after review and concurrence with the Water Quality Control Division.

~~Table 5 Analytical Methods~~

~~Matrix~~	~~Parameter~~	~~Analytical Method~~	~~Approach~~
~~Water~~	~~pH~~	~~Field~~	~~Horriba U-10 or Equivalent~~
~~Water~~	~~Temperature~~	~~Field~~	~~Horriba U-10 or Equivalent~~
~~Water~~	~~Specific Conductance~~	~~Field~~	~~Horriba U-10 or Equivalent~~
~~Water~~	~~Dissolved Oxygen~~	~~Field~~	~~Horriba U-10 or Equivalent~~
~~Water~~	~~Total Suspended Solids~~	~~M160.2~~	~~Gravimetric~~
~~Water~~	~~E. Coli~~	~~APHA 9221F~~	~~ID and Enumeration~~
~~Water~~	~~Total Organic Carbon~~	~~M415.1~~	~~Oxidation/IR~~
~~Water~~	~~Total Phosphorus~~	~~M365.1~~	~~Auto Ascorbic Acid~~
~~Water~~	~~Ortho Phosphorus~~	~~M365.1~~	~~Auto Ascorbic Acid~~
~~Water~~	~~NO2-NO3 – Nitrogen~~	~~M353.2~~	~~Auto Cadmium Reduction~~
~~Water~~	~~Ammonia – Nitrogen~~	~~M350.1~~	~~Auto Phenate~~
~~Water~~	~~Total Nitrogen~~	~~SM4500NORG-D~~	~~Persulfate digestion~~
~~Water~~	~~Chlorophyll A~~	~~Magnified observation~~	~~Hot ethanol extraction~~
~~Water~~	~~Phytoplankton~~	~~Magnified observation~~	~~ID and Enumeration~~
~~Water~~	~~Zooplankton~~	~~Magnified observation~~	~~ID and Enumeration~~
~~Water~~	~~Hardness~~	~~SM2340B~~	~~Calculation~~
~~Water~~	~~Cadmium (Dissolved)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Copper (Dissolved)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Lead (Dissolved)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Mercury (Dissolved)~~	~~M245.1~~	~~CVAA~~
~~Water~~	~~Selenium (Dissolved)~~	~~SM3500~~	~~AA-hydride~~
~~Water~~	~~Iron (Dissolved)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Iron (Total Recoverable)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Arsenic (Dissolved)~~	~~M206.2~~	~~GFAA~~
~~Water~~	~~Arsenic (Total)~~	~~M206.2~~	~~GFAA~~
~~Water~~	~~Manganese (Dissolved)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Nickel (Dissolved)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Chromium III (Dissolved)~~	~~SM3500~~	~~CR-D~~
~~Water~~	~~Chromium VI (Dissolved)~~	~~SM3500CR-D~~	~~CR-D (Colorimetric)~~
~~Water~~	~~Zinc (Dissolved)~~	~~M200.7~~	~~ICP~~
~~Water~~	~~Cyanide - WAD~~	~~SM4500-CN~~	~~Distillation/Colorimetric~~
~~Sediment~~	~~Cadmium (Total)~~	~~M6010B~~	~~ICP~~
~~Sediment~~	~~Copper (Total)~~	~~M6010B~~	~~ICP~~
~~Sediment~~	~~Lead (Total)~~	~~M6010B~~	~~ICP~~
~~Sediment~~	~~Mercury (Total)~~	~~M7471~~	~~CVAA~~
~~Sediment~~	~~Phosphorous (Total)~~	~~M365.1~~	~~Auto Ascorbic Acid~~
~~Sediment~~	~~Selenium (Total)~~	~~M7742 Modified~~	~~AA-hydride~~
~~Sediment~~	~~Percent Solids~~	~~CLPSOW390~~	~~Gravimetric~~
~~Sediment~~	~~Total Organic Carbon~~	~~ASA No. 9 29-2.2.4~~	~~Combustion/IR~~

4.4 Sampling Equipment, Sample Containers and Preservation

Refer to Table 3 for specifications for sample containers, preservatives, and holding times for all analytes. The analytical laboratory's SOPs also contain information concerning sampling containers and preservatives. In addition to any preservatives, all samples will be placed in a cooler on ice immediately after sample collection.

~~4.8~~4.5 Failures in Measurement Systems and Corrective Actions

Failures in field and laboratory measurement systems involve, but are not limited to such things as, instrument malfunctions, failures in calibration, blank contamination, quality control samples outside ~~QAPP~~ defined limits, etc. In many cases, the field technician or lab analyst will be able to correct the problem. When the problem is resolvable by the field technician or lab analyst, then they will document the problem on the field data sheet or laboratory record and complete the analysis. When the problem is not immediately resolvable, then it is conveyed to the CRMC Project Manager, who will make the determination whether the analytical system failure caused invalid results. If the problem is due to laboratory instrument failure, then lab personnel will implement the following corrective actions:

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1. ~~1.~~ The lab will immediately contact the CRMC Project Manager to inform of the nature and potential consequences of the problem.

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2. If instrument failure will result in loss of analytical data and there is adequate holding time remaining, the lab will be instructed to send unopened samples to an alternate lab.

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3. If alternate sample analyses cannot be performed, the ~~consultant~~CRMC Project Manager will make a decision whether a resample is appropriate and necessary, with concurrence from the ~~Project~~Program Administrator. The corrective action plan is intended to ensure that every effort is made to obtain analytical data from all samples. The nature and disposition of problems are reported on the data report that is sent to the ~~consultant~~CRMC Project Manager. The ~~consultant~~CRMC Project Manager will include this information in its next monthly status report to the CWA.

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~~4.9~~4.6 Quality Control Requirements

~~4.9.0.~~4.6.1 *Sampling Quality Control Requirements*

Field QC samples are submitted as separate samples to the laboratory and reported accordingly, on the data reports. Specific requirements are outlined below. The only field QC samples routinely used on this program are field duplicates.

Field duplicates ~~–~~ A routine water quality monitoring field duplicate is defined as a second sample, from the same location, collected in immediate succession, using identical techniques. This applies to all cases of routine surface water collection procedures, including in-stream grab samples, bucket grab samples (e.g.,~~-~~ from bridges), pumps, and other water sampling devices. Field duplicates are collected on all samples on a 10% basis. Duplicate samples are sealed handled, stored, shipped, and analyzed in the sample manner as the primary sample. Precision of duplicate results is calculated by the relative percent difference (RPD) as defined by 100 times the difference (range) of each duplicate set, divided by the average value (mean) of the set. For duplicate results, D_1 and D_2, the RPD is calculated from the following equation:

~~Equation 1~~ Field Relative Percent Difference

$$RPD = ((D1-D2)*100)/((D1+D2)/2)$$

Best professional judgment is used to determine the acceptability of field duplicate analyses.

~~4.9.1.~~4.6.2 *Laboratory Measurement Quality Control ~~Requirements~~ Procedures*

Detailed laboratory QC requirements are contained within each ~~laboratory Quality Assurance Plan~~analytical laboratory's Standard Operating Procedures (SOP) and are also ~~specified in the EPA-approved analytical methods. The minimum requirements that all participants abide by are stated below.~~

available upon request. Laboratory ~~duplicate –~~ quality control procedures include the following practices.

Laboratory ~~duplicates~~replicate – Laboratory replicates are used to assess precision. A laboratory ~~duplicate~~replicate is prepared by splitting aliquots of a single sample (or a matrix spike or a laboratory control standard) in the laboratory~~.~~ after prep techniques have been completed. Both samples are carried through the entire ~~preparation and~~

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analytical process. Laboratory ~~duplicates~~replicates are performed on 10% of samples analyzed. Precision is calculated by the relative percent difference (RPD) of duplicate results as defined by 100 times the difference (range) of each ~~duplicate~~replicate set, divided by the average value (mean) of the set. For ~~duplicate~~replicate results, D1 and D2, the RPD is calculated from the following equation:

~~Equation 2~~ Laboratory Relative Percent Difference

RPD = ((D1-D2)*100~~)/((~~/((D1+D2)/2)

Laboratory Control Standard (LCS) ~~-~~ – A laboratory control sample is analyte-free water spiked with the analyte of interest prepared from standardized reference material. The laboratory control standard is generally spiked at a level less than or equal to the mid-point of the calibration curve for each analyte. The LCS is carried through the complete preparation and analytical process. The LCS is used to document the accuracy of the method due to the analytical process. LCS's are generally run at a rate of one per batch. Acceptability criteria are laboratory specific and usually based on results of past laboratory data. The analysis of LCS's is a measure of accuracy and is calculated by Percent Recovery (%R) and defined as 100 times the observed concentration, divided by the true concentration of the spike. Acceptance criteria are based on laboratory control charts, but not greater than the prescribed criteria. The formula used to calculate percent recovery, where %R is percent recovery includes SR as the sample result and SA as the spike added:

~~Equation 3~~ Laboratory Control ~~Sample~~Standard Percent Recovery

Percent R = SR * 100/SA

Matrix spikes (MS~~)~~) – A matrix spike is an aliquot of sample spiked with a known concentration of the analyte of interest. Percent recovery of the known concentration of added analyte is used to assess accuracy of the analytical process. The spiking occurs prior to sample ~~preparation and~~ analysis. The MS level varies based on the method, but is typically spiked at a level less than or equal to the midpoint of the calibration or analysis range for each analyte. The MS is used to document the accuracy of a method due to sample matrix and not to control the analytical process. The analysis of matrix spikes is a measure of accuracy and is calculated by Percent Recovery %R is defined as 100 times the observed concentration, minus the sample concentration, divided by the true concentration of the spike. The formula used to calculate percent recovery, where %R is percent recovery; SSR is the observed spiked sample concentration; SR is the sample concentration; and, SA is the spike added; is:

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~~Equation 4~~ Laboratory Matrix Spike Percent Recovery

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Percent R = [(SSR -SR)/SA] * 100

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Method blank ~~– a~~ – A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in the sample processing. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination in the preparatory and analytical processes. The analysis of method blanks will yield values less than the Minimum Analytical Level. For very high-level analyses blank value will be less ~~then~~than 5% of the lowest value of the batch.

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Additional method specific QC requirements ~~–~~ – Additional QC samples are run (e.g., ~~-~~ surrogates, internal standards, continuing calibration samples, interference check samples) as specified in the methods. The requirements for these samples, their acceptance criteria, and corrective action are method-specific and are therefore not listed in this plan.

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~~4.9.2.~~4.6.3 *Quality Control Failures and Corrective Action*

The ~~consultant~~CRMC Project Manager, in consultation with the ~~Project~~CWA Program Administrator, evaluates all sampling QC excursions. In that differences in duplicate sample results are used to assess the entire sampling process, including environmental variability, the arbitrary rejection of results based on pre-determined limits is not practical. Therefore, judgment will be relied upon in evaluating results. Rejecting sample results based on wide variability is a possibility. Notations of field duplicate excursions are noted in the ~~consultant's~~ monthly status report and annual data report. The laboratory staff evaluates laboratory measurement failures. The dispositions of such failures and conveyance to the ~~CWA~~CRP are discussed under Failed Analytical Systems and Corrective Action section.

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~~4.10~~4.7 Instrument and Equipment Testing/Maintenance

All sampling equipment testing and maintenance requirements are detailed in the ~~*these*~~ *SOPs*. Equipment records are kept on all field equipment and a supply of critical spare parts is maintained. All laboratory tools, gauges, instruments, and equipment testing and maintenance requirements are contained within each laboratory's Quality Assurance Manual.

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Testing and maintenance records are maintained and are available for inspection by the consultant and/or ~~CWA.~~ CRP.

~~4.10.0.~~4.7.1 *Instrument Calibration and Frequency*

Detailed laboratory calibrations are contained within each laboratory's Quality Assurance Manual and are also specified in the EPA-approved analytical methods. ~~Table 6~~Table 4 lists field equipment calibrations.

Prior to each sampling event, the multiprobe for field measurements must be calibrated based on the manufacturer's recommended calibration protocols for pH, specific conductance, dissolved oxygen, oxidation reduction potential, and chlorophyll *a* (Table 4). Temperature should be calibrated on a monthly basis. Total phosphorous and Nitrate-Nitrogen should be calibrated on an annual basis.

Table 4: Field Equipment Calibration Requirements

Analysis	QC Elements	Frequency
pH	One Point Calibration	~~Each~~ Day of Event
Temperature	NIST Thermometer Cal.	Monthly
Specific Conductance	Control	~~Each~~ Day of Event
Dissolved Oxygen	Control	~~Each~~ Day of Event
~~Total Phosphorous (Field)~~Oxidation Reduction Potential	~~Manufacturer's Cal.~~Control	~~Annually~~Day of Event
~~Nitrate-Nitrogen~~Chlorophyll *a* (Field)	Manufacturer's Cal.	~~Annually~~Monthly

~~4.10.1.~~4.7.2 *Supply Inspection and Acceptance Requirements*

The procurement of equipment and supplies and verification that the equipment and supplies received met the required specifications is a critical step to maintain the quality of samples collected under this program. As applicable, procurement documents include: a definitive scope of work; administrative requirements; technical requirements describing items to be furnished; applicable quality requirements for the supplier(s); right of access to supplier's facilities and records for the purposes of inspections and audit; and documents to be provided by the supplier in support of compliance to procurement requirements. Procurement

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Once procured items are received, receiving personnel will ensure that the items received are in conformance with the specifications of the order. Any items determined to not be in conformance will be clearly identified as such in order to prevent their use. All documentation regarding quality received with the items shall be maintained as quality records and shall be traceable to the items procured via lot numbers, bar codes, or other appropriate system. Examples of these types of records include documentation related to cleanliness levels of equipment and sample containers.

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~~4.10.2.~~*4.7.3* *Other Data Acquisitions*

In addition to the data collected under this monitoring program, data is obtained from the following sources for use in preparation of the annual data report: 1)~~-~~ stream flow data for Plum Creek (field code PC) – U.S.~~-~~ Geological Survey; 2)~~-~~ stream flow data for the South Platte River (field code SP) – Colorado Division of Water Resources; and 3)~~-~~ stream flow data for the Chatfield Reservoir outfall (field code SO) – U.S. Army Corps of Engineers. These data are included in the annual data report but are not used for making any regulatory decisions. Consequently, no additional quality requirements are applied to these data. These data are qualified as provisional data in the annual data report to indicate that the agencies have not completed verification of the data.

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5.0 ~~data~~Data Management, ~~assessment AND OVERSIGHT~~Assessment and Oversight

5.1 Data Management

Field data sheets are reviewed and signed by the ~~sampling team leader~~Field Team Leader at the end of each sampling event. Field sheets are then given to the ~~consultant~~CRMC Project Manager for review. Any discrepancies noted during this review are promptly resolved. Field and laboratory data are recorded in an Access database developed by the project consultant and are transferred electronically to the ~~Authority's administrator~~CWA's Project Administrator in conjunction with the final annual monitoring report. A database is maintained which contains information on each site visit including (at a minimum) sampling date, sampling time, consultant personnel, volunteer assistance, weather conditions, subjective stream and reservoir observations or conditions (e.g.,~~-~~ reservoir - choppy surface with turbid green water), problems, instrument calibrations, and quality assurance and quality control samples. The database belongs to the CWA and must be transferred ~~to the Authority on~~upon request.

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The database has been designed so that the majority of the analytical data received from laboratories can be loaded into the database directly from electronic files received from the laboratory. The database also performs some basic error checking routines when the electronic files are loaded to flag erroneous data prior to the data being loaded into the database. Data is analyzed with EXCEL spreadsheets.

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5.2 Assessment and Response Actions

Review of Chatfield Watershed field activities is the responsibility of the ~~consultant~~CRP Field Team Leader, in conjunction with the CRMC Project Manager. Each field team will be accompanied and their performance evaluated by one of these individuals once a year. When possible, field technicians in need of performance improvement will be retrained on-site during the evaluation. When errors in sampling techniques are consistently identified, additional training may be scheduled more frequently. All field and laboratory activities may be reviewed by state, ~~CWA~~CRP and other appropriate personnel as requested.

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5.3 Data Validation and Usability

All data obtained from field and laboratory measurements will be reviewed and verified for integrity and continuity, reasonableness, and conformance to project requirements, and then validated against the data quality objectives. Only those data that are supported by appropriate quality control data and meet the data quality objectives defined for this project will be considered acceptable.

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The procedures for verification and validation of data are described below. The ~~consultant~~ Field ~~Leader~~Team Leaders will be responsible for ensuring that field data are properly reviewed, verified, and submitted in the required format to the ~~consultant~~CRMC Project Manager. Likewise, the Laboratory Supervisor for each laboratory will be responsible for ensuring that laboratory data are reviewed, verified, and submitted in the required format to the ~~consultant~~CRMC Project Manager for uploading to the project database. The ~~consultant~~CRMC Project Manager is responsible for verifying that field and laboratory data have been entered correctly into the project database and for validating that all data collected meet the data quality objectives of the project.

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All data will be verified to ensure they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control data conform to project specifications. The consultant staff and management and subcontract laboratories are responsible for verifying the data each task generates or handles. The field and laboratory staff ensures the verification of raw data, electronically generated data, and data on chain-of-custody forms and hardcopy output from instruments.

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Verification of data will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the CRMC Project Manager. The data to be verified are evaluated against project specifications and are checked for errors, especially errors in transcription, calculations, and data input. Potential outliers are identified by examination for unreasonable data, or identified using computer-based statistical software. When a question arises or an error or potential outlier is identified, the CRMC Project Manager is responsible to resolve the issue. Issues that can be corrected are corrected and documented electronically or by initialing and dating the associated paperwork. When an issue cannot be corrected, the task manager consults with the CRP Project Administrator to establish the appropriate course of action, or the data associated with the issue are rejected.

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The CRMC Project Manager is responsible for validating that the verified data are usable. One element of the validation process involves evaluating the data again for anomalies. The

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CRMC Project Manager may designate other experienced water quality experts familiar with the project to perform this evaluation. Before data validation can be completed the CRMC Project ~~Manger~~Manager must address any suspected errors or anomalous data.

As soon as possible after each sampling event, calculations and determinations for precision, completeness, and accuracy will be made and corrective action implemented if needed. When data quality indicators do not meet the project's specifications, data may be discarded and re-sampling may occur. The cause of failure will be evaluated. When the cause is found to be equipment failure, calibration/maintenance techniques will be reassessed and improved. When the problem is found to be sampling team error, team members will be retrained. Any limitations on data use will be detailed in both monthly status and annual data reports, and other documentation as needed.

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When failure to meet project specifications is found to be unrelated to equipment, methods, or sample error, specifications may be revised for the next sampling season.

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6.0 Standard Operating Procedures

6.1 Purpose

The standard operating procedures (SOP) describe the collection, preparation, and handling of surface water from streams and reservoirs, alluvial well, and sediment samples. These SOPs are applicable to the water-quality monitoring program for the ~~Chatfield Watershed Authority (~~CWA~~).~~ and CRP. SOPs are used in conjunction with the ~~CWA Quality Assurance Project Plan and~~ Sampling and Analysis Plan (~~QAPP/~~SAP) that defines sample locations, schedules, list of analytes, and quality assurance/quality control (QA/QC) procedures.

6.2 Field-Survey Preparations

All field instruments and meters are calibrated and a maintenance check is performed to ensure proper function. Calibration of the equipment is conducted in accordance with the manufacturers' specifications~~ (The Program Administrator maintains a PDF file on the Manufacturers' Instructions for Calibration, Maintenance and Use Of Hach Dr 2010 Spectrophotometer And Horiba U-10 Water Quality Checker). Spare~~, and spare parts are kept on hand while in the field in the event of an equipment malfunction. A record of all calibrations, standardization including standard lots and expiration ~~datesand~~dates and maintenance is maintained in a bound logbook. Information on dates, operator, time, location, comments and recommended maintenance also are recorded for each use. The logbook is inspected regularly by the ~~Project Manager~~Field Team Leader to ensure recommended maintenance is completed. The ~~Project Manager~~Field Team Leader will sign and date the logbook to indicate approval. Several general procedures are applicable to the collection of all surface water samples. These procedures include:

1. Prepare all sampling equipment and containers prior to site visit;
2. Follow sampling plan in every detail;
3. Document steps in the sampling procedures (The CRMC Project Manager will maintain field forms that can be used for documenting sampling procedures);

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4. Evaluate site for safety hazards and any physical conditions that may affect sample condition before commencing sample collection;

5. Observe number and location of sample points, landmarks, references, and routes of access or escape;

6. Record pertinent observations, including a sketch, where appropriate, identifying sample locations;

7. Collect samples and securely closing containers as quickly as feasible; and

8. Make field observations (pH, temperature, specific conductance) at the source using a probe rather than in the containers, whenever possible.

~~6.3 Sample Containers And Preservation~~

~~Refer SOPs for specifications for sample containers, preservatives, and holding times for all analytes. In addition to any preservatives specified in the SOPs, all samples will be placed in a cooler on ice immediately after sample collection.~~

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~~6.4~~6.3 In-Stream Water Sampling

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In-stream water samples are collected as grab or composite samples. from the South Platte River inflow, Plum Creek inflow, and the South Platte River outflow sites. The GPS coordinates for the in-stream sampling locations are:

1. SP inflow: N 39.48804 W -105.09354
2. PC inflow: N 39.50692 W -105.02432
3. SP outflow: N 39.56118 W -105.06031

Composite samples can be flow or time based. Grab samples characterize a medium at a particular point in time and space. Grab samples are collected by container immersion or by using a transfer device such as a beaker or dipper. A representative sample is obtained as near the centroid of flow as safety allows. Sample sites located in standing water or near streambanks will be avoided. Sampling from the upstream side of a bridge aids in the prevention of contamination of the sample from ~~paint chips~~debris or ~~dirt~~sediment from the road. When suspended particles are unlikely to be uniformly distributed across the channel cross section, a composite sample consisting of several grab samples is used. Do not include large non-homogeneous particles, such as leaves and detritus, in the sample. Collection of in-stream water samples by container immersion is performed as follows:

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1. Submerge the sample bottle below the water surface with the opening pointing upstream at the centroid of the stream flow.

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2. The sampler will minimize the disturbance of bottom sediment.

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3. Allow container to fill to the desired volume.

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4. Sample containers containing preservatives are filled to just below the bottom of the container neck to prevent loss of preservative.

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5. Remove container from the water.

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6. Decontaminate the sample containers outside surface by rinsing with deionized water.

7. Tighten sample container lid.

8. Complete all information on the sample label.

9. Sign and date custody seal and place over the sample container’s lid.

10. Place sample in a zip-lock bag and seal.

11. Place bagged sample in a prepared U.S.- Department of Transportation (DOT) compliant shipping container with ice as required.

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Collection of in-stream water samples by the dip and transfer method is performed as follows:

1. Select the correct composition of the transfer device for the selected analytes.
2. Decontaminate the transfer device.
3. Place the device at the centroid of stream flow facing upstream
4. Rinse the device three times with surface water.
5. Collect and transfer sample directly into sample container.
6. Do not overfill containers that have preservative.
7. Do not let transfer device contact anything except surface water.
8. Tighten sample container lid.
9. Decontaminate sample container’s outside surface by rinsing with deionized or distilled water.
10. Complete all information on sample label.
11. Sign and date custody seal and place over the container lid.
12. Place in a zip-lock plastic bag and seal.

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13. Place bagged samples in a prepared DOT-compliant shipping container with ice as required.

~~6.5~~6.4 In-Reservoir Depth ~~And~~and Secchi Depth Measurement

Sample depths are measured with a calibrated sounding line to the nearest 0.1- meter. The Secchi depth may be used to determine the mid-euphotic ~~sampling~~ point, which is equal to the Secchi depth, and it may also be used to determine the euphotic layer depth by multiplying the Secchi depth by a factor of two. The euphotic layer is characterized as the layer where photosynthetic activity occurs. The Secchi depth is determined ~~by~~ using ~~a Secchi disk as follows~~the following procedure:

1. The sampler must not wear sunglasses.
2. Measurements are taken between 9 a.m. and 3 p.m. and the time noted.
3. Weather and other conditions are noted.
4. Measure on the shady side of the boat with the sampler’s face as close to the surface as possible.
5. Lower the Secchi disk until it disappears from view.
6. Raise the disk until it reappears and record this depth.
7. Repeat the procedure three times and average the results.

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~~6.6~~6.5 In-Reservoir Water Sample Collection

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Reservoir samples are collected from ~~approximately~~ the same ~~location for every~~three locations during each sampling event. The sample ~~location is~~locations should be determined ~~by visual orientation, due west of the Chatfield Dam outlet tower and due south of~~using a ~~permanent picnic structure on the north bank.~~ GPS unit. The ~~lake is sounded to locate a point with a water depth of 11 meters, or 33 feet.~~ GPS coordinates for the in-reservoir sampling locations are:

1. CR-1: N 39.55301 W -105.06395
2. CR-2: N 39.54313 W -105.07619
3. CR-3: N 39.54902 W -105.05333

The boat is then anchored if drift control is necessary. Water samples at the appropriate depths are collected with a Van~~-~~ Dorn or a similar discrete-zone sampling device. A Van Dorn sampler consists of an 18-inch long, three-inch diameter PVC cylinder, open on both ends, with a mechanism that can be triggered to close the caps of the sampler at the desired sampling depth, thereby collecting a discrete sample at the depth where the caps were closed. The method followed for such a sampler is as follows:

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1. Rinse Van Dorn samplers and sample transfer device with reservoir water.

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2. Open the device and lower it to the desired depth using a calibrated rope.

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3. Gently raise and lower to device to rinse it at the sampling depth.

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4. Trigger the closure mechanism to collect the sample and lift to the surface.

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5. Rinse sample transfer device with sample water

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6. Transfer sample into sample containers.

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7. Tighten sample container lid.

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8. Decontaminate sample container outside surface by rinsing with deionized water.

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9. Complete all information on the sample label.

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10. Sign and date custody seal and place over the sample container’s lid.

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11. Place sample in a zip-lock plastic bag.

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12. Place bagged sample in prepared DOT-compliant shipping container with ice when required.

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In-reservoir water samples are taken through the ice using this same method when it is safe to do so. A Secchi disc reading will not be reliable so the mid-euphotic zone will be assumed at 1.5~~-~~ meters.

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~~6.7~~6.6 Metals Chemistry Water Sample Collection

Samples that will be submitted to a laboratory for analysis of dissolved metals are filtered prior to transferring into sample containers. Do not preserve the samples prior to filtration. These samples are filtered using a vacuum filter holder, hand-vacuum pump, flask with a side arm, and 0.45~~-~~ µm filter paper. The method to be followed is as follows:

1. Thoroughly decontaminate the filter holder and flask with deionized water.

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2. Place a new 0.45 µm filter paper on the vacuum filter holder and re-attach the funnel to the filter holder.

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3. Insert the stopper of the filter holder into the flask.

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4. Attach the hand-vacuum pump to the side arm of the flask.

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5. Pour the sample water into the funnel and begin pumping the vacuum pump to draw the water through the filter into the flask. Repeat until sample has been filtered.

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6. Transfer the sample from the flask into the appropriate sample containers.

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7. Tighten sample container lid.

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8. Decontaminate sample container's outside surface by rinsing with deionized water.

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9. Complete all information on sample label.

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10. Sign and date custody seal and place over the sample container lid.

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11. Place sample in a zip-lock plastic bag.

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12. Place bagged sample in prepared DOT-compliant shipping container with ice as required.

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~~6.8~~6.7 In-Reservoir Sediment Sample Collection

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Reservoir sediment samples ~~are~~may be obtained by using either an Ekman ~~Dredge~~dredge or similar device~~.~~, or using a sediment coring device such as the K-B core sampler depending upon the type of sample required for analysis. The sampler in current use is a metal clamshell-type dredge approximately 8~~-~~ inches across, attached at the hinge to a line by which the sampler is dropped to the bottom. After dropping to the bottom, the jaws of the sampler are quickly closed by triggering the mechanism from the surface. Details of the sampling method are as follows:

1. Rinse the device in reservoir water.
2. Lower the device to the reservoir bottom.
3. Trigger the closure mechanism and lift to the surface.
4. Transfer the sample into a stainless steel mixing bowl.
5. Mix the sample to homogenize after required volume is obtained.
6. Transfer sample into sample containers with a stainless steel spoon after mixing.
7. Wipe residual sample from sample container cap threads.
8. Tighten sample container's lid.
9. Decontaminate sample container's outside surface by rinsing with deionized water.
10. Complete all information on sample label.
11. Sign and date custody seal and place over sample container's lid
12. Place sample in a zip-lock bag.

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13. Place bagged sample in prepared DOT conveyance with ice when required.

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A sediment coring device would be similarly deployed, although the sample core would remain intact for additional studies, or sub-sectioned to collect the active layer (i.e., 5-10 cm top layer) for phosphorus fractionation and metals analysis. This type of sampling provides a more quantitatively defined sediment area to determine the available nutrient mass that may contribute to internal nutrient loading. Details of the sampling method are as follows:

1. Rinse the device in reservoir water.
2. Lower the device to the reservoir bottom.
3. Trigger the closure mechanism and slowly lift to the surface.
4. Cap the lower end of the coring device while the tube is still in the water to prevent loss of sample.
5. Remove the polycarbonate tube from the coring device and ensure the end caps are securely fastened to the tube to maintain sample integrity.
6. Complete all information on sample label and place polycarbonate tube vertically in a cooler with ice packs.
7. Transfer to laboratory for analysis.

~~6.9~~6.8 Alluvial Well Sampling

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The well sampling sites consist of a faucet at the wellhead, a pumping station, or open cistern. Sampling procedures for the pumped wells follow the sampling by dip and transfer method after the water source has been purged of stale water. Notes regarding the color, flow, and general character of the water are recorded. The open cistern is sampled with a transfer device secured with a rope. The device is lowered into the water and the sample transferred to the sample containers using the dip and transfer method. Safety issues will cause any sampling activities to cease.

~~6.10~~6.9Phytoplankton Sampling

Phytoplankton samples are collected at the same ~~location~~locations and using the same methods as the in-reservoir water samples. Phytoplankton samples are always collected from

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the ~~mid-euphotic sampling~~near surface depth~~. Samples are~~ that corresponds with the chlorophyll *a* sample depth. At the laboratory, samples are placed into an amber ~~glass jar~~HDPE bottle and preserved with ~~Lugols~~Lugol's Iodine Solution~~. Phytoplankton samples are packed in a cooler with blue ice and~~, then ~~transported~~shipped to ~~the University of Colorado Limnology Laboratory in Boulder~~PhycoTech for analysis~~. Samples are typically delivered to the lab on the same day they are collected~~.

~~6.11~~6.10 Zooplankton Sampling

Zooplankton samples ~~are typically~~will only be collected ~~only once per year. Zooplankton samples are collected at the same location as the~~from Site CR-1 when other in-reservoir water samples~~. So as not to compromise the integrity of the water samples, the~~ are collected from this site. The zooplankton sample is always collected following the collection of water samples, so as not to compromise the integrity of the water samples. Collection of a vertical water column zooplankton ~~samples is done with a 500-micorn sieve zooplankton net. Collection of zooplankton samples using a zooplankton net~~sample is performed using a Wisconsin 80 µm mesh net as follows:

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1. Rinse the device with reservoir water.

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2. Fill the collection vessel at the end of the net with reservoir water to provide weight.

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3. Lower the net to the bottom of the sample column (1 meter from the bottom) in such a manner so as to prevent the net from becoming inverted.

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4. Slowly raise the net through the water column to the surface.

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5. Rinse all organic matter from the net into the collection vessel using distilled water.

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6. Pour the contents of the vessel into a stainless-steel composting bowl.

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7. Repeat the sampling procedure two more times for a total of three sample collections.

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8. Pour the composites into the net to remove excess water.

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9. Rinse the net contents into the collection vessel for a concentrated sample.

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10. Transfer the sample to the required sample container prepared with the appropriate alcohol preservative.

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~~6.12~~6.11 Visual Flow Measurements

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Flow measurements are determined in the field using a tape measure, stopwatch, and a float. The float will be light enough to represent the current of the stream but not be influenced by air current. Flow measurements are taken after the collection of samples.

Choose a section of streambed that uniformly matches one of the three area types: rectangular, inverted triangle, or semicircle. Measure the width and the depth of the streambed to the nearest 0.1~~-~~ ft and apply it to one of the following formulas for a cross sectional area:

- Rectangular area = (width) X (depth)

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- Triangular area = ½ [(width) X (depth)]

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- Semicircle area = ½ (3.14 X depth) [note depth will be ½ of the width]

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Measure a section of streambed between two and six feet to the nearest foot. Start the float upstream from the measured section and time it as it flows through the measured section in the centroid of flow. Repeat the timing procedure three times to get an average value in seconds. Multiply the cross sectional area by the measured streambed length and divide by the average seconds to get a result in the units of cubic feet per second. Field-flow measurements are compared to any additional available flow data for the sampling site from sources such as the USGS, State of Colorado, or U.S.~~-~~ Army COE.

~~6.13~~6.12 Field Measurements

Field measurements of indicator variables consist of dissolved oxygen (DO), ~~Specific~~specific conductivity (SC), temperature, pH, oxidation reduction potential (ORP), and ~~pH.~~ chlorophyll *a*. Measurements of DO and pH are recorded to the nearest 0.1 of the appropriate units; temperature is recorded to the nearest 0.5° C. Use, calibration, and maintenance procedures follow the manufacturer instructions. Field measurements are taken

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~~6.14~~6.13 Field QA/QC Samples

The goal of the QA/QC program is to ensure the accuracy, precision, completeness, representativeness, and comparability of sampling data. In order to document the consistency and accuracy of analytical data generated by the contract water-quality laboratory, one or more of the following QA/QC samples can be employed. The CRP/CWA QAPP/SAP defines which QA/QC samples are to be collected and the frequency of collection.

~~6.14.0.~~6.13.1 Field Duplicates

A double volume of water is collected and preserved at the appropriate sampling site. The sample is then divided into identical containers that are given different location identification names. Label sample collection time for the duplicate sample will be entered as four letters (e.g.,~~-~~ AAAA, BBBB, CCCC, XXXX, YYYY, ZZZZ). These are recorded in the field notes for future reference. Both samples are submitted to the laboratory for identical analyses. The laboratory is not advised of the duplication.

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~~6.14.1.~~6.13.2 Field Blanks

A volume of commercially distilled water is taken to the field and placed in an identical sample container using the sampling techniques employed for standard sampling. The procedure for identifying duplicate samples above is followed for field blanks.

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~~6.14.2.~~6.13.3 Equipment Blanks

Equipment blanks are prepared for metals-in-water samples whenever a new batch of filters is used or every tenth sample filtered (or collected for total metal analysis). Equipment blanks consist of a volume of commercially distilled water that is taken to the field and

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Formatted: Body Text, Hyphenate, Tab stops: Not at -0.5" filtered and/or handled like a regular sample. The procedure for identifying duplicate samples above is followed for equipment blanks.

~~6.15~~6.14 Sample Shipment, If Necessary

Samples going to labs outside the Denver-metro area are packed into plastic bags and placed in a DOT-compliant shipping container (e.g., cooler) with sufficient ice to maintain sample temperatures as close to 4°C as feasible for a 24-hour period. Void space within the container is filled with packing material to avoid shifting of the samples during transport. The completed, signed, and dated chain-of-custody (COC) is enclosed in a plastic bag and placed inside the container on top of the contents. Copies of the COC and the shipping bill are kept with the field notes. The container lid is closed and secured with two complete wraps of packaging tape. Labeling consists of directional labels on all four sides and fragile stickers and the shipping label on the lid of the container. The container is shipped overnight to the contracted lab using a commercial carrier (e.g., Federal Express). Samples going to labs in the Denver metro area are transported in a cooler on ice and delivered the same day as collection or secured in a refrigerator pending delivery.

~~7.0 AUTHORITY REFERENCES~~

7.0 References

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