Plum Creek Watershed Monitoring Network

Sampling and Analysis Plan

Developed for:

Chatfield Watershed Authority

Prepared by:

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TETRA TECH

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1. INTRODUCTION

In March 2012 through April 2013, water quality monitoring took place to characterize and identify pollutant sources in the Plum Creek drainage area of Chatfield Watershed. The results of that monitoring study are presented in *Plum Creek Watershed Monitoring Report, Data Collection and Analysis* (CWCB 2013). Monitoring efforts have continued with the support of Tetra Tech, Inc., Colorado Watershed Authority members, and voluntary efforts from Plum Creek Water Reclamation Authority (PCWRA) and the Town of Castle Rock.

The Chatfield Reservoir receives drainage from the South Platte River basin (2,701 mi^2) and Plum Creek Basin (321 mi^2). The Chatfield Watershed boundaries, however, include the lower portion of the South Platte River basin downstream of Strontia Springs Reservoir (118.5 mi^2) and the entire Plum Creek basin.

The Water Quality Control Commission (WQCC) Control Regulation No.73 for Chatfield Reservoir limits the pounds of phosphorus allowable to the reservoir, as well as concentrations of total phosphorus (TP) and chlorophyll-a (chla). NPS pollutants are not well understood in the watershed. The objectives of this water quality monitoring program are:

- Characterize water quality and pollutant loading in the Plum Creek watershed,
- Attempt to identify and evaluate pollutant sources,
- Promote decision-making on where to focus limited resources on future priority NPS projects in Plum Creek,
- Present data on Chatfield website (www.ChatfieldWatershedAuthority.org).

This Sampling and Analysis Plan (SAP) provides guidance for the planning, collection, laboratory analysis, and data quality assessment for surface water samples in Plum Creek throughout the Plum Creek watershed. The water quality objectives are presented below:

- Provide background surface water quality and flow data in the upper reaches of the basin including East Plum Creek and West Plum Creek.
- Evaluate changes in surface water chemistry and flow at various locations within the Plum Creek watershed to help identify pollutant sources.
- Provide surface water chemistry and flow data to help evaluate their impacts on the Plum Creek watershed and Chatfield Reservoir.
- Provide surface water quality and flow data that supplements historic sampling data, where available.
- Provide the optimal location for water quality and streamflow monitoring equipment to support project objectives.

This SAP guides field personnel by defining, the number, type, and location of samples to be collected; and the type of analyses to be performed. This SAP follows the general guidelines for development of field sampling plans presented in *Surface Water Sampling* (U.S. EPA 1994).

This SAP was developed for use by Authority members and sampling personnel. Tetra Tech will provide support to assist the Authority with data management, data analysis and reporting aspects related to this work as financial resources allow. Other qualified personnel will perform the following specific tasks:

- **Chris Carson and Martha Hahn, PCWRA** - PCWRA will provide sampling and analytical support in the Plum Creek watershed. As lab manager, Chris Carson will conduct monthly water chemistry analyses at the PCWRA laboratory. PCWRA will also coordinate volunteer sampling efforts with their own staff time and laboratory equipment. Water chemistry results will be maintained in an excel database. PCWRA Manager and Authority member, Martha Hahn, will provide technical support, oversight, and guidance on the sampling program.
- **David Van Dellen, Town of Castle Rock –** As Technical Review Committee Chairman and Stormwater Manager at Town of Castle Rock, David Van Dellen will provide technical support and guidance on the sampling program. His staff will support sampling efforts in coordination with PCWRA.
- **Julie Vlier, PE, Manager, Chatfield Watershed Authority and Tetra Tech, Inc. –**As Authority Manager, Ms. Vlier will provide support and guidance on sampling protocol, analytes, and data analyses.
- **Chatfield Watershed Authority, Technical Review Committee –** The technical review committee will assist with the review and analysis of data collected as part of this monitoring network.

2. SAMPLING LOCATIONS

This SAP covers work for monthly monitoring that began in April 2012 – March 2013 as part of the Healthy Rivers Grant program and continues now through December 2014 along West Plum Creek, East Plum Creek, and the Plum Creek mainstem (Figure 1). Sampling locations summarized in Table 1 were selected taking into consideration project objectives, coordination with existing data collected by others along Plum Creek, site access, potential NPS, and coordination with recommendations in the Chatfield Watershed Plan. The surface water sampling locations include ten (10) sites along West Plum Creek, East Plum Creek and the Plum Creek mainstem. Some of these monitoring sites are shown in photographs below (Figures 2 through 8).

Figure 1 – *Surface Water Monitoring Locations within the Plum Creek Watershed*

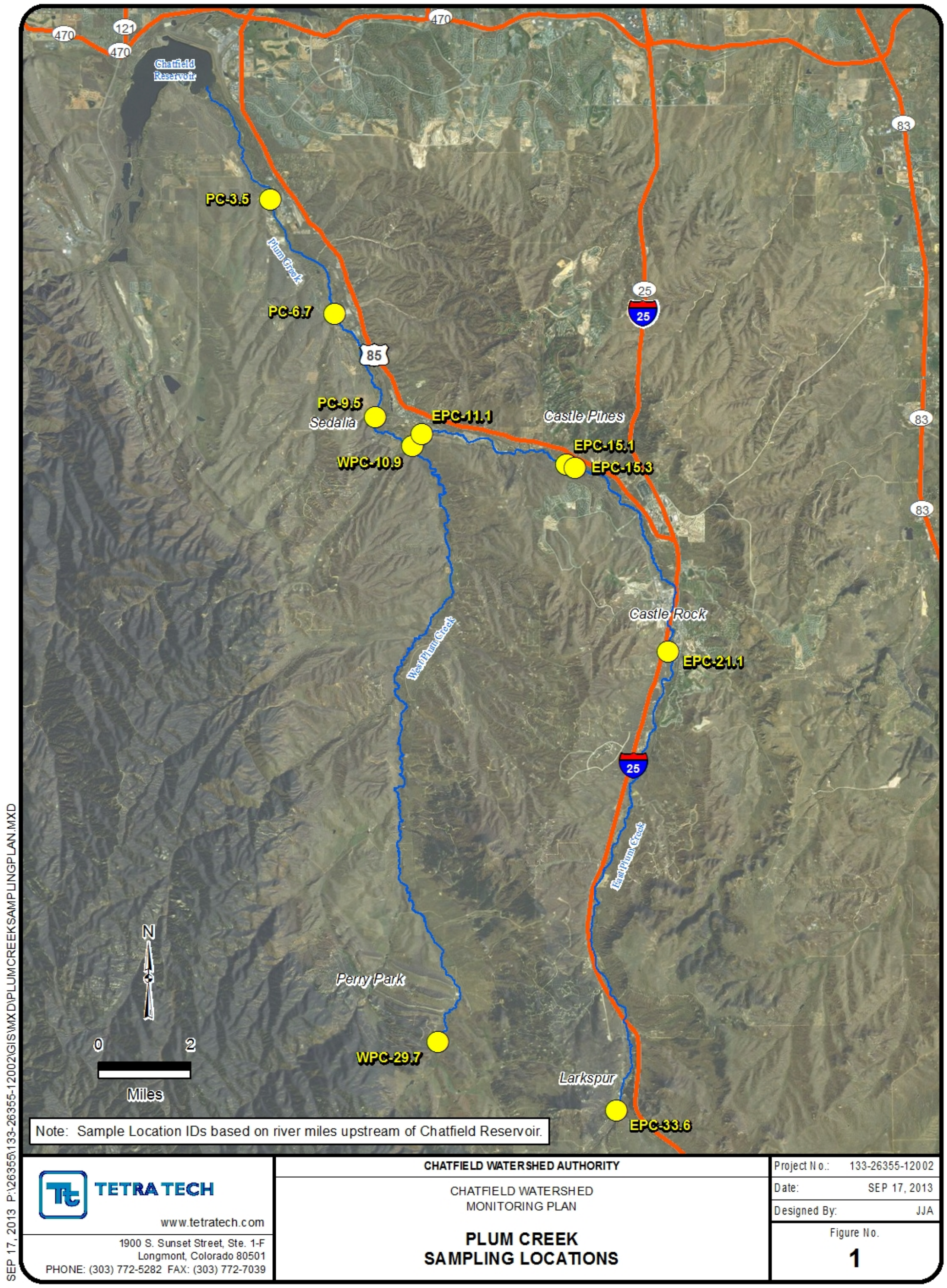

Table 1: Plum Creek Sampling Locations

Sample Identification*	Location	Reasoning for Sample Location	Potential NPS Influences
WPC-29.7	West Plum Creek, Near Perry Park	Background water quality condition of W. Plum Creek; in reach of native fishery	Sedimentation, stream bank erosion
WPC-10.9	West Plum Creek, Above Confluence with Plum Creek	Water chemistry contributions from rural land use/primarily agricultural zoning	Runoff from agricultural lands
EPC-33.6	East Plum Creek, Near Larkspur	Background water quality condition	Sedimentation, stream bank erosion
EPC-21.1	East Plum Creek, in Castle Rock	Urbanized area	Stormwater runoff
EPC-15.3	East Plum Creek, Upstream of PCWRA	Upgradient of WWTF discharge	Stormwater runoff from urban and non-urban areas
EPC-15.1	East Plum Creek, Downstream of PCWRA	Downgradient of WWTF	Stormwater and stream bank erosion
EPC-11.1	Near Sedalia, above confluence	Near Sedalia	Aged ISDS
PC-9.5	Plum Creek at Sedalia	In northernmost part of Sedalia	Aged ISDS
PC-6.7	Plum Creek Near Louviers, CO	Downstream of Louviers	Urban and anthropogenic impacts, runoff from rural lands
PC-3.5	Plum Creek At Titan Road	Near Titan Road Industrial Park, at USGS gaging station, near Chatfield Reservoir	ISDS, stream bank erosion, agricultural runoff from stables.

*Sample identification reflects initials of waterbody sampled and approximate number of river miles upstream from Chatfield Reservoir; therefore, WPC-29.7 is West Plum Creek, sampled approximately 29.7 miles upstream of Chatfield Reservoir.

Figure 2 – *East Plum Creek Upstream of Larkspur (EPC – 33.6)*

Figure 3 – *East Plum Creek Upstream of Confluence with West Plum Creek (EPC – 11.1)*

Figure 4 – *West Plum Creek near Perry Park (WPC-29.7)*

Figure 5 – *West Plum Creek Upstream of Confluence with East Plum Creek (WPC – 10.9)*

Insert New **Figure 6** of PC-9.5 (*Photo of Plum Creek @ 9.5 Miles (PC@9.5*)

Figure 7 – *Plum Creek near Louviers (PC-6.7)*

Figure 8 – *Plum Creek at Titan Road (PC-3.5)*

2.1 Constituents and Sampling Frequency

Surface water samples will be collected monthly (i.e., 4th week of every month) and analyzed for the parameters summarized in Table 2. PCWRA will coordinate annual scheduling of monitoring events with sampling staff. Samples from all sites will be analyzed for the parameters listed below.

Table 2 – Analyte List, Methods, and Analytical Labs for Surface Water Samples

	Constituent	U.S. EPA Method Number	Sample Preservation and Treatment	Holding Times	Analytical Lab
Field Parameters	pH	----	Measure In-Situ	Immediately	In-situ
	Specific Conductance	----		Immediately	In-situ
	Temperature	----		Immediately	In-situ
	Streamflow	----		Immediately	In-situ
	Dissolved Oxygen	----		Immediately	In-situ
Bacteriological	E. coli	SM 9223-B Enzyme Substrate	Chill to 4 degrees C	8 hours	PCWRA
Wet Chemistry	Alkalinity	SM2320-B - Titration	Chill to 4 degrees C	14 days	PCWRA
	Total Phosphorus	M365.1 Auto Ascorbic Acid	Chill to 4 degrees C	48 hours	PCWRA
	Ortho-Phosphorus	M365.1 Auto Ascorbic Acid	Chill to 4 degrees C	48 hours	PCWRA
	Nitrate-nitrite	SM 4500-NO3-I FIA	H_2SO_4 to pH<2, Chill to 4 degrees C	28 days	PCWRA
	Ammonia	SM 4500-NH3-H FIA	H_2SO_4 to pH<2, Chill to 4 degrees C	28 days	PCWRA
	Total Suspended Solids (TSS)	160.2 Gravimetric	Chill to 4 degrees C	7 days	PCWRA

Field measurements and surface water samples will be collected by PCWRA and Castle Rock staff and placed in sample bottles. Sample aliquots collected for dissolved analyses will be field filtered using a 0.45-micron filter. Upon collection, the samples will be processed, placed in a cooler with ice, and delivered under chain-of-custody procedures to PCWRA laboratory for analytical testing.

2.2 Nutrient Analyses

Analyses of nutrient species (i.e., phosphorous and nitrogen species) are necessary to assess 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. Additionally, these species are measured in order to evaluate the relative contributions of nonpoint sources to the Reservoir from various sources. As emphasized in the Chatfield Watershed Plan, nutrient management is a critical objective of the Authority's long-term watershed and reservoir management program. Analyses of nutrient species (i.e., phosphorous and nitrogen species) were necessary to assess the relative contributions of NPS to the watershed and reservoir from various nutrient sources such as fertilizers, animal and human waste.

2.3 Bacteriological Analysis

E. coli is often used as an indicator that waters are polluted with animal or human waste. In agricultural portions of the Plum Creek basin, sources of E. coli include failed septic systems, livestock manure, and wildlife.

2.4 Sediment Analysis

Sediments in the watershed also have a high mass loading of phosphorus per cubic yard of material, allowing it to enter waterways through sediment runoff and increase TP concentrations. When sediment enters Plum Creek, it smothers valuable aquatic habitat, damages riparian areas, fills in stream channels, increases the chance of flooding, contributes to the erosion of stream banks, reduces the storage volume and life of Chatfield Reservoir, and increases phosphorus loading from TP that absorbs to soil particles.

3. SAMPLE DESIGNATION

Surface water sample designation will identify the sample location and date of sample collection. The assigned sample identification will be divided into the following two fields:

WPCX.X-070114

The first field identifies the location of the sample (e.g., WPCX.X refers to West Plum Creek station X.X[1]). East Plum Creek and Plum Creek will be identified as EPC and PC, respectively. The second field contains the date in a month-day-year (MMDDYY) format and in the example above, sample collection occurred on July 1, 2014.

4. SAMPLING METHODS

4.1 In-Stream Water Sampling

Water samples are collected as grab samples. 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.

[1] The X.X refers to river mileage upstream of Chatfield Reservoir or upstream of the confluence of East Plum Creek and West Plum Creek.

A representative sample is obtained as near the centroid of flow as safety allows. If a site is dry, but a pool of water with a surface area greater than 1 m^2 and a depth greater than 10 cm is present, samples and field measurements are taken from that pool of water. On the field data form, note that the sample was not flowing water but ponded. A copy of the field forms are provided in Appendix A. Data from these ponded sites will be maintained but represented separately in monthly and yearly analyses. When suspended particles are unlikely to be uniformly distributed across the channel cross-section, a composite sample consisting of several grab samples is used. Large, non-homogeneous particles, such as leaves and detritus, should not be included in the sample.

Collection of in-stream water samples by container immersion is performed as follows:

1. Submerge the sample bottle below the water surface with the opening pointing upstream at the centroid of the stream flow.
2. The sampler will minimize the disturbance of bottom sediment.
3. Allow container to fill to the desired volume.
4. Sample containers containing preservatives are filled to just below the bottom of the container neck to prevent loss of preservative.
5. Remove container from the water.
6. Tighten sample container lid.
7. Decontaminate the sample containers outside surface by rinsing with distilled water or drying off with a clean paper towel.
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 container/cooler with ice as required.

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 or utilize new equipment.
3. Place the device at the centroid of stream flow facing upstream
4. Vigorously rinse the device three times with surface water.
5. Collect sample using transfer device.
6. Do not let transfer device contact anything except surface water.
7. Transfer sample directly into sample container from transfer device.
8. Do not overfill containers that have preservative.
9. Tighten sample container lid.

10. Decontaminate outside surface of sample container by rinsing with distilled water or drying off with a clean paper towel.
11. Complete all information on sample label.
12. Sign and date custody seal and place over the lid of sample container.
13. Place in a zip-lock plastic bag and seal.
14. Place bagged sample in a container/cooler with ice as required.

Reusable sampling equipment that comes in contact with environmental media will be thoroughly cleaned before use in the field and between sampling stations. The cleaned sampling equipment will be bagged between sampling stations in order to avoid environmental contamination. Personnel involved in sampling equipment preparation and sample collection and processing will wear clean, nitrile or latex gloves to protect themselves and to minimize the opportunity for sample contamination. Disposable sampling equipment will be discarded following sample collection. Disposable equipment must be new and sealed by the manufacturer to minimize the introduction of contaminants.

5. QUALITY CONTROL REQUIREMENTS

5.1 Sampling Quality Control Requirements

Field Quality Control (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.

5.2 Laboratory Measurement Quality Control Requirements

Detailed laboratory QC requirements are contained within each laboratory Quality Assurance Plan and are also specified in the EPA-approved analytical methods. The minimum requirements that all participants abide by are stated below.

Laboratory duplicates - Laboratory duplicates are used to assess precision. A laboratory duplicate is prepared by splitting aliquots of a single sample (or a matrix spike or a laboratory control standard) in the laboratory. Both samples are carried through the entire preparation and analytical process. Laboratory duplicates 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 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 1.

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 2 Laboratory Control Sample Percent Recovery

$$\text{Percent R} = SR * 100/SA$$

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 is 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), which 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:

Equation 3 Matrix Spike Percent Recovery

$$\%\ R = [(SSR - SR)/SA] * 100$$

Method blank- 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 than 5% of the lowest value of the batch.

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.

5.3 Quality Control Failures and Corrective Action

The PCWRA water chemistry lab manager, Chris Carson, 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 monthly status report and annual data report. Laboratory staff evaluates laboratory measurement failures. Dispositions of such failures and conveyance to the CWA are discussed under Failed Analytical Systems and Corrective Action section.

5.4 Instrument and Equipment Testing/Maintenance

All sampling equipment testing and maintenance requirements are detailed in the Chatfield Watershed Authority's Standard Operating Procedure (*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 the PCWRA laboratory's Quality Assurance Manual. Testing and maintenance records are maintained and are available for inspection by the consultant and/or CWA.

5.5 Instrument Calibration and Frequency

Detailed laboratory calibrations are contained within the PCWRA laboratory's Quality Assurance Manual and are also specified in the EPA-approved analytical methods. Table 3 lists field equipment calibrations.

Table 3 Field Equipment Calibration Requirements

Analysis	QC Elements	Frequency
pH	One Point Calibration	Each Day
Temperature	NIST Thermometer Cal.	Monthly
Specific Conductance	Control	Each Day
Dissolved Oxygen	Control	Each Day

5.6 *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 maintaining 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 documents are reviewed by the Project Manager to ensure that they include appropriate and adequate provisions to meet intended requirements.

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.

6. DATA MANAGEMENT AND REPORTING

Data obtained throughout the monitoring program (i.e., analytical data and water quality data) will be maintained by PCWRA in a Microsoft Excel database. As resources are available, Tetra Tech will analyze water quality data and evaluate the surface water monitoring results for temporal and spatial trends. Anomalous data will also be identified and flagged in the database so they are not used in statistical analyses.

As resources are available, monitoring data summaries will be provided in a user-friendly format, with graphical representations of tabular data analyzed by PCWRA for distribution to the TRC and Chatfield Board at scheduled meetings. Anticipated Plum Creek data analyses and information include the following:

- Seasonality graphical interpretations of Plum Creek watershed data (as sufficient number of data allows).
- Box and whiskers plots of Plum Creek data.
- Time series graphs of Plum Creek data.
- Identification of anomalous data.
- Laboratory procedures and MDLs.
- Comparison of monitoring results to standards and assessment thresholds
- Discussion of elevated concentrations at certain sampling locations; discussion of field conditions that may have contributed such concentration increase (i.e. large rainfall event occurred over the past 24 hours and the TSS concentration in Plum Creek was very high)
- Occasional data discrepancies or potential outliers.
- Follow up on field documentation and conditions (i.e. no free flow of river, only a stagnant puddle of water, etc.)

7. STANDARD OPERATING PROCEDURES

The Chatfield Watershed Authority's standard operating procedures (SOP), adopted by the Board in November 2007, describes the collection, preparation, and handling of surface water samples from streams and reservoirs, alluvial well, and sediment samples (Chatfield Watershed Authority, 2007). These SOPs are applicable to the water quality monitoring program for the Plum Creek watershed and incorporated by reference. SOPs are used in conjunction with this SAP that defines sample locations, schedules, list of analytes, and quality assurance/quality control (QA/QC) procedures.

8. REFERENCES

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