BOX ELDER CREEK NUTRIENT-ADDITION PROJECT: 2010 DOSING STUDY

Sampling and Analysis Plan

Prepared By:

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Water Quality Standards Section, Water Quality Planning Bureau
P.O. Box 200901
Helena, MT 59620-0901

Approvals

_____	_____
Michael Suplee, Ph.D. (WQ Standards Section)	Date
_____	_____
Rosie Sada (Monitoring & Assessment Section Supervisor)	Date
_____	_____
Dave Feldman (WQ Standards Section)	Date
_____	_____
Steve Fernandes (Monitoring & Assessment Section)	Date
_____	_____
Mindy McCarthy (QA Officer)	Date

TABLE OF CONTENTS

1.0 Introduction and Background Information 1

2.0 Objectives and Design of the Investigation.....1
2.1 Project Objectives 1
2.2 Sampling Timeframe 1

3.0 Field Sampling Methods.....1
3.1 Re-establishment of Study Reaches 1
3.2 Meteorological Measurements. 2
3.3 Flume Installation and Use 2
3.4 Nutrient Solution Tanks and Delivery System-Installation 2
3.5 Stream Nutrient Uptake Length (Nutrient Spiraling Study).....3
3.6. Initiation and Maintenance of Nutrient Additions.....4
3.7. Visual Estimates of Benthic Algae and Macrophyte Coverage.....5
3.8 Measurement of Physical Parameters 5
3.8.1 Cross-check Measurements 5
3.8.2 Continuous Water Quality Measurements (YSI Sondes) 5
3.9 Water Sample Collection 6
3.10 Benthic Chlorophyll *a* and Periphyton Samples.....7
3.11 Macroinvertebrate Samples 8
3.12 Hydraulic Measurements 9

4.0 Sample Handling Procedures.....9

5.0 Laboratory Analytical Measurements 10

6.0 Quality Assurance and Quality Control Requirements 11

7.0 Data Analysis, Record Keeping, and Reporting Requirements 11

8.0 Schedule 12

9.0 Project Team and Responsibilities 12

10.0 References.....13

Appendices (YSI Pre- and Post-Deployment Forms, algae visual assessment form 15

1.0 Introduction and Background Information

Relevant background information is found in the project's approved QAPP, section 2.0. The following SAP applies to year 2 of the four year stream nutrient-addition study.

DEQ is working closely with the Carter Country Conservation District (CCCD) on the implementation of this project, particularly in this, year 2, when CCCD staff will actively maintain the study throughout the summer. The CCCD Board met on June 9, 2009, and approved the project, and again indicated their ongoing support in a March 2010 meeting. All necessary instream work permits (404, 124) have been acquired. Consultation with DEQ's Permitting Section indicated that we would not request a permit for release of the N and P solutions into the stream.

2.0 Objectives and Design of the Investigation

2.1 Project Objectives

The goals and basic project design have been presented in the project QAPP, in sections 2.0 and 3.0. Please refer to that document for details.

2.2 Sampling Timeframe

Sampling will occur from early July 2010 to the end of September, 2010. Sample collection will occur 5 times in each of three study reaches at approximately 3-week intervals (see projected calendar, Section 8.0). YSI 6600s will be continuously deployed in each of the three study reaches from mid-July to end-September, with possible extension of YSI deployment for another week into October, to be determined based on discussion among project participants.

3.0 Field Sampling Methods

3.1 Re-establishment of Study Reaches

In 2009 three study reaches were established; the Control reach (150 m long), the Low-Dose reach (200 m), and the High-Dose reach (200m). At the end of the 2009 field season the midpoint (transect F) of each reach was benchmarked. These will be relocated and each reach laid out to its 2009 dimensions, including specified run, riffle, and pool proportions. Slight modifications to the 2009 layouts may occur to account for any geomorphic changes the winter and springtime high flows may have caused.

3.2 Meteorological Measurements

The independent Hobo weather station installed by DEQ in 2009 alongside Box Elder Creek will be relocated in its original location in 2010. Measurements will be the same and occur from early July to the end of September.

3.3. Flume Installation and Use

Nine inch Parshall flumes will be installed at a) the head of the Low Dose reach and b) the head of the High Dose reach. These will allow flow to be easily monitored in order to make adjustments to the nutrient delivery rate. This will be done in accordance with conditions in the Corp of Engineer's 404 and MT Fish, Wildlife and Parks 124 permits. Wayne Yost (NRCS office, Ekalaka, MT) will loan DEQ the use of two flumes for the summer, and assist with their installation. Sandbags filled with local sand (very abundant at the site) will be use to channel water through the flumes. Georgia Bruski (CCCD) will be trained on how to read flow gages on the flumes and derive stream flow (in CFS) from standardized look-up tables. Open channel flow measurements (Marsh –McBirney) will be taken after flume installation as a cross-check.

3.4 Nutrient Solution Tanks and Delivery System- Installation

In early July, the tanks and associated delivery lines will be set up and tested for leaks following the design shown in Fig. 3.0. The 12 v DC electric circuit that shuts the system down in case of free-flow will be installed and tested. The 12 v battery will be maintained to full charge via a solar panel and charge regulator installed at each tank site.

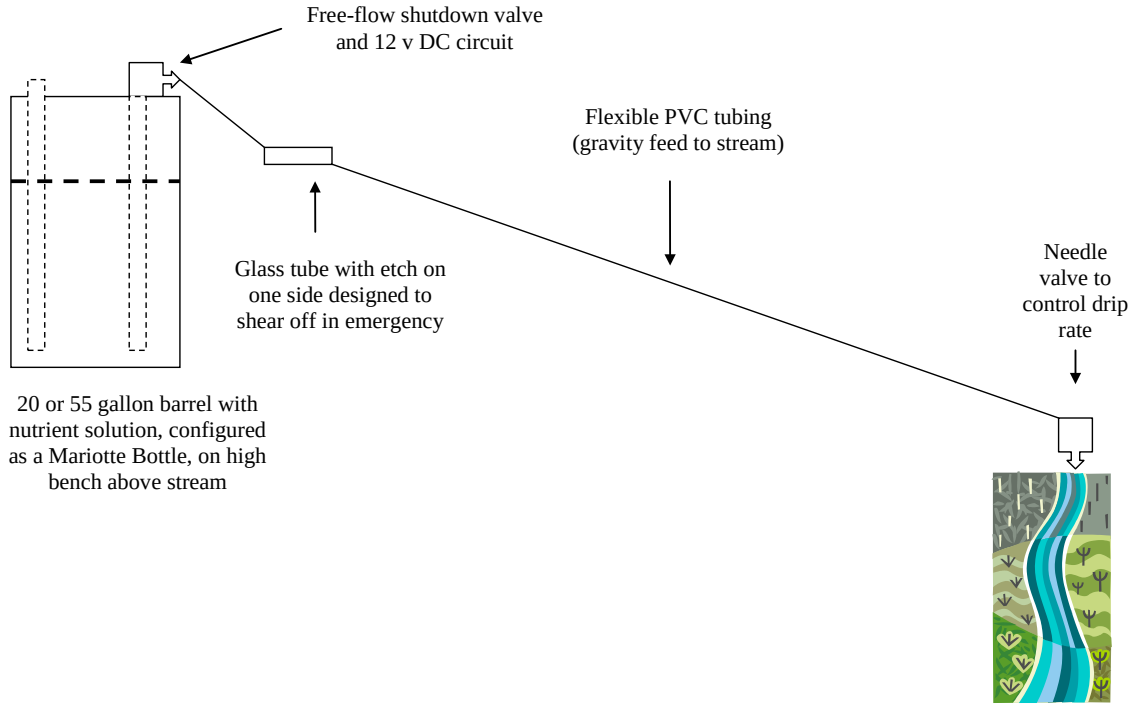

Figure 3.0. Diagram of a basic tank and nutrient solution delivery system.

Once set up, the size of drops delivered by each tank system will be checked. These may vary somewhat from system to system due to differences in delivery line length, height above channel, etc. This information will be input into the dose calculator spreadsheet (DoseCalc_CarterCD_FNL.xls) as needed.

3.5 Stream Nutrient Uptake Length (Nutrient Spiraling Study)

Following the final 'Before' data collection, but prior to the initiation of the full nutrient dosing study, a 1-day experiment will be undertaken. The purpose is to estimate the stream length (S_w) necessary for added nitrate to have time to be taken up by biota within the experimental reach. It will likely occur around July 14th. Work will be carried out at the High-Dose reach, using the nutrient dosing tanks and delivery systems that will have already been installed and tested.

Sodium nitrate solution will be added to one of the tank and delivery systems, and sodium bromide (NaBr) solution to the other. Sodium nitrate solution will be prepared to the standard strength (400 g $NaNO_3$/L), whereas the sodium bromide solution strength (likely to be 100-250 g NaBr /L) will be decided after determining the stream's ambient Br^- concentration. A spreadsheet, "SpiralingCalc_FNL.xls" was prepared in order to run all necessary calculations in the field and to determine ambient stream bromine concentrations.

Box Elder Cr's ambient bromine concentration is unknown, but likely ranges from 0.008 to 0.3 mg/L (Flury and Papritz 1993). This range is well below the ion-selective probe's detection level (DL; 0.4 mg Br^-/L). Therefore, to determine the ambient bromine concentration:

- A 1 L solution will be made by mixing a pre-prepared bromine solution (15 mg NaBr/L[1]; 11.65 mg Br^-/L) and ambient stream water. Targeting a final concentration >1 mg Br^-/L, well above the probe's DL, the prepared solution's bromine concentration will then be measured with the probe. Then, using the spreadsheet, the stream's ambient bromine concentration can be back calculated. This calculated ambient value will be used in the dose-rate calculations for the bromine tracer.

No MT water quality standard exists for bromine, but literature shows that the most sensitive freshwater aquatic organism tested (*Daphnia magna*) had a no observed effect concentration of 2.3 mg Br^-/L (Flury and Papritz 1993). Flury and Papritz (1993) also show that other freshwater organisms (e.g., fish) demonstrate no-effects levels within much higher ranges, i.e. 8 to 2,500 (and higher) mg Br^-/L and it recommend that bromine concentrations be kept below 1 mg Br^-/L. Therefore, tracer concentrations in Box Elder Cr will be targeted to be kept below 1 mg Br^-/L.

Three stepwise nitrate enrichment treatments will occur, as follows:

- 40 µg NO_3-N/L
- 80 µg NO_3-N/L
- 120 µg NO_3-N/L

[1] In the LCG laboratory, the NaBr compound will be dried at 100° C for two hours and then held in a desicator prior to weighing and solution preparation.

Delivery of the $NaNO_3$ and NaBr solutions to treatment one (40 µg NO_3-N/L) will begin simultaneously. The Br- tracer solution will be added in treatment one to achieve a final concentration of 0.4 or 0.5 mg Br^-/L. Addition of both solutions will continue until the bromine solution strength at the bottom of the reach (200 m) has reached full strength (approx. 1-1.5 hrs), as determined via the probe. Nitrate+nitrite (NO_3+NO_2) water samples will then be collected at transects spaced every 20 meters. Bromine concentration will also be measured midstream at each transect using the probe. Duplicate NO_3+NO_2 samples will be collected at three randomly selected transects.

After water sample collection for treatment one is complete, the nitrate drip rate will be increased to achieve the next target dose for treatment two. The Br- tracer dose will be increased to 0.5 or 0.6 mg Br^-/L. Both nitrate and Br- tracer will be added simultaneously and the Br- concentration monitored, as before, until it plateaus. Sample collection will proceed as for treatment 1, except that the 3 transects where duplicate water samples are collected will be randomly selected again.

The third and final treatment will follow the second. If stream flow has remained stable and the time-to-plateau of the Br- concentration has been fairly consistent for treatments 1 and 2, the Br- tracer dose will not be increased; we will simply use the time-to-plateau previously measured. If stream conditions have changed, another, higher-level tracer addition will be introduced. Sampling collection at transects for NO_3+NO_2 and bromine will proceed as before.

Finally, wetted width and depth will be measured every 10 meters (20 total). Five (5) depth locations across each transect will be measured, per EMAP methods (R, RC, C, LC, L).

3.6 Initiation and Maintenance of Nutrient Additions

Low-Dose reach and High-Dose reach nutrient additions will commence on the same day, around mid July. The dose calculator spreadsheet "DoseCalc_CarterCD_FNL.xls" will be used to determine the addition rates for N and P. **Nitrogen tanks will be white, phosphorus tanks will be blue.** From the initiation day forward, Georgia Bruski (CCCD) will visit the site approximately every other day and reset the delivery rates, as needed, based on stream flow changes. Nutrient solutions will be prepared in Ekalaka, MT and brought to the site and added to the tanks. Ms. Bruski will be trained in the use of all equipment and solution preparation, per the QAPP.

DEQ staff will measure stream SRP and (if time allows) nitrate concentrations during its periodic visits, and adjustments to ambient values used in calculations may occur. <u>See Section 4.2 of the QAPP for details.</u>

QC of nutrient solutions. During DEQ visits, samples will be collected from the nutrient dosing solutions (N and P) being routinely prepared in Ekalaka. If time allows, their concentrations will be tested *in situ* with the Hach DR890. Samples will also be collected for delivery to the DPHHS laboratory. <u>The DPHHS laboratory must be made aware that the concentrations in these samples are extremely high!!!!!</u>

3.7 Visual Estimates of Benthic Algae and Macrophyte Coverage

Algal growth is likely to change rapidly after nutrient additions begin and may outstrip the planned quantitative sampling intervals. Therefore, biweekly, or at least weekly, visual estimates will be undertaken following the 11 transects visual estimation method of EMAP (Lazorchak *et al.* 1998), in each study reach. The form in the appendix (page 17) will be used for this purpose. Georgia Bruski (CCCD) will be trained in its use.

During each DEQ visit, digital photographs will be taken at each transect of each study reach. Georgie Bruski (CCCD) will take photo series more often, on an *ad hoc* basis. The objective of the photos is to document visible changes in the stream flora as time passes, and as such photos may be a mix of close-ups and stream panoramas. The photo number will be recorded along with the transect identification and the study unit ID. A minimum of one photo per transect will be taken.

3.8 Measurement of Physical Parameters

Water quality will be measured using YSI meters, the YSI85 hand-held model and/or YSI 6600 sonde. The YSI 85 will be used to collect *in situ* data during each site visit and the YSI 6600s will be deployed to collect continuous data at each site throughout the study.

3.8.1 Cross-check Measurements

A YSI 85 or YSI 6600 will be used to measure temperature, pH, DO (mg/L and % saturation), and conductivity at each study reach. These data will be used mainly as periodic cross-checks of the continuously collected YSI 6600 data. See calibration details, Section 6.0. This will occur during the start of each of DEQ's planned visits.

3.8.2 Continuous Water Quality Measurements (YSI 6600 Sondes)

YSI 6600 Sondes. Water temperature, pH, DO, specific conductivity, turbidity, and chlorophyll *a* (Chl*a* is <u>optional</u>) concentrations will be continuously monitored from at least one week before nutrient additions begin, and then until September 30th, 2010. Data will be logged every 15 min. They have a memory capable of storing up to 90 days of logged data, although a YSI representative indicated that 60 days in a more prudent timeframe. YSI's website states that the 6600 sondes have a 75 day battery life at 15 min logging intervals. The sondes will be calibrated in the laboratory according to the manufacturer's instructions (YSI 2006; YSI 2009), and checked again in the field prior to deployment (see Section 6.0). The following shows the planned placement of continuously deployed YSI sondes:

- **Control reach**: One sonde (mounted to deployer) at the same location as 2009.
- **Low-Dose reach**: One sonde (mounted to deployer) at 2009 location, and a 2nd sonde (mounted to deployer) in the pool at the bottom of the study reach, near flag A.
- **Upstream of High-Dose reach**: One sonde (mounted to deployer) placed just upstream of the head of High-Dose reach, above the nutrient addition equipment and flume.

- **High-Dose reach:** One sonde (mounted to deployer) at 2009 location, and a 2nd sonde (mounted to midstream fencepost) in the pool at the bottom of the study reach, near flag A.

Six sondes total will be deployed. To minimize problems due to biofouling, the sondes will be checked and cleaned of growth weekly by Georgia Bruski (CCCD) or DEQ staff. If a probe fails and replacement and recalibration is required, instrument drift (probe reading *vs.* a standard) will first be recorded prior to re-calibration. Data will be downloaded from the sondes at least twice prior to September 30th, and memory cleared towards the end of the study to assure adequate memory.

Upon sonde retrieval at the *end* of the project, sonde readings will be compared to laboratory standards for pH, conductivity, etc. to determine calibration drift. (See QAPP for drift criteria, section 4.1.) DO drift will be checked by using the sonde to measure DO via the single-point, water-saturated air method (YSI 2006).

3.9 Water Sample Collection

See Table 8.1 of this SAP for the scheduled water sampling.

Water samples will be collected from each study reach after completing *in situ* YSI measurements.

- Water samples will be collected towards the downstream end of each study reach to assure the full affect of the treatment has occurred. The only exceptions are samples collected just upstream of the headwaters of the High-Dose reach.

Stream water samples will be placed in acid-washed polyethylene bottles. Sample replicates will be randomly taken on 10% of the total samples for each parameter. Field blanks and filter blanks will be made during each sampling run ("trip") to evaluate contamination and detection levels under field conditions.

- The site just above the headwaters of the High-Dose reach shall be sampled, on the same schedule as the other sites, for phytoplankton Chl*a* , nutrients, and CNP.

For Soluble Nutrients: For nitrate + nitrite (NO_{2+3}), ammonia, and SRP samples, water from each sample will be filtered through a 0.45 um filter. Then 250 ml of the filtrate will be placed in a HDPE bottle and frozen until analyzed (Table 3.1). Filtration will be accomplished with a large syringe connected to a disposal filter capsule or a reusable filter holder. A small amount of deionized water followed by a small amount of the sample will be wasted through the filter before the filtered sample is collected. All reusable gear will be acid washed (10% HCl) and triple rinsed in deionized water between uses. All sample bottles will be high-density polyethylene (HDPE). All sample bottles will be new. Sample bottles will be pre-rinsed with a small amount of the filtered sample before collecting the final filtered sample.

For Total Nutrients, TSS & TDS, Turbidity, Common Ions, and Biochemical Oxygen Demand (BOD_5): Summary information is in Table 3.1. A 250 ml HDPE bottle will be collected for TP and TN and immediately frozen. Common ions will be collected in two 250 ml HDPE bottles and held on ice (not frozen). Sample frequency for common ions will likely be reduced to every other DEQ visit. One bottle will be tested for cations (including hardness and cation/anion balance) and the other for anions (including total alkalinity). The common cation sample will be preserved with nitric acid and held on ice (not frozen). The common anion sample will be held on ice (not frozen). TSS and TDS will be collected in a 500 ml HDPE bottle and held on ice (not frozen). NOTE THE SHORT HOLDING TIME FOR TSS & TDS. All sample bottles will be new. Biochemical oxygen demand (BOD) will be collected in a 1000 ml HDPE bottle and held on ice (not frozen). NOTE THAT BOD SAMPLES MUST BE AT THE LAB WITHIN 48 HRS!

For water column sestonic CNP samples: AFDW will be determined on GF/F filters used to filter known volumes of stream water (Section 10300 C; APHA 1998). (AFDW can be determined from the samples discussed in the next paragraph.) Two samples of known volume from each study reach, including just upstream of the High-Dose reach, will be collected on GF/F filters and stored in 50 cc centrifuge tubes on ice (*not* frozen). **Equal volume of water must be filtered on to each of these filters.** Do not fold. Vacuum on the filters will be kept below 9.0 inches Hg to prevent cell rupture and loss of their contents into the filtrate (Wetzel and Likens 1991). At the LCG Water Laboratory in Helena, one of the filters (for C & N analysis) will be placed on a filter holder and rinsed with 10% HCl until they stop fizzing, to remove inorganic carbonates (Niewenhuize et al., 1994). 50 ml tap water will then be pulled through it to remove the acid, and then it will be dried at 105 ^{o}C. The remaining filter (for P analysis) will be dried directly.

For phytoplankton Chl *a* and AFDW: Known volumes of water — which should match the same volume used for the CNP filters—will be filtered on to 2 different GF/F filters until a distinct green color is observable on each filter. Vaccum must be held below 9 inches Hg. Filters are folded in half (green side in), put in centrifuge tubes & frozen (dry ice).

3.10 Benthic Chlorophyll *a* and Periphyton Samples

See Table 8.1 of this SAP for the scheduled sampling.

For benthic Chl*a*: Benthic Chl*a* monitoring will generally follow the DEQ SOP (URL below). Benthic Chl*a* samples will be taken using either the template, hoop, or core method at established transects, depending upon what is appropriate for each sub-location. *See SOP at* http://www.deq.state.mt.us/wqinfo/QAProgram/SOP%20WQPBWQM-011v4_final.pdf.

For PERI-1 diatom samples: Within each study reach (Control, Low-Dose, High-Dose), a qualitative composite periphyton sample will be taken for species presence following DEQ's "PERI-1 mod" method except that (as for Chl *a*) the reach length and distance between transects will be established by the length of the study unit, not by stream wetted width. Periphyton material will be placed in a 50 ml centrifuge tube and preserved with formalin (Table 3.1). Samples will be provided to a DEQ-approved laboratory for identification and counting.

Table 3.1. Sampling Volumes, Containers, Preservation, and Holding Times

Analyte	Bottle Size	Container	Preservation and Storage	Holding Time
TP, TN	250 ml	HDPE bottle	Freeze (dry ice)	45 days
NO_2+NO_3, NH_3+NH_4, and SRP	250 ml	HDPE bottle	Field filter 0.45 µm & freeze (dry ice)	45 days
BOD_5	1000 ml	HDPE bottle	Cool to <4°C (on ice)	2 days
TSS, TDS	500 ml	HDPE bottle	Cool to <4°C (on ice)	7 days
Common Cations (including hardness)	250 ml	HDPE bottle	1.5 ml conc. HNO_3, cool to <4°C (on ice)	28 days
Common Anions (including total alkalinity)	250 ml	HDPE bottle	Cool to <4°C (on ice)	14 days
Benthic chlorophyll a (template method)	50 ml	Centrifuge tube	Freeze, dry ice	45 days
Benthic chlorophyll a (hoop method)	n/a	Large freezer storage bag	Freeze, dry ice	45 days
Benthic chlorophyll a (core method)	50 ml	Centrifuge tube	Freeze, dry ice	45 days
Chlorophyll a (phytoplankton : water sample)	50 ml	Centrifuge tube	Freeze, dry ice	45 days
Macroinvertebrates (species presence & biomass)	1000 ml	HDPE bottle	ETOH	n/a
Periphyton (species presence)	50 cc	Centrifuge tube	formalin	n/a
Water column C&N	50 cc	Centrifuge tube	Cool to <4°C (on ice)	Process ASAP in Helena; afterwards, unlimited
Water column P	50 cc	Centrifuge tube	Cool to <4°C (on ice)	Process ASAP in Helena; afterwards, unlimited

3.11 Macroinvertebrate Samples

See Table 8.1 of this SAP for the scheduled sampling.

All macroinvertebrate samples collected under this SAP will be collected following a modification of the EMAP-RW sampling protocol (Lazorchak et al. 1998). The macroinvertebrate samples will be collected from the same transects (but not the same locations on each transect) as the periphyton samples. Samples will be provided to a DEQ-approved laboratory for identification and counting. In addition to standard taxa IDs and counts, samples will have an additional sorting of an equivalent number of grids, followed by ashing of the macroinvertebrates from the additional grids. This will provide macroinvertebrate biomass per unit area of stream bottom (g AFDW/m^2).

These steps will be followed to collect macroinvertebrate samples:

1. The sampler should randomly decide whether to start at R, C, or L of transect A (most downstream). ***Note: "right bank" and "left bank" are determined by facing downstream.***

2. Collect a 30-second kick sample at each transect within the study unit. The kick sample will be collected by vigorously disturbing a 1 ft square area of the substrate immediately upstream of the net.

3. After the first sample is collected at transect A (either at the right, center, or left part of the transect), the sampler will proceed upstream to transect B. At B, the sampler will collect the next sample from the appropriate point within the following collection sequence: right-center-left (e.g., if A was sampled "center", B would be sampled "left").

4. One co-located replicate from one study reach will be taken during 2 (at most 3) of the five planned sampling events. The study unit and sampling event from which the replicate is to be taken will be picked randomly. The replicate sample will be collected in the same manner as the initial sample, however, the sampler will follow the mirror image collection pattern. It will be assured that sampling locales do not overlap with the diatom sampling.

5. Kick samples from each transect will be transferred to the sample bottle. The kick samples from each transect will be composited together in the bottle. ***Ninety-five percent* e*thanol (ETOH) will be added to the bottle after a kick sample is completed at each transect.*** After the bottle is half full with detritus, the sampler will begin to use another bottle. The sampler will fill the bottle with 95% ETOH and a label the bottle. Each replicate will be contained in its own bottle(s).

6. The crew will inventory all sample bottles collected at the site on the DEQ site visit form. Each bottle will be closed tightly, and sealed with Parafilm-M.

3.12 Hydraulic Measurements

During each DEQ visit, at each of the three reaches, 3 cross-sections representative of the reach as a whole will be measured for water depth at 5 equidistant points across the channel.

4.0 Sample Handling Procedures

This project follows the WQPB "internal process". Appropriate storage times for water quality samples are shown in Table 3.1 above. Chlorophyll-a samples will be delivered to the laboratory of Dr. Vicki Watson (University of Montana, Missoula), all other chemistry samples will be delivered to the DPHHS laboratory (Helena) by the Monitoring and Assessment section staff after each sampling trip. The periphyton samples will be sent to the Philadelphia Academy of Sciences. The macroinvertebrate samples will be delivered to *Rhithron Associates, Inc.* (Missoula). The location of where particulate CNP samples will be analyzed is still pending but most likely will be carried out by the University of Montana.

5.0 Laboratory Analytical Measurements

TABLE 5.1 Analytical Methods and Required Detection Limits.

Analyte	Method	Analytical Detection Limit
Total Phosphorus (TP)	EPA 365.1	0.001 mg/l
Total Nitrogen (TN)	4500-N B or C	0.01 mg/l
Nitrate + Nitrite-Nitrogen (NO_2+NO_3-N)	EPA 353.2	0.001 mg/l
Total Ammonia-Nitrogen (NH_3+NH_4-N)	EPA 350.1	0.01 mg/l
Total Suspended Solids (TSS)	EPA 160.2	10 mg/l
Total Dissolved Solids (TDS)	EPA 160.1	10 mg/l
Soluble Reactive Phosphorus (SRP)	EPA 365.1	0.001 mg/l

Table 5.2. Further Analytical Methods and Required Detection Limits.

Analyte	Preferred Method	Req. Report Limit (µg/l)
Specific Conductance	SM2510B	
Sulfate	EPA 300.0	50
Chloride	EPA 300.0	50
Alkalinity (Bicarb., Carb.)	EPA 310.2/A2320 B	1000
Calcium, Magnesium, Potassium, Sodium	EPA 200.7	1000
Total Hardness as $CaCO_3$	A2340 B (Calc)	1000
Sodium Absorption Ratio (SAR)	Calc	
Cation-Anion Milliequivalent	SM 1050 A	
BOD_5	SM 5210 B	4000
Chlorophyll-a	A 10200 H	
Ash Free Dry Weight (AFDW)	A 10300 C (5)	

Reporting limits for water column sestonic CNP are as yet unknown as a laboratory has yet to be identified. However, for the 2007 Yellowstone River QUAL2K model project, the University of Montana achieved detection limits of 0.03 mg C/L, 0.002 mg N/L, and 0.0003 mg P/L.

6.0 Quality Assurance and Quality Control Requirements

This project will follow the WQPB "internal process". All QA/QC requirements followed by MT DEQ will be instituted for this project. The QA/QC requirements are described in MT DEQ (2005) or the project QAPP.

YSI Calibration:

YSI 85 & YSI 6600EDS or V2-4s: The pH will be calibrated in the laboratory using the two-point method using pH 7.0 and 10.0 standards, and checked against a 7.0 standard at the start of each day's measurements. Just prior to measurement, DO will be calibrated using the single-point, water-saturated air method (YSI 2006). Conductivity will be calibrated using a 1000 µS/cm standard in the laboratory and checked monthly. All calibrations will be recorded in the instruments' logbooks.

Deployed YSI V2-4s only: Calibrations will be carried out in the LCG building laboratory in Helena. Turbidity will be calibrated in the using the two-point method using 0 and 126 NTU standards, followed by a drift-test benchmark using the 12.7 NTU standard. DO will be calibrated using the air-saturated water method (a 5 gallon bucket sparged with air via an airstone for 1 hr)(see page 6, YSI 2009). The pH will be calibrated using the two-point method (7.0 and 10.0 standards), followed by a drift-test benchmark using pH 8.0 standard. Chl *a* measurements recorded by the YSI 6600s are made using a fluorometric probe, and are relative; that is, to determine the true stream Chl *a* values, they must be regressed against laboratory-measured Chl *a* samples, collected separately from the stream at the same location[2]. To check instrument drift, the Chl *a* probe will be benchmarked against a 2% Rhodamine WT dye standard (YSI, 2006). Calibrations will be recorded using the first form in the Appendix.

YSI Sondes – Post Deployment

Instrument drift will be checked and recorded post-deployment on standard forms (Appendix, form 2) for pH and DO (immediately, in the field), while turbidity, EC, and Chl *a* (if Chl *a* is measured) drift will be checked in the water laboratory in Helena within two weeks after the instruments have been retrieved from the streams. Drift criteria have been presented in the project QAPP.

7.0 Data Analysis, Record Keeping, and Reporting Requirements

This project will follow the WQPB "internal process". Site Visit/Chain of Custody forms, field forms digital photos, and lab will be processed by WQPB staff following QA/QC procedures as indicated in section 6.0. The GPS coordinate system datum used will be NAD 1983 State Plane Montana, in decimal degrees, to at least the third decimal.

---

[2] At least 4 Chl *a* water samples will be collected at each long-term sonde deployment site during the course of the study in order to calibrate the probe measurements.

8.0 Schedule

The following table, very slightly modified from the project QAPP, outlines the planned schedule. As stated in Section 3.5, the nutrient spiraling study will occur after the last 'before' sampling but prior to the commencement of the nutrient dosing.

Prior to departure to the field, Michael Suplee will prepare a detailed equipment checklist to assure all necessary equipment has been packed and checked.

Table 8.1. 2010 schedule for Box Elder Creek data collection. Numbers represent number of samples to be collected. Data collection includes one before event, and four after events.

BACIP Period	Month & Days	Reach	Macro-invertebrate samples (composite)	Peri-1 mod samples (composite)	Benthic Chl *a* (No. replicates)	Phytoplankton Chl*a* *	Continuous Monitoring (DO, pH, temperature, SC, turbidity, Chl*a*)	Sestonic CNP*	Nutrients (N & P)*, TSS, TDS, common ions	BOD_5	Visual Assessment of Bottom Algae Cover	Weather Station (air temp, wind speed/direction, solar radiation, relative humidity)
Before	~July 12	Control	1	1	11	2	24/7, 15 min time-step	1	1	1	Biweekly	24/7, 15 min time-step
Before	~July 12	Low Dose	1	1	11	2		2	1	1		
Before	~July 12	High Dose	1	1	11	2		1	1	1		
Nutrient Dosing Begins about July 15th												
After	~ Aug 3	Control	1	1	11	2		2	1	1		
After	~ Aug 3	Low Dose	1	1	11	2		2	1	1		
After	~ Aug 3	High Dose*	1	1	11	4		4	2	1		
After	~ Aug 22	Control	1	1	11	2		2	1			
After	~ Aug 22	Low Dose	1	2	11	2		2	1			
After	~ Aug 22	High Dose*	1	1	11	4		4	2			
After	~ Sept 9	Control	1	1	22	2		2	1	1		
After	~ Sept 9	Low Dose	2	1	11	2		2	1	1		
After	~ Sept 9	High Dose*	1	1	11	4		4	2	1		
After	~Sept 30	Control	1	1	11	2		2	1	1		
After	~Sept 30	Low Dose	2	1	11	2		2	1	1		
After	~Sept 30	High Dose*	1	1	11	4		4	2	1		

* For simplicity, the new site just upstream of the head of the High-Dose reach has been lumped with the High-Dose reach. Phytoplankton Chl*a* , CNP, and nutrients will be collected at this site during each visit.

9.0 Project Team and Responsibilities

The project in 2010 will be carried out by field crews of the MT DEQ. Michael Suplee (Water Quality Standards Section) is in charge of overall project design, and will assist with field training and oversight. Michael Suplee and Rosie Sada (Monitoring & Assessment Supervisor) will train Georgia Bruski (CCCD) in all areas for which she has responsibility (see Section 7.0, QAPP). Dave Feldman (Water Quality Standards Section) is in charge of macroinvertebrate sampling design and training of crews for macroinvertebrate sampling, and assistance with other field training and sampling. Rosie Sada (Head, Water Quality Monitoring Section) will directly oversee field crews and is in charge of field training and project implementation. Stephen Fernandes of the Monitoring Section has been assigned as lead field person on this project.

10.0 References

APHA (American Public Health Association), 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. APHA, Washington, D.C.

Flury, M., and A. Papritz, 1993. Bromide in the Natural Environment: Occurrence and Toxicity. Journal of Environmental Quality 22: 747758.

Lazorchak, J. M., D. J. Klemm, and D. V. Peck. 1998. Environmental Monitoring and Assessment Program-Surface Waters: Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams. EPA/620/R-94/004F. Washington, D.C.: Office of Research and Development, United States Environmental Protection Agency.

MT DEQ (Montana Department of Environmental Quality), 2005. Quality Assurance Project Plan (QAPP) Sampling and Water Quality Assessment of Streams and Rivers in Montana, 2005. *Available at* http://www.deq.state.mt.us/wqinfo/QAProgram/WQPBQAP-02.pdf.

Nieuwenhuuize, J., E.M. Maas, and J.J. Middelburg, 1994. Rapid Analysis of Organic Carbon and Nitrogen in Particulate Materials. Marine Chemistry 45: 217-224.

Wetzel, R.G., and G.E. Likens, 1991. Limnological Analyses, 2nd Edition. Springer-Verlag, New York, p 391.

YSI (Yellow Springs Instruments, Incorporated), 2006. YSI 6-Series Manual Supplement: Configuration and Deployment Instructions for YSI Model 6600EDS Sondes. Item No. 655467.

YSI (Yellow Springs Instruments, Incorporated), 2009. Calibration Tips for YSI 6-Series Sondes and Sensors. YSI Incorporated, 1/26/2009.

Appendices (next page)

YSI Sondes: Pre-Deployment Form

Sonde:_____

Serial No.:_____

☐ Completed all probe installations, initialization procedures, date, etc.?
Date: _____

☐ Completed run test for unattended deployment?
Date: _____

☐ Calibrations Completed

	Parameters	Date	# of Points	Low Point	High Point	Calibrant used and lot # of calibrant	Parameter drift: pre-deployment benchmark	Temp °C	Barometric Press. mmHg or inHg	Initials of Operator
1	pH									
2	Conductivity									
3	Turbidity									
4	Chlorophyll-a									
5	Dissolved 0_2									

☐ Launched unattended deployment?

Date Start: _____ Time Start:_____

Launch Date: _____ Logging Interval:_____

File Name: _____

Launch Location: _____

YSI 6600 Sondes: Post-Deployment Form

Sonde: _____

Serial No.: _____

Retrieval Date (m/d/yr) & Time: _____

Condition Upon Retrieval:

File Name: _____

File Termination Date (m/d/yr) & Time: _____

Calibration Drift Tests

Parameter	Date Calibrated (m/d/yr)	Drift-test Readings at original calibration, & Units	Drift-Check Date (m/d/yr)	Drift-Check Time	Drift-Check conducted where?	Drift-check Description	Drift-Check Reading, & Units	Comments
pH*†								
Conductivity								
Turbidity								
Chlorophyll a								
DO†								

*Try to calibrate as near to original calibration temperatures as possible.

† Needs to be done in field. May be done even before shutting down logging file, so that drift-check is part of logged file.

Waterbody: _____
Site Visit Code: _____
Date: _____ Reach: EMAP layout
Visit No.: _____

Transect Letter: A

FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			

COMMENTS

Transect Letter: B

FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			

COMMENTS

Waterbody: _____
Site Visit Code: _____
Date: _____ Reach: EMAP layout
Visit No.: _____

Transect Letter: C

FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			

COMMENTS

Transect Letter: D

FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			

COMMENTS

Waterbody: _____
Site Visit Code: _____
Date: _____ Reach: EMAP layout
Visit No.: _____

Transect Letter: E				
FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin** = < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			
COMMENTS				

Transect Letter: F				
FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	**G** = Green **GLB**=Green/light brown **LB**= Light brown **BR** = Brown/reddish **DBB** =Dark brown/black	**Gr** = Growing **M** = Mature **D** = Decaying	**Thin** = < 0.5 mm thick **Medium** = 0.5-3 mm thick **Thick** = > 3 mm thick **Short** = < 2 cm long **Long** = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			
COMMENTS				

Waterbody: _____
Site Visit Code: _____
Date: _____ Reach: EMAP layout
Visit No.: _____

Transect Letter: G				
FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			
COMMENTS				

Transect Letter: H				
FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			
COMMENTS				

Waterbody: _____
Site Visit Code: _____
Date: _____ Reach: EMAP layout
Visit No.: _____

Transect Letter: I

FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			

COMMENTS

Transect Letter: J

FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category
Microalgae	0 1 2 3 4			
Filamentous Algae	0 1 2 3 4			
Macrophytes	0 1 2 3 4			
Moss	0 1 2 3 4			
Woody Debris >0.3 m (large)	0 1 2 3 4			
Brush/Woody Debris <0.3m (small)	0 1 2 3 4			
Live Trees or Roots	0 1 2 3 4			
Overhanging Veg. =<1m of surface	0 1 2 3 4			
Undercut Banks	0 1 2 3 4			
Boulders	0 1 2 3 4			
Artificial Structures	0 1 2 3 4			

COMMENTS

Waterbody: _____
Site Visit Code: _____
Date: _____ Reach: EMAP layout
Visit No.: _____

Transect Letter:	K				
FISH COVER/OTHER	0 = Absent (0%) 1 = Sparse (< 10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	G = Green GLB=Green/light brown LB= Light brown BR = Brown/reddish DBB =Dark brown/black	Gr = Growing M = Mature D = Decaying	Thin = < 0.5 mm thick Medium = 0.5-3 mm thick Thick = > 3 mm thick Short = < 2 cm long Long = >2 cm long	
	Actual Cover in channel (circle one)	**Predominant Color**	**Condition**	**For microalgae & filamentous algae:** Record thickness or length category	
Microalgae	0 1 2 3 4				
Filamentous Algae	0 1 2 3 4				
Macrophytes	0 1 2 3 4				
Moss	0 1 2 3 4				
Woody Debris >0.3 m (large)	0 1 2 3 4				
Brush/Woody Debris <0.3m (small)	0 1 2 3 4				
Live Trees or Roots	0 1 2 3 4				
Overhanging Veg. =<1m of surface	0 1 2 3 4				
Undercut Banks	0 1 2 3 4				
Boulders	0 1 2 3 4				
Artificial Structures	0 1 2 3 4				
COMMENTS					