Quality Assurance Project Plan

Shade Monitoring for the Wenatchee Basin Water Quality Restoration Project

Agreement: G1400501

Prepared by:

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Each study conducted by the Washington State Department of Ecology must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study on the Internet.

This report is available on the Department of Ecology website at http://fortress.wa.gov/ecy/publications/1510049.html.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm.

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January 2015

Approved by*:

Signature:	Date:
Adrienne Roumasset, Author and Project Manager, Chelan County Natural Resources Dept. Signature:	Date:
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1.0 Table of Contents

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2.0 Abstract

The Chelan County Natural Resources Department (CCNRD) received a Centennial grant in 2014 from the Washington Department of Ecology (Ecology) to implement up to 10 riparian restoration sites in the Wenatchee Basin. All sites are along flowing water bodies that were listed as impaired in the 2005 Wenatchee River Watershed Temperature TMDL (Cristea and Pelletier 2005). This protocol may also be implemented on CCNRD riparian projects funded by Ecology in the future. The intention of the riparian planting is to improve habitat by increasing native vegetation cover, stabilizing banks, and increasing shade; thereby improving water quality (reducing stream temperature and increasing dissolved oxygen). CCNRD has proposed a shade study to monitor change in the parameters listed above. The study will measure all parameters (shrub cover, bankfull width, shade, stream temperature, dissolved oxygen) every year from year 1-10, as well as repeat photo points established year 0. Results of the study will be used to assess whether restoration goals are being met and to implement adaptive management actions if necessary.

3.0 Background

3.1 Study area and surroundings

The Wenatchee watershed (WRIA 45, Figure 1) is located in central Washington on the eastern slope of the Cascades (Cristea and Pelletier 2005). The Wenatchee Watershed is 1,370 square miles and is highly diverse in climate, geography, and level of anthropogenic impacts. The watershed spans from the steep and forested Cascade mountains that receive an average of 150 inches of precipitation to the orchards and towns of the lower Wenatchee River Valley that receive an average of 8.5 inches (WRIA 45 Planning Unit 2006). The Wenatchee watershed supports steelhead, Chinook salmon, Bull trout, and Coho salmon. Spring Chinook are listed as endangered under the Endangered Species Act; Bull trout and steelhead are listed as threatened (WRIA 45 Planning Unit 2006).

The proposed study would collect data on CCNRD riparian restoration (planting) sites within the Wenatchee Watershed (CCNRD 2013). Currently, this includes 2 sites on the mainstem Wenatchee River and 3 on Wenatchee River tributaries (Table 1, Chumstick and Mission Creek). CCNRD will include additional riparian restoration projects to this protocol as they are funded and implemented under future Ecology grants. Site ownership will likely be >90% private. All current sites are on private property with the exception of Enchantment Park, which is publicly owned by the city of Leavenworth.

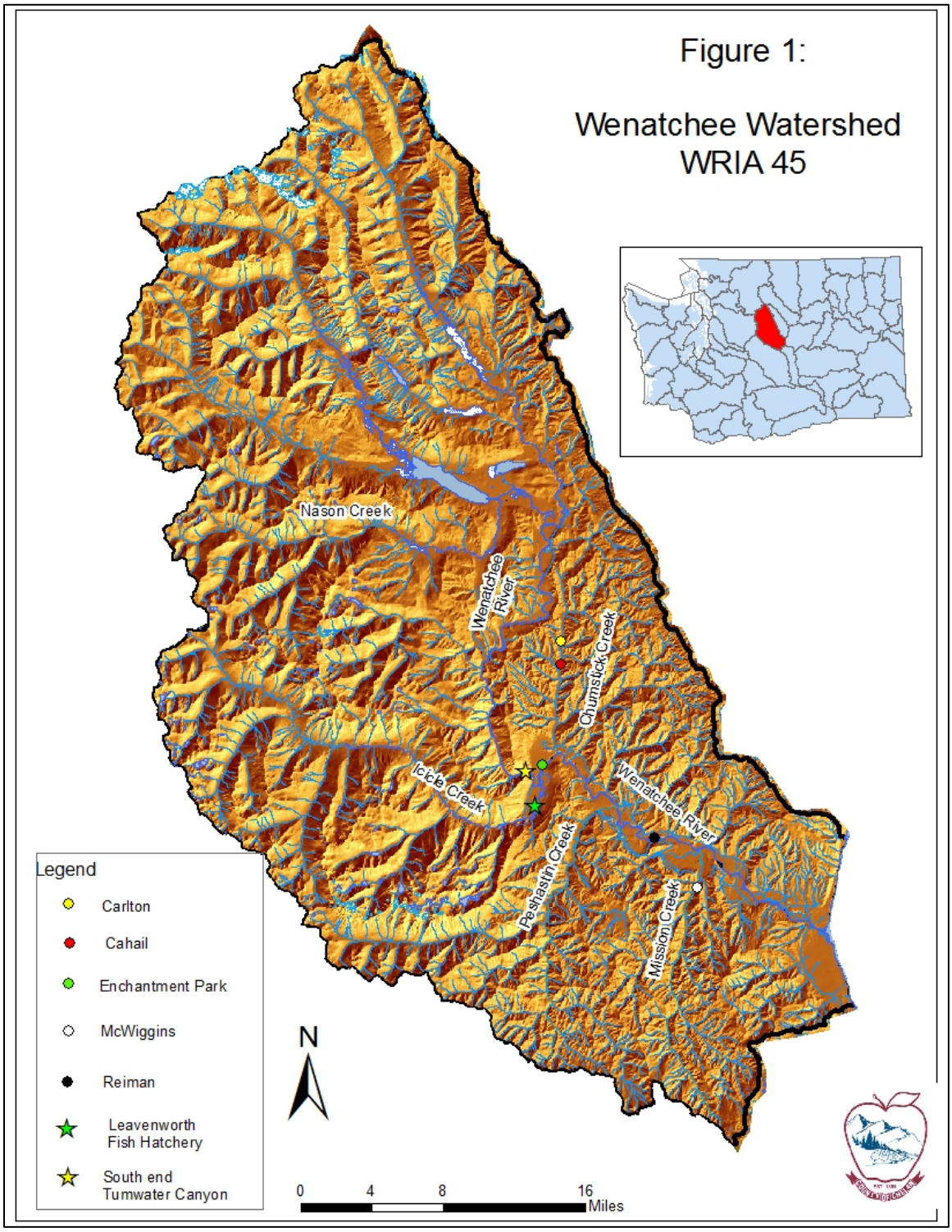

Figure 1. Wenatchee Watershed with Riparian sites, WRIA 45.

Table 1. CCNRD riparian restoration sites funded by Ecology, 2014.

Site name	Stream and River Mile	Stream meters planted	Meters squared planted	2007 TMDL allocation effective shade
Cahail	Chumstick, RM 5.7	76 m (left bank)	744 m^2	>85%
Carlton	Chumstick, RM 7.1	86 m (both banks)	1467 m^2	>85%
McWiggins	Mission, RM 2.5	232 m (right bank)	2378 m^2	60%
Rieman	Wenatchee, RM 13.5	52 m (right bank)	16 m^2	4%
Enchantment Park	Wenatchee, RM 24.7	137 m (left bank)	1249 m^2	5%

3.2 Logistical problems

Since the majority of riparian restoration sites are on private property, site access may be a logistical problem for this project. CCNRD staff will contact the landowner prior to all field visits. All landowners signed agreements that allow CCNRD site access prior to implementation of riparian restoration. However, landowners reserve the right to deny access. CCNRD has a history of positive relationships with all landowners and getting permission is not anticipated to be a problem.

Visits will be conducted just once a year, during the peak of growing season and during low flow or the receding limb of the hydrograph so stream flow will not be hazardous at tributary sites. However, the mainstem Wenatchee sites may pose unsafe wading conditions even at low flow.

3.3 History of the study area

Although overall development is low, the watershed has been impacted by concentrated development, agriculture, and transportation infrastructure in the valley bottom and along stream corridors (Schneider and Anderson 2007). Activities such as livestock grazing, recreation, agriculture, and logging have contributed to reduced riparian shade throughout the lower watershed. Low elevation tributaries such as Mission, Icicle, and Chumstick creeks have significantly reduced riparian corridor due to historical and current cattle ranching and agriculture. The riparian corridor of the lower Wenatchee River is heavily impacted by highway 2, BNSF railroad, and agriculture (primarily fruit orchards).

Land use in the watershed is 69.4% forested upland, 8.1% shrub land, 11.8% herbaceous upland, 1.4% orchard/vineyard/other non-natural, 0.4% developed and 1.5% water (Schneider and Anderson 2007).

3.4 Contaminants of concern

This shade study will focus on riparian restoration projects implemented on the mainstem Wenatchee and its tributaries that are on Washington State's list of water-quality impaired waters (Table 2). Water temperature is the primary parameter that this study is focused on. Temperature

is identified as a Category 4 contaminate of concern on Ecology's 303 (d) list in segments of the Wenatchee River, Chumstick Creek, Icicle Creek, Peshastin Creek, Mission Creek, Nason Creek, and the Little Wenatchee River. Instream Flow is a category 4 listing in the Wenatchee River, Chumstick Creek, Icicle Creek, Mission Creek, and Peshastin Creek. Dissolved Oxygen and pH are category 4 listings in Icicle Creek and the Wenatchee River with an additional pH listing in Mission Creek. Fecal Coliform bacteria is a category 4 listing in Chumstick Creek and Mission Creek. Mission Creek is also listed for DDT. There are no category 5 water quality listings in the Wenatchee watershed. However, there are current category 5 listings for Mountain Whitefish tissue, including PCBs in the Wenatchee and Icicle River (listing ID 52947 and 20306), and 4,4'-DDE on the Wenatchee River (listing ID 52940).

Table 2. Ecology's 303(d) category 4 contaminants of concern for the Wenatchee River and its tributaries.

Streambody	Parameter of Concern	Water Quality Assessment Category	Listing ID #
Chumstick Creek	Bacteria	Polluted waters (category 4a)	41689, 41691, 41693, 41722, 41724, 41725
Chumstick Creek	Temperature	Polluted waters (category 4a)	42915, 42916
Chumstick Creek	Instream Flow	Polluted waters (category 4c)	5789
Chiwawa Creek	Temperature	Polluted waters (category 4a)	39357, 39359
Icicle Creek	Temperature	Polluted waters (category 4a)	39343, 42825, 42827, 42828, 42872
Icicle Creek	Instream Flow	Polluted waters (category 4c)	5790
Icicle Creek	Dissolved Oxygen	Polluted waters (category 4a)	8416
Icicle Creek	pH	Polluted waters (category 4a)	8417
Little Wenatchee River	Temperature	Polluted waters (category 4a)	39365, 39366, 39367, 39368, 39370, 40764
Mission Creek	Temperature	Polluted waters (category 4a)	8424,11282, 34803, 39374, 39375, 42837, 42838, 42841
Mission Creek	pH	Polluted waters (category 4a)	11281, 34799
Mission Creek	Bacteria	Polluted waters (category 4a)	41557, 41559, 41561, 41562, 41938
Mission Creek	Instream Flow	Polluted waters (category 4c)	5791
Mission Creek	DDT	Polluted waters (category 4a)	8958, 34829
Nason Creek	Temperature	Polluted waters (category 4a)	42841, 39376, 39377, 42918, 42919, 42920, 42921, 42922, 42923, 42924, 42925, 42926
Peshastin Creek	Temperature	Polluted waters (category 4a)	39344, 39381, 42881, 42884, 42885
Peshastin Creek	Instream Flow	Polluted waters (category 4c)	5792
Wenatchee River	Temperature	Polluted waters (category 4a)	39386, 41111, 41113, 41114, 41115, 41145, 42855, 42858, 42860, 42861, 42862, 42865, 42866, 42977
Wenatchee River	Instream Flow	Polluted waters (category 4c)	5793, 6209
Wenatchee River	pH	Polluted waters (category 4a)	10702
Wenatchee River	Dissolved Oxygen	Polluted waters (category 4a)	10705

The Wenatchee River Watershed plan calls for actions that address exceedances of State and Federal water quality standards for temperature in the Wenatchee River and its tributaries (WRIA 45 Planning Unit 2006). CCNRD's riparian revegetation project goals include increasing shade to reduce water temperatures. Supplemental goals include improving water quality by enhancing riparian functions of bank stabilization, surface runoff and pollutant filtration, and sediment deposition.

3.5 Results of previous studies

Ecology has monitored water quality in the Wenatchee basin for over a decade. TMDL studies have identified several category 4, 303 (d) listings for water temperature that exceed levels detrimental to threatened and endangered salmonids (spring Chinook salmon, summer steelhead, and bull trout) present in the Wenatchee watershed. A network of continuous data loggers measured stream temperature (at 50 sites) and dissolved oxygen (at 25 sites) in 2002 and 2003 (Carroll et al. 2006, Cristea and Pelletier 2005). Elevated temperature was the main factor causing DO excursions from acceptable values (Carroll et al. 2006).

Model simulations found that with mature riparian vegetation, an average reduction of 2.7°C could be achieved compared with current conditions (Cristea and Pelletier 2005). This study will measure canopy cover over time and collect discrete measurements of DO and stream temperature adjacent to riparian projects. DO and stream temperature will be tracked and assessed with respect to established criterion.

Percent canopy cover will be used as an index for shade in this study. Percent canopy cover can be used as a surrogate for shade and both measurements are valuable in tracking changes in riparian characteristics due to restoration (OWEB 2001). Percent canopy cover will be converted to percent shade using the linear relationship developed by the Stream Shade Monitoring Team, a subcommittee to the Oregon Plan for Salmon and Watersheds Monitoring Team (OWEB 2001, Figure 2). This conversion will allow comparisons between measurements and effective shade and load allocations developed in the Wenatchee watershed TMDL (see below).

Near stream vegetation and effective shade were mapped in the 2005 Wenatchee watershed TMDL. Effective shade is defined as the "fraction of total possible solar radiation above the vegetation and topography that is blocked from reaching the surface of the stream and summed over a full day" (Stohr and Bilhimer 2008). A combination of GIS analysis, aerial photography interpretation, and 2002/2003 LIDAR data were used to generate metrics, including near stream vegetation, effective shade, shade deficit and percent improvement.

Effective shade deficit, representing the difference between the shade from potential mature vegetation and current riparian vegetation, was calculated for Wenatchee River, Nason Creek, Icicle Creek, Peshastin Creek, and Mission Creek. Results indicate shade deficits in all of the 5 waterbodies, with the highest deficits in Nason Creek, lower reaches of Icicle Creek, and lower half of Mission Creek (Figure 3).

Load allocations for effective shade were developed for each 0.5 mile river reach of the Wenatchee River, Icicle Creek, and Nason creek and for miscellaneous perennial streams in the Wenatchee River basin based on bankfull width and stream aspect. Load allocations represent target percent effective shade values that, if achieved, would lower stream temperatures

(Schneider and Anderson 2005). Percent stream shade values generated in this study will be compared to load allocations for the appropriate reach (Table 1).

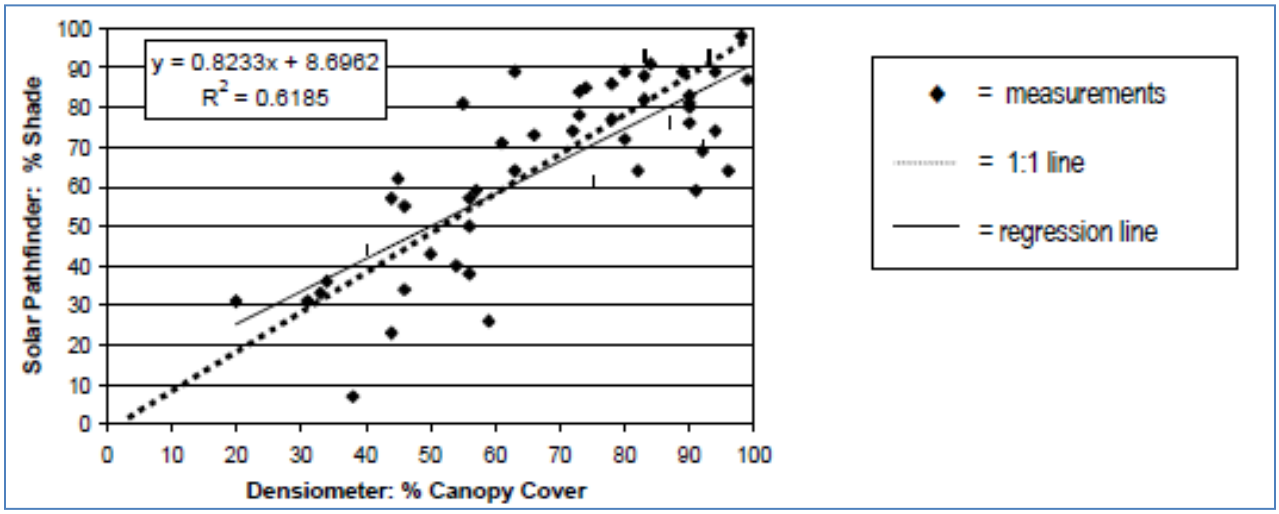

Figure 2. Graph showing the relationship between percent canopy cover (convex densiometer) and percent shade (solar pathfinder), (OWEB 2001).

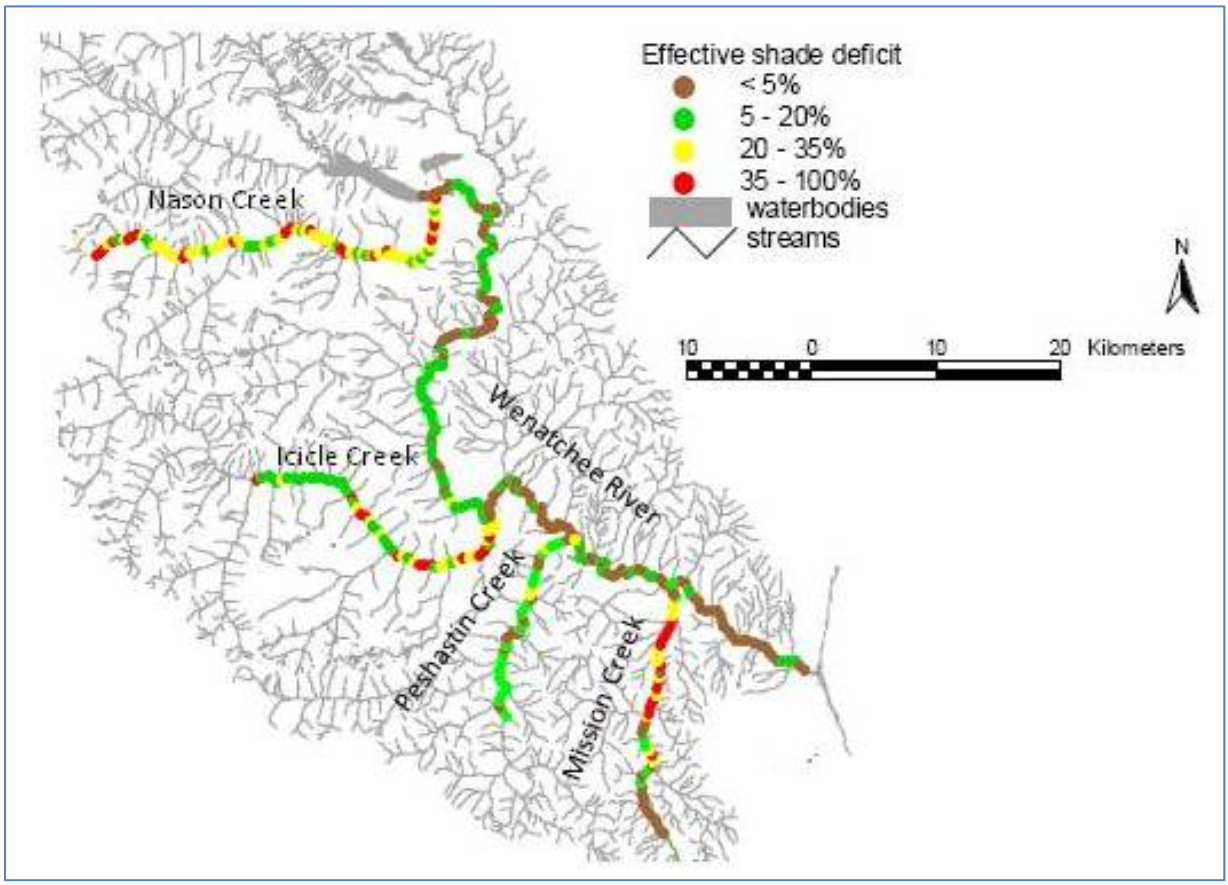

Figure 3. Effective shade deficits, Wenatchee watershed (Cristea and Pelletier 2005).

3.6 Regulatory criteria or standards

Ecology has designated specific aquatic life uses for protection in Washington freshwaters. Wenatchee watershed has criteria and designations for the aquatic life uses Char spawning and rearing, core summer habitat, and spawning and incubation (Water Quality Program 2012, Payne 2011, Table 3). Temperature and Dissolved Oxygen criteria for the aquatic life uses designated for the Wenatchee watershed are listed in Table 3. Water temperature is measured by the 7-day average of the daily maximum temperatures (7-DADMax) and DO in milligrams per liter. Reaches in the Wenatchee watershed that have designated aquatic life uses are listed in Table 4 (includes Char spawning and rearing and core summer habitat). Reaches that require supplemental spawning and incubation protection are shown in Figure 4.

Load allocations for effective shade represent target values for stream shade at channel center and were listed in the 2005 Wenatchee watershed TMDL for each 0.3 mile of stream on Wenatchee River, Icicle Creek, and Nason Creek, and for varying bankfull widths. These will serve as target stream shade values for this study. Values for the 5 current riparian projects included in this study are listed in Table 1. Load allocations for Chumstick Creek were not included in the TMDL, so values for a bankfull width of 15ft (the approximate bankfull width of Chumstick Creek at the Cahail and Carlton sites) were used (Table 1).

Table 3. Water temperature (7-DADMax) and Dissolved oxygen (mg/L) criteria for aquatic life uses designated in the Wenatchee watershed.

Parameter	Char Spawning and Rearing	Core summer habitat	Spawning Incubation Criteria
Dissolved Oxygen	9.5mg/L	9.5 mg/L	N/A
7-DADMax Temperature	12.0 °C	16.0 °C	13.0°C (see Figure 4 for dates)

Table 4. Aquatic life use designations for Fresh Waters in WRIA 45, Wenatchee River basin (Water Quality Program 2012).

Stream Reach in WRIA 45	Char Spawning / Rearing	Core Summer Habitat
Chiwaukum Creek from confluence with Skinney Creek to headwaters (including tributaries)	X	
Chiwawa River from mouth to Chikamin Creek (including tributaries).		X
Chiwawa River (and all tributaries) above and including Chikamin Creek.	X	
Chumstick Creek and tributaries downstream of the National Forest boundary (not otherwise designated char).		X
Chumstick Creek and tributaries in or above the National Forest boundary (not otherwise designated char).		X
Dry Creek and Chumstick Creek: All waters (including tributaries) above the confluence, except those waters in or above the Wenatchee National Forest.	X	
Dry Creek and Chumstick Creek: All waters (including tributaries) above the confluence that are in or above the Wenatchee National Forest.	X	
Eagle Creek and the unnamed tributary at latitude 47.6544 longitude -120.5165: All waters (including tributaries) above the junction, except those waters in or above the Wenatchee National Forest.	X	
Eagle Creek and the unnamed tributary at latitude 47.6544 longitude -120.5165: All waters (including tributaries) above the confluence that are in or above the Wenatchee National Forest.	X	
Eagle Creek below Bjork Canyon.		
Icicle Creek (including tributaries) from mouth to the National Forest Boundary.		X
Icicle Creek (including tributaries) from National Forest boundary to confluence with Jack Creek.		X
Icicle Creek above and including Jack Creek (including all tributaries).	X	
Ingalls Creek (including tributaries).	X	
Mission Creek from latitude 47.4496 longitude -120.4945 to headwaters (including tributaries) downstream of the National Forest boundary.		X
Mission Creek from latitude 47.4496 longitude -120.4945 to headwaters (including tributaries) in or above the National Forest boundary.		X
Peshastin Creek from National Forest Boundary to headwaters (including tributaries) except where designated char.		X
Peshastin Creek from confluence with Mill Creek to National Forest Boundary (including tributaries).		X
Second Creek and the unnamed tributary at latitude 47.7384 longitude -120.5935: All waters (including tributaries) above the confluence.	X	
Van Creek and the unnamed tributary at latitude 47.6722 longitude -120.5373: All waters (including tributaries) above the confluence.	X	
Wenatchee River mainstem between Peshastin Creek and the boundary of the Wenatchee National Forest (river mile 27.1).		X
Wenatchee River from Wenatchee National Forest boundary (river mile 27.1) to Chiwawa River (including tributaries) except where designated otherwise.		X
Wenatchee River and all tributaries above Chiwawa River confluence.	X	

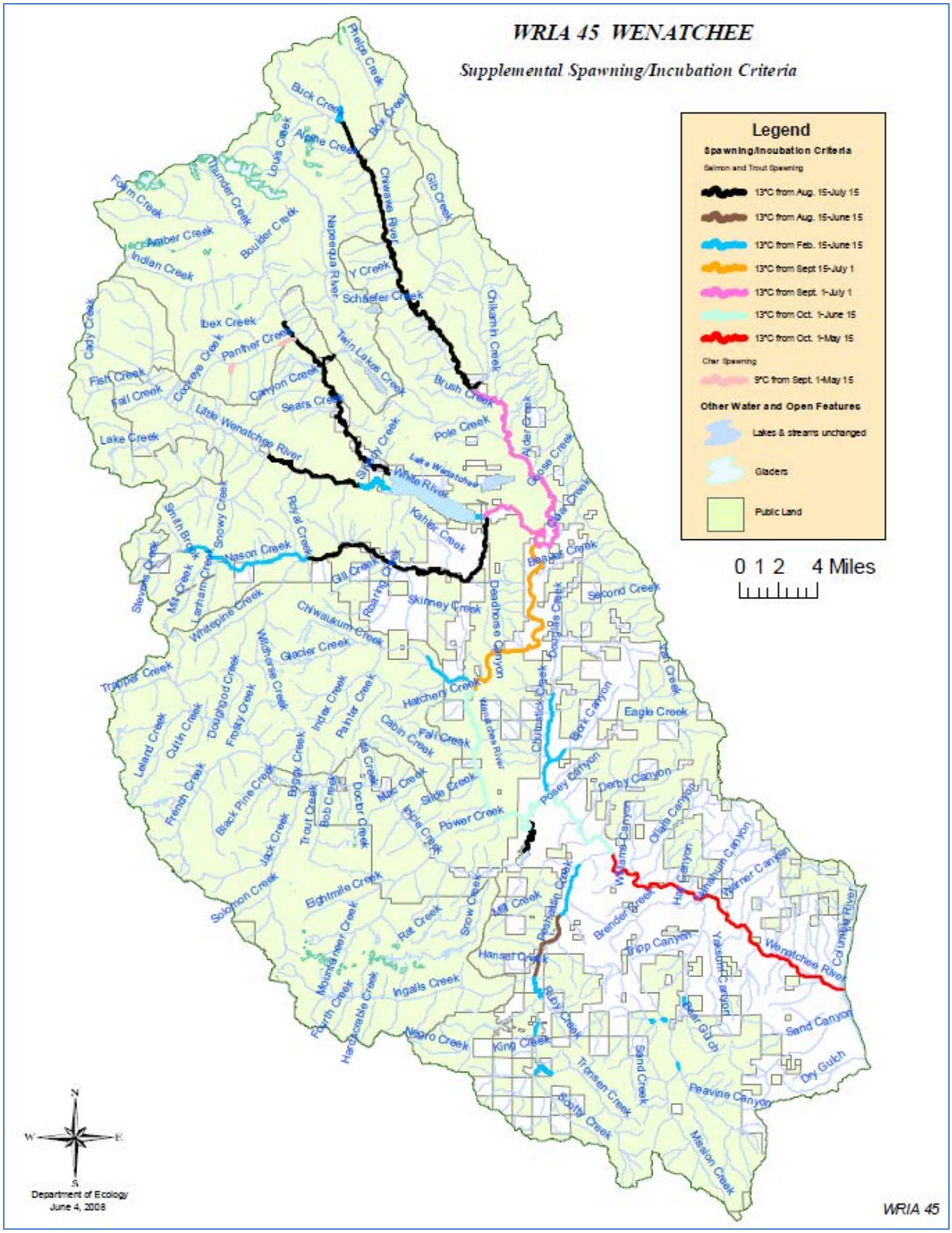

Figure 4. Supplemental spawning and incubation criteria for the Wenatchee watershed.

4.0 Project Description

4.1Project goal

The project goal is to assess the effectiveness of riparian planting to increase shade at riparian planting sites.

Implementation action number 4 of the Wenatchee watershed 2005 TMDL calls for actions that improve shade near surface waters, including monitoring of action sites (2005 TMDL). Ecology has granted the CCNRD with funding for five riparian planting projects. This study applies to these five projects and any additional projects that may be funded in the future.

Anticipated water quality improvements of CCNRD riparian planting projects include improving shade, lowering stream temperatures and improving dissolved oxygen content. Without adequate monitoring, it would be impossible to assess whether projects are achieving these improvements. Since improvements in stream temperature and dissolved oxygen both depend on improvements in shade, percent canopy cover (as an index of shade) will be the primary focus of this study. Results of the study will guide adaptive management decisions, such as additional plantings or weed control. Results will also help guide logistics of future projects, i.e., appropriate buffer widths.

4.2 Project objectives

1. Monitor changes in percent canopy cover (as an index of shade) at CCNRD riparian restoration sites over a ten-year period.
2. Track associated changes in percent native shrub cover in the planted area, bankfull width, and bank stability of the stream reach.
3. Take discrete measurements of dissolved oxygen and water temperature in the stream adjacent to planting sites during each visit.
4. Compare stream temperature measurements to the stream flow and temperature monitoring gage site that is located at the mouth of the planting site stream. Use relative stream temperature to provide anecdotal support for a cooling/warming trend at the site. Use data to display an increasing trend, decreasing trend, or no change in shrub cover and shade within a site over time.
5. As funding for new sites is acquired, increase site sample size (currently 5 sites) to support general conclusions regarding the relationships between bankfull width, buffer width, and stream shade for final (10 yr) report.

4.3 Information needed and sources

To meet the above objectives, percent shade, DO, bankfull width, bank stability, and stream temperature will be measured and several photo points at each site will be established and repeated each year. Vegetative cover will also be visually estimated. Measurements will be

collected during site visits made at each riparian site during the growing season (leaf-on), year 1 (post project) through year 10. To meet the project objectives, the following activities will be performed during site visits:

- Qualitatively monitor yearly changes to sites by **photo points** established project year 0 and repeated years 1-10
- Measure **canopy cover** using a convex densiometer along transects established perpendicular to the channel. Measurements will be taken at 3-5 (dependent on if one or both banks were planted) locations along each transect- stream center, top of bank, and halfway between transect edge and top of bank. Measurements will be taken during the peak of the growing season years 1-10. Canopy cover will be converted to **percent shade** using the equation in Figure 2 (OWEB 2001).
- **Stream temperature** and **dissolved oxygen** will be measured once during the peak of the growing season years 1-10 at the centermost transect at each site.
- **Bankfull width** will be measured at each transect. **Bank stability** will be measured between two sets of transects.
- **Plant survival** (year one) and **vegetative cover** will be visually estimated within the total planted area.

This study will reference riparian planting plans for information regarding site geometry (i.e. buffer width, planting area, etc.).

Ecology operates stream gages at the mouth of Icicle Creek, Chumstick Creek, Mission Creek, Peshastin Creek, and Nason Creek. These gages measure continuous stage and stream temperature and will provide important information for this study. The discrete nature of this study's temperature measurements precludes comparison year to year. However, these measurements will be compared to the nearest gage value recorded at the same day and time to get a relative temperature (planting site vs. mouth of stream). These values will make discrete data more robust for qualitative comparisons with shade values and year-to-year.

4.4 Target population

The project will track changes in the metrics and photos listed in bold above. The target population will consist of the data collected during the yearly visit to each riparian site. An assumption will be made that the data collected is representative of the stream reach adjacent to the riparian site.

4.5 Study boundaries

This monitoring effort will include all CCNRD sponsored riparian restoration projects within the Wenatchee watershed (Figure 1). Currently, this includes the five 2014 riparian restoration sites that were funded by Ecology's Centennial Grant (Table 1). Data will be collected within the planted area of the riparian project and in the stream reach adjacent.

4.6 Tasks required

General project tasks include equipment maintenance, data management, and reporting. The equipment that will be used in this project are an YSI Professional Optical Dissolved Oxygen Instrument (YSI ProODO), a hand held mercury thermometer, a Model-C spherical convex densiometer, and a waterproof camera. The YSI PODO will be calibrated and the ODO sensor cap replaced before each field season. The camera, densiometer, and thermometer will require minimal maintenance. The battery of the camera will be charged prior to each field visit. Data management will involve data entry from data sheets to excel spreadsheets and QA/QC. Data will be organized into a general project folder with sub-folders for each site. Data will be entered into excel within a week of collection to ensure enough time to return to the site if something was missed or written incorrectly. Pictures will be uploaded and saved in the appropriate site file. Canopy cover will be converted to percent shade (Figure 2) and compared to load allocations and effective shade estimates and to past measurements. Bankfull width, bank stability, and estimated vegetative cover will be compared to past measurements. Analysis of changes over time in percent shade, bankfull width, bank stability, and vegetative cover will drive decisions for additional plantings, as well as inform future projects.

Analysis of temperature, shade, and DO measurements will be done at the end of the field season. Analysis of temperature will compare to the nearest gage measurement collected at the same day and time, to past measurements, and to regulatory criteria. DO measurements will be compared to past measurements, regulatory criteria, and recorded temperature. Changes in relative temperature between gage site and riparian site, along with an increase in shade over time, will qualitatively suggest that water quality has improved due to the project. Comparisons of DO values will be largely anecdotal, since it will be difficult to distinguish a project effect from discrete measurements.

This study is not designed to inform decision-making. However, results may be used to inform or support future projects, adaptive management, and overall success of riparian planting projects. Reporting for the project will occur annually with reports submitted to Ecology every March. The current funding available will fund one annual report submitted in March 2016.

4.7 Practical constraints

Funding for long-term monitoring is the primary practical constraint. To effectively monitor changes in shade as a result of restoration activities, 5-year intervals are required (OWEB 2001). However, Ecology funding for the Wenatchee Basin Water Quality Restoration Project expires in August 30th, 2016 (CCNRD 2013). CCNRD is confident that additional funding can be obtained through future Ecology grants and other sources if needed. Ideally, the shade study will continue for 10 years and this QAPP will be written under the assumption that funding to support this duration will be obtained. If additional funding is not obtained a report that summarizes one year of data collection (summer of 2015) will be submitted to Ecology by August, 2016.

Practical constraints include landowner permission to access sites. However, a relationship with landowners and permission to be on the property is granted when the landowner agrees to the riparian planting. Maintaining a relationship and permission to access will be required.

No equipment will be left on site, so vandalism or damage should not be a major issue. Wading will be during low flow but care will still be necessary when entering the stream.

Discreet measurements of stream temperature are not robust enough to discern daily/hourly changes in temperature from changes in temperature due to shading. Ideally, temperature probes would be installed at each site so that stream shade could be monitored with stream temperature. However, a practical constraint of this project is funding for stream temperature probes. Should more funding become available, the project will be expanded to include continuous temperature monitoring at sites where permission to install is granted from the landowner.

4.8 Systematic planning process used

Project planning will be undertaken within the guidelines of this QAPP. Work scheduling will be designed to meet objectives and will include pre-season equipment calibration and maintenance, field visits during growing season, data management immediately following visits, and data analysis and reporting during the following winter. The timing and duration of data collection is described in section 9.

5.0 Organization and Schedule

5.1 Key individuals and responsibilities

The project planning and implementation team for this small study is Adrienne Roumasset and Lee Duncan. Contact info and responsibilities are presented in Table 5.

Table 5. Key individuals and responsibilities.

Name/Contact	Title	Responsibilities
Adrienne Roumasset Chelan County Natural Resources Dept. (509) 667-6436	Natural Resource Specialist	Project (study) management, data collection and management, field technician, equipment maintenance, report writing
Pete Cruickshank Chelan County Natural Resources Dept. (509) 667-6612	Natural Resource Specialist	Consultation and support. Management of all other grant tasks.
Heather Simmons Washington Dept. of Ecology (509) 454-7207	Ecology, Water Quality, Project Manager	Provides initial review and feedback of QAPP. Reviews and approves final report.
Daniel Dugger Washington Dept. of Ecology (509)454-4183	Ecology, EAP, Technical Reviewer	Provides internal review of QAPP.

5.2 Organizational chart

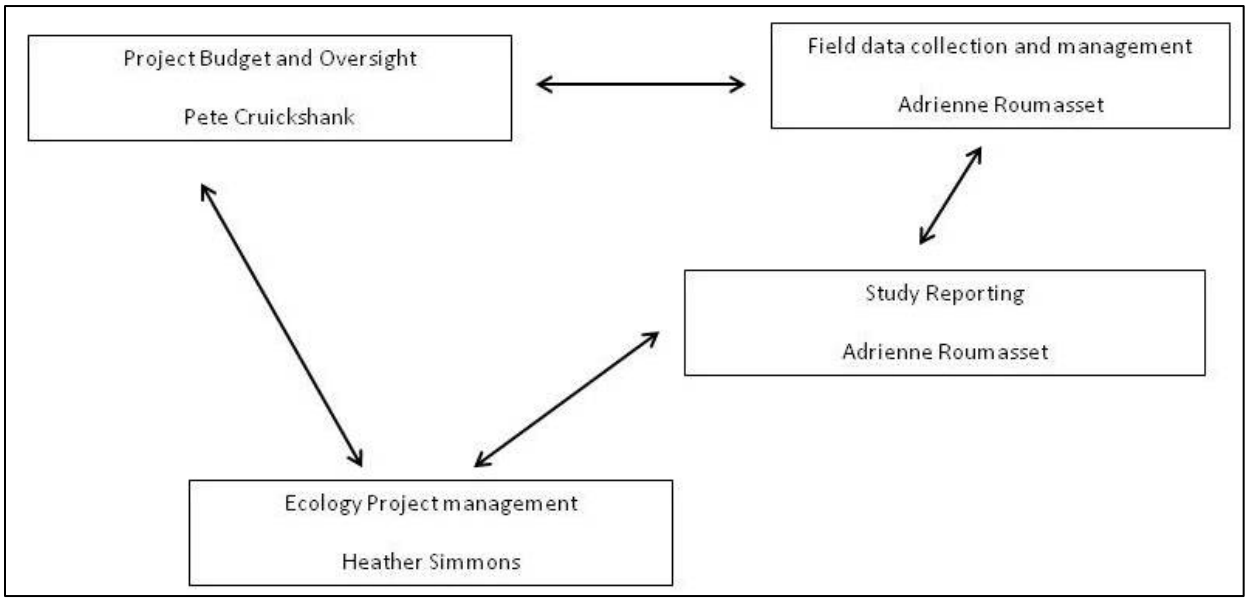

Figure 5. Organizational flow chart for the CCNRD shade study.

5.3 Project schedule

A schedule for this project is presented in Table 6.

Table 6. Project schedule.

Task	Dates
Quality Assurance Project Plan	Winter 2014/15
Transect, measurement points, and photo point establishment	Summer 2015
Data collection- % canopy (shade), stream temperature, DO, bankfull width, percent cover	Field visit once a year per site during peak of leaf on (July – September) for 10 years post project implementation
Data entry, organization, and analysis	On-going as needed beginning in Summer 2015
Annual report	March 2016 through study end
Final Report	For each site, 10 years post implementation

5.4 Limitations on schedule

Significant limitations on the schedule are not anticipated since site visits to several riparian projects could be accomplished in one day. Peak leaf on is generally mid-July to mid-September, which provides plenty of time to alert landowners and coordinate staff time.

5.5 Budget and funding

The total eligible cost of the Wenatchee Basin Water Quality Restoration Project is $288,067 and expires August 30th, 2016. Shade monitoring activities described in this QAPP represent a portion of these funds. CCNRD anticipates additional funding to support 10 years of data collection (see section 6.7). An estimated budget for the Shade study (Table 3) is presented in Table 7 and represents costs associated with project implementation from January 2014 – August 30th, 2016 using funding available under the current grant.

Table 7. Estimated Budget for Task 3.

CCNRD staff time:	$17,000 (Adrienne Roumasset and field assistant)
Adaptive Management	$20,000 (described in grant proposal)
Materials, goods, and services (major items):	$1,150 (Calibration standards, YSI meter, densiometer)
Travel:	$2,000 (field travel to monitoring sites)
Total Eligible Cost	$40,150

6.0 Quality Objectives

6.1 Decision quality objectives (DQOs)

Decision quality objectives will be employed to ensure that data collected can support adaptive management decisions and inform future project development. The key objectives will be to collect accurate and representative data that monitors changes in shrub cover and shade (canopy cover) over time (unit, year). Water quality data will only be collected once a year and therefore will be treated as anecdotal and not applied to decision making (e.g., hourly and daily fluctuations will not be accurately accounted for). The information will be used to inform project objectives of assessing the effectiveness of riparian planting to increase shade and exploring the relationship between buffer width, bankfull width, and shade.

6.2 Measurement quality objectives (MQOs)

Measurement quality objectives (MQOs) for this project will focus on the collection of data following the protocol outlined in this QAPP. Bias, precision (for DO measurements), completeness, representativeness, and comparability indicators are used to establish data quality objectives. These processes will ensure quality data is collected to support project objectives.

6.2.1 Targets for precision, bias, and sensitivity

Sampling and data assessment steps have several sources of error that should be addressed by data quality objectives. Indicators including precision, bias, completeness, representativeness, and comparability are used to establish data quality objectives. All data will be collected following collection protocols and data quality objectives will be used to ensure quality data is available for TMDL development and project effectiveness assessment.

6.2.1.1 Precision and Bias

Percent shade (canopy cover), stream temperature, bankfull width, bank stability, and shrub cover will be measured only once per visit. Therefore, precision, which is maximized by repeated measurements, is not an applicable way of ensuring accuracy. DO measurements will be taken five times in succession and the average will be used for all comparisons.

An YSI handheld Professional Optical Dissolved Oxygen meter (YSI ProODO) will be used to measure stream temperature and DO. To reduce bias, stream temperature measurement will be validated using a alcohol in glass thermometer. The YSI ProODO will be calibrated following the protocol in the operation manual before each field season. The sensor cap will also be replaced once a year. Appendix B, Table 12 maintenance and calibration of the YSI ProODO. Table 8 describes measurement quality objectives for the YSI ProODO.

Possible sources of bias may include variation in time of day or year of sample collection, improper measurement point selection, and sampling error. Careful adherence to established procedures for calibration, equipment storage and maintenance, data collection and analyses

should reduce bias. Information in data sheets (Appendix B) will provide detailed location information and will be supplemented with additional notes written in a field book if needed. Study conclusions will be based on comparison of values that are equally biased (compared between years or between sites). Therefore, bias will likely be low for this study.

6.2.1.2 Sensitivity

Sensitivity for this project will be the lowest concentration or degree to which a parameter can be measured (Table 8). Water quality parameters will be compared to established criteria only anecdotally, and will not influence decision-making since it is impossible to account for daily and hourly changes with discrete measurements.

Table 8. Targets for Range, Accuracy, and Resolution for metrics.

Metric	Instrument	Range	Accuracy	Resolution
DO	YSI ProODO	0 to 50 mg/L	0 to 20 mg/L, or +/- 0.1 % of reading, whichever is greater; 20 to 50 mg/L, or +/- 10% of the reading	0.01 mg/L
Temperature	YSI ProODO	-5 to 70°C	+/- 0.2°C	0.1°C
Shade (% Canopy), discrete points	Spherical convex densiometer	0 to 100 %	5.9 %	5.9 %
Bankfull width	Measuring tape	0 to 200 m	0.1 m	0.01 m
Site wide shrub cover	Visual estimation	0 to 100%	~ 5 %	1 %

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

The goal of this study is to assess the effectiveness of riparian projects to increase shade. Comparability will be high between yearly shade measurements taken at the same location within the same site following the same protocol. Similarly, within site shrub cover measurements will also have high comparability. Between site comparisons may also be made with shrub cover and shade data to discern relative effectiveness of planting restoration at different locations. MQOs for comparability will be following the measurement protocol and detailed location descriptions of transects and measurement points.

Comparability between water quality measurements will be low given the discrete, grab sample nature of the data. As discussed in previous sections, decisions will not be made based on this data and it will be treated anecdotally. Load allocations of effective shade were calculated using

a different method than the ones used in this study. Comparability between these values will thus be low and also treated anecdotally.

6.2.2.2 Representativeness

Representative measurements provide a true representation of the population characteristic of interest. This study's characteristic of interest is change in shade at riparian projects. Canopy cover, a surrogate for shade (OWEB 2001), will be measured along several transects that span the channel and planted area. The number of transects will depend on the length of the stream bank that has been treated. Riparian planting treatments along stream banks typically do not exceed 1000 feet (Table 1). Multiple transects and multiple measurements along each transect will assure that conditions at the site are adequately represented. Measurements will be taken during the peak of the growing season to best represent maximum canopy cover. Water quality measurements would need to be measured continuously to be representative and therefore will be treated qualitatively and not quantitatively.

6.2.2.3 Completeness

Completeness is a measure of the amount of valid data needed to meet the goals defined by the project. This project will measure shade at multiple points within a site along transects (see section 9.1). The location of transects and points will be established following established SOPs (see section 10), therefore data collected will be adequate to make within site conclusions (i.e., effectiveness of restoration in the reach). To date, five riparian projects are included in this study, which is too small a sample size to support any conclusions regarding conditions between sites (i.e., effectiveness of restoration on different reach types). However, pending more funding, additional sites will be monitored resulting in a larger sample size.

In addition to number of sites and measurement points, completeness will be measured by the number of years monitored relative to 10 years - the number of years required to meet project objectives.

MQOs for completeness are 10 years of data with data collected along transects established an average of 15 meters apart. Another MQO for completeness is data sheets filled out in their entirety (Appendix A-B).

7.0 Sampling Process Design

7.1 Study design

The sampling boundary for this monitoring program is the Wenatchee river basin. The project will collect data on riparian planting sites included in the 2014 Wenatchee Basin Water Quality Restoration Project and other riparian planting sites funded in future Ecology grants awarded CCNRD. Pending funding, sites will be monitored once a year from year one to year ten. Parameters to be measured include percent canopy cover (used as an index of shade and measured with a densiometer), estimated percent shrub cover (of total planted area, visual estimate), percent plant survival (year one only), dissolved oxygen, stream temperature, bank stability, bankfull width, and wetted width. Dissolved oxygen and stream temperature will be discrete measurements and considered anecdotal. Photo points will also be established and pictures taken year zero through year ten. All measurements in this study will be taken in the field.

7.1.1 Field measurements

Field measurements will be conducted using a variety of field tools, including an YSI ProODO, spherical densiometer, field measuring tape, and visual estimation. Details regarding these tools are in Section 8.

7.1.2 Sampling location and frequency

Site visits and all data collection will occur at riparian planting sites once a year during the peak of growing season (between July and September) for ten years. Percent canopy cover, dissolved oxygen, stream temperature, bankfull width and wetted width will be measured along transects (Figure 6). Dissolved oxygen and stream temperature will be discrete measurements collected during site visits at the centermost transect and will therefore be treated anecdotally and not necessarily in relation to changes in shade. Visual estimates of percent cover and plant survival will reflect the entire planted area. Plant survival is the only parameter that will be recorded in year one but not repeated in subsequent years. Visual estimates of bank stability will occur between transects.

There are currently only five sites included in this study. However, grants for additional planting projects have been submitted and will be added pending funding. The duration of the project (ten years post planting site implementation) is also pending funding. CCNRD will continue to apply for funding with Ecology to ensure both more planting sites and the resources to monitor them using the protocol outlined in this QAPP. Table 9 outlines a sampling schedule with approximate dates for each field task.

Table 9. Sampling schedule.

	task done once (2014 or 2015)			*task repeated each year for 10 years*						
	# of transects	**establish photo points (2015)**	**establish transects (2015)**	**percent survival (2015)**	**repeat photo points**	**% canopy data**	**DO and temp**	**bankfull and wetted**	**bank stability estimate**	**shrub cover**
Cahail	4	4/9/2014	7/20/2015	7/20/2015	7/20	7/20	7/20	7/20	7/20	7/20
Carlton	4	4/9/2014	7/21/2015	7/21/2015	7/21	7/21	7/21	7/21	7/21	7/21
McWiggins	7	4/9/2014	7/23/2015	7/23/2015	7/23	7/23	7/23	7/23	7/23	7/23
Rieman	3	4/9/2014	7/24/2015	7/24/2015	7/24	7/24	7/24	7/24	7/24	7/24
Enchantment Park	6	4/9/2014	7/22/2015	7/22/2015	7/22	7/22	7/22	7/22	7/22	7/22
transect/ location where measured	N/A	N/A	N/A	every other transect	N/A	all transects	X transect	all transects	bank between 2 pair of transects	every other transect

7.1.3 Parameters to be determined

Parameters to be determined include: percent canopy cover, estimated percent shrub cover, estimated percent plant survival, dissolved oxygen, stream temperature, bank stability, bankfull width, and wetted width.

7.2 Maps or diagrams

Figure 6 is presented as an example site layout to facilitate understanding of the study design. An aerial view of the Carlton riparian planting site, located on Chumstick Creek, is overlaid with transects and measurement points.

Figure 6. The Carlton planting sites with transects and measurement points.

7.3 Assumptions underlying design

It is assumed that shade measurements taken along measurement points are representative of shade conditions at the site as a whole. It is assumed that percent canopy cover can be used as an index of shade and is valuable in tracking changes in riparian characteristics due to restoration (OWEB 2001). It is assumed that if changes in percent canopy cover occur due to plantings, they will occur within ten years. It is also assumed that changes in percent canopy cover may continue beyond ten years. It is assumed that yearly changes in DO and stream temperature measurements are not necessarily due to the project and may include daily or seasonal variation. It is also assumed that the QA/QC procedures outlined in this QAPP will allow for meaningful and accurate data.

7.4 Relation to objectives and site characteristics

The study design selected for this project is directly related to specific study objectives as well as the overall project goal to assess the effectiveness of riparian planting to increase shade at riparian planting sites. Sites are pre-established areas that were selected because they were riparian planting sites included in the Wenatchee Basin Water Quality Restoration Project. The 5 sites currently included in the study, excepting the Cahail and Carlton sites on Chumstick Creek, are broadly distributed throughout the watershed and are representative of reaches needing riparian restoration in various sub-basins. As sample size increases with the addition of new sites, representativeness will increase and help ensure that collected field measurements are representative of impact reaches (degraded sites that have undergone riparian planting) throughout the Wenatchee watershed.

7.5 Characteristics of existing data

This is a new study and therefore no data has been collected under the current protocol. However, existing protocols will be implemented and modified if necessary to meet the specific objectives of this project. Diligent adherence to QA/QC procedures will ensure that data collected throughout the duration of the study will be compatible for analysis with data collected at project commencement.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

Sampling sites will include CCNRD riparian projects within the Wenatchee watershed. Measurements will be taken along transects (percent canopy cover, bankfull and wetted width, bank stability, stream temperature, dissolved oxygen) in vegetative plots in the planted area (percent shrub cover and survival). Photo points will also be taken of the site. To collect data, the following protocols will be followed.

8.1.1 Photo documentation (photo points)

Although it is not a direct measurement of shade or cover, photo monitoring is a powerful qualitative method for monitoring the establishment and growth of riparian vegetation (OWEB 2001). The following method has been modified from Chapter 14 of the Water Quality Monitoring: Technical guide Book, “Stream Shade and Canopy Cover Monitoring Methods (OWEB 2001):

1. Establish Camera Points (location of the camera) and photo points (center of focus of the picture. Use data sheets to record detailed location information. (Appendix C, Figure 7 and Figure 8).
2. Photo points will include upstream and downstream of the X transect (see 'Transect establishment' below) and the planted area.
3. Photo points will be repeated each year during leaf on.
4. Pictures will be downloaded and labeled electronically as soon as possible following when they were shot.

8.1.2 Transect establishment

Measurements will be taken along transects that are perpendicular to the channel and extend across the planted area. Transects will be established following a modified protocol, based on the Salmon Recovery Funding Board MC-2, Method for Laying Out Control and Impact Stream Reaches for Wadeable Streams (Crawford 2004):

1. Find the approximate center of the impact reach and record GPS point of the X site (edge of treated bank or left bank facing downstream at sites where both sides were treated). Record latitude longitude on waterproof sheets. Note the X site relative to an existing monument, i.e., a large tree or corner of a structure. Record azimuth and distance of X site relative to the existing monument. Take a photo of monument and X site.
2. Transects will span bankfull width and the riparian planted area.
3. Establish an equal number of transects upstream and downstream of the X site (i.e., A, B, X=C, D, E). Distance between and number of transects will vary site to site. Number of transects will not exceed seven.

4. Distance between transects will be equidistant if possible, with a minimum distance of 20 m between transects. If a transect is near a structure that would highly influence canopy cover reading, location of transect will be adjusted and distance from proceeding and following transect noted.
5. Transect information will be recorded on data sheets (Appendix C, Figure 9).

8.1.3 Percent canopy measurements

Percent Canopy will be measured with a convex densiometer and used as an index of shade (OWEB 2001). The procedure for using a densiometer to measure stream cover from Chapter 14 of the Water Quality Monitoring: Technical guide Book, "Stream Shade and Canopy Cover Monitoring Methods (OWEB 2001) will be followed exactly. Four measurements will be taken at the center of each transect (upstream, downstream, facing right bank, and facing left bank), and one with the densiometer 0.3 m from each treated bank for a total of six measurements (OWEB 2001).

This study will include one additional measurement point on each transect, located halfway between the channel bank and the upland end of the planted width. Four densiometer measurements will be recorded at this spot (N, E, S, W). Detailed notes including distance from top of bank and distance and azimuth from an existing monument will be taken. Values from all percent canopy cover readings taken within the planted area will be averaged and used as an approximate index of total upland shade. All data will be recorded in data sheets (Appendix C, Figure 10).

8.1.4 Water quality and channel measurements

Water quality measurements (DO and temperature) will be taken along the centermost transect using an YSI ProODO meter. Temperature measurements will be validated with a handheld alcohol thermometer. A stadia rod or cloth measuring tape will be used to measure bankfull width and wetted width along each transect. In larger rivers, like the Wenatchee, a range finder will be used. Field staff will choose two sections of bank (i.e., between transects A and B and D and E) in which bank stability will be estimated. Field staff will choose bank sections randomly unless a section of bank is actively eroding, in which case this area should be chosen so erosion can be monitored over time. Bank stability will be visually estimated as the percent of lineal distance that is actively eroding at the active channel height on the side of the channel that was planted (Hillman 2005).

8.1.5 Shrub cover and percent survival

At least three 10m X 10m plots will be established within the planting area for estimating percent shrub cover (year 1-10) and percent survival (year 1 only) The protocol for estimating shrub cover has been adapted from established USGS protocol (Scott and Reynolds 2007). Plots will use established on every other transect using "planting measurement points" as plot center point, unless only the bank was planted, in which case "bank measurement points" will be used (Figure 6). Field staff will visualize plot boundaries by spreading two cloth measuring tapes

perpendicularly along the ground, each pulled to 10 m and crossing at 5m. Within the plot field staff will:

1. Estimate total percent native tree and shrub cover within the plot.
2. Break down total cover by species, (i.e., 60% total cover = 60% willow, 30% cottonwood, 10% snowberry).
3. Estimate total percent invasive cover; break down by species.
4. Use classes shown in Table 10.
5. Estimate plant survival in year one if visual signs of plant mortality are apparent.

If possible, percent shrub cover for the entire planted area will also be estimated using the same method.

Table 10. Cover classes for percent vegetative cover estimates.

Cover class	Range of cover (%)	Class midpoints (%)
1	<1	0.5
2	1–5	3.0
3	5–10	7.5
4	10–25	17.5
5	25–50	37.5
6	50–75	62.5
7	75–100	87.5

8.2 Containers, preservation, and holding times

Not applicable.

8.3 Equipment decontamination

Field staff will follow the Ecology SOP to Minimize the Spread of Invasive Species (Parsons et al. 2012), particularly section 6.2 on how to inspect, clean, and drain all equipment after fieldwork. Field staff do not wear felt soled boots at CCNRD and the Wenatchee watershed is not an Area of Extreme Concern so decontamination beyond the "inspect, clean, and drain" process should not be necessary. However, staff will be diligent in inspection for invasives and employ SOP decontamination techniques should the status of the watershed change or a pair of felt soled boots or waders be used.

8.4 Field log requirements

Data sheets (transect establishment, densiometer, shrub cover) include spaces for all necessary field measurements. Example data sheets are in Appendix C. Additional detailed notes will also be kept in a field notebook. Additional information will include:

- Date, time, and site of field activity.
- Water quality measurements (DO and temperature).
- Site and /or atmospheric conditions or any unusual circumstances or possible bias that may affect data.
- Procedures performed during site visit (i.e., shrub cover estimates, water quality measurements, photo points, etc.).

9.0 Measurement Methods

SOP's and measurement procedures used in this study are outlined in the previous section. The nature of the measurements taken will not manipulate the environment or remove any samples from the site. Instrument calibration is described in Appendix B and Section 8.2. Methods for field collection are in Section 9. Protocols cited in methods are listed in Table 11. The adapted column indicates whether methods in the listed protocol were adapted for this study.

Table 11. Protocols referenced in this study.

Task	Protocol	Adapted?
Photo Points	OWEB 2001	yes
Transect establishment	Crawford 2004	yes
Canopy Cover	OWEB 2001	no
Shrub Cover	Scott and Reynolds 2007	yes
Water quality measurements	YSI Field Manual	no

10.0 Quality Control

10.1 Field quality control

All field data collected for this study will be conducted and/or overseen by the author of this QAPP, who consequently understands all aspects of the field collection process. The author also has extensive experience with all data collection procedures outlined in this QAPP. Any field technician that may become involved in the future will be trained by the author to assure consistency in data collection. Additional QC measures include:

- **Follow Protocols.** Protocols will be followed in the establishment of transects and vegetation plots, and collection of dissolved oxygen, water temperature, canopy cover, bankfull width, shrub cover and bank stability data.
- **Perform Calibrations.** Calibration procedures will be conducted each year as specified in Appendix B and checked against air-saturated water for the ProDO meter.
- **Check data before leaving site.** Data sheets must be reviewed for omissions at the conclusion of each site visit (Appendix C). The field notebook will also be reviewed for clarity and completeness, DO and stream temperature measurements.

Quality Control Procedures (QCPs) will be implemented to best ensure that shade variability across the site will be effectively represented. To do so:

- Multiple transects will be established (see section *"transect establishment")* to accurately represent vegetative conditions of the site as a whole.
- Densiometer readings will be measured at multiple points along a transect to capture spatial variability from channel to planted floodplain.
- Photo points will give qualitative reinforcement to quantitative shade measurements.

QCP's will also be implemented to accurately represent changes in shade, DO, bankfull width, percent shrub cover and stream temperature over time. To do so:

- Thorough information on transect and measurement point location will be recorded so to ensure staff can return to the same point to collect parameter data.
- Every visit will be during August or September, during the peak of leaf-on. This will reduce study error by reducing the influences of seasonal differences on detected changes in shade.

10.2 Corrective action processes

Data sheets will be thoroughly reviewed and entered into electronic spreadsheets within a week of collection. The field site will be re-visited promptly should any piece of data be lost or missed during the first field visit. The site will also be re-visited if any photos were missed, which will also be downloaded and named within a week. If the location of a transect, measurement point or vegetation plot is not clear from notes, GPS coordinates and maps then the site will be revisited and a new location established.

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

The author, and project manager, will be responsible for project data management activities. The following steps will be followed:

- Before leaving a site, and again in the office immediately after field collection, completed data sheets will be reviewed and checked for completeness and accuracy. Field book will be checked and collection of water quality parameters confirmed. Sheets will be filed in the project binder.
- Data sheets will be transcribed to excel within a week of collection. Data will be saved in the electronic project folder in the appropriate site's sub folder.
- Photos will be downloaded and saved in the appropriate electronic folder.
- All data will be backed up on an external device to safeguard against data loss.

11.2 Lab data package requirements

Not applicable.

11.3 Acceptance criteria for existing data

All collected data will be reviewed in spreadsheets to ensure the results fall within the expected range for the given parameter (Table 8). If the results fall outside the expected range, the project manager will investigate sources of the error. If there is time in the season the parameter will be re-measured; if not the data point will be flagged or deleted. The data will also be reviewed in graphic form and relative to past measurements to assist in identifying outliers. Outliers will be flagged appropriately.

11.4 EIM data upload procedures

Data acquired for all parameters monitored will be entered into Ecology's Environmental Information Management system (EIM) following Ecology's on-line data submission guidelines.

12.0 Audits and Reports

12.1 Audits

A systems audit will be conducted during the second season of the monitoring program (2015). The audit will review staff conformance to QAPP procedures. Corrective procedures will be taken if project implementation is not in conformance with the QAPP. If the audit identifies a deficiency or required change in the QAPP, that change will be made and submitted to Ecology as soon as possible.

12.2 Responsible personnel

The audit will be conducted by the project manager (Table 5).

12.3 Reports

Annual project reports will be submitted by the March following each year of project implementation. Reports will include all monitoring data collected during the preceding period. The first report will be submitted by March 2016 and will include summaries of project status, QA/QC reporting and assessment of data usability, significant data quality problems and corrective actions taken, summary of results in graphical and tabular form, photo points and transect maps, and any other information requested by Ecology.

In addition to the above, a progress report (year 5) and final report (year 10) will be submitted. Progress reports and the Final Report will include:

- Maps showing transect and measurement points.
- Descriptions of sites and summary of data collected.
- Plant survival and shrub cover estimates.
- Line graphs and tables of changes in shade, shrub cover and bankfull width over time.
- Tables of water quality variables.
- Additional graphs that depict the main findings of the study.
- Year 5 - Discussion on data's ability to meet project goals and objectives. If objectives are not being met, adjustments to protocol will be proposed.
- Year 10 - Objectives will be addressed and study conclusions discussed.
- Adaptive management actions (especially at year 5, i.e., changes in irrigation methods or additional plantings).

12.4 Responsibility for reports

The project manager will be responsible for writing and submitting the reports.

13.0 Data Verification

The project manager will be responsible for data verification. Before leaving the site, field staff will check all data sheets for missing data or incongruous measurements (see Appendix B for data sheets). Field notes will include a list of field tasks completed and will be checked to verify that all proper procedures were followed and quality objectives were met. Data will be saved electronically in the project file, and paper data sheets will be filed into physical files. Field data will be checked electronically against previous years' data to further check measurement congruity. Valid data will then be flagged as *Final.*

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether objectives have been met

Data will be reviewed to assure that quality objective standards have been met. Any data that does not will be flagged. The following methods will be used to assess data usability:

1. The YSI ProODO meter will be calibrated and checked for accuracy based on protocol.
2. Any data that does not fall within appropriate ranges will be rejected (Table 8).
3. Bias will be minimized by following protocols. Any bias will be identified and related data flagged appropriately.
4. Completeness will be measured by the number of years of monitoring relative to 10 years.
5. Established transects, measuring points, and vegetation plots will be utilized every year so that data is comparable over time. Changes in the location in any of the above will be designated as unique points.
6. Shrub cover and shade data will be evaluated using photo points, which will confirm whether data are adequately representing conditions at the site.

14.2 Data analysis and presentation methods

Reports will include tables and graphs of quantitative measurements, a discussion on temperature changes within sites and between years (relative to nearest continuous temperature logger in the same stream), and recommended actions if necessary.

Data will be analyzed and presented as to display within site trends over time. Graphs will show time on the x axis and percent canopy or shrub cover on the y axis. The shrub cover metric used in graphs will be the average across all plots in a given year. Variability in canopy cover across a site (i.e. stream center, stream bank, riparian) will be depicted using multiple lines on a single graph. Shrub cover and percent canopy will also be presented in tabular format and include all data. Additional plantings will be considered if shade values have not increased significantly by year 5.

Bank stability and bankfull width will be presented in tabular format. A graph with bankfull width on the x-axis and percent canopy on the y-axis will show between site variability.

Percent canopy at stream center will be converted to percent shade using the equation in Figure 2. These values will be compared to the load allocations from the *Wenatchee River Temperature Total Maximum Daily Load Study* (Cristea and Pelletier 2005).

Dissolved oxygen and stream temperature will be presented in tabular format with date, time, and site. Temperature data will include the temperature measured at the site, temperature recorded at the gage site, and the difference between the two.

Results of data analysis should indicate trends over time (unit = year), i.e., an increase in shade and shrub cover, an increase in invasive cover, and constant shade. Photo points will be used to evaluate whether data trends match site conditions. If a mismatch is apparent, the sampling design will be modified.

The project manager will be responsible for data analysis, graphs, tables, maps, and reports.

14.3 Sampling design Evaluation

All elements of the sampling design for this project are based on established protocols (Table 11). The design as presented in this QAPP will be evaluated internally by CCNRD staff and by Ecology staff to ensure that it effectively addresses study objectives. In addition and especially since the design as a whole is new, the project will undergo continual evaluation by the study team to ensure objectives are being met in the most efficient and effective way possible. Study design modifications will be presented to Ecology and incorporated if design improvement is expected. Evaluation will occur during data QA/QC and also during annual report assessment.

14.4 Documentation of assessment

The author of this QAPP, also the Project Manager of task 3 and this study, will be responsible for all documentation and assessment of data quality and of the overall project monitoring progress. All data will be available for review by CCNRD staff, project partners and Ecology. Annual and final project reports will be submitted to Ecology and available to the public and partnering agencies by request.

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Appendix A - Term and abbreviation definitions

- **Accuracy -** The degree to which a measured value agrees with the true value of the measured property.
- **Bankfull width** – The lateral extent of the water surface when the channel is completely filled.
- **Bias –** The difference between the population mean and the true value.
- **BNSF –** Burlington Northern Santa Fe (Railway)
- **Canopy cover –** The percent of sky covered by the riparian vegetation within a given portion of sky.
- **CCNRD** – Chelan County Natural Resources Department.
- **Comparability** – The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator.
- **Completeness** – The amount of valid data obtained from a data collection project compared to the planned amount; usually expressed as a percentage. A data quality indicator.
- **Contaminants of concern –** Substances found at a site that Ecology has determined pose an unacceptable risk to human health or the environment.
- **DO** – Dissolved oxygen.
- **DQOs –** Decision Quality Objectives. Specify how good a decision must be.
- **Ecology –** Washington Department of Ecology
- **EIM** - Environmental Information Management system
- **Effective shade deficit –** The difference between the shade from potential mature vegetation and current riparian vegetation
- **LIDAR** – Light detection and ranging.
- **Load allocations for effective shade** - target percent effective shade values that, if achieved, would lower stream temperatures.
- **MQOs –** Measurement Quality Objectives. Performance of acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness.
- **OWEB** – Oregon Watershed Enhancement Board
- **Precision** – A measure of the variability in the results of replicate measurements due to random error.
- **Range –**The lower and upper limits of measurement.

- **Representativeness** – The degree to which a sample reflects the population from which it is taken; a data quality indicator.
- **Resolution –** The degree to which a change can be detected.
- **Riparian –** Along the banks of a river.
- **Sensitivity** – In general, denotes the rate at which the analytical response varies with the concentration of the parameter being determined.
- **Shade –** The amount of incoming solar radiation obscured or reflected by vegetation above a stream.
- **TMDL** – Total Maximum Daily Load.
- **QAPP -** Quality Assurance Project Plan.
- **QA/QC** – Quality Assurance/Quality Control.
- **WQA –** Water Quality Assessment.
- **WRIA** – Water Resource Inventory Area.

Appendix B – Calibration Data Sheets

Table 12. YSI ProODO Calibration and Maintenance Sheet.

YSI ProODO Calibration Sheet

Calibration performed by				Date	

Maintenance	yes	no
Probe firmware updated		
Instrument updated		
Battery compartment gasket checked/cleaned		
sensor cap cleaned/replaced		
sensor cap hydrated		
batteries replaced		

DO Calibration (in water saturated air)	value
barometer reading ProODO	
barometer reading level logger	
barometer calibrated (y/n)	
% DO precalibration	
% DO value based on baro reading	
calibration accepted (y/n)	

battery volts remaining	

Temperature	ProODO	thermometer
Ice bath temperature		

Appendix C – Field Collection Data sheets

Site Description and Location
Date:_____ Observer:_____
Project: _____
Location Description (key features): _____
_____
Weather: _____
Number of Camera Points: _____ Number of Photo Points:_____
Notes/Discussion:_____
_____
_____
_____

MAP

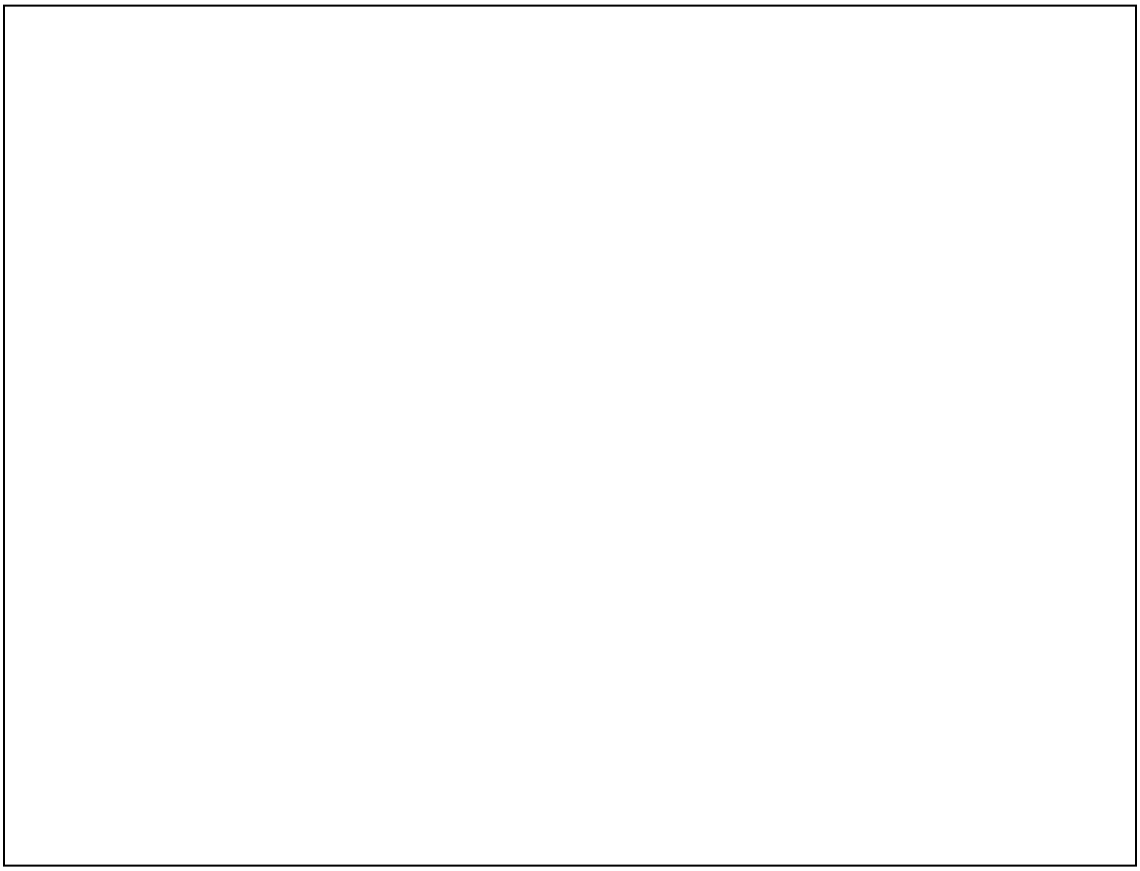

Figure 7. Camera and photo point location and detail sheet.

Date:_____ Observer: _____
Project: _____
Camera Location: _____Number of Photo Points: _____

Photo Point A:
Compass Bearing: _____
Distance: _____
Notes: _____
_____
_____
_____
_____
_____

Photo Point B:
Compass Bearing: _____
Distance: _____
Notes: _____
_____
_____
_____
_____
_____

Photo Point C:
Compass Bearing: _____
Distance: _____
Notes: _____
_____
_____
_____
_____
_____

Figure 8. Camera and photo point location and detail sheet.

Transects						X site description:
Site						
Date/time						
GPS X site						
Monument type						
Monument description						
azimuth to X						
distance to X						
photo of monument?						
photo of X?						
Number of transects						
	A - B	**B - C**	**C - D**	**D - E**	**E - F**	**F - G**
distance btwn transects (circle X site)						
	Transect Notes and Map					

Figure 9. Transect location data sheet.

DENSIOMETER DATA

Site

Date/Time

Transect :		Upstream	Downstream	Right	Left
Stream Center	1-17				
Right Bank	1-17				
Left Bank	1-17				
Bankfull width		North	South	East	West
Riparian Point	1-17				
Distance : bank - RP					
azimuth: bank - RP					
RP location notes					

Transect:		Upstream	Downstream	Right	Left
Stream Center	1-17				
Right Bank	1-17				
Left Bank	1-17				
Bankfull width		North	South	East	West
Riparian Point	1-17				
Distance : bank - RP					
azimuth: bank - RP					
RP location notes					

Transect:		Upstream	Downstream	Right	Left
Stream Center	1-17				
Right Bank	1-17				
Left Bank	1-17				
Bankfull width		North	South	East	West
Riparian Point	1-17				
Distance : bank - RP					
azimuth: bank - RP					
RP location notes					

Transect:		Upstream	Downstream	Right	Left
Stream Center	1-17				
Right Bank	1-17				
Left Bank	1-17				
Bankfull width		North	South	East	West
Riparian Point	1-17				
Distance : bank - RP					
azimuth: bank - RP					
RP location notes					

Figure 10. Canopy cover data sheet.

DATE **SITE**

Total shrub cover =

PLOT	SPECIES	Cover	coverclass	NOTES

Total invasive cover =

PLOT	SPECIES	Cover	coverclass	NOTES

Total shrub cover =

PLOT	SPECIES	Cover	coverclass	NOTES

Total invasive cover =

PLOT	SPECIES	Cover	coverclass	NOTES

Figure 11. Shrub cover data sheet.