ESS Group, Inc.

Quality Assurance Project Plan

FOR TAXONOMIC IDENTIFICATION OF BENTHIC MACROINVERTEBRATES, RHODE ISLAND

PREPARED FOR

Rhode Island Department
of Environmental Management
Office of Water Resources
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Project No. R298-005

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EPA-NE Worksheet 1 Title and Approval Page

QUALITY ASSURANCE PROJECT PLAN FOR TAXONOMIC IDENTIFICATION
OF BENTHIC MACROINVERTEBRATES,
RHODE ISLAND

January 8, 2007

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QUALITY ASSURANCE PROJECT PLAN
TAXONOMIC IDENTIFICATION OF BENTHIC MACROINVERTEBRATES

Table 1 provides a summary of EPA-NE Quality Assurance Project Plan (QAPP) Worksheets (USPEA, 1999) not submitted in this QAPP and details the rationale for their omission. The decision to omit several worksheets from this QAPP was made in an attempt to limit redundancy within the document and to remove worksheets which are not relevant to the current project. Table 1 also summarizes information requested from Appendix A, Worksheet 2, Item 9.

1.0 DISTRIBUTION LIST AND PROJECT PERSONNEL SIGN-OFF SHEET

The information requested on the distribution list and project personnel sign-off sheets is encompassed on Worksheet 1, Title and Approval Page, located at the front of this document and therefore, Worksheet 3 Distribution List and Worksheet 4; Project Personnel Sign-Off Sheets have been omitted from this QAPP.

2.0 PROJECT ORGANIZATION

ESS Group, Inc. (ESS) has been contracted by the Rhode Island Department of Environmental Management (RIDEM) to execute a three-year biological sampling and taxonomic identification program that will provide the RIDEM with benthic macroinvertebrate data from selected wadeable streams in the state of Rhode Island. The primary tasks include (1) collection of benthic macroinvertebrates, water quality data and habitat quality information; (2) sorting of benthic macroinvertebrate samples; (3) taxonomic identification of benthic macroinvertebrates; and (4) analysis of results. The RIDEM will provide oversight on the project.

Figure 1 (Worksheet 5A), Organizational Chart describes the principal officials and investigators from academic and private institutions associated with the project. In addition, this figure illustrates the pathways of communication that will be utilized during the project and therefore, serves to replace Worksheet 5B, Communication Pathways.

2.1 Communication Pathways

Carl Nielsen of ESS will serve as Lead Project Manager and will coordinate all field and office work to ensure that it meets the standards established for the project and that work is performed in a timely manner. He will be responsible for overseeing all laboratory efforts (for benthic macroinvertebrate processing and identification) and will ensure that all involved personnel are properly trained in all appropriate protocols relating to the collection, sorting and identification of samples. Mr. Nielsen will review field and laboratory data and oversee the completion of all draft and final reports. In addition, Mr. Nielsen will provide regular written or verbal progress updates to RIDEM staff and will be responsible for meeting all project requirements. Mr. Nielsen will serve as the primary point of contact for the entire project.

Carl Nielsen of ESS will act as Quality Assurance Officer. He will verify the accuracy and correctness of procedures and protocols described in the QAPP and will confirm that reporting requirements are met with respect to time of delivery and the product quality.

The ESS Field Data Collection Team and Macroinvertebrate Taxonomic Identification Specialists consist of Carl Nielsen, Matt Ladewig and Dan Herzlinger of ESS. Carl Nielsen will serve as the data collection, analysis and reporting Task Leader and will be in charge of organizing field data collection. Mr. Nielsen will actively participate with fieldwork to ensure that all procedures are implemented as outlined in the QAPP and to resolve any problems that may be encountered in the field. Matt Ladewig will conduct all macroinvertebrate collection and water quality measurements in the field. He will also perform all taxonomic identification in the laboratory and ensure data collection protocols listed in the QAPP are followed (refer to Appendix B, ESS Standard Operating Guidelines for methodology). Dan Herzlinger will assist with collection of macroinvertebrates and habitat data in the field and will sort macroinvertebrate samples in the ESS lab.

Todd Askegaard of Aquatics Resources Center will be responsible for the systematic taxonomic identification of Oligochaete and Chironomid larvae. Responsibilities include the proper mounting of larvae, if necessary, and the successful identification to sub-family or tribe for chironomids (refer to Appendix C, Aquatic Resources Center Methodology for Mounting and Identifying Chironomid and Oligochaetes for methodology).

Mr. Douglas G. Smith (retired) of The University of Massachusetts - Amherst (hereafter Mr. Smith) will be responsible for the taxonomic identification of Crustaceans and Mollusks. Responsibilities include the successful identification to the lowest taxonomic level possible (usually species).

For a full description of the project plan in terms of organizations involved and their respective duties, please refer to Appendix A, Worksheet 6, Personnel Responsibilities and Qualifications Table.

2.1.1 Modifications to the QAPP

In the event that the QAPP requires substantial modification, Carl Nielsen will contact involved parties at RIDEM before proceeding with any further project activities. The organization chart (Figure 1, Worksheet 5A Organizational Chart) describes the principal officials and investigators associated with the project and illustrates the chain of communication and authorization.

This QAPP covers the first year of this three-year project. Although work during subsequent years is likely to be similar in nature, it is expected that a written update to the QAPP will be submitted to RIDEM and to EPA prior to initiating field work during each of the subsequent years (by July, 2007 and July, 2008).

2.2 Personnel Responsibilities and Qualifications

For a full description of the project plan in terms of the organizations involved and their duties, refer to Figure 1, Worksheet 5A, Organizational Chart and Appendix A, Worksheet 6, Personnel Responsibilities and Qualifications.

2.3 Special Training Requirements/Certification

The Project Team has extensive experience in the collection, processing and analysis of benthic samples. ESS staff assigned to this project has been conducting benthic community assessments for

over eighteen years, while members of the ESS Project Team, the staff at the Aquatic Resources Center (ARC) and Mr. Douglas G. Smith formerly of UMASS have dedicated the majority of their professional careers toward macroinvertebrate biology and taxonomy.

No special training or certification courses were attended specifically in preparation for this project. However, ESS staff, specializing in benthic community assessments, received training in macroinvertebrate identification from previous academic study as well as during informal ESS in-house training associated with a variety of similar projects. ESS has also conducted this project annually since 2002. As a result, Worksheet 7, Special Personnel Training Requirements Table, is not included as part of the QAPP.

3.0 PLANNING/PROJECT DEFINITION

The Rapid Bioassessment Protocol (RBP) is an integrated approach for assessing aquatic ecosystems and entails assessing local habitat features (e.g., physical structure, flow regime), water quality parameters and biologic indicators and comparing these data to an empirically defined reference condition (Barbour et. al., 1999). The power of the RBP approach is that it allows for predictions and/or inferences to be made on aquatic ecosystem quality from a relatively "rapid" assessment of the prevailing biologic conditions (in the present study macroinvertebrate community composition). Aquatic ecosystem health of freshwater bodies, as inferred from the benthic macroinvertebrate community, has gained increasing popularity among the academic community, environmental scientists from the private sector and state and federal regulatory agencies. Biological monitoring can provide information about past and/or episodic pollution and readily gives an accurate representation of relative health of aquatic ecosystems.

Bioassessments of freshwater streams and lakes aid in assessing the effectiveness of mitigation actions, evaluating point and non-point sources of pollution and prioritizing water bodies for future mitigation activities. Information about benthic macroinvertebrate community structure may also be used to help determine water quality characteristics for Total Maximum Daily Load (TMDL) determinations and to provide additional data for National Pollutant Discharge Elimination System (NPDES) permit modifications (Plotnikoff, 1998). Benthic macroinvertebrates act as indicators of habitat quality and are useful in the biological monitoring of their freshwater surroundings because:

- Some species of benthic macroinvertebrates are sensitive to pollution and some are tolerant, therefore, even short-term environmental fluctuations may be readily inferred from benthic community composition.
- Often, invertebrates are relatively sedentary and long-lived and therefore, information inferred from community composition may accurately characterize local conditions.
- Generally, invertebrates are easy to collect and identify and therefore, are often regarded as a time- and cost-effective technique to assess aquatic ecosystem health.

3.1 Project Planning Meetings

Initial scoping of this project was defined by the RIDEM in their Request for Proposals (RFP) for this project. Since the work to be carried out was well defined in this RFP, an initial scoping meeting was

not held in order to ascertain the work to be carried out or the project role of the organizations involved. However, a project "kick-off" meeting was held on 7 September 2006 in order to refine the project schedule, identify specific sampling locations, and to clarify project and contract details. Consequently, Appendix A, Worksheet 8A, Project Scoping Meeting Attendance Sheet has been prepared.

3.2 Problem Definition/Site History and Background

The importance of biological assessments in the evaluation of water quality has long been recognized by Rhode Island state regulatory agencies. The RIDEM Office of Water Resources (OWR) has monitored benthic macroinvertebrates according to the EPA's RBPs (Barour et al., 1999) in the past and has successfully characterized the health of several freshwater habitats across the state in this manner. This program was initiated as a baseline study in the early 1990's and has proven to be a rapid and economically effective technique in determining the relative health of freshwater waterbodies throughout Rhode Island.

The RIDEM adopted the EPA's RBP technique (first instilled in 1992) and has since been involved in field testing and refining the RBP methodology. Data obtained during these formative years were compared to Fall River, the designated reference station. In 1993, further evaluation resulted in the designation of the Wood River and Adamsville Brook as reference stations. At present, further refinement of protocols has established the presence of two sub-ecoregions within the State: coastal areas and inland areas. The current program has evolved from a broad state-wide assessment into a 5-year rotating basin approach. This has allowed the state to effectively utilize the available budget to assess a greater number of streams and tributaries, many of which were previously unassessed.

4.0 PROJECT DESCRIPTION AND SCHEDULE

The goal of the benthic macroinvertebrate study is to execute a three-year biological sampling and taxonomic identification program that will provide the RIDEM with benthic macroinvertebrate data on selected rivers in the state of Rhode Island. The primary tasks include (1) collection of benthic macroinvertebrates, water quality data and habitat quality information; (2) sorting of benthic macroinvertebrate samples; (3) taxonomic identification of benthic macroinvertebrates; and (4) analysis of results. In order to successfully achieve study objectives, ESS and/or their sub-contracted laboratories (ARC and UMASS) will complete the following tasks:

- Develop a QAPP and Monitoring Plan
- Collect benthic macroinvertebrate samples and assess water quality and physical/habitat parameters at selected sites
- Conduct laboratory processing and taxonomic identification of benthic macroinvertebrates
- Manage and analyze data and interpret results
- Prepare a final report

For the current project, ESS will sample, sub-sample and sort organisms in accordance with the EPA's Rapid Bioassessment Protocols For Use In Wadeable Streams and Rivers, July 1999, EPA 841-B-99-002 (Barbour et al., 1999). After macroinvertebrates have been sorted by ESS scientists, Oligochaetes (worms) and Chironomids (midges) will be sent to ARC care of Todd Askegaard and Crustaceans and Mollusks will be identified by ESS scientist and/or sent to Douglas G. Smith at UMASS for further taxonomic identification or confirmation of ESS identification. ESS scientists trained in macroinvertebrate identification will identify all remaining organisms.

Based on the results generated from the taxonomic identification effort, it will be possible to compare and assess each site with respect to an appropriate reference site. In order to complete this task, ESS will adhere to the EPA recommended metrics as detailed in the EPA's Rapid Bioassessment Protocols For Use In Streams and Rivers, May 1989, EPA/444/4-89/00 (Plafkin et al. 1989). This process will allow ESS scientists to characterize stream segments into one of the following categories: fully supporting, slightly impaired, moderately impaired or severely impaired as compared to the reference sites for each eco-region.

ESS will develop a draft final report which presents all data and information obtained from the present study including: field sampling and habitat description information, sample collection and processing information, taxonomic lists of organisms observed at each station, selected metrics and indices, and the overall assessment of aquatic environmental health at each sampling location for review by RIDEM. The draft report will summarize our findings following each year's sampling effort.

For an overview of the activities to be performed, field and quality control details, and the overall project schedule time line, refer to Appendix A, Worksheets 9A, Project Description, Worksheet 9C, Field and Quality Control Sample Summary Table, and Worksheet 10, Project Schedule and Timeline Table. Since no contaminants or other target analytes will be assessed in the present study, Worksheet 9B, Contaminants of Concern and Other Target Analytes Table (Reference Limit and Evaluation Table), has been omitted from this QAPP submittal.

5.0 PROJECT QUALITY OBJECTIVES AND MEASUREMENT PERFORMANCE CRITERA

Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of the data, define the type of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error because of uncertainty in the data (if applicable). DQOs are developed by data users to specify the data quality needed to support specific decisions.

5.1 Project Quality Objectives

The quality of an environmental monitoring program can be evaluated in three steps: (1) Establishing scientific assessment quality objectives; (2) Evaluating program design for whether the objectives can be met; and (3) Establishing assessment and measurement quality objectives that can be used to evaluate the appropriateness of the methods being used in the program. The process of establishing DQOs involves identifying the allowable uncertainty of a data set that may lead to two types of error:

false positives (Type I error: a problem is found to exist when in fact it does not) and *false negatives* (Type II error: a problem is not found when in fact it does exist). The acceptance probabilities of those errors as established by the data users are the DQOs. The DQO process entails establishing action-triggering values and selecting rates of false positives and false negatives that are acceptable to the data user (decision maker). The quality of a particular data set is some measure of the types and amount of error associated with the data. Additional information pertaining to this section can be found in Appendix A, Worksheets 9A, Project Description, and Worksheet 9C, Field and Quality Control Sample Summary Table.

Sources of error or uncertainty associated with variables and indicators include the following:

1. Sampling error: The difference between actual representative values and sampling values that are related to error in sampling design. Sampling error consists of station specific natural variability due to unknown stream characteristics (may produce adequate living conditions in an isolated area of water) and anthropogenic variability associated with the impact of unknown recent disturbance events (may result in temporary loss of adequate living conditions).
2. Identification error: The difference between sample values and in situ "true" values associated with the sorting and identification process. Identification error includes bias and imprecision associated with sample labeling, handling, storage, sorting and taxonomic classification.

The data requirements for this project encompass aspects of field analysis, laboratory identification and database management to reduce sources of errors and uncertainty in the use of the data. Methods and procedures described in this document are intended to reduce the magnitude of measurement error sources and frequency of occurrence. The relevant quality objectives for this project are related to sample handling, sample area selection and sample identification. General project quality objectives include the following:

- Use of standardized, repeatable sample collection procedures.
- Use of trained scientists to perform the sample collection and analyses.
- Use of Chains-of-Custody when sending samples to taxonomic experts involved with the identification procedures.
- A random quality check on a minimum of 10% of the samples analyzed during sorting and identification.
- Maintenance of a taxonomic reference collection.

The purpose of these quality checks is to minimize human error throughout these processes. Also, the checks will validate the identifications made by personnel. In addition, ESS will confirm the identifications made with other regional experts as necessary.

5.2 Measurement Performance Criteria

Measurement performance criteria are quantitative statistics used to interpret the degree of acceptability or utility of the data to the user. These criteria, also known as data quality indicators (DQIs), include the following:

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability

DQIs that cannot be expressed in terms of accuracy, precision, or completeness will be reported by fully describing the specified method. Because no contaminants or other target analytes will be assessed in the present study, Worksheet 11B, the Measurement Performance Criteria Table has been omitted from this QAPP submittal. Refer to Section 5.0 of the Freshwater Macroinvertebrate Collection and Analysis included in Appendix B, ESS Standard Operating Guidelines (hereafter, SOGs) for additional information.

6.0 SAMPLING PROCESS DESIGN, PROCEDURES AND REQUIREMENTS

Sampling and data collection conducted as part of this project will include a benthic macroinvertebrate kick sample from each specified sampling location and an assessment of habitat following the protocols as detailed in Barbour et al. (1999). In addition, water quality physical parameters to be measured include: dissolved oxygen (mg/L and % saturation), temperature, pH, conductivity, turbidity and flow and these data will be attained according to the protocols as outlined in Appendix B SOGs. Information presented in this section will supplant the need for Worksheet 12A, Sampling Design and Rationale.

Refer to Appendix A, Worksheet 14 Field Sampling Equipment Calibration Table and Worksheet 15 Field Equipment Maintenance, Testing and Inspection Table for further information regarding the acquisition of physical water quality parameters. Refer to Appendix B, ESS SOGs for additional information and field protocols for all equipment proposed for the present study. Because no contaminants or other target analytes will be assessed in the present study Worksheet 9B, Contaminants of Concern and Other Target Analytes Table, Worksheet 11B, Measurement Performance Criteria Table, Worksheet 21, Fixed Laboratory Instrument Maintenance and Calibration Table, Worksheet 24A, Fixed Laboratory Analytical QA Sample Table, and Worksheet 24B, Fixed Laboratory Analytical QC Sample have been omitted from this QAPP submittal.

6.1 Sampling Design Rational

As requested in the Scope of Work, a single habitat assessment approach for inferring aquatic ecosystem health has been adopted for the present study. This approach entails sampling benthic

invertebrates from riffle/run communities at each sampling location. This technique is valid and widely used today because benthic organisms are commonly found in rocky or cobble substrate (riffles or runs). When this sampling regime is conducted over a long time period (years), as in the present study, variations in macroinvertebrate composition are readily observed within a single sampling location. Moreover, when this sampling regime is employed simultaneously at several sampling locations, as in the present study, comparisons of macroinvertebrate composition and inferences of relative aquatic ecosystem health may be ascertained between sampling locations.

The single habitat assessment approach is not intended to represent a sampling of all macroinvertebrate taxa that may be present in any given stream segment since many other habitats are likely to be present (e.g. pools, backwaters, etc.).

7.0 SAMPLING PROCEDURES AND TRACKING AND CUSTODY REQUIREMENTS

All macroinvertebrate samples will be collected and subsequently stored in clean, labeled containers prior to transport from the field. A chain-of-custody form will be completed for each set of samples and will be provided to the laboratory personnel along with the samples. A copy of the chain-of-custody forms will be maintained in the project file at ESS' East Providence office.

After the sorting of the samples has commenced, ESS scientists randomly perform a quality check on a minimum of 10% of the samples analyzed. This quality check will ensure that the sorting of samples is conducted in accordance with the EPA RBP guideline (Barbour et al., 1999).

During the sorting phase, if more than a 10% discrepancy is detected between the numbers of organisms identified by the sorter and those identified by the quality assurance check, the sample will be re-processed. The re-sorted sample will receive a second quality assurance check. If the second check again reveals that too many organisms are being missed (>10%), then four (4) additional samples, previously handled by the same ESS sorter, will be randomly selected to undergo a similar quality assurance check. If the percent error in these four (4) additional samples is again more than 10%, then all samples handled by the sorter will be reprocessed.

In order to conduct a Quality Control (hereafter, QC) review for the identification process, an ESS staff member trained in macroinvertebrate identification will randomly check a minimum of 10% of the samples. The purpose of this check will be to validate that identifications are being made accurately and to confirm that that Oligochaetes (worms), Chironomids (midge), Crustaceans, Mollusks are placed in the appropriate labeled and preserved containers for shipping to ARC and Mr. Smith. If necessary, ESS will confirm the identifications made with other regional experts or with ARC and Mr. Smith.

A reference collection of samples from the years 2002-2005 has been developed and is currently maintained at the ESS East Providence office. Any new taxa found during subsequent years of the study will be added to this collection. It is anticipated that this collection will continue to be a valuable resource for confirming identifications with regional experts as well as for proficiently identifying organisms in subsequent years of the study. All new specimens will be labeled and preserved in 70% ethanol and stored for future reference and/or for study by ESS or other regional experts as necessary. A record of

the results of each of the various quality assurance checks described above will be kept in an EPA approved Laboratory Analysis Log (Barbour et al., 1999).

7.1 Sampling Procedures

ESS will sample macroinvertebrates in accordance with the EPA's single habitat approach (Barbour et al., 1999). Timed kick samples will be obtained from each sampling station (for complete list of selected sampling stations please refer to Appendix D, Sampling Locations for the Taxonomic Identification of Benthic Macroinvertebrates Project, Rhode Island).

Prior to macroinvertebrate sample collection, an EPA Habitat Assessment Field Data Sheet (Barbour et al., 1999) will be completed in order to assess habitat quality within each selected stream reach. Data obtained during this effort include: a generalized site description, weather conditions during the time of sampling, and predominant land usages within close proximity to the stream reach. As specified within the EPA methodology (Barbour et al., 1999), the habitat assessment will also include in-field measurement of the following water quality parameters: dissolved oxygen (mg/L and % saturation), pH (SU), conductivity (µmhos/cm), turbidity (NTU), temperature (°C), and flow (cfs or mgd). ESS personnel will follow the SOGs outlined in Appendix B to obtain these field measurements. In addition, a map depicting the entire sampling reach, riffle/run areas where sampling is conducted, and in-stream physical features such as riffles, falls, fallen trees, pools, bends and other important structures will be sketched in the field.

Upon completion of the EPA Habitat Assessment Field Data Sheet (Barbour et al., 1999), a representative 100-meter section of each stream sampling location will be selected for macroinvertebrate sampling. Whenever possible, the area will be at least 50 meters away from any road or bridge crossing to minimize its effect on stream velocity, depth and overall habitat quality and effort will be made to not sample immediately downstream of the confluence of any inflowing tributaries.

Sampling will begin at the downstream end of the 100-meter reach and will proceed in an upstream direction. All kick samples will be taken with a standard D-frame, 500 µm-mesh net (0.3 m width) at various velocities within the riffle or within a series of riffles for a total cumulative duration of 3-minutes. Larger substrate particles and debris will be picked up and rubbed by hand to remove attached organisms. Collected material will be washed by running clean stream water through the net 2 to 3 times as deemed necessary.

Samples will be transferred from the net to glass or plastic sample container(s) and preserved in enough 95% ethanol solution to cover the entire sample. A label will be placed inside the container indicating the sample identification code, date, stream name, sampling location and collector's name. The outside of each container will be labeled similarly, but will also have the words "preservative: 95% ethanol" printed on the label. Sample container information will be recorded on the EPA Sample Log-In Sheet (Barbour et al., 1999).

Preserved and labeled macroinvertebrate samples will be transported to ESS' East Providence office for sorting. Prior to analysis, ESS scientists will review the EPA Sample Log-In Sheet (Barbour et al., 1999) to verify that all samples have arrived and are in proper condition for processing. ESS scientists, experienced in the handling/sorting of benthic macroinvertebrate samples, will rinse each sample with tap water in a 500 µm-mesh sieve to remove preservative and fine sediment. Care will be taken to ensure that macroinvertebrates are not damaged by coming between the direct flow of tap water and the mesh screen. Large organic material (whole leaves, twigs, algal or plant materials, etc.) will be rinsed, inspected and discarded if no associated macroinvertebrates are identified on these substrates. Because the samples have been preserved in ethanol it may be necessary to soak the sample contents in water for about 15 minutes in order to hydrate the macroinvertebrates, thereby preventing organisms from floating on the water surface during the sorting process.

After each sample has been adequately washed, all material remaining will be evenly distributed within one of two trays sized at 10 x 7 x 2.5 inches and 11.5 x 8 x 2 inches with 16 delineated sections. Using a random number sheet, one section will be selected to undergo the macroinvertebrate sorting phase of the analysis. A 6-cm flat scoop will be used to remove all debris and organisms from the selected section and any overhanging debris will be cut with scissors. This "sub-sample" will then be temporarily transferred to a glass or plastic container of adequate size.

ESS scientists will sort each sub-sample under a dissecting microscope on a clean Petri dish. Sub-samples will be scoured for benthic macroinvertebrates and all organisms will be removed and placed in appropriately labeled glass vials (see below). If less than 100 macroinvertebrates are removed from the sub-sample then another randomly selected section of the tray will be sorted. This process will continue until 100 macroinvertebrates are sorted from the debris collected from each sample or until the entire sample has been inspected for macroinvertebrates. At this time any large, rare or unique organisms identified throughout the entire sample in any delineated tray sections will be removed, identified and reported as supplemental data for each sampling location. However, these data will not be considered as a component of the targeted 100-organism sub-sample. The sorter will complete the EPA Laboratory Bench Sheet (Barbour et al., 1999), noting sub-sampling/sorting information, the number of grids picked, time expenditure, and number of organisms found. If a QC check is performed on a particular sample, the QC findings will be noted on the back of the Laboratory Bench Sheet (Barbour et al., 1999). In addition, the sorter will record the date of sorting on the Log-In Sheet (Barbour et al., 1999) as documentation of progress and status of the completion of the sample group.

All sorted macroinvertebrates will be placed into glass vials and preserved in 70% ethanol solution. All macroinvertebrates discovered in every sub-sample will be appropriately placed in one of the following three pre-labeled glass vials: (1) Oligochaetes (worms) and Chironomids (midges); (2) Crustaceans and Mollusks; and (3) other remaining organisms. These three vials will be labeled inside and out with the sample identifier code, date, stream name, and taxonomic grouping. If more than one vial is needed, each will be appropriately labeled and will be numbered sequentially (e.g. 1 of n, 2 of n, etc.).

Sorted debris residue for each sub-sample will be saved in a separate container or sealed in a biological sample bag (e.g. Whirl-Pak®), then, labeled with the following information: the sample identification code, date sorted, stream name, sampling location, sorter's name and have the words "sorted residue" and "preserved in 70% ethanol" printed on the label. The remaining unsorted sample debris residue (if any) will be saved in a separate container labeled with all above information as specified for the sorted residue container, but will have the words "sample residue" and "preserved in 70% ethanol" printed on the label.

The glass vials containing Oligochaetes (worms) and Chironomids (midge) will be sent to the ARC care of Todd Askegaard for further taxonomic identification. Likewise, glass vials containing Crustaceans and Mollusks will be identified by ESS scientists or sent to Douglas G. Smith at UMASS for further taxonomic identification. A Chain of Custody will be prepared for each sample. ESS scientists will analyze the glass vials labeled "Other" containing all remaining organisms. Before the samples are sent to respective laboratories, a numeration and identification reference list (to Family level for chironomids, crustaceans and mollusks and to Order level for oligochaetes) will be compiled. This list will be maintained for sample verification and data recovery in the event that the samples are destroyed or lost during transport. For further details regarding sample handling refer to Appendix A, Worksheet 16, Sample Handling System.

The staff at ARC will be responsible for Chironomid (midges) and Oligochaet (worms) identification which may require mounting specimens on slides. If this is deemed necessary to identify Chironomids to the sub-family or tribe level, the larvae and/or pupae will be mounted on slides in an appropriate medium (e.g., Eupcral, CMC-9). Slides will be labeled with the site identification code, date collected, and the first initial and last name of the collector. As with Chironomids, Oligochaetes will also be mounted on slides and will be a similarly labeled. All mounted specimens will be returned to the RIDEM at the end of the project upon request.

At each respective laboratory, further taxonomic identification (to the genus/species level or the lowest practical taxonomic level) and counts of all organisms within each sample will be determined through the use of either a compound microscope or a dissecting microscope (up to 45X magnification), a fiber optic lamp, standard dissecting tools, and using appropriate taxonomic keys. Each taxon found in a sample will be recorded and enumerated in a laboratory bench notebook and will then be transcribed to the Laboratory Bench Sheet (Barbour et al., 1999). Any difficulties encountered during identification will be noted on these sheets.

Upon completion of the taxonomic identification effort, samples will be returned to ESS' East Providence office and a master list of all taxa will be compiled along with the accompanying reference collection of macroinvertebrates. The master list of macroinvertebrates observed during year-1 of the project will be delivered to the RIDEM at the end of the first year's identification effort as part of our annual reporting.

ESS will manage, compile, and analyze all collected data. The data will be recorded in electronic format and summarized in table form for inclusion in the final report. EPA approved metrics, as

detailed in Plafkin et al. (1989) will be employed by ESS scientists in order to develop in an empirical value representative of each site's macroinvertebrate community. Similarly, all habitat and water quality parameters will be consolidated into an empirical value to represent these conditions at each study site. These values will then be compared in relation to an appropriate reference station and will enable ESS scientists to characterize stream segments into one of the following categories: fully supporting, slightly impaired, moderately impaired or severely impaired.

As identified through discussions with RIDEM personnel and ESS scientists, reference stations for the current project include the Wood River and Adamsville Brook for sampling locations occurring in the Narragansett/Bristol Lowland region and Southern New England Coastal Plains and Hills Region, respectively.

Metrics employed by ESS are expected to conform to those detailed in Plafkin et al. (1989) and as such, the following biological metrics will be assessed:

- Total taxa richness: Total taxa richness is a measure of biodiversity and includes all invertebrates collected from a stream site to obtain an overall assessment. High taxa richness is typically indicative of a healthy aquatic environment.
- EPT Taxa Richness: EPT is an abbreviation for Ephemeroptera, Plecoptera and Trichoptera, insect groups that are generally intolerant to many kinds of pollution. This metric is specific and uses only these insects for evaluation. Generally, a high EPT taxa richness indicates healthy water quality.
- EPT Abundance: Number of individuals in sample that are EPTs. This number measures the composition and tolerance of the sample. A high EPT abundance is typically indicative of a healthy aquatic environment.
- Hilsenhoff Biotic Index (modified; 1998): Individual taxa are classified on the basis of their tolerance or intolerance to various levels of domestic wastes. The HBI is calculated by multiplying the number of organisms in each invertebrate taxon by the pollution tolerance value assigned to each, adding all individuals represented in the sample, and dividing by the total number of individuals in the sample. A high HBI index number is generally indicative of an unhealthy aquatic environment.
- Shannon-Weaver Diversity Index (1949): A mean diversity measurement of species composition. The calculation is affected by richness of species and by the distribution of individuals among the species (species composition).
- Percent Contribution of Dominant Taxon: Measure of diversity found by adding the relative abundance percentage of the dominant taxon. Communities highly dominated by a few taxa may reflect an impaired condition. This is generally not indicative of healthy aquatic conditions.
- Ratio of EPT to Chironomid Abundance: EPT count divided by chironomid count. An elevated chironomid abundance may represent poorer aquatic environmental conditions.
- Percent Hydropsychidae to Total Trichoptera: The rationale behind this metric is that Hydropsychidae are perceived to be pollution-tolerant relative to other more pollution sensitive trichopterans. Compare with a non-stressed habitat, a stressed habitat may reflect an imbalance between these groups.

- Ratio of Shredders to Total Number of Macroinvertebrates: The rationale behind this metric is that shredder organisms and their microbial food base are sensitive to toxicants and to modifications to the riparian zone (Plafkin et al., 1989). The focus of the approach is on a comparison to the reference community, which should have an abundance and diversity of shredders representative of the particular area under study.
- Ratio of Scrapers to Filterers: This ratio reflects the riffle/run community food base. Predominance of a particular feeding group may indicate an unbalanced community responding to an overabundance of a particular food source.
- Community Loss Index: This metric measures the loss of benthic species between a reference station and the station of comparison. The rationale behind the metric is that the communities will become more dissimilar as stress increases at the station of comparison.

7.2 Sampling SOG Modifications

Major modifications will not be made to the EPA's Rapid Bioassessment Protocols For Use In Wadeable Streams and Rivers, July 1999, EPA 841-B-99-002 (Barbour et al., 1999) or the EPA's Rapid Bioassessment Protocols For Use In Streams and Rivers, May 1989, EPA/444/4-89/00 (Plafkin et al., 1989) unless explicitly communicated to the RIDEM and the EPA in advance. Therefore, Appendix A, Worksheet 13, Project Sampling SOP Reference Table is not necessary as part of the QAPP.

7.3 Cleaning and Decontamination of Equipment/Sample Containers

After sampling is completed at each site, all sampling equipment (including nets and pans) will be rinsed with fresh water and closely examined to remove any remaining organisms and/or debris. Any organisms and/or debris found on the equipment will be put into appropriate sampling containers. New sampling containers will be utilized at each sampling location and sampling containers will be rinsed with fresh water prior to use.

7.4 Field Equipment Calibration

This project includes the use of equipment that provides water quality data including dissolved oxygen (mg/L and % saturation), pH, conductivity, temperature, turbidity and flow. Please refer to Appendix A, Worksheet 14, Field Sampling Equipment Calibration Table and Appendix B, ESS SOGs, for a summary of the calibration procedures required for all water quality equipment.

7.5 Field Equipment Maintenance, Testing and Inspection Requirements

Appendix A, Worksheet 15, Field Equipment Maintenance, Inspection and Testing Table and Appendix B, ESS SOGs both detail the practices that will be used during the project to ensure that equipment is properly functioning during sampling events.

7.6 Inspection and Acceptance Requirements for Supplies/Sample Containers

An itemized list of all supplies and sampling containers is included in Appendix B, ESS SOGs. No specific vendors or suppliers are included in this project and all supplies will be commercially purchased.

8.0 FIELD ANALYTICAL METHOD REQUIREMENTS

All field parameters will be measured in accordance with the ESS SOGs included in Appendix B. All field meters will be calibrated prior to fieldwork on the selected date of sampling. Calibration will be conducted in the ESS office prior to each field day or in the field prior to sampling as dictated by the SOGs. For further details regarding instrument calibration refer to Appendix A, Worksheet 14, Field Sampling Equipment Calibration Table and Worksheet 15, Field Equipment Maintenance, Testing and Inspection Table.

9.0 FIXED LABORATORY ANALYTICAL METHOD REQUIREMENTS

The staff at ARC, led by Todd Askegaard, will perform the taxonomic identification of Oligochaetes and Chironomid larvae. Mr. Douglas G. Smith, formerly of UMASS, will perform Crustacean and Mollusk identification. ESS scientists trained in macroinvertebrate identification will perform the taxonomic identification of all remaining benthic organisms. For information about laboratory taxonomic identification methods, please refer to Appendix B ESS SOGs, and Appendix C Aquatic Resources Center Methodology for Mounting and Identifying Chironomid Larvae and Oligochaetes.

10.0 QUALITY CONTROL REQUIRMENTS

QC requirements are the system of technical activities that measure the performance of a process. For the purpose of this study, QC requirements will be utilized within the various aspects of field and laboratory analysis. Information on QC protocols followed in this project is provided in Section 5.0 Project Quality Objectives and Measurement Performance Criteria and 6.0 Sampling Process Design, Procedures and Requirements. Because no contaminants or other target analytes will be assessed in the present study Worksheets 11B, Measurement Performance Criteria Table, and Worksheet 24A, Fixed Laboratory Analytical QC Table have been omitted from this QAPP submittal.

A summary of quality controls to be utilized in the present study is provided below:

1. **Water Quality Monitoring:** All equipment used in the field efforts will be calibrated, and data will be recorded in a consistent fashion. Duplicate field measurements of a single sample will be performed at a rate of approximately 10% and should agree within 10% (please see Section 7.0 Sampling Procedures and Tracking and Custody Requirements). In general, if a discrepancy of greater than 10% is observed between the sample and its duplicate, the piece of equipment will be recalibrated and the sample will be reassessed. ESS SOGs specific to specific water quality parameters are included as Appendix B.

2. **Macroinvertebrate Identification:** A random quality check will be performed on a minimum of 10% of the samples analyzed during sorting and identification. In addition, a taxonomic reference collection will be maintained throughout the duration of the project. Please see Section 7.0 Sampling Procedures and Tracking and Custody Requirements for other related quality control measures.
3. **Laboratory Identification:** For information pertaining to laboratory taxonomic identification methods and quality control checks, please refer to Appendix B ESS SOGs, and Appendix C Aquatic Resources Center Methodology for Mounting and Identifying Chironomid Larvae and Oligochaetes.

11.0 DATA ACQUISITION REQUIREMENTS

This section describes protocols associated with data obtained from external sources (i.e., not collected during sampling). As no data will be obtained from external sources throughout the entirety of this project this section is not applicable to this project and as a consequence, Appendix A, Worksheet 25, Non-Direct Measurements Criteria and Limitations Table is not included as part of the QAPP.

12.0 DOCUMENTATION, RECORDS AND DATA MANAGEMENT

Carl Nielsen, the Lead Scientist and Project Manager, will be in charge of ensuring the proper collection of data and preparation of tables and figures for the entirety of the project. Data collected from the project will be provided to the RIDEM in the form of a bound report, with data tables, figures, and a narrative description of findings. The report will be prepared by the report writing team and reviewed by the Project Manager prior to submittal. All data and the narrative report will also be submitted to the RIDEM in electronic format. The data will be compiled in Microsoft Excel and the narrative will be written in Microsoft Word format. The data will also be made available in an alternate format (specified by RIDEM) should RIDEM require future data uploads to State of RI database (RI SWIMS: Rhode Island State Water Information Management System).

A permanently bound notebook with waterproof pages will be maintained for field notes during data collection and water quality sampling. All entries into the notebook and on the form will be made with ink or pencil; however, corrections will be made using a single line through the mistake with the initials of the individual who made them. A photocopy of field forms will be maintained in the project files. Entries will include location, time of sampling, date, weather conditions, parameters to be measured, and associated data, as well as any problems encountered during sampling. Copies of the field notebook and field forms will be checked by the Quality Assurance Officer after each sampling event and will be made available for review upon request. Refer to Appendix A, Worksheet 26, Project Documentation and Records Table for additional information regarding the organization of project files.

Data presented in the final report will be made available for distribution by the RIDEM. The RIDEM will maintain and distribute copies of the report on a necessary basis. Tables and figures will be attached as appendices to draft and final reports.

of the study.

- The Project Manager will provide oversight for each field data collection effort to ensure that protocols described on the QAPP are being followed. This duty includes: ensuring that field equipment is properly calibrated, data are recorded in a consistent manner, sampling methodology is being conducted in accordance with Barbour et al. (1999), and samples are being properly distributed to laboratories.

- The Project Manager will review field and laboratory data, including macroinvertebrate field-sampling methods, water quality parameter measurements and macroinvertebrate sorting and identification to ensure that appropriate methodology is adhered to and reported data is within the accepted range for each parameter. If inconsistencies are detected or perceived, the Project Manager will discuss field instrument calibration and data collection with field personnel. Any "outlier" data discovered will be reported in the final report, and potential sources of error will be described.

- The Project Manager will review ARC and Mr. Smith's laboratory results to ensure that identifications are acceptable. Refer to Section 5.0 of the ESS SOP and to the ARC Methodology, included as Appendix B and Appendix C respectively, for additional information pertaining to acceptable ranges. Any discrepancies will be discussed with the respective Laboratory Project Manager and Katie DeGoosh of RIDEM to assess the need to re-sample a particular site. Laboratory "outlier" data will be reported in the final report, and potential sources of error will be described.

14.0 QUALITY MANAGEMENT REPORTS

Quality management reports serve to ensure that the management organization (ESS), and the review agency RIDEM are regularly informed on the project status. To accomplish this goal, the following will be conducted.

- ESS will verbally inform the appropriate RIDEM personnel upon commencement of field sampling.

- Upon receipt and review by ESS, laboratory results for the first round of macroinvertebrate taxonomic identification will be sent to the RIDEM for review. Any problems detected in the data will be verbally discussed between ESS and the RIDEM.

- Any "non-conformance" of Laboratory data will be verbally discussed with the RIDEM and the appropriate Laboratory.

- A draft report summarizing findings at the conclusion of the year-1 sampling effort will be provided to the RIDEM for review and comment.

15.0 VERIFICATION AND VALIDATION REQUIRMENTS

Data review, validation, and verification provide methods for determining the usability and limitations of data, as well as a standardized data quality assessment. ESS will be responsible for reviewing field and laboratory data sheets, data entries, and transmittals for completeness, correctness, and adherence to QC requirements. The Project Manager from ESS will review data received from the laboratories, to assess the data against applicable precision, accuracy and acceptance criteria. The laboratories

conducting the analyses will be required to conduct internal data verifications before submitting the data to ESS.

16.0 VERIFICATION AND VALIDATION PROCEDURES

Information on the verification and validation of data is presented in this section; additional information on personnel responsibilities is included as Figure 1, aka Worksheet 5A, Organizational Chart and in Appendix A, Worksheet 6, Personnel Responsibilities and Qualifications Table. All field logbook entries, Chain-of-Custody forms, and other records will be reviewed by the ESS Project Manager for completeness and correctness. Analytical data provided by the laboratories will be reviewed and validated internally to provide information on whether data are acceptable, qualified, or should be rejected. The ESS Project Manager will be responsible for reviewing the laboratory reports and data packages, as well as data entries and transmittals, for completeness and adherence to QA requirements. Data packages will include, to the extent possible, sample receipt and tracking information, chain-of-custody forms, tabulated data summary forms, and raw analytical data for all field samples, standards, QC checks, and other project-specific documents. Data quality will be assessed by comparing entered data to original data or by comparing results with the measurement performance criteria summarized in Section 5.2 Measurement Performance Criteria to determine whether to accept, reject, or qualify the data.

Results of the verification and validation processes will be reported to the RIDEM Project Manager (Katie DeGoosh). The RIDEM Project Manager will make the final determination to reject data and remove any unusable data. If fewer than 90% of the data are judged valid (completeness requirement), statistical procedures and best professional judgment will be applied to verify whether the remaining data will make it possible to draw the correct conclusions for the project. Limitations in the data set will be communicated to the end user, RIDEM, in the draft and final reports prepared for the project.

17.0 DATA USABILITY/RECONCILIATION WITH PROJECT QUALITY OBJECTIVES

Following completion of each year's sample collection, the precision, accuracy, and completeness measures will be assessed by ESS and compared with the criteria discussed in Section 5.2 Measurement Performance Criteria. This will represent the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for this project. All analytical data will undergo an assessment to determine their suitability for meeting project objectives outlined in Section 4.0 Project Description and Schedule. This assessment will be conducted by ESS. If data collected meet the DQOs for the study, then the data are considered to meet the objectives of the study. Uncertainties and limitations in the use of these data and interpretation of results will be provided to the RIDEM and will be reconciled, if necessary and possible.

Reconciliation might involve reanalyzing a sample or reviewing the performance criteria to determine whether different criteria (for example, less than 90 percent complete) are capable of meeting project objectives. Noncompliant data that cannot be reconciled will be rejected.

18.0 REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment

Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Hilsenhoff, W.L. 1998. A modification of the biotic index of organic stream pollution to remedy problems and to permit its use throughout the year. Great Lakes Entomology.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. *Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish.* U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Plotnikoff, R., 1998. Stream Biological Assessments for Watershed Analysis. Washington State Department of Ecology.

Shannon, C.E. and W. Weaver. 1949. The Mathematical Theory of Communication. The University of Illinois Press, Urbana.

USEPA. 1999. Region I EPA-New England Compendium of Quality Assurance Project Plan Requirements and Guidance. U.S. Environmental Protection Agency, Office of Environmental Measurement and Evaluation.

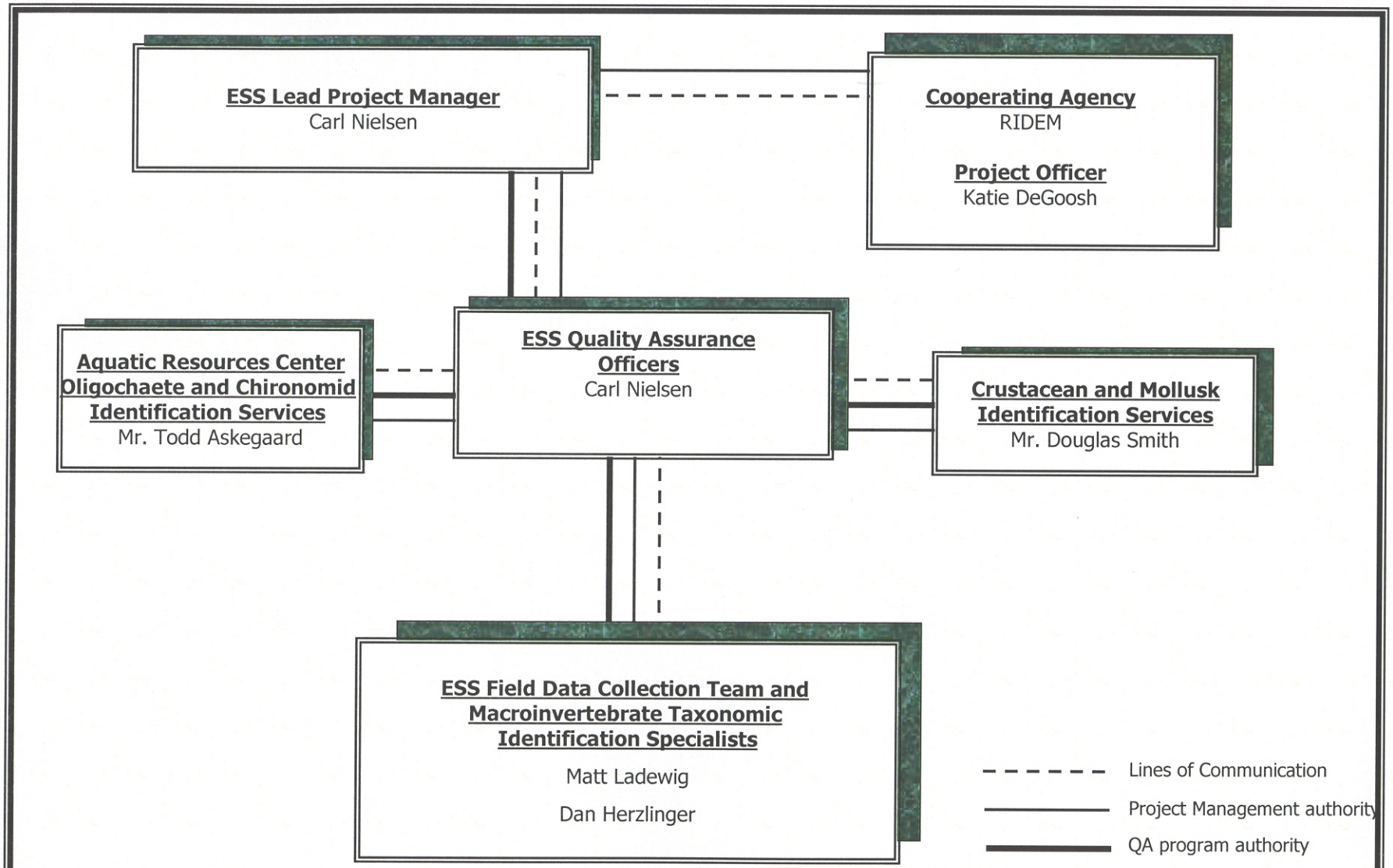
Tables

Table 1. Summary of Omitted EPA-NE QAPP Worksheets and Rationale.

This Table summarizes information requested from Appendix A, Worksheet 2, Item 9.

Worksheets not included in QAPP	Rationale
3	Information located on Worksheet 1
4	Information located on Worksheet 1
5B	Refer to Organizational Chart (Figure 1)
7	No special training courses attended, training received from previous academic study and during in-house, informal training sessions
8B	Problem definition and background provided in text, Section 3.2
9B	No contaminants or other target analytes will be assessed
11A	Project quality objectives discussed in Section 5.0
11B	No contaminants or other target analytes will be assessed
12A	Refer to Section 6.0
13	Refer to Appendix B and C (ESS and ARC methodology)
17	Refer to Appendix B and C (ESS and ARC methodology)
18	Refer to Worksheet 14
19	Refer to Worksheet 15
21	No contaminants or other target analytes will be assessed
22A, 22B	Refer to Sections 5.0-6.0
23A, 23B	Not applicable to this study
24A, 24B	No contaminants or other target analytes will be assessed
25	No data will be obtained from non-direct measurements
27A-30	Refer to Sections 13.0-17.0

Figures



Organizational Chart for the Taxonomic Identification of Benthic Macroinvertebrate Project, ESS 2006
EPA-NE Worksheet 5A

FIGURE 1

ESS Group, Inc.

Appendix A

EPA-NE QAPP Worksheets

EPA-NE QAPP Worksheet #2 - Rev. 10/99

Site Name/Project Name: Macroinvertebrate Identification
Site Location: Rhode Island
Site Number/Code: N/A
Operable Unit: N/A
Contractor Name: ESS
Contractor Number:
Contract Title:
Work Assignment Number:
Anticipated date of QAPP Implementation:

Title: QAPP For Taxonomic Identification of Benthic Macroinvertebrates
Revision Number: 1
Revision Date: January 8, 2007

1. Identify Guidance used to prepare QAPP: Region 1, EPA-New England Compendium of Quality Assurance Project Plan Requirements And Guidance. October 1999

2. Identify EPA Program:

   (1) Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

   (2) Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. *Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish.* U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

3. Identify approval entity: EPA-NE or State: RIDEM
or other entity:

4. Indicate whether the QAPP is a generic program QAPP or a project specific QAPP. (underline one)

5. List dates of scoping meetings that were held: **09/07/2006** (See Worksheet # 8a)

6. List title of QAPP documents and approval dates written for previous site work, if applicable: N/A

Title	Approval Date
2002 Quality Assurance Project Plan for Taxonomic Identification of Benthic Macroinvertebrates, Rhode Island	October 2002

7. List organizational partners (stakeholders) and connection with EPA and/or State:
See attached sheets

8. List data users: RIDEM, EPA-NE, ESS Group, Inc.

9. If any required QAPP Elements (1-20), Worksheets and/or Required Information are not applicable the project, then circle the omitted QAPP Elements, Worksheets and Required Information on the attached Table. Provide an explanation for their exclusion below: Refer to Table 1. Summary of Omitted EPA-NE QAPP Worksheets and Rationale.

Bold QAPP Elements, Worksheets and/or Required Information that are not applicable to the project and provide an explanation on EPA-NE QAPP Worksheet #2, Item 9. (Refer to Attached Table 1 for information on worksheets not included).

REQUIRED EPA QA/R-5 QAPP ELEMENTS	REQUIRED EPA-NE QAPP ELEMENTS and CORRESPONDING EPA-NE QAPP SECTIONS	EPA-NE QAPP Worksheet #	REQUIRED INFORMATION
Project Management and Objectives			
A1	1.0 Title and Approval Page	1	- Title and Approval Page
A2	2.0 Table of Contents and Document Format 2.1 Table of Contents 2.2 Document Control Format 2.3 Document Control Numbering System 2.4 EPA-NE QAPP Worksheet #2	2	- Table of Contents - EPA-NE QAPP Worksheet
A3	3.0 Distribution List and Project Personnel Sign-off Sheet	**3** **4**	- **Distribution List** - **Project Personnel Sign-off Sheet**
A4, A8	4.0 Project Organization 4.1 Project Organizational Chart 4.2 Communication Pathways 4.2.1 Modifications to Approved QAPP 4.3 Personnel Responsibilities and Qualifications 4.4 Special Training Requirements/ Certification	5a **5b** 6 7	- Organizational Chart - **Communication Pathways** - Personnel Responsibilities and Qualifications Table - **Special Personnel Training Requirements Table**
A5	5.0 Project Planning/Project Definition 5.1 Project Planning Meetings 5.2 Problem Definition/Site History and Background	8a **8b**	- Project Scoping Meeting Attendance Sheet with Agenda and other Project Planning Meeting Documentation - **Problem Definition/Site History and Background** - **EPA-NE DQO Summary Form** - **Site Maps (historical and present)**
A6	6.0 Project Description and Schedule 6.1 Project Overview 6.2 Project Schedule	9a **9b** 9c 9d 10	- Project Description - **Contaminants of Concern and Other Target Analytes Table** - Field and Quality Control Sample Summary Table - Analytical Services Table - System Designs - Project Schedule Timeline Table
A7	7.0 Project Quality Objectives and Measurement Performance Criteria 7.1 Project Quality Objectives 7.2 Measurement Performance Criteria	**11a** **11b**	- **Project Quality Objectives/Decision Statements** - **Measurement Performance Criteria Table**

Measurement/Data Acquisition			
B1	8.0 Sampling Process Design 8.1 Sampling Design Rationale	**12a** 12b	- **Sampling Design and Rationale** - Sampling Locations, Sampling and Analysis Method/SOP Requirements Table - Sample Location Map
B2, B6, B7, B8	9.0 Sampling Procedures and Requirements 9.1 Sampling Procedures 9.2 Sampling SOP Modifications 9.3 Cleaning and Decontamination of Equipment/Sample Containers 9.4 Field Equipment Calibration 9.5 Field Equipment Maintenance, Testing and Inspection Requirements 9.6 Inspection and Acceptance Requirements for Supplies/Sample Containers	**13** 12b 14 15	- **Sampling SOPs** - **Project Sampling SOP Reference Table** - Sampling Container, Volumes and Preservation Table - Field Sampling Equipment Calibration Table - Cleaning and Decontamination SOPs - Field Equipment Maintenance, Testing and Inspection Table
B3	10.0 Sample Handling, Tracking and Custody Requirements 10.1 Sample Collection Documentation 10.1.1 Field Notes 10.1.2 Field Documentation Management System 10.2 Sample Handling and Tracking System 10.3 Sample Custody	16	- Sample Handling, Tracking and Custody SOPs - Sample Handling Flow Diagram - Sample Container Label (Sample Tag) - Chain-of-Custody Form and Seal
B4, B6, B7, B8	11.0 Field Analytical Method Requirements 11.1 Field Analytical Methods and SOPs 11.2 Field Analytical Method/SOP Modifications 11.3 Field Analytical Instrument Calibration 11.4 Field Analytical Instrument/ Equipment Maintenance, Testing and Inspection Requirements 11.5 Field Analytical Inspection and Acceptance Requirements for Supplies	**17** **18** **19**	- **Field Analytical Methods/SOPs** - **Field Analytical Method/SOP Reference Table** - **Field Analytical Instrument Calibration Table** - **Field Analytical Instrument/Equipment Maintenance, Testing and Inspection Table**
B4, B6, B7, B8	12.0 Fixed Laboratory Analytical Method Requirements 12.1 Fixed Laboratory Analytical Methods and SOPs 12.2 Fixed Laboratory Analytical Method/SOP Modifications 12.3 Fixed Laboratory Instrument Calibration 12.4 Fixed Laboratory Instrument/ Equipment Maintenance, Testing and Inspection Requirements 12.5 Fixed Laboratory Inspection and Acceptance Requirements for Supplies	20 **21**	- Fixed Laboratory Analytical Methods/SOPs - Fixed Laboratory Analytical Method/SOP Reference Table - **Fixed Laboratory Instrument Maintenance and Calibration Table**

B5	13.0 Quality Control Requirements 13.1 Sampling Quality Control 13.2 Analytical Quality Control 13.2.1 Field Analytical QC 13.2.2 Fixed Laboratory QC	22a 22b 23a 23b 24a 24b	**Sampling** - **Field Sampling QC Table** - **Field Sampling QC Table cont.** **Analytical** - **Field Analytical QC Sample Table** - **Field Analytical QC Sample Table cont.** - **Field Screening/Confirmatory Analysis Decision Tree** - **Fixed Laboratory Analytical QC Sample Table** - **Fixed Laboratory Analytical QC Sample**
B9	14.0 Data Acquisition Requirements	25	- **Non-Direct Measurements Criteria and Limitations Table**
A9, B10	15.0 Documentation, Records and Data Management 15.1 Project Documentation and Records 15.2 Field Analysis Data Package Deliverables 15.3 Fixed Laboratory Data Package Deliverables 15.4 Data Reporting Formats 15.5 Data Handling and Management 15.6 Data Tracking and Control	26	- Project Documentation and Records Table - Data Management SOPs
Assessment/Oversight			
C1	16.0 Assessments and Response Actions 16.1 Planned Assessments 16.2 Assessment Findings and Corrective Action Responses 16.3 Additional QAPP Non-Conformances	27a 27b 27c	- **Assessment and Response Actions** - **Project Assessment Table** - **Project Assessment Plan** - **Audit Checklists**
C2	17.0 QA Management Reports	28	- **QA Management Reports Table**
Data Validation and Usability			
D1	18.0 Verification and Validation Requirements		- **Validation Criteria Documents ***
D2	19.0 Verification and Validation Procedures	29a 29b 29c	- **Data Evaluation Process** - **Data Validation Summary Table** - **Data Validation Modifications**
D3	20.0 Data Usability/Reconciliation with Project Quality Objectives	30	- **Data Usability Assessment**

* Include Data Validation Criteria Document as an attachment to the QAPP if Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses will not be used for validating project data.

Note: Required project-specific information should be provided in tabular format, as much as practicable. However, sufficient written discussion in text format should accompany these tables. Certain sections, by their nature, will require more written discussion than others. In particular, Section 6.0 should provide an in-depth explanation of the sampling design rationale and Sections 13-17 should describe the procedures and criteria that will be used to verify, validate and assess data usability.

Personnel Responsibilities and Qualifications Table

Name	Organizational Affiliation	Responsibilities	Location of Personnel Resumes, if not included[1]	Education and Experience Qualifications[2]
Carl Nielsen	ESS	ESS Lead Project Manager, Quality Assurance Officer		See attached resume
Matt Ladewig	ESS	ESS Field Data Collection Team and Macroinvertebrate Taxonomic Identification Specialist		See attached resume
Dan Herzlinger	ESS	ESS Field Data Collection Team and Macroinvertebrate Taxonomic Identification Specialist		See attached resume
Todd Askegaard	Aquatics Resources Center	Oligochaete and Chironomid identification		See attached resume
Douglas G. Smith	University of Massachusetts-Amherst (Retired)	Crustacean and Mollusk identification		See attached resume

[1]If a resume is on file elsewhere, document location in this column and summarize the individual's education and experience in the next column. If a resume does not exist for an individual, then indicate not available in this column and summarize the individual's education and experience in the next column.
[2]If a resume is attached to this worksheet, then write "See attached" in this column.

Project Scoping Meeting Attendance Sheet

EPA Regulation Program: RCRA FIFRA TSCA CERCLA DW CWA CAA (underline one)	**Site Name:**
Program (Brownfields, NPDES, etc.):	**Site Location:** 50 locations throughout RI
Project Date(s) of Sampling: To be determined	**CERCLA Site/Spill Identifier No.:**
Project Manager: Carl Nielsen, ESS Inc	**Operable Unit:**
	Other Site Number/Code:
	Phase: ERA SA/SI Pre-RI RI (phase I, etc.) FS RD RA post-RA (underline one)
	Other phase:

Date of Meeting: 09/07/2006
Meeting Location: RIDEM, Providence, RI

Name	Project Role	Affiliation	Phone #	e-Mail Address
Sue Kiernan	Contract Officer	RIDEM	401-222-4700 Ext. 7600	sue.kiernan@dem.state.ri.us
Connie Carey	Contract Officer	RIDEM	401-222-4700 Ext. 7239	connie.carey@dem.state.ri.us
Katie DeGoosh	Project Officer	RIDEM	401-222-4700 Ext. 7211	katie.degoosh@dem.state.ri.us
Carl Nielsen	Project Manager & QA/QC	ESS	401-330-1224	cnielsen@essgroup.com
Dan Herzlinger	Field Staff & Lab analysis	ESS	401-330-1210	dherzlinger@essgroup.com

Project Description

Sampling Tasks: Benthic macroinvertebrate sampling, habitat characterization and water quality sampling (dissolved oxygen, pH, conductivity, flow, temperature and turbidity).

Analysis Tasks: Taxonomic Identification of all organisms collected from each sampling location to the lowest practical taxonomic level.

Biological Metrics selected and employed to develop a single value representative of each site's macroinvertebrate community.

Quality Control Tasks: Duplicate field samples for turbidity sampling, Laboratory sorting and identification check (10% of all samples).
Reference collection will be compiled for Taxonomic Identification Verification.

Secondary Data: N/A

Data Management Tasks: Management and organization of data. Data will be presented in tables.

Documentation and Records: Field notebooks, EPA Sample Log-In Sheet, Habitat Assessment Field Data Sheets, Laboratory Bench Sheet, Chains of Custody.

Data Packages: Final report including a taxonomic list of all taxa, Reference Collection, Draft and final reports containing tables of metrics.

Assessment/Audit Tasks: - RIDEM did not include funding for audits to be conducted during this project.

Data Verification and Validation Tasks: Project Manager will review data prior to submission. Laboratories will provide internal review of data generated.

Data Usability Assessment Tasks: Final report will be written for technical and non-technical review. Project Manager will review all deliverables for data usability assessment before data are used in benthic studies to determine whether data have met project objectives.

Field and Quality Control Sample Summary Table

Medium/ Matrix	Analytical Parameter	Conc. Level	Analytical Method/ SOP Reference[1]	No. of Sampling Locations[2]	No. of Field Duplicate Pairs	Organic		Inorganic		No. of Trip Blanks	No. of Bottle Blanks	No. of Equip. Blanks	No. of PE Samples	Total No. of Samples to Lab
						No. of MS	No. of MSD	No. of Duplicates	No. of MS					
Benthos	Sampling		Refer to Appendix B, ESS SOGs	50 sites with 4 alternates	N/A						N/A			50
Surface Water	Dissolved oxygen		Refer to Appendix B, ESS SOGs	50 sites with 4 alternates	N/A						0			0
Surface Water	Temperature		Refer to Appendix B, ESS SOGs	50 sites with 4 alternates	N/A						0			0
Surface Water	Conductivity		Refer to Appendix B, ESS SOGs	50 sites with 4 alternates	N/A						0			0
Surface Water	pH		Refer to Appendix B, ESS SOGs	50 sites with 4 alternates	N/A						0			0
Surface Water	Turbidity		Refer to Appendix B, ESS SOGs	50 sites with 4 alternates	10 % of all samples						0			0
Surface Water	Flow		Refer to Appendix B, ESS SOGs	50 sites with 4 alternates	N/A						0			0

[1]**Complete the Field Analytical Method/SOP Reference Table (EPA-NE QAPP Worksheet #17), and the Fixed Laboratory Method/SOP Reference Table (EPA-NE QAPP Worksheet #20) and specify the appropriate letter/number reference in the above table.**
[2]**If samples will be collected at different depths at the same location, count each discrete sampling depth as a separate sampling location/station.**

Analytical Services Table

Medium/ Matrix	Analytical Parameter	Analytical Method/SOP[1]	Data Package Turnaround Time	Laboratory/Organization (Name and Address: Contact Person and Telephone Number)
Macroinvertebrates	Chironomid and Oligochaete Identification	Appendix C	30 Days	Aquatic Resources Center Mr. Todd Askegaard
Macroinvertebrates	Crustacean and Mollusk identification	Not available but similar to Appendix B	30 Days	University of Massachusetts- Amherst Mr. Douglas G. Smith
Macroinvertebrates	Ephemeroptera, Plecoptera, Trichoptera and all remaining organisms	Appendix B	30 Days	ESS, Inc. Matt Ladewig

[1]**Specify appropriate reference number/letter from the Field Analytical Method/SOP Reference Table (EPA-NE QAPP Worksheet #17) and from the Fixed Laboratory Method/SOP Reference Table (EPA-NE QAPP Worksheet #20).**

Project Schedule Timeline Table

Activities	Dates (09/06)		Deliverable	Deliverable Due Date
	Anticipated Date(s) of Initiation	Anticipated Date of Completion		
QAPP and Monitoring Plan Development	07/06	08/06	QAPP	-
Collection of Benthic Macroinvertebrates and Habitat Assessment	09/06	09/06	Samples, field notes, habitat assessment sheets	-
Laboratory Processing and Identification	09/06	01/06	Identification report, reference collection	-
Data Management, Analyses, Interpretation	09/06	01/06	Draft/Final Reports	-
Final Report	01/06	03/06	Final Report (3 copies) and electronic format	-

Sampling Locations, Sampling and Analysis Method/SOP Requirements Table

Sampling Location[1,2]	Medium/ Matrix	Depth (Units)	No. of Samples (Identify field duplicates and replicates)	Sampling SOP[3]	Analytical Method/SOP[3]	Sample Volume	Containers (Number, size and type)	Preservation Requirements (chemical, temperature, light protected)
Riffle/Run	Benthic Macroinvertebrates	Benthic substrate	50 samples	See Appendix B and Appendix C	Appendix B and Appendix C	1 L	1L jars	95 % ethanaol

[1]Indicate critical field sampling locations with "1".
[2]Indicate background sampling locations with "2".
[3]Complete the Project Sampling SOP Reference Table (EPA-NE QAPP Worksheet #13), Field Analytical Method/SOP Reference Table (EPA-NE QAPP Worksheet #17), and Fixed Laboratory Method/SOP Reference Table (EPA-NE QAPP Worksheet #20) and specify the appropriate letter/number reference in the above table.

Field Sampling Equipment Calibration Table

Equipment	Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
YSI Model 55 Dissolved Oxygen/ Temperature Meter	Refer to SOG Appendix B	Daily	Refer to ESS SOGs Appendix B	Refer to ESS SOGs Appendix B	Field Personnel	Refer to ESS SOGs Appendix B
Cole Palmer Conductivity Meter	Refer to SOG Appendix B	Factory calibrated	Refer to ESS SOGs Appendix B	Refer to ESS SOGs Appendix B	Field Personnel	Refer to ESS SOGs Appendix B
Sensorex pH Meter or Hach mid-range pH test kit	Refer to SOG Appendix B	Daily	Refer to ESS SOGs Appendix B	Refer to ESS SOGs Appendix B	Field Personnel	Refer to ESS SOGs Appendix B
Hanna or LaMotte 2020 Turbidity Meter	Refer to SOG Appendix B	Daily	Refer to ESS SOGs Appendix B	Refer to ESS SOGs Appendix B	Field Personnel	Refer to ESS SOGs Appendix B
Global Flow Probe	Refer to SOG Appendix B	Factory calibrated	Refer to ESS SOGs Appendix B	Refer to ESS SOGs Appendix B	Field Personnel	Refer to ESS SOGs Appendix B

Field Equipment Maintenance, Testing and Inspection Table

Sampling Equipment/ Instrument	Maintenance Activity	Testing Activity	Inspection Activity	Responsible Person	Frequency	Acceptance Criteria	Corrective Action	SOP Reference
Global Water Flow Probe	Cleaning	Operation	Visual Inspection for defective parts	Dan Herzlinger/Matt Ladewig	Prior to use	Probe is operable	Use back up flow probe	See Appendix B
YSI Model 55 Dissolved Oxygen/ Temperature Meter	Replacing probe membrane and liquid. Keeping sponge in storage chamber wet.	Operation	Visual Inspection for defective parts Extreme readings	Dan Herzlinger/Matt Ladewig	Prior to use	Probe is operable with accurate readings	Replace faulty parts and liquid and Calibrate	See Appendix B
Cole Palmer Conductivity Meter	Keep probe clean Rinse with tap water pre-storage	Operation	Visual Inspection for defective parts Extreme readings	Dan Herzlinger/Matt Ladewig	After use	Probe is operable with accurate readings	Extra cleaning, and calibration	See Appendix B
Sensorex pH Meter or Hach mid-range pH test kit	Rinse with tap water pre-storage	Operation	Visual Inspection for defective parts Extreme readings	Dan Herzlinger/Matt Ladewig	Prior and after use	Probe or kit is operable with accurate readings	Extra cleaning, and calibration. Replace Bromothymol blue indicator (for Hach pH test kit).	See Appendix B
Hanna or LaMotte 2020 Turbidity Meter	Replacing battery Replacing lamp	Operation	Extreme readings	Dan Herzlinger/Matt Ladewig	While in use	Meter is operable with accurate readings	Extra cleaning, and calibration	See Appendix B

Sample Handling System

SAMPLE COLLECTION, PACKAGING AND SHIPMENT
Sample Collection: ESS data collection field team
Sample Packing: ESS data collection field team
Coordination of Shipment: ESS data collection field team
Type of Shipment (Courier): Hand delivery to lab
SAMPLE RECEIPT AND ANALYSIS
Responsible Organization: Aquatics Resources Center, Mr. Doug Smith (University of Massachusetts- Amherst)
Sample Receipt: Laboratory sample custodian
Sample Custody and Storage: Laboratory sample custodian
Sample Preparation: Laboratory personnel
Sample Determinative Analysis: Laboratory personnel
SAMPLE ARCHIVAL
Field Sample Storage (No. of days from sample collection): 2 months, Samples preserved in 95% ethanol solution
SAMPLE DISPOSAL
Responsible Organization: ESS
Responsible Personnel: Carl Nielsen

Fixed Laboratory Analytical Method/SOP Reference Table

Reference Number	Fixed Laboratory Performing Analysis	Title, Revision Date and/or Number	Definitive or Screening Data	Region I NESTS Method Code*	Analytical Parameter	Instrument	Modified for Project Work Y or N
1	Aquatic Resources Center	Appendix C Aquatic Resources Center, SOP No. 5	Definitive		Identification	N/A	No
2	Aquatic Resources Center	Appendix C Aquatic Resources Center, SOP No. 6	Definitive		Identification	N/A	No
3	ESS Group, Inc	Appendix B SOGs	Definitive		Identification	N/A	No

Project Documentation and Records Table

Sample Collection Records	Field Analysis Records	Fixed Laboratory Records	Data Assessment Records	Other
Field Notes	Habitat Assessment Sheets	Laboratory chain of custody, Sample Log-In forms, Laboratory Bench Sheets	Draft report, organism mountings on slides, reference collection	Final report

Carl D. Nielsen, CLM
Senior Water Resource Scientist
Practice Leader

EXPERIENCE

ESS Group, Inc. – January 1998 to Present
Years of Prior Related Experience – 8

EDUCATION

MS, Fisheries and Wildlife, University of Missouri - Columbia, 1994
BA, Biology, Colgate University, 1990
Tufts University, Water Quality Monitoring Workshop, 2001

SUMMARY OF PROJECT EXPERIENCE

Mr. Nielsen has more than 16 years of experience in the assessment and evaluation of aquatic ecosystems. Mr. Nielsen has worked extensively in identifying and understanding the ecology of most aquatic organisms including marine shellfish and benthos, freshwater macroinvertebrates, aquatic plants, algae, zooplankton, fish, reptiles and amphibians. Mr. Nielsen works to understand how each site's unique physical and chemical characteristics shape the biology of the organisms occurring within the waterbody that is being assessed. By understanding the ecological needs of the organisms present in an aquatic system Mr. Nielsen is able to tailor management recommendations and mitigation strategies that are appropriate and viewed favorably by most developers and permitting authorities. Mr. Nielsen is also actively involved in the restoration of aquatic systems and has worked to improve water quality and aquatic habitat conditions in numerous lake and river systems throughout New England. As part of these efforts, Mr. Nielsen regularly designs and conducts assessments of various aquatic biota to evaluate the potential for impacts from development and to make recommendations on how a project may be conducted in order to minimize or mitigate these impacts. Mr. Nielsen has been Senior Project Scientist for more than 100 aquatic resource studies which have been performed for numerous clients including: federal, state and local governments, municipal water districts, local lake and watershed associations, industrial facilities, property developers, major corporations, utilities, golf courses, ski areas, and airports. Mr. Nielsen's representative project experience specific to biological monitoring includes:

- **Town of Norton, Massachusetts. Diagnostic and Feasibility Assessment for Management of Lake Winnecunnet, Norton, Massachusetts.** Mr. Nielsen was responsible for conducting an assessment of Lake Winnecunnet and its watershed which are located within a Massachusetts ACEC (Area of Critical Environmental Concern). The deep-water habitat associated with the lake is threatened by the invasive and exotic plant *Cabomba caroliniana* (fanwort) which has spread throughout the lake to the detriment of native plants and potentially native fauna. The need to manage this situation while protecting the potentially rare or threatened species that exist within the lake required extensive survey of the lake shoreline, the major tributaries to the lake (Canoe River and Mulberry Meadow Brook), and the lake outlet (Snake River). Mr. Nielsen conducted a survey of freshwater mussels, aquatic macroinvertebrates, minnows and young-of-the-year fish, aquatic and semi-aquatic plants, reptiles, and amphibians. Based on these detailed surveys, Mr. Nielsen developed a comprehensive lake and watershed management plan for the Town.

- **Town of Westford, Massachusetts. Baseline Characterization, Drawdown Feasibility Assessment, and Long-term Monitoring Program for Nabnasset Lake,**

Westford, Massachusetts. Mr. Nielsen served as Project Manager and lead scientist in an investigation of the baseline characteristics of Nabnasset Lake and a hydrologically-linked wetland system known as Shipley Swamp. The purpose of the investigations was to determine the nature of impacts that could be anticipated as a result of a proposed winter lake drawdown for the purpose of controlling nuisance aquatic plants. As part of the baseline assessments, Mr. Nielsen established numerous plant monitoring plots within the wetland, biological monitoring stations (including both macroinvertebrate and freshwater mussels) within the wetland and lake, and established aquatic plant transects within the lake. These stations are currently being monitored annually to determine the response to drawdown (if any) to allow for immediate management actions to be taken as necessary to prevent significant damage from occurring to the ecosystem. Mr. Nielsen also prepared a Notice of Intent for the control of nuisance aquatic plants at Nabnasset Lake by lake drawdown.

- **Neponset River Watershed Association - Neponset River Flow Stressed Stream Habitat Assessment & Fish Passage Evaluations, Boston, Massachusetts.** Mr. Nielsen evaluated streamflow augmentation and instream habitat restoration alternatives and recommended enhancements that would restore habitat for macroinvertebrates and a target list of freshwater fish species in six sub-watersheds draining to the East Branch of the Neponset River, a tributary to Boston Harbor. Mr. Nielsen served as the macroinvertebrate expert on a team designated as the "trio of experts" (a fisheries biologist, macroinvertebrate specialist, and stream hydrologist) charged with assessing 12 selected stream reaches within the study area during a variety of flow regimes. Mr. Nielsen was responsible for preparing the final report.

- **Club Motorsports, Inc. – 401 Water Quality Certificate and Baseline Monitoring, Tamworth, New Hampshire.** Mr. Nielsen was the lead investigator tasked with designing and implementing a complete baseline monitoring program for the Club Motorsports, Inc.'s proposed racetrack development in New Hampshire. Mr. Nielsen worked closely with NHDES to design and implement a program that would be protective of the aquatic resources of the State on-site and down stream of the property. This program was accepted and the client received their 401 Water Quality Certificate. A long-term monitoring program including water quality, macroinvertebrates, and stream habitat quality is ongoing.

- **Massachusetts Department of Conservation and Recreation – Diagnostic/Feasibility Assessment of Big Pond, Otis, Massachusetts.** Mr. Nielsen designed and conducted an investigation of Big Pond and its watershed to gather baseline information on water quality, stormwater quality, macroinvertebrate community composition, aquatic and wetland plants, fish, and wildlife. Mr. Nielsen made recommendations for monitoring and preserving the ecological integrity of this relatively healthy aquatic system.

- **Town of Hinsdale, Massachusetts – Diagnostic/Feasibility Assessment of Ashmere Lake and Plunkett Reservoir, Hinsdale, Massachusetts.** The Hinsdale lakes are located in a Massachusetts ACEC (area of critical environmental concern). Mr. Nielsen designed and carried out an assessment of the physical, chemical and biological characteristics of these lakes which included water quality assessment, fish and wildlife evaluations, rare/threatened/endangered species investigations (including freshwater mussels), and wetland plant assessments. The work served as the basis for making recommendations for controlling nuisance aquatic vegetation within the lakes while minimizing the potential to cause adverse effects on sensitive or rare species common to the ACEC and their watersheds.

- **Murtha Cullina, LLP – Macroinvertebrate and Stream Habitat Evaluation, Danbury, Connecticut.** Mr. Nielsen was responsible for designing and implementing a biomonitoring program that was prompted in response to claims by the State of Connecticut that activities

at an industrial site may have resulted in an impact to the Still River as it flowed through the site. In order to respond to these concerns Mr. Nielsen conducted an investigation of benthic macroinvertebrates, water quality and surrounding stream habitat in several reaches of the Still River bracketing the discharges associated with the site. Although storm water runoff was observed to alter turbidity and temperature, the similarity of the various macroinvertebrate population statistics calculated indicated that the observed influence of the site's runoff was not of a magnitude that was translating into an impact on the macroinvertebrate community. Recommendations were made as to how the storm water structures at the site might be modified to improve retention of sediment and further cool storm water runoff prior to being discharged to the river.

- **Rhode Island Department of Environmental Management – Statewide Biomonitoring of Rhode Island's Wadeable Streams, Rhode Island.** Mr. Nielsen is currently responsible for managing and conducting a long-term biomonitoring program for wadeable streams of Rhode Island. The purpose of the program is to provide the Rhode Island Department of Environmental Management (RIDEM) with benthic macroinvertebrate and stream habitat data from selected streams within the state's two main eco-regions. The biological data collected is being used to fulfill the state's 305(b) reporting requirements and to provide a greater understanding of the relationship between the macroinvertebrate community and stream habitat. ESS collected and analyzed macroinvertebrate data according to the US EPA's Rapid Bioassessment Protocol, which allows for predictions and or inferences to be made on aquatic ecosystem quality from a relatively "rapid" assessment of the prevailing macroinvertebrate community composition. A total of up to 50 stream segments are assessed each year during the contract period. Once samples are collected from the field, Mr. Nielsen and other ESS staff process the samples and identify the macroinvertebrates to the lowest practical taxonomic level, typically Genus, and perform a comprehensive statistical analysis of the results. Yearly data reports are being provided to RIDEM during the contract period. Mr. Nielsen also provided a multi-year data trend analysis along with recommendations for future monitoring and stream restoration as part of the comprehensive final report. This contract began in 2002 and has been renewed for the period from 2006-2009.

- **The Mayaguana Development Company – Study of the Water Quality and Aquatic Life Associated with Coastal Ponds and Embayments, Mayaguana Island, Bahamas.** The Mayaguana Development Company's long-term development goal for the Mayaguana Project is to obtain approximately 9,999 acres of Crown Lands on Mayaguana Island, Bahamas for the development of a boutique resort, associated utilities, marina, second home real estate development, airport improvements and community projects. The Project involves development of three geographic areas on Mayaguana (Flamingo Island/North Beach, Pirate's Well Creek/Northwest Point, and the Airport). Development in these areas will include improvements to existing utilities and infrastructure as well as creation of new utilities and infrastructure. New tidal inlets will be constructed at Pirate's Well Creek and Flamingo Pond to restore tidal flow and "blue-water" conditions to these waterbodies to make them more ecologically diverse and more appealing to residents and visitors. Mr. Nielsen was directly responsible for the assessment of baseline conditions for the surface water bodies and coastal embayments associated with the proposed project and for preparing the corresponding sections of the Environmental Impact Assessment (EIA) document for submission to the Bahamas, Environment, Science, and Technology (BEST) Commission. Mr. Nielsen's investigations included the assessment of water quality conditions in each waterbody along with the associated aquatic biota which included the fish, aquatic plants, benthic organisms, phytoplankton, and zooplankton present in each system.

- **Connecticut Light & Power Company and Long Island Power Authority – Submarine Replacement Cable Project, Norwalk, Connecticut to Northport, New York.** Mr. Nielsen was responsible for managing the marine benthic sampling and analysis as part of the environmental impact evaluations and regulatory permitting for an 11-mile, 300 MW Alternating Current (AC) submarine cable system that will replace an existing series of electric transmission cables connecting existing power stations in Connecticut and Long Island. The seven existing fluid-filled submarine cables will be taken out of service and replaced with three new solid dielectric AC cables within the Mr. Nielsen's focus on this project was to evaluate the existing condition of the marine benthic community in order to assess potential impacts from the cable replacement and operation and to recommend actions to minimize potential impacts. For this project, Mr. Nielsen assisted in the preparation project permitting under the Connecticut Siting Council, CTDEP, New York Article VII, and USACE review processes.

- **TransÉnergie US, Ltd. – Cross Sound Cable Project, Long Island Sound, Connecticut and New York States.** Mr. Nielsen was responsible for designing and implementing the assessment of marine macroinvertebrates (benthos) along the proposed and alternative linear routes related to the Cross Sound Cable Project. Mr. Nielsen was responsible for preparing benthic sections for the following regulatory permits and reviews: Application for Certificate of Environmental Compatibility and Public Need to the Connecticut Siting Council, permits to the Connecticut Department of Environmental Protection (CTDEP) Office of Long Island Sound Program, and joint application and review by the New England and New York Districts of the Army Corps of Engineers. The Cross Sound Cable Project is a merchant energy transmission project proposed for installation along a selected coastal and offshore route originating in New Haven Harbor, Connecticut, across Long Island Sound, and then interconnecting with the Long Island energy transmission system at the decommissioned Shoreham generating facility in Brookhaven, New York.

- **PSEG Power LLC – "In-City" Project, Lower Hudson River Between New Jersey and Manhattan.** Mr. Nielsen was responsible for designing and coordinating a program for assessing the marine benthic organisms along the proposed submarine electric cable system between New Jersey and New York City. The proposed cable system will transmit power from the PSEG Bergen Station in Ridgefield, New Jersey to the ConEd West 49th Street substation in New York City. The cable system will be approximately 7 miles long (including upland and submarine portions), and will transmit approximately 1,000 MW of AC energy as well as fiber optic communications. Mr. Nielsen was responsible for planning, directing, and overseeing marine environmental field investigations, overseeing benthic organism processing and identification, and for developing the corresponding text for submittal with all permit applications.

- **Cape Wind Associates, LLC – Offshore Renewable Energy Generation and Submarine Cable Project.** Mr. Nielsen was responsible for designing and implementing an evaluation of the marine benthic resources associated with a proposed renewable energy generation project involving up to 130 offshore wind turbines with a potential to generate 454 MW of electricity. The proposed wind farm is sited on Horseshoe Shoal in Nantucket Sound and will interconnect with the regional power grid through an AC submarine cable to the southern shore of Cape Cod. Mr. Nielsen contributed to the preparation of a Baseline Environmental Impact and Feasibility Study associated with the project. ESS is the prime environmental/regulatory permitting consultant on this assignment.

- **AES Enterprise – Biomonitoring and Habitat Assessment, New Britain and Southington, Connecticut.** Downstream resources associated with the New Britain Water Supply System were evaluated by Mr. Nielsen as part of a water diversion permit application

for a proposed power generating plant in the Town of Southington, Connecticut. Mr. Nielsen designed studies to determine impacts associated with the withdrawal of an additional four million gallons per day. Fish, aquatic invertebrates, water chemistry and habitat were assessed to determine means by which the water supply system could be operated to deliver the required volume of water while minimizing environmental impacts associated with the project. ESS was the prime environmental/regulatory permitting consultant on this assignment.

- **Aquarion Water Company – Biological Survey in Response to Fish Kill, Easton, Connecticut.** ESS responded quickly to design and conduct a biological (fish and macroinvertebrates) assessment of numerous sites upstream and downstream of a reported chlorine spill downstream of a water supply reservoir managed by Aquarion Water Company. Mr. Nielsen initiated work immediately following reports of a fish kill in order to characterize the true nature of impacts to Mill River and to develop an appropriate remedial response. The scope of work was coordinated directly with CTDEP staff. Although work on this project is ongoing, initial results seem to indicate that the effects of the spill on the macroinvertebrate community was minimal and that a natural recovery of the stream would be expected within a very short period of time. ESS recommended that baseline macroinvertebrate data be collected for other key streams within the watershed so that any future problems within the water supplier's watershed could be easily evaluated. ESS was the prime environmental/regulatory permitting consultant on this assignment and continues to support compliance with DEP requirements

- **Northeast Utilities Service Company – Cross Long Island Cable (CLIC) Project, Norwalk, Connecticut to Hempstead Harbor, New York.** ESS managed marine surveys, environmental impact evaluations, and initial regulatory permitting for a proposed 30-mile, 300 MW direct current submarine cable between Norwalk, Connecticut and Hampstead Harbor, New York. Benthic surveys of the proposed Norwalk River crossing were conducted under CTDEP guidance. Bethic and other data available for the project area were consolidated and used to develop permit applications and other submittals. ESS was responsible for project planning and permitting under the Connecticut Siting Council, CTDEP, New York Article VII, and USACE review processes.

- **City of New Haven – Impact Assessment of a Proposed Water Diversion from the Mill River, New Haven, Connecticut.** Provided third party review of a report entitled "Lake Whitney Water Treatment Plant Environmental Evaluation", dated January 1999. This report was prepared by an environmental study team contracted to the South Central Connecticut Regional Water Authority to evaluate potential impacts and propose mitigation associated with the withdrawal of up to 15 million gallons per day of water from Lake Whitney. The area of evaluation included the Mill River system below Eli Whitney Dam, much of which flows through East Rock Park, a significant resource located in an urbanized area of New Haven. The third party evaluation was prompted in response to concern by the City of New Haven and members of the community over decreased flows and reduced water quality in Mill River below the Eli Whitney Dam.

- **Massachusetts Department of Environmental Protection – Aquatic Habitat Evaluation, French and Quinebaug Watersheds, Massachusetts.** Developed and implemented a watershed-wide aquatic habitat assessment program to identify potential problems within the watersheds and to serve as baseline data for future monitoring efforts. Aquatic habitat monitoring was conducted in a manner consistent with MassDEP's Method 004 Aquatic Habitat Assessment Protocol at 50 sites within the two watersheds. Aquatic invertebrates and water quality data were collected and assessed at 10 key sites. All sampling was conducted in accordance with a project specific Quality Assurance Project Plan (QAPP).

All information was incorporated into a GIS database and provided to MassDEP as an interactive CD-ROM for use by the French and Quinebaug Watershed Team.

- **Lake Monomonac Association, Drawdown Feasibility Assessment, Winchendon Springs, Massachusetts and Rindge, New Hampshire.** Conducted a feasibility assessment of Lake Monomonac to ascertain the potential effectiveness of lake drawdown as a method for controlling the nuisance aquatic weed variable leaf milfoil (*Myriophyllum heterophyllum*). Based on the potential impacts of drawdown on the surrounding wetlands and the relatively small area of actual plant infestation, drawdown was not recommended as an appropriate control method at the time.

- **Massachusetts Department of Environmental Protection – Determination of Sources of Water Quality Impairment, Westfield Watershed, Massachusetts.** Designed and implemented a watershed-wide pollutant source identification program for the Westfield River Watershed. The main stem of the Westfield River is threatened by poor water quality; the sources of this pollution were determined through an extensive sampling program. The project included water quality sampling of both dry and wet weather conditions at over 40 stations, as well as habitat, aquatic invertebrate and periphyton analysis. Impaired sub-basins within the watershed were identified and solutions for identified pollutant sources were recommended. The report included an extensive database presented in GIS format for the purposes of illustrating patterns in water quality for each sampled parameter.

- **Burke Mountain/Northern Star Ski Area - Biomonitoring, Burke, Vermont**. Performed an invertebrate assessment at two sites on the Passumpsic River in Burke, Vermont as part of a multi-year monitoring program associated with the Burke Mountain/Northern Star Ski Area discharge permit. Invertebrate analysis was performed to the species level and verified by the Vermont Department of Environmental Conservation. No significant impact to the river has been detected as a result of the water treatment discharge area.

- **Massachusetts Highway Department – Ecological Monitoring Investigation, Taunton, Massachusetts.** Examined five stream systems along the Route 44 corridor near Taunton, Massachusetts to document existing conditions in order to assess potential environmental impacts associated with a proposed highway expansion. This investigation included an evaluation of water chemistry, physical habitat, fish community composition, algal community composition, and macroinvertebrate community composition.

- **National Science Foundation – Investigation of the Effects of Artificial Shading on the Macroinvertebrate and Periphyton Communities, New Hampshire**. A study of stream shading on several tributaries in the Hubbard Brook Experimental Forest in New Hampshire was designed as part of a National Science Foundation grant. Macroinvertebrate communities were not significantly different between shaded and non-shaded stream segments. This unexpected result was due to low nutrient levels being the limiting factor controlling primary productivity rather than light levels. Information from this study was used as part of a broader study researching the effects of clear-cutting practices by the forest industry.

- **National Parks Service – Baseline Survey, Missouri**. Investigated baseline characteristics of Big Spring, the second largest spring system in the United States, for the Ozark National Scenic Riverways branch of the National Parks Service. Work focused on differences in substrate use by macroinvertebrates, temporal changes in the aquatic plant bed, and storm water discharge monitoring. Habitat throughout the system was mapped via

GPS and the HABSIM protocol. The study was prompted by proposed lead mining within Big Spring's recharge area.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- North American Benthological Society
- North American Lake Management Society, Certified Lake Manager
- Northeast Aquatic Plant Management Society
- NAUI Open Water SCUBA Diver Certification
- 40-Hour OSHA Health and Safety Certification
- American Heart Association – CPR and First Aid

PUBLICATIONS

- Fuller, R.L., B.P. Kennedy and C. Nielsen. 2004. Macroinvertebrate responses to algal and bacterial manipulations in streams. Hydrobiologia 523:113-126.
- Nielsen, C. D. and D. L. Galat. 1996. Substrate association by macroinvertebrates in a large, cold-water springbranch. University of Missouri- Columbia.
- Schubert, A. L. S., C. D. Nielsen, and D.B. Noltie. 1993. Habitat use and gas bubble disease in southern cavefish (*Typhlichthys subterraneus*). International Journal of Speleology 22(1-4): 131-143.

PRESENTATIONS

- The Quaboag River watershed non-point source pollution assessment, a modeling approach. April, 2001. New England Association of Environmental Biologists Annual Conference.
- Water Quality and Sediment Quality within the Deerfield River Watershed. March, 2001. 2nd Annual Deerfield River Watershed Conference.
- Innovative watershed study design – Techniques for locating sources of non-point source pollution. April, 2000. Environmental Protection Agency – Region 1.
- An investigation of the sources of non-point source pollution affecting water quality within the lower Westfield River watershed. March, 2000. 6th Annual Westfield River Symposium.
- Impaired Waters. April, 1999. 5th Annual Westfield River Symposium.
- Differences in substrate use by macroinvertebrates of a large, cold-water springbranch. May, 1993. 42nd Annual Meeting of the North American Benthological Society.
- Seasonal variation in macroinvertebrate and fish assemblages in a thermally constant aquatic system. 1993. George Wright Society (National Park Service).
- The aquatic plant and fish communities of Big Spring. 1992. Ozark National Scenic Riverways (National Park Service).

Matthew D. Ladewig
Environmental Scientist

EXPERIENCE

ESS Group, Inc. – September 2006 to Present
Years of Prior Related Experience – 3

EDUCATION

MS, Aquatic Resource Ecology and Management, University of Michigan, 2006
BA, Geography, University of Illinois at Urbana-Champaign, 2000, Magna Cum Laude and Highest Distinction

SUMMARY OF EXPERIENCE

Mr. Ladewig possesses a broad range of field and lab skills useful in bioassessment, monitoring, and modeling of aquatic ecosystems. His past experience includes the organization of overnight field sampling campaigns and the development of river habitat maps using Geographic Information System (GIS) software. In addition, Mr. Ladewig is experienced in the sampling and identification of aquatic invertebrates and fish, and is proficient in freshwater macroinvertebrate identification to genus level. He is also familiar with the standard methods used to collect and process hydrologic, geomorphologic, and water chemistry data.

Mr. Ladewig's representative work experience includes:

- **Rose Island Holding Company; Rose Island, Bahamas – Environmental Impact Assessment for Rose Island Resort.** Mr. Ladewig identified and enumerated invertebrate species from benthic samples collected in shallow coastal habitats.

- **Gomez and Sullivan, Willow Mill, South Lee, Massachusetts – Housatonic River Freshwater Mussel Survey.** Mr. Ladewig assisted with a field survey for mussels in the bypass channel of a hydro-powered paper mill on the Housatonic River. No rare or endangered mussels were found in the initial survey. Mr. Ladewig summarized the findings of the survey in a report to the client.

- **Gomez and Sullivan, Glendale Power Station, Stockbridge, Massachusetts – Housatonic River Freshwater Mussel Survey.** Mr. Ladewig assisted with a field survey for mussels in the bypass channel of a hydro power station on the Housatonic River. In addition, he was responsible for filing a Rare Animal Observation Form with the Massachusetts Natural Heritage and Endangered Species Program when evidence of a state-listed mussel species was found in the channel. Mr. Ladewig summarized the findings of the survey in a report to the client.

- **Rhode Island Department of Environmental Management – Statewide Biomonitoring of Wadeable Streams, Rhode Island.** Mr. Ladewig is responsible for the annual collection and identification of macroinvertebrates from up to 50 sites across the state of Rhode Island. He analyzes the habitat, water quality and macroinvertebrate community data in accordance with state guidelines and summarizes the results in report form for submission to the US Environmental Protection Agency.

- **ARCADIS, Inc., Staten Island, New York – Wetland Biomonitoring.** Mr. Ladewig is responsible for the macroinvertebrate taxonomy and reporting of samples collected annually from a landfill wetland.

- **Winchester Country Club (WCC), Winchester, Massachusetts – Stream Biomonitoring.** Mr. Ladewig completed all macroinvertebrate identification, statistical analysis and report writing for the monitoring of Herbert Meyer Brook following completion of an irrigation improvement project in 2003. Mr. Ladewig compared a stream reach within the zone of potential impact to a control reach upstream. He also compared these data to baseline data collected prior to construction and operation of the small well supplying water for irrigation. No significant impacts of well operation to the stream biota were identified.

- **Vespera, Inc., East Lyme, Connecticut – Darrow Pond Baseline Assessment, Nutrient Modeling and Long-Term Management Plan.** Mr. Ladewig assisted with collection of baseline water quality data on Darrow Pond.

- **University of Michigan, School of Natural Resources and Environment, Ann Arbor, Michigan – Muskegon River Habitat Mapping and Hydraulic Modeling**. Mr. Ladewig was instrumental in the execution of all stages of a major river habitat mapping and modeling project, including the collection of field data, development of GIS maps, and hydraulic modeling (using HEC-RAS and HEC-GeoRAS modeling software). These accomplishments allowed other researchers to couple fish and invertebrate models with six years of modeled hydraulic output.

- **University of Michigan, School of Natural Resources and Environment, Ann Arbor, Michigan – Estimation of Sediment Transport Rates on the Lower Muskegon River.** Mr. Ladewig collaborated with state agencies and citizen groups to complete a sediment transport study on the lower Muskegon River and three major tributaries. He spearheaded organization and execution of field sampling campaigns, lab processing and data analysis. Mr. Ladewig developed a model of annual suspended sediment and bedload transport rates across the sub-watershed.

- **University of Michigan, School of Natural Resources and Environment, Ann Arbor, Michigan – Quantitative Assessments of Fish and Invertebrate Communities in the Muskegon River Watershed.** As an integral member of a multidisciplinary team, Mr. Ladewig collected and processed hydrologic, geomorphic, chemical and biological data on wadeable tributaries and navigable segments of the Muskegon River in Michigan. In addition to operating portable and boat-mounted electrofishing equipment, he helped deploy minnow traps, fyke nets and a smolt trap to estimate fish abundance and migration. He also deployed standard quantitative sampling equipment (including zooplankton tow nets, Hess samplers and Ponar grab samplers) to estimate abundance and biomass of macroinvertebrates and flux of larval fish and zooplankton. Mr. Ladewig provided taxonomic identification of fish and macroinvertebrates in the field as a regular part of this work.

- **US Geological Survey, Ottawa National Wildlife Refuge, Ohio – Coastal Freshwater Wetland Management Study.** As a volunteer with the US Geological Survey Great Lakes Science Center in Ann Arbor, MI, Mr. Ladewig conducted fieldwork on the Crane Creek/Lake Erie wetlands of the Ottawa National Wildlife Refuge. As part of this project, Mr. Ladewig operated towed barge and small watercraft electrofishing units to help characterize the seasonal movements of fish in the freshwater estuary system. He also surveyed diked pools and unmanaged wetlands using a laserplane and survey-grade GPS unit.

- **University of Michigan, School of Natural, Resources and Environment, Ann Arbor, Michigan - Graduate Student Instructor.** Mr. Ladewig taught laboratory sections of upper-level aquatic and fluvial ecosystems courses for three semesters. He directed student field efforts in wetlands, lakes, and streams; introducing them to hydrologic, chemical, and

biological sampling methods. Additionally, Mr. Ladewig developed PowerPoint presentations to introduce students to the taxonomic diversity of aquatic algae, macrophytes, invertebrates, and vertebrate organisms. To provide students with a more complete set of tools for identifying aquatic invertebrates, Mr. Ladewig improved the class reference collection by adding 50 new families.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- American Fisheries Society
- American Red Cross First Aid and CPR certification

PRESENTATIONS

- Riseng, C.M., M.J. Wiley, B. Sparks-Jackson, M. Ladewig and S.R. David. Assessment of the Interacting Effects of Channel Unit Substrate and Hydraulics on Benthic Standing Stock in the Lower Muskegon River, Michigan. North American Benthological Society 53rd Annual Meeting, June 2006. Anchorage, AK.

- Ladewig, M.D. and M.J. Wiley. Estimation of Sediment Transport Rates in the Lower Muskegon River, Michigan. 48th Annual Conference of the International Association for Great Lakes Research, May 2005. Ann Arbor, MI.

Daniel J. Herzlinger
Environmental Scientist

EXPERIENCE

ESS Group, Inc. – January 2006 to Present
Years of Prior Related Experience – 2

EDUCATION

MEM, Resource Ecology, Duke University, 2001
BA, Biology, Bates College, 1997

EXPERIENCE

Mr. Herzlinger has over a year of experience working with environmental permitting as the Conservation Agent for the Town of Acushnet, Massachusetts. In addition, he has over 5 years of experience working with Geographic Information Systems (GIS). As Conservation Agent, Mr. Herzlinger developed a strong working knowledge of the Massachusetts Wetlands Protection Act and associated regulations including the Massachusetts Rivers Protection regulations and Massachusetts Department of Environmental Protection (MassDEP) Storm Water Policy. Mr. Herzlinger reviewed proposed projects for compliance with these regulations, monitored construction sites, reviewed wetland delineations for accuracy and administered enforcement proceedings for wetland violations. Mr. Herzlinger served as the Chair of the Town's NPDES Phase II Storm Water Committee and assisted drafting a Storm Water Bylaw for the Town of Acushnet. He managed over 250 acres of open space in Acushnet and assessed the ecological value of various Town-owned parcels. In earlier positions as an Environmental Educator, Mr. Herzlinger collected and presented water quality data to the public and conducted interpretive tours, presenting ecological concepts in straightforward manner to a wide range of audiences. Mr. Herzlinger's representative project experience includes:

- **Rhode Island Department of Environmental Protection (RIDEM) — Biomonitoring and Habitat Assessment of Rhode Island Wadeable Streams.** Mr. Herzlinger sorted macroinvertebrate samples from various streams within the Pawcatuck River watershed for identification. He worked on the data analysis and calculated various metrics of water quality based on macroinvertebrate species found at each site. The data is used in RIDEM's annual study of wadeable streams and rivers in Rhode Island.

- **Narragansett Bay Commission — Midge Larvae Monitoring and Management Recommendations, Bucklin Point, East Providence.** The focus of this study was to establish a baseline data set upon which to base management recommendations, develop site-specific management recommendations, and assist the Narragansett Bay Commission with community outreach activities. Mr. Herzlinger conducted an invertebrate monitoring effort in order to identify midge larvae "hot spots" in the mud flats of the area of concern. Monitoring involved sampling set locations within the mud flats numerous times throughout the season for midge larvae, and documenting the numbers of midge larvae found. Habitat data was also collected in order to identify habitat conditions that typically correlate with high midge concentrations (i.e., water depth, DO at bottom, salinity, algal density, and substrate type).

- **Cape Wind Associates, LLC — Offshore Renewable Energy Generation and Submarine Cable Project, Horseshoe Shoal, Nantucket Sound.** Mr. Herzlinger assists project manager with a proposed renewable electric generating facility involving installation

of 130 offshore wind turbine generators with a potential to generate 454 MW in Nantucket Sound, Massachusetts. The proposed wind park is sited on Horseshoe Shoal, and will interconnect with the regional power grid through an AC submarine cable system between the wind park and the southern shore of Cape Cod. Mr. Herzlinger is assisting with the preparation of the following regulatory permits and reviews: Environmental Impact Reports for Massachusetts Environmental Policy Act (MEPA) review, Environmental Impact Statements for US Army Corps of Engineers, and Wetlands Protection Act Notice of Intent. Mr. Herzlinger has conducted research on potential impacts of the project to protected marine species such as whales, sea turtles and seals. He has collected and analyzed data on migratory duck populations that are present in the vicinity of the project area. Mr. Herzlinger is one of the lead authors of the final product of the duck studies, the *Nantucket Sound, Winter Long-Tailed Duck Survey, 2005-2006 Report.*

- **Winchester Country Club – Macroinvertebrate Sampling and Analysis in Support of an Irrigation Supply Improvement Project at Herbert Meyer Brook, Arlington, Massachusetts.** ESS was responsible for design and permitting of a new irrigation supply well adjacent to Herbert Meyer Brook at Winchester Country Club (WCC) in Arlington, Massachusetts. Concern was expressed by the Arlington Conservation Commission that water withdrawals from the well might impact the biology of the brook. Mr. Herzlinger is currently responsible for implementing the field collection of macroinvertebrate and habitat data as part of an ongoing sampling program for Herbert Meyer Brook, required by the Arlington Conservation Commission as a condition to the project.

- **Winchendon Ventures, LLC — Winchendon Golf Course & Residential Community Project.** Mr. Herzlinger assists the project manager with the permitting of a golf course and associated residential development on a 275-acre parcel in Winchendon, Massachusetts. Mr. Herzlinger is assisting with the preparation of an Abbreviated Notice of Resource Area Delineation (ANRAD) and Notice of Intent (NOI) under the Massachusetts Wetlands Protection Act as well as an Environmental Notification Form (ENF) under MEPA. Mr. Herzlinger conducted extensive fieldwork at the site to determine the wetland resource area boundaries of Bordering Vegetated Wetland (BVW) and inland stream banks.

- **Town of Brookfield, Massachusetts — 319 Non-point Source Pollution Grant.** Mr. Herzlinger is assisting the project manager with the implementation of this state grant for the Town of Brookfield and the Quaboag/Quacumquasit Lake Association. Mr. Herzlinger assisted with the plant mapping of Quaboag Pond and completed a field assessment to determine sources of phosphorous loading within the Quaboag and Quacumquasit Pond watersheds. Mr. Herzlinger is responsible for collection of water quality data at targeted sites throughout the watershed. The results of the monitoring and watershed assessment will be used to design and implement Best Management Practices (BMPs) to address non-point source pollution in Quaboag Pond.

- **Vespera — Darrow Pond, East Lyme, Connecticut.** Mr. Herzlinger conducted herpetological surveys, biological surveys and water quality sampling to collect baseline data at the Darrow Pond Property. The data is being collected for a proposed subdivision at the site, which will be using Low Impact Development (LID) practices. Results of the herpetological survey were presented as a report to the East Lyme Conservation Commission. Water quality data has been used to model nutrient loading to Darrow Pond so that BMPs can be designed appropriately to achieve target nutrient removal rates.

- **EMI Chelsea — Energy Generating Facility, Chelsea, Massachusetts.** Mr. Herzlinger completed field work to determine the extent of state and federal wetland resource areas present on this 6-acre site along the Chelsea River. Mr. Herzlinger worked with another wetland scientist to flag coastal resource areas at the site that fall under jurisdiction of the

Massachusetts Wetlands Protection Act. Mr. Herzlinger is drafting the Notice of Intent (NOI) for the proposed energy generating facility at the site.

- **Plymouth EDF — Plymouth, Massachusetts.** Mr. Herzlinger and another ESS Environmental Scientist completed a survey of a 1,000-acre parcel to assess natural communities at the site and evaluate constraints on development based on the presence of rare natural communities and species. Mr. Herzlinger mapped the location of rare natural communities and produced GIS figures delineating sensitive areas based on the field assessment.

PROFESSIONAL REGISTRATIONS AND AFFILIATIONS

- OSHA 40-Hour Health and Safety Certification
- American Heart Association – CPR
- Association of Massachusetts Wetland Scientists

TODD W. ASKEGAARD
President

EDUCATION

B.S., Biological Science, University of Wisconsin-Superior, 1989

PROFESSIONAL HISTORY

President, Aquatic Resources Center, Inc, 2003 - present
Vice President, Aquatic Resources Center, 2000 - 2003
Assistant Director, Aquatic Resources Center, 1996 - 2000
Biologist, Aquatic Resources Center, 1993 - 1996
Associate Research Scientist, Lake Superior Research Institute, 1990- 1993
Private consultant, 1990 - 1992

REPRESENTATIVE EXPERIENCE

Mr. Askegaard has more than 15 years of experience in freshwater invertebrate taxonomy and ecology. Projects that he has been involved in include quantitative and qualitative surveys for: endangered mussels, benthic invertebrates, crustacean zooplankton and fish. He has participated in projects across the United States, particularly in the Southeast, Northeast and Northwest. He identifies all groups of benthic invertebrates, specializing in water mites and zooplankton. Mr. Askegaard has also participated in terrestrial surveys for endangered or threatened plant species.

Mr. Askegaard manages the business affairs of Aquatic Resources and has experience in all aspects of benthological studies, including sampling design, field surveys, laboratory analysis, habitat assessment, data analysis and report preparation. He has employed numerous benthic invertebrate collecting techniques such as coring devices, grab samplers (Ekman, ponar), kick or disturbance samplers (kicknets, Surbers, Hess) and multi-plate samplers. He has developed and implemented standard operating procedures for projects. Mr. Askegaard has been manager of many projects, scheduling and performing quality control and quality assurance checks and establishing voucher collections of species found during projects. He is familiar with the use of various computer programs (e.g., NCSS, Statistix, Cluster, Sigtree and Minitab) to perform statistical data analyses for interpretation. Mr. Askegaard is also well versed in the various biological measures employed by state and federal agencies (such as RBP protocols) for use in interpreting benthological data. He has experience in data presentation using computer programs such as Excel, Lotus, QuatroPro, WordPerfect and Freelance graphics. Mr. Askegaard has authored or coauthored many grant applications, contract proposals and project reports for clients.

At previous positions, Mr. Askegaard has been involved in various types of experimental work. For an *in-situ* sediment toxicity project, he helped design and assemble cages to hold amphipods, chironomids and oligochaetes at mid-water and the sediment/water interface in a large river. During limno-corral/mesocosm toxicity tests for pesticide effects on aquatic communities, Mr. Askegaard collected zooplankton, periphyton and macroinvertebrate samples. This project also involved studying the effects on young-of-the-year bluegills. He has been involved in fish surveys and has employed collecting techniques such as gill-netting in open water and under the ice, trawling, backpack electro-shocking and pole fishing. Mr. Askegaard established and supervised a Zebra mussel field monitoring program. He has performed flow-through and static toxicity tests using Zebra mussels, amphipods, fathead minnows, chironomids and oligochaetes. During many of these

projects, he trained and supervised undergraduate students involved in these research endeavors. He also was a lecturer on a university research vessel during public education tours on Lake Superior on the chemistry and biology of the lake ecosystem, where he also served as deckhand and engineer.

PRESENTATIONS

Benthic invertebrates from a stream in Massachusetts: comparison of six surveys conducted over a three-year period. New England Association of Environmental Biologists Meeting, March 1998. Todd W. Askegaard (presenter and co-author), R. Deedee Kathman and Brad Wamsley (co-authors)

SEMINARS/WORKSHOPS

Aquatic Oligochaete Workshop, Logan Utah, April 1999. Field collection, biology, ecology and taxonomy of aquatic oligochaetes. R. D. Kathman, S. Fend and T. W. Askegaard (lecturers).

Parasitengona Seminar. Ohio State University, Columbus, Ohio, July 1997. Two week course on the biology, ecology and taxonomy of terrestrial and aquatic mites.

AFFILIATIONS

Tennessee Academy of Science
North American Benthological Society
New England Association of Environmental Biologists
Southeastern Water Pollution Biologists Association

DOUGLAS G. SMITH

EDUCATION

University of Miami, Coral Gables, Florida, 1964-1967 (12 hours Zoology).

B.S. University of Massachusetts, Amherst, Massachusetts, 1977, (Fisheries Biology, cum laude).

M.S. University of Massachusetts, Amherst, Massachusetts, 1982, (Zoology).

MILITARY SERVICE

United States Navy, Submarine Service, 1967-1971. Last rank: Quartermaster Second Class (QM2SS). Received Honorable Discharge, 1971.

Life member, U.S.S. Nautilus (SSN 571) Alumni Association.

WORK EXPERIENCE

Technical Assistant (full time), Museum of Zoology, University of Massachusetts, Amherst, 1971 to 1984.

Technical Assistant II (full time), Museum of Zoology, University of Massachusetts, Amherst, 1984 to 1993.

Acting Curator of Invertebrates, Museum of Zoology, University of Massachusetts, Amherst, 1977 to 1993.

Laboratory Instructor, "Biology of Lower Invertebrates" University of Massachusetts, Amherst, 1980; "Biology of Higher Invertebrates" University of Massachusetts, Amherst, 1982 to 1987.

Lecturer/Curator of Invertebrates, Department of Biology, University of Massachusetts, Amherst, 1993 to present.

Courses taught:
Biology 497H - Tropical Field Studies (team instructed, includes field trip to Caribbean)
Biology 530 - Biology of Invertebrates
Biology 576 - Aquatic Invertebrates (team instructed)
Biology 396, 496, 696 - Independent study
Biology 597B - Metazoan parasites of fishes

APPOINTMENTS

Consultant in Malacology, American Museum of Natural History, New York, 1979 to 1983.

Associate in Invertebrate Zoology, Museum of Comparative Zoology, Harvard University. 1981 to present.

Citizens Advisory Committee on Massachusetts Water Supply Project (WSCAC), 1982 to 1987.
Chair, Scientific Task Force, WSCAC, 1982 to 1987.

Member, Special Subcommittees on Fish and Invertebrates, Vermont Endangered Species Program, 1983 to 1992.

Associate Member, Massachusetts Non-game and Endangered Species Program Advisory Committee. 1985 to 1990.

Associate, Wetlands/Wildlife Technical Advisory Committee (MDEQE). 1987.

Member, Exotic Plant and Animal Species Subcommittee, Massachusetts Department Environmental Protection. 1989 to present.

Member, Massachusetts Non-game and Endangered Species Program Advisory Committee. 1990 to 1993.

Member, Invertebrate Advisory Group, Connecticut Department Environmental Protection. 1990 to present.

Member, Nature Preserves Council, Massachusetts Division Fisheries and Wildlife. 1990 to 1993.

Member, Massachusetts Endangered Species Act Technical Advisory Committee. 1991.

AWARDS, HONORS

Chancellor's Citation, University of Massachusetts. 1986.

Audubon "A" award, Massachusetts Audubon Society, awarded to Water Supply Citizens Advisory Committee (WSCAC). 1986.

Certificate of Appreciation, 25 years of service, University of Massachusetts. 1997.

RESEARCH AND TRAVEL GRANTS RECEIVED

Received almost 30 research and travel grants from private, state, and federal sources to conduct research.

PUBLICATIONS

BOOKS:

1. Smith, D.G. 1991. Keys to the Freshwater Macroinvertebrates of Massachusetts. Including the Porifera, Cnidaria, Entoprocta, Ectoprocta, Platyhelminthes, Nematomorpha, Nemertea, Mollusca (Prosobranchia and Pelecypoda), and Crustacea (Branchiopoda and Malacostraca). , Douglas G. Smith. 236 pp. Second Edition completed in 1995

2. Smith, D.G. 2001. Pennak's Freshwater Invertebrates of the United States. 4th Edition. John Wiley and Sons, New York. 638 pp.

CHAPTER in BOOK:

1. Smith, D.G. 2001. Systematics and Distribution of the Recent Margaritiferidae. In: G. Bauer and K. Wachtler (eds.) Ecology and Evolution of the Freshwater Mussels Unionoida. Ecological Studies 145:33-49. Springer-Verlag, Berlin.

Over 70 original research papers in peer reviewed journals.

CONSULTING

Operated private consulting business since 1993. Projects include wetlands surveys for rare and endangered invertebrates, habitat evaluation, and general aquatic surveys. Performed identification services for private, state, and federal institutions.

ESS GROUP, INC.
STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF SPECIFIC CONDUCTANCE

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine calibration and operation of a variety of specific conductance meters, including the Cole-Parmer Portable Waterproof Conductivity Meter that will be used during this study. Although this meter measures additional parameters (e.g., temperature, TDS), this SOG addresses specific conductance measurement only (other capabilities are outlined in the appropriate SOG and manufacturer's individual instrument manuals). This SOG is designed specifically for the measurement of specific conductance in accordance with EPA Method 120.1 and Standard Method 2510 B which address specific conductance measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (OAM) and may include duplicate or replicate measurements or confirmatory analyses.

2.0 RESPONSIBILITIES

2.1

The analyst is responsible for verifying that the specific conductance meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

2.2

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Specific conductance meter
- Specific conductance meter manufacturer's instruction manual

- Deionized water
- KCI standard at concentration that approximates sample concentrations
- Lint-free tissues
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Calibration sheets or logbook
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

4.1.1

Specific conductance measurements should be taken soon after sample collection since temperature changes, precipitation reactions, and absorption of carbon from the air can affect the specific conductance. If specific conductance measurements cannot be taken immediately (within 24 hours), samples should be filtered through a 0.45 μm filter, stored at 4°C and analyzed within 28 days.

4.1.2

Report results as specific conductance, μmhos/cm at 25°C.

4.1.3

As temperature can affect the specific conductance measurements obtained, record both the specific conductance and the temperature of the sample. The Cole-Parmer Portable Conductivity Meter has the ability to compensate for temperature.

4.1.4

Secondary standards may be purchased as a solution from commercial vendors. These standards should not be used after their expiration dates as provided by the manufacturer. An expiration date of one year should be used if the manufacturer does not supply an expiration date or if the standards are prepared from various salts (e.g., KCI).

4.2 Calibration and Measurement Procedures

4.2.1

The specific conductance meter must be calibrated daily (or the calibration checked) before any analyses are performed.

4.2.2

Set up the instrument according to the manufacturer's instructions.

4.2.3

Rinse the probe with deionized water and dry with a lint-free tissue.

4.2.4

Dip the probe into the calibration standard. Immerse the probe tip beyond the upper steel band. Stir the probe gently to create a homogenous sample.

4.2.5

Record the stabilized specific conductance reading of the standard and the temperature. Enter the calibration mode (according to manufacturer's instructions) and change the value on the primary display to match the value of the calibration standard. The meter can be adjusted to ± 20% from the default setting. If the measurement differs by more than ± 20%, the probe should be cleaned or replaced as needed. If the meter does not have automatic temperature compensation (ATC), correct all measurements to 25°C by adding 2% of the reading per degree if the temperature is below 25°C or by subtracting 2% of the reading per degree if the temperature is above 25°C.

4.2.6

An additional check may be performed, if required by the project plan, by placing the probe into an additional KCI standard. This standard should be from a different source than the standard used for the initial calibration. This standard should read within 5% of the true value.

4.2.7

Verify the calibration every 15 samples and at the end of the day. Recalibrate or replace the instrument if the check value is not within 15% of the true value.

4.2.8

The probe will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analyses.

4.2.9

The meter must be recalibrated following any maintenance activities and prior to the next use.

4.2.10

Conductivity data may be post calibrated using any of a variety of calibration data including, but not limited to field calibration points, manufacturer calibration data, and analytical results from samples collected during field deployment of the sensors. The decision criteria for post

calibration, and the technique used will be specified in the project plan, and will be consistent with the manufacturer's recommendations.

4.3 Troubleshooting Information

If there are any performance problems with any of the specific conductance meters which result in inability to achieve the acceptance criteria presented in Section 5.0, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

4.4.1

Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.

4.4.2

The probe must be stored and maintained according to the manufacturer's instructions.

4.4.3

If an instrument with ATC is being used, the meter should be checked annually for accuracy with an NIST thermometer.

5.0 QUALITY CONTROL

5.1

The meter must be calibrated daily before sampling and recalibrated every 12 hours, and will not be used for sample determinations of specific conductance unless the initial check standard value is within 5% of the true value.

5.2

Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within 10%.

5.3

The temperature readout of the meter will be checked against an NIST traceable thermometer at least quarterly. If the difference is greater than 0.2°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.

5.4

Some agencies may require the analysis of USEPA Water Pollution (WP) performance evaluation samples. These performance evaluation samples will be analyzed as required.

6.0 DOCUMENTATION

6.1

All specific conductance meter calibration, temperature check, and maintenance information will be recorded on the daily calibration sheet (an example is presented as Figure 1). Specific conductivity data may be recorded on the appropriate laboratory or field data sheets or logbooks.

6.2

Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:

- Date and time of calibration
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Expiration dates and batch numbers for all standards
- Reading for standard before and after meter adjustment
- Readings for all continuing calibration checks
- Temperature of standards (corrected for any difference with reference thermometer)
- Comments

6.3

Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Sample identification/station location
- Temperature (corrected for any difference with reference thermometer) and conductance of sample (including units and duplicate measurements) Note: show all calculations for converting instrument reading to μmhos/cm if the instrument provides readings in any other units. Useful conversions are: 1 mS/m = 10 μmho/cm or 1 μmho/cm = 0.1 mS/m.

- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform specific conductance measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that specific conductance measurements be taken in the field by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

ESS GROUP, INC.
STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF DISSOLVED OXYGEN

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of dissolved oxygen using a polarographic sensor equipped dissolved oxygen meter with a digital read-out such as the YSI Model 55 Handheld Dissolved Oxygen System. Measurements are made in accordance with EPA Standard Methods that addresses dissolved oxygen measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

2.1

The analyst is responsible for verifying that the dissolved oxygen measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

2.2

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Dissolved oxygen meter with digital read-out device
- Manufacturer's instruction manual for the instrument
- YSI Model 5775 Standard Membrane Kit with KCl solution and O-rings
- NIST-traceable thermometer

Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

To achieve accurate dissolved oxygen measurements, samples should be analyzed *in situ*. Measurements in flowing waters should be made in relatively turbulent free areas. Measurements in standing waters will require probe agitation to create water movement around the probe.

4.2 Calibration and Measurement Procedures

To accurately calibrate the YSI Model 55, you will need to know the approximate altitude of the region in which you are located and the approximate salinity of the water you will be analyzing. Fresh water has a salinity of approximately zero. Seawater has an approximate salinity of 35 parts per thousand (ppt). If uncertain, measure salinity with an appropriate device.

4.2.1

Ensure that the sponge inside the instrument's calibration chamber is wet then insert the probe into the chamber. Turn the instrument on and wait for readings to stabilize (approximately 15 minutes).

4.2.2

To calibrate, enter the calibration menu by pressing and releasing both the up and down arrow keys at the same time. Enter the altitude (in hundreds of feet) at the prompt by using the arrow keys to increase or decrease the altitude (example: 12 = 1,200 feet). Press enter when correct altitude is shown.

4.2.3

The meter should display CAL in the lower left of the display with the calibration value in the lower right of the display and the current D.O. reading (before calibration) should be on the main display. Once the D.O. reading is stable, press ENTER. Enter the salinity at the prompt by using the arrow keys. Press ENTER when finished and the instrument will return to normal operation.

4.2.4

Calibration should be performed at a temperature within ± 10°C of the sample temperature. Verify the calibration every 15 samples and at the end of the day.

4.2.5

If erratic readings occur, replace membrane as per the manufacturer's manual. The average replacement interval is two to four weeks.

4.2.6

Replace the membrane as per the manufacturer's manual if bubbles appear (>1/8 inch diameter), or if the membrane becomes damaged, wrinkled, or fouled.

4.2.7

Avoid contact with any environment which contains substances that may attack the probe materials (e.g. acids, caustics, and strong solvents).

4.2.8

The meter must be re-calibrated following any maintenance activities and prior to the next use.

4.3 Troubleshooting Information

If there are any performance problems with the dissolved oxygen-measuring device, consult the appropriate section of the instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

Instrument maintenance for meter-type dissolved oxygen measuring devices should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

5.1

Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within ± 0.2 mg/L.

5.2

The temperature readout of the meter will be checked regularly (at least weekly) against a NIST-traceable thermometer. If the difference is greater than 0.5°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.

6.0 DOCUMENTATION

All dissolved oxygen meter calibration, checks, and maintenance information will be recorded on the daily calibration sheet or logbook. Dissolved oxygen data may be recorded on the appropriate laboratory or field data sheets or logbooks.

6.1

Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:

- Date and time of calibration
- Signature or initials of person performing the measurement

- Instrument identification number/model
- Expiration dates and batch numbers for all standard solutions
- Readings for all continuing calibration checks
- Comments

6.2

Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Sample identification/station location
- Dissolved oxygen, both in mg/L and percent saturation (corrected for any difference with reference thermometer) and temperature of sample (including units and duplicate measurements)
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform dissolved oxygen measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that dissolved oxygen measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983

ESS GROUP, INC.
STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF FLOW RATE

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of flow rate in bodies of running water. The two techniques under consideration are the Time of Travel Method and the Global Flow Probe Procedure.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

2.1

The analyst is responsible for verifying that the instrumentation is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

2.2

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

3.1

The following materials are necessary for the Global Flow Probe Procedure:

- Global Flow Probe FP101, Global Water, Gold River, CA
- LCD computer display
- Radio Shack 675 HP or equivalent batteries

- Manufacturer's instruction manual for the instrument
- Laboratory or field data sheets or logbooks

3.2

The following materials are necessary for the Time of Travel Method:

- A neutral buoyancy floating object, such as a cracked ping-pong ball
- Twine of other heavy-duty string material
- Water proof yard-stick to measure stream depth
- Stop-watch
- Permanent marker (e.g., sharpie)
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 General Measurement Procedures For Global Flow Probe Procedure

To achieve accurate flow measurements samples must be analyzed in the field. Flow measurements may be taken in small and large streams, rivers and within pipes.

4.1.1

The average velocity of stream flow multiplied by the cross-sectional area is equal to the flow rate (Q=VxA). The cross sectional area is determined manually by measuring the depth of the water at several points across the channel. The cross section in square feet times the average velocity in feet per second gives the cubic feet per second (c.f.s.).

4.1.2

When sampling within round pipes, one needs only to measure the water depth and then refer to the tables in the Global Flow Probe Instruction Manual to determine the cross-sectional area.

4.2 Calibration and Measurement Procedures for Global Flow Probe Procedure

The Flow Probe is set up and calibrated at the factory. The calibration sequence is entered automatically when the batteries are changed or by holding down both Right and Left buttons simultaneously for 8 seconds. Calibration should be checked annually.

4.2.1

To change between English and Metric units and to enter the calibration sequence, hold down both Left and Right buttons simultaneously for 8 seconds. The Left button scrolls between English "mi" and Metric "km".

4.2.2

To check the calibration push the Right button to "CAL". For "mi" calibration set Probe calibration to 33.31. For "km" calibration set Probe calibration to 1603. The Left button increases the number when the arrow points up and decreases the number when the arrow points down.

4.2.3

The Flow Probe computer has a simple 2 – button operation. The Right button changes between Function and the Left button picks the Option. Pushing both buttons simultaneously for 1 second zeros the displayed value.

4.2.4

By pushing the Right button you may scroll through the following functions. Velocity Function: "V" is instantaneous velocity to the nearest 0.1 feet per second. Push the Left button to scroll between "AV" (average velocity) and "MX" (maximum velocity) which reads out to the nearest 0.01 feet per second. Stop Watch / Clock Function: Push the Left button to start and stop watch.

4.2.5

Make sure the prop turns freely and point the prop directly into the flow with the arrow on the bottom of the probe pointing down-stream.

4.2.6

Press the Right button until the "V" for velocity appears and select the desired velocity parameters to be measured by pushing the Left button. Average velocity readings "AV" must be collected for flow rate measurements (c.f.s.).

4.2.7

Put the probe at your measuring point and press both Right and Left buttons simultaneously and release to re-zero and begin recording. Hold in the flow for several seconds until you have steady average velocity.

4.2.8

When sampling in small streams and within pipes, the probe should be moved slowly and smoothly along a vertical plane throughout the flow to ensure that the probe evenly samples the cross-sectional area of the flow.

4.2.9

When sampling larger streams and rivers divide the stream into subsections (e.g. 2-3 feet in width). At the center of each subsection, insert the probe and sample vertically from the surface to the bottom smoothly to obtain a vertical average velocity profile. The Average Velocity times the Area of the subsection is the Flow for the subsection. Add all the subsection flows to obtain the Total Stream Flow.

4.2.10

Repeat procedure three times in at least three different locations, recording data in field notebook. The flow rate should be calculated as an average of the three measurements taken at different locations within the channel or pipe.

4.2.11

Calculate discharge (Q) from the measured data, as follows:

- Measure and calculate the cross-sectional area of your flow stream in square feet and multiply this by the average velocity in feet / second to obtain discharge in cubic feet per second (c.f.s.).
- Cross-sectional area (ft^2) x AV (ft/sec) = Q (ft^3/sec)

4.3 Calibration and Measurement Procedures for the Time of Travel Method

4.3.1

To measure travel time, the length of time taken for the floating object to travel 3 feet will be measured as follows:

1. Select an appropriate stream cross section with relatively uniform and uninterrupted flow
2. Securely attach 3 feet of string to floating object (i.e., cracked ping-pong ball)
3. Release floating object in the water and activate timer
4. Record time (T) from when the floating object is released to the time when the string goes taut, indicating that the object has traversed 3 feet
5. Repeat procedure three times at three different locations, recording data in a field notebook. The flow rate should be calculated as an average of the three measurements

taken at different locations within the stream channel. Flow rate = 3 feet/T (seconds) = X feet / second

6. Measure stream average width and average depth at sampling location

4.3.2

Calculate discharge (Q) from the measured data, as follows:

1. Calculate cross-sectional area (A) of the stream, by multiplying average width and average depth
2. Select a coefficient or correction factor (C): 0.8 for rocky bottom streams, 0.9 for muddy bottom streams. The coefficient allows correction for the fact that water travels faster at the surface than at the stream bottom, due to resistance from bottom materials
3. $Q = \frac{A \times C \times L}{T}$ Where L= 3 feet and T= time of travel (seconds)

   Units of Q are typically cubic feet per second.

4.4 Troubleshooting Information for Global Flow Probe Procedure

If there are any performance problems with the Global Flow Probe, consult the appropriate section of the instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department at (916) 638-3429 immediately for further instructions.

4.5 Maintenance for Global Flow Probe Procedure

Instrument maintenance for the Global Flow Probe should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

5.1 Quality Control for Global Flow Probe Procedure

5.1.1

The Global Flow Probe calibration should be checked annually to ensure that the Flow Probe is operating up to factory specifications.

5.2 Quality Control for the Time of Travel Method

5.2.1

To ensure a quality measurement, a minimum of three times of travel measurements will be obtained and recorded at each sampling point. An average value will be used to measure of flow rate / discharge.

6.0 DOCUMENTATION

6.1 Documentation for Global Flow Probe Procedure

All Global Flow Probe calibration, checks, and maintenance information will be recorded on the daily calibration sheet or logbook. Flow data may be recorded on the appropriate laboratory or field data sheets or logbooks.

6.1.1

Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:

- Date and time of calibration
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Readings for all continuing calibration checks
- Comments

6.1.2

Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Sample identification/station location
- Flow Rate in cubic feet per second (c.f.s.), average water velocity and maximum water velocity
- Comments

6.2 Documentation for the Time of Travel Method

6.2.1

All data will be recorded in a field logbook. Documentation for recorded data must include a minimum of the following:

- Date, time and location of measurement
- Time of travel and distance traveled
- Comments, if any

7.0 TRAINING/QUALIFICATIONS

7.1

To properly perform Global Flow Probe measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that flow measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

7.2

No special training is required to implement the Time of Travel Method; however, the analyst must be familiar with the calibration and measurement techniques stated in this SOG.

8.0 REFERENCES

Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003, November 1997.

Global Flow Probe Instruction Manual.

ESS GROUP, INC.
STANDARD OPERATING GUIDELINES
FOR FRESHWATER MACROINVERTEBRATE SAMPLING AND ANALYSIS

1.0 INTRODUCTION

The following guidelines are to be used by ESS Group, Inc. (ESS) for sampling a single habitat type for freshwater macroinvertebrates. They are to be conducted using a standard D-frame kick net deployed within wadable rivers and streams, as outlined by EPA (1999). The laboratory analysis procedures outlined below are specific with respect to critical techniques and quality assurance and quality control procedures.

2.0 REQUIRED MATERIALS

The following materials are likely to be necessary for this procedure:

Field Equipment

- Standard D-frame kick-net, 500 µm mesh size, 0.3 meter width (~1.0 ft frame width)
- Stopwatch
- Sieve bucket, 500 µm opening mesh
- 95% ethanol
- Sample containers (1 liter jars or plastic bags)
- Labels and markers for sample jars
- Write-in-the-rain paper for internal sample lables
- Wash Bottle or similar device
- Fine Forceps
- Pencils, clipboard
- Benthic Macroinvertebrate Field Data Sheet
- Chest waders
- Rubber gloves (arm length)
- Camera
- Global Positioning System (GPS) Unit (Optional)

Laboratory Equipment

- Log in sheet for samples
- 70% Ethanol for storage of specimens
- Sieve with screen size less than 0.5 mm (500 µm)
- Forceps – fine gauge
- Sorting sieve tray (36cm x 30cm)
- Metal frame (6cm x 6cm)
- Flat scoop (6cm)
- Specimen vials with caps or stoppers
- Sample labels
- Standard laboratory bench sheets for sorting and identification
- Dissecting microscope for organism identification
- Compound microscope for slide mounted organism identification
- Fiber optics light source
- Plastic petri dishes – sectional preferred
- Appropriate invertebrate taxonomic keys for Genus/Species level identification

HABITAT ASSESSMENT FIELD DATA SHEET

SARIS NO. _____ RIVER BASIN _____

RIVER MILE _____ ECOREGION REFERENCE SITE _____

DATE _____ INVESTIGATOR _____

DESCRIBE SITE LOCATION _____

Comments:

Riffle/Run Prevalent Streams are those in moderate to high-gradient landscapes that sustain water velocities of approximately 30 cm/sec or greater. Natural streams have substrates primarily composed of coarse sediment particles (i.e., gravel or larger) or frequent coarse particulate aggregations along stream reaches.

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
1. Instream Cover (Fish)	A mix of snags, submerged logs, undercut banks, rubble, or other stable habitat in greater than 50% of the sample area	30-50% of area with a mix of stable habitat; adequate habitat for maintenance of populations.	10-30% of area with a mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% of area with a mix of stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble. (Boulders prevalent in headwater streams).	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or bedrock prevalent; some cobble present.	Riffles or runs virtually nonexistent; bedrock prevalent; cobble lacking.
SCORE _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Frequency of Riffles (or bends) / Velocity-Depth Combinations	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important; All 4 velocity/depth patterns present.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. Only 3 of 4 velocity/depth patterns present (i.e., slow [<0.3 m/s]-deep [>0.5 m]; slow-shallow; fast-deep; fast-shallow).	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. Only 2 velocity/depth patterns present; usually lacking deep areas.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. Dominated by one velocity/depth pattern.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
8. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 9 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score:

___

3.0 MACROINVERTEBRATE COLLECTION

The details provided below assume that the "single habitat sampling approach" will be taken, as referred to by EPA (1999), in order to standardize assessments among streams. It is assumed that cobble substrate will represent more than 30% of the sampling reach in reference streams, therefore sampling the riffle/run habitat will provide a representative sample of the stream reach.

Summary of Requirements:

- All kick samples to be taken with a standard D-frame net (0.3 m width) within a representative 100 m reach.
- Conduct kick sampling for a timed three minutes duration, removing organisms from larger substrate particles by hand. Empty net as it becomes full, keeping track of the timed 3-minute level of effort with a stopwatch.
- All samples must be preserved in the field on the day of collection with a 95% ethanol solution in a leak proof container, samples can be diluted with water as necessary to bring preservative level to about 75%.
- Record location for each sample taken on a map of each sampling reach.
- Complete physical EPA field sheet and Habitat Assessment field sheet and sample log-in sheet.
- Clearly label all sample containers with sample identification code, date, stream name, sampling location, and collector name.

Specific Requirements:

1. A 100 m reach representative of the characteristics of the stream will be selected. Whenever possible, the area will be at least 100 meters upstream from any road or bridge crossing to minimize its effect on stream velocity, depth. and overall habitat quality, with no major tributaries discharging to the stream in the study area.

2. Before sampling, the physical/chemical EPA field sheet will be completed to document site description, weather conditions, and land use (Appendix 1). Sheet entries will be reviewed after sampling.

3. A map will be drawn of the sampling reach indicating the areas that were sampled for macroinvertebrates. This map will also include in-steam attributes (e.g., riffles, falls, fallen trees, pools, bends, etc.) and important structures. An arrow will indicate the direction of flow. If available, a hand-held Global Positioning System (GPS) will be used for latitude and longitude determination taken at the furthest downstream point of the sampling reach.

4. Sampling will begin at the downstream end of the reach and proceed upstream. Using a D-frame kick net, kick sampling will be conducted at various velocities in the riffle or series of riffles for a total of 3 minutes. Larger substrate particles and debris will be picked up and rubbed by hand to remove attached organisms. After every kick, the collected material will be washed by running clean stream water through the net 2 to 3 times. If clogging does occur, the material in the net will be discarded and that portion of the sample redone in a different location.

5. The sample will be transferred from the net to sample container(s) and preserved in enough 95 percent ethanol to cover the sample. Forceps may be needed to remove organisms from the net. A label will be placed into the sample container indicating the sample identification code, date, stream name, sampling location, and collector name. The outside of the container will include the same information and the words preservative: 95% ethanol. If more than one container is needed for a

sample, each container label will contain all the information for the sample and should be numbered (e.g., 1 of 2,2 of 2, etc.).

6. Sample container information as noted in step (5) will be recorded, on the EPA "Sample Log-In sheet" (Appendix 2).

7. Walking the reach, an assessment of the surrounding habitat will be conducted by completing the EPA "Habitat Assessment Field Data Sheet" (Appendix 3).

4.0 PROTOCOL FOR LABORATORY ANALYSIS

Summary of Requirements:

- Samples will be rinsed to remove preservatives and fines.
- Sub-samples will be taken using a grid-marked sorting sieve tray and metal frame.
- Remove and identify large, unique, or rare species.
- Sub-samples will be sorted under a dissecting microscope until 100 organisms have been removed.
- Organisms will be preserved with 70% ethanol in small, appropriately labeled, vials or jars.
- Unsorted residue and sorted residue will be preserved in 70% ethanol in appropriately labeled jars.
- Midges and worms will be mounted on labeled slides.
- Identification to genus/species level or the lowest practical taxon using a compound microscope for mounted slides and a dissecting microscope for other organisms.

Specific Requirements:

1. The Sample Log-in sheet will be reviewed to verify that all samples have arrived and are in proper condition for processing.

2. The sample will be rinsed in a 500 µm-mesh sieve to remove preservative and fine sediment, never allowing the animals to come between direct flow of water and the screen. Large organic material (whole leaves, twigs. algal or macrophyte mats, etc.) not removed in the field will be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting.

3. After washing, the sub-sample will be evenly spread across the grid-marked sorting sieve tray by immersing in water. Large rare or unique organisms will be picked out and identified and reported as supplemental information for each location but not as part of the rest of the sub-sample. A random grid from the tray will be selected and the sieve lifted to temporarily drain the water. A metal frame (6 cm x 6 cm) will be used to clearly define the selected grid; debris overhanging the grid may be cut with scissors. A 6cm flat scoop will be used to remove all debris and organisms from the grid. The sub-sample will then be transferred to a small container temporarily.

4. The sub-sample will be sorted under a dissecting microscope on a Petri dish. At least 100 organisms should be removed from the sub-sample, if less than 100 are removed then another random grid from the sorting sieve tray must be selected and steps (3) and (4) repeated. These steps will be repeated until the whole sample has been sorted through or 100 organisms have been removed.

5. The organisms will be placed into glass vials and preserved in 70% ethanol. The vials will be labeled inside and out with the sample identifier or lot number, date, stream name, sampling location and

taxonomic group. If more than one vial is needed, each will be labeled separately and numbered (e.g., 1 of 2, 2 of 2).

6. The sorted debris residue will be saved in a separate container labeled as "sorted residue" in addition to all prior sample label information and preserved in 70% ethanol. The remaining unsorted sample debris residue will be saved in a separate container labeled "sample residue".

7. Midge (Chironomidae) larvae and pupae will be mounted on slides in an appropriate medium (e.g., Eupcral, CMC-9); slides will be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) will also be mounted on slides and will be appropriately labeled.

8. The sorter will fill out the EPA "Laboratory Bench Sheet" (Appendix 4), noting sub-sampling/sorting information, the number of grids picked, time expenditure, and number of organisms. If QC check was performed on a particular sample, person conducting QC will note findings on the back of the Laboratory Bench Sheet. The sorter will record the date of sorting and slide monitoring, if applicable, on Log-In Sheet as documentation of progress and status of completion of sample lot.

9. Types (to the genus/species level or the lowest practical taxonomic level) and counts for all organisms within each sample will be determined through the use of a dissecting microscope (up to 45X magnification), a fiber optic lamp, standard dissecting tools, and using appropriate taxonomic keys. Midges (Diptera: Chironomidae) and worms (Oligochaeta) mounted on slides will be identified using a compound microscope. Each taxon found in a sample will be recorded and enumerated in a laboratory bench notebook and will then be transcribed to the laboratory bench sheet (Appendix 4) for subsequent reports. Any difficulties encountered during identification (e.g.. missing gills) are noted on these sheets.

10. For archiving samples, specimen vials, (grouped by station and date), will be placed in labeled jars with a small amount of denatured 70% ethanol and tightly capped.

5.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The QA/QC protocol for the benthic monitoring program will be comparable to procedures outlined for other similar assessment programs. In the field, after sampling has been completed at a given site, all nets, pans etc that have come into contact with the sample will be rinsed thoroughly examined carefully and picked free of debris or organisms. Also, a duplicate sample will be taken at 10% of the sites to evaluate the precision or repeatability of the sampling technique or the collection team.

In the lab, ESS will randomly perform a quality check on a minimum of 10% of the samples analyzed. This quality check will cover both the sorting and the identification phases of the analysis.

For the sorting phase, if more than 10 % error (calculated by dividing the number found in the quality check by the total number of individuals) is found between the sorter and the quality assurance check, 4 additional samples will be reprocessed. If the percent error in those samples is more than 10% in those samples, then all samples sorted by that individual will be reprocessed.

For identification, a second ESS staff member trained in macroinvertebrate identification will randomly check a minimum of 10% of the samples analyzed. The purpose of this check will be to validate the identifications made on the individuals comprising the sample. In addition, ESS will confirm the identifications made with other regional experts as necessary.

A reference collection of samples will be maintained. These specimens will be labeled and preserved in 70% ethanol and stored for future reference and/or for study by other regional experts as necessary

Record of the results of each of the various quality assurance checks described above will be kept in a laboratory analysis log.

6.0 REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

ESS GROUP, INC.
STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF pH

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine calibration and operation of a variety of pH meters, including the Hydac Multimeter Probe and the pHep pH Testers. Although these meters may measure additional parameters (e.g., temperature, specific conductivity, etc.), this SOG addresses pH measurement only (other capabilities are outlined in the appropriate SOG and manufacturer's individual instrument manuals). This SOG is designed specifically for the measurement of pH in accordance with EPA Method 150.1 and Standard Method 4500-H B which address electrometric pH measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory analyses.

2.0 RESPONSIBILITIES

2.1

The analyst is responsible for verifying that the pH meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

2.2

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials may be necessary for this procedure:

- pH meter
- pH meter manufacturer's instruction manual

- Deionized water
- 4.0, 7.0, and 10.0 buffer solutions
- Lint-free tissues
- Mild detergent
- 10% hydrochloric acid
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Calibration sheets or logbook
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

4.1.1

To achieve accurate pH measurements, samples should be analyzed in the field (preferably within 15 minutes), or as soon as possible after collection. Sample should be collected in plastic or glass containers.

4.1.2

After measuring a sample containing oily material or particulate matter, the electrode must be cleaned by carefully wiping with a lint-free cloth, or washing gently in a mild detergent, followed by a deionized water rinse. If this does not suffice, an additional rinse with 10% hydrochloric acid (followed by deionized water) may be needed.

4.1.3

As temperature can affect the pH measurements obtained, both the pH and the temperature of the sample must be recorded. Both the Hydac Multimeter and the pHep Tester that will be used in this study have the ability to compensate for temperature.

4.1.4

Calibration must include a minimum of two points that bracket the expected pH of the samples to be measured. Calibration measurements must be recorded in logbook.

4.1.5

Primary standard buffer salts available from NIST can be purchased and are necessary for situations where extreme accuracy is required. Secondary standard buffers may be purchased as a solution from commercial vendors and are recommended for routine use. Buffers should not be used after their expiration dates as provided by the manufacturer. An expiration date of one

year should be used if the manufacturer does not supply an expiration date or if the buffers are prepared from pH powder pillows, etc.

4.1.6

When using the meter in the laboratory, always place the buffer/sample beaker on the magnetic stirrer, and make sure the stirring bar is rotating during measurements. Rinse the stirring bar as well as the beaker between buffers/samples.

EXCEPTION: Do not use the magnetic stirrer for acid rain samples. It is crucial not to induce dissolved gases into the sample to be absorbed or desorbed, as this will alter the pH. Stir the sample gently for a few seconds after introducing the electrode, then allow the electrode to equilibrate prior to recording temperature and pH readings.

4.1.7

When the meter is being used in the field, move the probe in a way that creates sufficient sample movement across the sensor; this insures homogeneity of the sample and suspension of solids. If sufficient movement has occurred, the readings will not drift (<0.l pH units). Rinse the electrode with deionized water between samples and wipe gently with a lint-free tissue.

4.1.8

When measuring the pH of hot liquids, wait for the liquid to cool to 160°F or below.

4.1.9

Fluctuating readings may indicate more frequent instrument calibrations are necessary.

4.2 Calibration and Measurement Procedures

4.2.1

The pH meter must be calibrated daily before any analyses are performed. The meter should be re-calibrated every 12 hours or at the frequency specified in the project plan.

4.2.2

Connect the electrode to the meter. Choose either 7.0 and 10.0 (high range) or 4.0 and 7.0 (low range) buffers, whichever will bracket the expected sample range. Place the buffer in a clean glass beaker. If the pH is being measured in a laboratory, place the beaker on the magnetic stirrer and place the stirring bar in the beaker. Measure and record the temperatures of the buffers using a calibrated thermometer or automatic temperature compensation (ATC).

4.2.3

Place the electrode into the 10.0 buffer or into the 7.0 buffer.

4.2.4

Adjust the instrument calibration according to the manufacturer's instructions. Discard the buffer and rinse the beaker and stirring bar thoroughly with deionized water.

4.2.5

Refill the beaker with the 7.0 buffer or the 4.0 buffer. Rinse the electrode, gently wipe with a lint-free tissue, and place it in the selected buffer solution. If the pH is being measured in a laboratory, place the beaker on the magnetic stirrer and place the stirring bar in the beaker. Continue adjusting the instrument calibration according to the manufacturer's instructions. Record the electrode slope (if provided by the instrument) on the calibration sheet (an acceptable slope is between 92 and 102 percent). Measure and record the temperature of the buffer using a calibrated thermometer or ATC. Discard the buffer and rinse the beaker and stirring bar thoroughly with deionized water.

4.2.6

An additional check may be performed, if required by the project plan, by placing the electrode into an additional buffer solution. This buffer should be from a different source than the buffers used for the initial calibration. This buffer should read within +0.2 pH units of the buffer's true pH value.

4.2.7

Verify the calibration every 15 samples and at the end of the day. Recalibrate the instrument if the check value varies more than 0.2 pH units from the true value.

4.2.8

The electrode will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analysis.

4.2.9

Recalibrate the instrument if the buffers do not bracket the pH of the samples.

4.2.10

The meter must be re-calibrated following any maintenance activities and prior to the next use.

4.3 Troubleshooting Information

If there are any performance problems with any of the pH meters which result in the inability to achieve the acceptance criteria presented in Section 5.0, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

4.4.1

Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.

4.4.2

The electrode must be stored and maintained according to the manufacturer's instructions.

4.4.3

If an instrument with ATC is being used, the device should be checked on a quarterly basis for accuracy with an NIST thermometer.

5.0 QUALITY CONTROL

5.1

Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within ±0.l pH units.

5.2

The temperature readout of the meter will be checked annually against an NIST-traceable thermometer. If the difference is greater than 0.2°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.

5.3

Some regulatory agencies may require the analysis of USEPA Water Supply (WS) or Water Pollution (WP) performance evaluation samples. These performance evaluation samples will be analyzed as required.

6.0 DOCUMENTATION

6.1

All pH meter calibration, temperature check, and maintenance information will be recorded on the daily calibration sheet (Figure 1). pH data may be recorded on the appropriate laboratory or field data sheets or logbooks.

6.2

Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:

- Date and time of calibration
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Expiration dates and batch numbers for all buffer solutions
- Reading for pH 7.0 buffer before and after meter adjustment
- Reading for pH 4.0 or 10.0 buffer before and after meter adjustment
- Readings for all continuing calibration checks
- Temperature of buffers (corrected for any difference with reference thermometer), including units
- Comments

6.3

Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Sample identification/station location
- Temperature (corrected for any difference with reference thermometer) and pH of sample (including units and duplicate measurements)
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform pH measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that pH measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

ESS GROUP, INC.
STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF TEMPERATURE

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of temperature using any high quality mercury-filled thermometer or thermistor with analog or digital read-out device such as the Hydac Multimeter Probe and YSI Model 55. Multimeter instruments used for temperature measurement may measure additional parameters (e.g., dissolved oxygen, conductivity, pH, etc.). This SOG addresses temperature measurement only (other capabilities are outlined in the appropriate SOG). This SOG is designed specifically for the measurement of temperature in accordance with EPA Method 170.1 and Standard Method 2550 B which address thermometric temperature measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

2.1

The analyst is responsible for verifying that the temperature measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

2.2

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Thermometer or thermistor with analog or digital read-out device

- Manufacturer's instruction manual for the instrument
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

To achieve accurate temperature measurements, samples should be analyzed immediately upon collection (preferably within 15 minutes). Samples should be collected in glass or plastic containers.

4.2 Calibration and Measurement Procedures

4.2.1

ESS-owned temperature measuring devices will, at a minimum, be checked annually as described in Section 5.0. The device will be checked against an NIST-traceable thermometer and the necessary compensation made for the difference in temperature between the two. Rental equipment will be checked by the manufacturer and documentation provided to ESS.

4.2.2

Immerse the thermometer or temperature measuring device into the sample.

4.2.3

Swirl and take a reading when the value stabilizes.

4.2.4

Record the temperature reading to the nearest 0.50 for a thermometer or 0.10 for digital meter-type instruments. Compensate for any difference with the NIST-traceable thermometer.

4.2.5

Temperature data may be post-calibrated using any of a variety of calibration data including, but not limited to, field calibration points, manufacturer calibration data, and analytical results from samples collected during field deployment of the sensors. The decision criteria for post calibration, and the technique used, will be specified in the project plan, and will be consistent with the manufacturer's recommendations.

4.3 Troubleshooting Information

If there are any performance problems with any of the meter-type temperature measuring devices, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions. If a performance problem exists with the thermometer, discard the thermometer and replace it.

4.4 Maintenance

Instrument maintenance for meter-type temperature measuring devices should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

5.1

The temperature measuring devices will, at a minimum, be checked against an NIST-traceable thermometer at the frequency stated in Section 4.2.1. This verification procedure will be performed as follows:

- Immerse the thermometer or temperature sensor and the NIST-traceable thermometer into a sample.
- Allow the readings to stabilize.
- Record the readings and document the difference.
- Label the thermometer or temperature sensor with the correction value/adjustment and the date the accuracy check was performed.
- Compensate for the difference when sample measurements are taken.

5.2

Duplicate measurements of a single sample will be performed at the frequency stated in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within $\pm$ 0.50C or approximately $\pm$ 1.00F.

6.0 DOCUMENTATION

6.1

Records for checking the accuracy of the thermometer or temperature measuring device (where applicable) will include:

- Date
- Thermometer or meter-type temperature measuring device checked

- Reference thermometer number
- Readings for reference thermometer and thermometer being checked
- Adjustment made for difference in readings
- Initials of analyst

6.2

Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Thermometer ID # or instrument identification number/model
- Sample identification/station location
- Temperature of sample (including units and duplicate measurements) compensated for any difference with the reference thermometer if applicable
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform temperature measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that temperature measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

ESS GROUP, INC.
STANDARD OPERATING GUIDELINES
FOR MEASUREMENT OF TURBIDITY

1.0 INTRODUCTION

1.1 Purpose and Applicability

These Standard Operating Guidelines (SOG) provide basic instructions for routine measurement of turbidity using a nephelometric turbidity meter with a digital read-out device such as the LaMotte 2020 Turbidimeter. Measurements are made in accordance with EPA Method 180.1 that addresses nephelometeric turbidity measurement of drinking, surface, and saline waters, and domestic and industrial wastes.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan or Quality Assurance Project Plan (QAPP) (hereafter referred to as the project plan) or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory measurements.

2.0 RESPONSIBILITIES

2.1

The analyst is responsible for verifying that the turbidity measuring device is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOG and the project plan.

2.2

The project manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOG and the project plan.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Turbidity meter with digital read-out device
- Manufacturer's instruction manual for the instrument
- Turbidity tubes

- Mild detergent
- Lint-free cloth
- Distilled water
- Nephelometric Turbidity Unit (NTU) calibration standards (1.00 NTU and 10.0 NTU)
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

To achieve accurate turbidity measurements, samples should be analyzed immediately upon collection (preferably within 15 minutes). Samples should be collected in glass or plastic containers.

4.2 Calibration and Measurement Procedures

4.2.1

Select a turbidity standard in the range of the samples to be tested (1.00 NTU or 10.0 NTU). Fill a turbidity tube with the standard, cap, and wipe the tube with the clean lint-free cloth.

4.2.2

Place the sample into the turbidity meter such that the indexing arrow on the turbidity tube is aligned with the indexing arrow on the meter face. Close the lid and press the "READ" button. If the displayed value is not the same as the value of the standard (within 2%), continue with the calibration procedure.

4.2.3

Follow the calibration procedures outlined by the manufacturer's manual.

4.2.4

Verify the calibration every 15 samples and at the end of the day. Recalibrate the instrument if the check value varies more than 2% from the true value.

4.2.5

The turbidity tubes will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analysis.

4.2.6

Recalibrate the instrument with the appropriate NTU standard if the standard is not of the same order of magnitude as the samples being tested.

4.2.7

The meter must be re-calibrated following any maintenance activities and prior to the next use.

4.2.8

Record the turbidity reading to the nearest 0.01 NTU for measurements less than 11 NTU and to the nearest 0.1 for measurements greater than 11 NTU but less than 110 NTU. For values greater than 110 NTU record to the nearest 1 NTU.

4.3 Troubleshooting Information

If there are any performance problems with any of the meter-type turbidity measuring devices, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

Instrument maintenance for meter-type turbidity measuring devices should be performed according to the procedures and frequencies required by the manufacturer.

5.0 QUALITY CONTROL

5.1

The turbidity measuring tubes will, at a minimum, be checked against NTU calibration standards at the frequency stated in Section 4.2.1. This verification procedure will be performed as follows:

- Insert the turbidity tube with distilled water into the turbidity meter.
- Press "READ".
- Record the readings and document the difference.
- Label each turbidity tube with its corresponding turbidity correction value.
- Record the adjustment and the date the accuracy check was performed in a logbook.
- Compensate for the difference when sample measurements are taken.

5.2

Duplicate measurements of a single sample will be performed at the frequency stated in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within ± 2% for readings below 100 NTU and ± 3% for readings above 100 NTU.

6.0 DOCUMENTATION

All turbidity meter calibration, checks, and maintenance information will be recorded on the daily calibration sheet or logbook. Turbidity data may be recorded on the appropriate laboratory or field data sheets or logbooks.

6.1

Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:

- Date and time of calibration
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Expiration dates and batch numbers for all standard solutions
- Reading for 1.00 NTU standard before and after meter adjustment
- Reading for 10.0 NTU standard before and after meter adjustment
- Readings for all continuing calibration checks
- Comments

6.2

Documentation for recorded data must include a minimum of the following:

- Date and time of analysis
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Sample identification/station location
- Turbidity of sample (including units and duplicate measurements)
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform turbidity measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOG. The analyst must also be experienced in the operation of the meter.

Certain state certification programs require that turbidity measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

Appendix C

Aquatic Resources Center Methodology for Mounting/Identifying Chironomid Larvae & Oligochaetes

SOP No. 5
Revision No. 0
August 2000

SUBJECT: MOUNTING AND IDENTIFYING CHIRONOMID LARVAE

Purpose

To determine the identity of all chironomid larvae to the lowest taxonomic level, usually genus/species

List of Equipment

Dissecting microscope capable of 40X magnification
Compound microscope capable of 1000X magnification
70% ethanol solution
Very fine tip jewelers forceps
Insect pin probes: sizes 00, 0, or 1
Large probe
Small covered petri dishes
CMCP 10 high viscosity mounting medium
Dropper
Sharpie ink pen
25 X 27 mm precleaned plain microscope slides
22 X 22 mm No. 1 square cover slips
Self adhesive slide labels
Laboratory bench sheet for chironomids
Immersion oil
Various keys which provide the most updated classification scheme

Procedure

1. Select a sample for identification from sorted materials. Samples should be roughly sorted into major taxonomic groups at this point, i.e., chironomid larvae.

2. Label a laboratory bench sheet so it corresponds with the numbers on the sample vial.

3. Open the vial and place contents into petri dish. Using a dissecting microscope, remove any foreign material from the contents of the petri dish.

4. Line up 3-4 slides and put two drops of mounting medium on each slide. The drops should be equidistant from each other, but enough room should be left to apply a self adhesive slide label on the left side. Do not place label on slide until the complete set of chironomids has been mounted.

5. Place 2-3 chironomids directly from the 70% ethanol solution onto each drop of medium. If the specimen floats away, there is too much medium. If you use less, you must ensure that no air

bubbles or pockets occur. Line up each of the chironomids so that the ventral side is up and all of the anterior ends face the same direction. If the chironomids (e.g., 4th instar *Dicrotendipes*) are large, the number placed under one coverslip may vary. Place one cover slip on the specimen, making sure that only the edges of the cover slip are handled--do not put your fingers on the cover slip itself. Make sure that there is only one cover slip.

6. Using a large probe or forceps press gently but firmly on the cover slip to distribute the medium and flatten the specimen without destroying it.

7. Carefully ring the cover slip with medium. Make sure that there is no medium on top of the cover slip and that air bubbles have not occurred. When the entire set has been mounted, place a self adhesive slide label on the slide and label with appropriate information:

Date Collected	e.g.:	03 Jul 94
Station ID		25139
Sampler & replicate		Basket A
Subsample identification		100
Taxonomic group		Chironomidae
Slide number		1 of 20 (or 1-20)

8. Once the medium has set, use a dissecting microscope to aid in the marking of the specimen position. Use a fine tipped Sharpie pen to put a dot immediately beneath or beside the specimen's head. Do this for every specimen regardless of size.

9. Put the slides on a mounting tray and place them under a hood. Allow the slides to dry for 2-3 days. It is generally a good idea to check each slide once a day to ensure that air bubbles have not developed or to see if more medium is needed.

10. Identification of the taxa may be accomplished by using a variety of available keys and a compound microscope. Because all of the organisms are not mature, accurate identifications may sometimes be difficult. In such cases, in-house experience is important. If there are any questionable identifications they are checked by other qualified individuals to ensure accurate identification.

11. Once a specimen has been identified it is recorded on the laboratory bench sheet for that group.

For example	A	B
1.	*Chironomus* sp.	*Dicrotendipes* sp.
	Tanytarsus sp.	*Polypedilum fallax*

If there are two cover slips per slide they are treated as sides A and B (three coverslips would be A. B, C). Consequently the 2-3 midges that are under the cover slip are written down as they appear from left to right under the microscope.

12. Notation of new taxa should be taken, as a species list is developed from these notations. Slides containing specimens that are large or in good condition should be marked for use in voucher collection.

SOP No. 6
Revision No. 0
August 2000

SUBJECT: **MOUNTING AND IDENTIFYING OLIGOCHAETES**

Purpose

To determine the identify of all oligochaetes to the lowest taxonomic level, usually species

List of Equipment

Dissecting microscope capable of 40X magnification
Compound microscope capable of 1000X magnification
70% ethanol solution
Very fine tip jewelers forceps
Insect pin probes: sizes 00, 0, or 1
Large probe
Small covered petri dishes
CMCP 10 high viscosity mounting medium
Dropper
Sharpie ink pen
25 X 27 mm precleaned plain microscope slides
No. 1 square cover slips (either 22 x 22 mm or 18 x 18 mm)
Self adhesive slide labels
Laboratory bench sheets for oligochaetes
Immersion oil
Various keys which provide the most updated classification scheme

Procedure

1. Select a sample for identification from sorted materials. Samples should be sorted into major taxonomic groups at this point, i.e., oligochaetes.

2. Find the corresponding laboratory bench sheet.

3. Open the vial and place contents into petri dish. Using a dissecting microscope, remove any foreign material from the contents of the petri dish.

4. Line up 3-4 slides and put two drops of mounting medium on each slide. The drops should be equidistant from each other, but enough room should be left to apply a self adhesive slide label on the left side. Do not place label on slide until the complete set of oligochaetes has been mounted.

5. Place 5 oligochaetes directly from the 70% ethanol solution onto each drop of medium. If the worm is large, it can be blotted on a paper towel and then put on the slide. If the specimen floats away, there is too much medium. If you use less, you must ensure that no air bubbles or pockets occur. Align oligochaetes so that all of the posterior ends are at the same side. If the oligochaetes are large (e.g., mature *Limnodrilus cervix*), the number placed under one coverslip may vary. Place one cover slip over the specimen(s) on the slide, handling only the edges of the coverslip--do not put your fingers on the cover slip itself. Make sure that there is only one cover slip.

6. Using a large probe or forceps press gently on the cover slip to distribute the medium and flatten the specimen without destroying it.

7. Carefully ring the cover slip with medium. Make sure that there is no medium on top of the cover slip and that large air bubbles have not occurred. When the entire set has been mounted, place a self adhesive slide label on the slide and label with appropriate information:

Date Collected	e.g.:	03 Jul 94
Station ID		Ogden R., RM 33
Sampler & replicate		Kick #2
Subsample identification		1/4 (or X4)
Taxonomic group		Oligochaeta
Slide number		1 of 15 (or 1-15)

Using a diamond-tipped pen to put only an identification number on the slide is not recommended, as this can become confusing if a large number of slides are processed.

8. Once the medium has set, use a dissecting microscope to aid in the marking of the specimen position. Use a fine-tipped Sharpie pen to put a dot immediately beneath or beside the oligochaete's head. Do this for every oligochaete regardless of size.

9. Put the slides on a mounting tray and place them under a hood. Allow the slides to dry for 2-3 days.

   The slides should be checked every day for several days (especially for large worms), as the medium often is absorbed as it displaces the tissue, and creates large air pockets. More medium must be added as this occurs.

10. Record mounting information on the original bench sheet, indicating how many were mounted, how many were fragments, and any other pertinent information.

11. For more permanent slides (that will last for many years), the outer edge of the cover slip can be ringed with Permount, nail polish or ringing solution when the original medium has dried completely.

12. Select a sample for identification from those mounted, dried and cleared.

13. Label a laboratory bench sheet so that it corresponds with the numbers on the slide. An example is attached. By using a system like this, you will be able to easily find any oligochaete and check the identification.

14. Identification of the various taxa may be accomplished by using a variety of available keys and a compound microscope. Because all of the organisms may not be mature or entire worms, accurate identifications may sometimes be difficult. In such cases, in-house experience is important. If there are any questionable identifications they are checked by other qualified individuals to ensure accurate identification.

15. Once a specimen has been identified it is recorded on the laboratory bench sheet for that group.

    For example:

    1) *Nais variabilis* *Dero digitata*

Specaria josinae	*Uncinais uncinata*
Limnodrilus cervix	*Nais elinguis*
Tubifex tubifex	Immature tubificid: bifids
Dero digitata	*Dero* sp. (no posterior end)

Identifications of the five oligochaetes that are under each cover slip are written down as they appear from left to right under the microscope. During routine identifications with lots of individuals, abbreviations can be used to identify oligochaetes on the bench sheets, e.g., *T. tubifex* or *T. tub.* or *T. t.*, as long as there are no other names with which to confuse it.

16. Notation of each different taxon should be made, as a species list is developed from these notations. Slides containing specimens that are large or in good condition should be marked for later use in the voucher collection. Notes can be made on the data sheets, as well as on the slide itself.

17. Once all the identifications have been made, the individuals are summed, and these data transferred to the original bench sort sheet. This ensures that all information is on one sheet.

2006 Sampling Stations

Watershed	ID	NAME	LAT	LONG
Queen River	QN-01	Usquepaug River	41.47599166670	-71.60713333330
Queen River	QN-02	Trib to Glen Rock Brook	41.50958611110	-71.60915833330
Queen River	QN-03	Glen Rock Brook	41.52221111110	-71.61241944440
Queen River	QN-04	Sherman Brook	41.51821388890	-71.60405277780
Queen River	QN-05	Locke Brook	41.55467123050	-71.60219968100
Queen River	QN-06	Locke Brook	41.53761944440	-71.58581111110
Queen River	QN-07	Queen River	41.54905277780	-71.56076666670
Queen River	QN-08	Sodom Brook	41.56499722220	-71.56408333330
Queen River	QN-09	Queen River	41.56256944440	-71.54817222220
Queen River	QN-10	Queens Fort Brook	41.54903333330	-71.54474444440
Queen River	QN-11	Queen River	41.57871111110	-71.54312500000
Queen River	QN-12	Queen River	41.59373333330	-71.54340555560
Queen River	QN-13	Dutemple Brook	41.57234722220	-71.57206111110
Queen River	QN-14	Fisherville Brook	41.58905555560	-71.57596666670
Queen River	QN-15	Fisherville Brook	41.61047222220	-71.58977222220
Queen River	QN-AA	Unnamed brook	41.53897201990	-71.57954741940
Queen River	QN-AB	Queen River	41.53899817630	-71.56861839160
Big River	BGR-01	Bear Brook	41.65988055560	-71.62856944440
Big River	BGR-03	Nooseneck River	41.63666777780	-71.65885777780
Big River	BGR-04	Racoon Brook	41.61977527890	-71.64804115510
Big River	BGR-05	Congdon River	41.61177777780	-71.62291666670
Big River	BGR-06	Trib to Congdon River	41.61288888890	-71.61816388890
Big River	BGR-07	Trib to Sweet Pond	41.62525833330	-71.59785277780
Big River	BGR-08	Capwell Mill Pond Out	41.64403888890	-71.60763888890
Big River	BGR-09	Nooseneck River	41.62676666670	-71.63289444440
Big River	*BGR-10*	*Big River*	*41.64495172000*	*-71.61281251950*
Big River	BGR-AA	Big River	41.63177200000	-71.61766100000
Lower Pawcatuck River	LPK-01	Spring Brook	41.40251944440	-71.83066944440
Lower Pawcatuck River	LPK-02	Mastuxet Brook	41.35839444440	-71.81504166670
Lower Pawcatuck River	LPK-03	Mastuxet Brook	41.34676944440	-71.81542500000
South Branch Pawtuxet River	SBP-01	Mishnock River (lake outlet)	41.65586111110	-71.59116944440
South Branch Pawtuxet River	SBP-02	Mishnock River	41.68043055560	-71.57836111110
South Branch Pawtuxet River	SBP-03	Unnamed Trib to Tiogue Lake	41.67434444440	-71.56175000000
South Branch Pawtuxet River	SBP-04	South Branch Pawtuxet	41.68971666670	-71.56536111110
South Branch Pawtuxet River	SPB-05	Hawkinson Brook	41.67646388890	-71.52687500000
South Branch Pawtuxet River	*SBP-06*	*South Branch Pawtuxet*	*41.69611111110*	*-71.52222222220*

Watershed	ID	NAME	LAT	LONG
South Branch Pawtuxet River	*SBP-07*	*South Branch Pawtuxet*	*41.71442222220*	*-71.51463611110*
South Branch Pawtuxet River	SBP-AA	Dam Ponds Outlet	41.69596970380	-71.54790825010
Flat River	FL-01	Boyd Brook	41.71495833330	-71.63007500000
Flat River	FL-02	Boyd Brook	41.72792777780	-71.62871111110
Flat River	FL-03	Flat River	41.71460833330	-71.65176944440
Flat River	*FL-04*	*Whaley Brook*	*41.71664384920*	*-71.66305533820*
Flat River	FL-05	Whaley Brook	41.71930555560	-71.66518055560
Flat River	FL-06	Negro Sawmill Brook (NSB or Flat River)	41.72095833330	-71.68392777780
Flat River	FL-07	Carr Pond Trib	41.66568142150	-71.69092159280
Flat River	FL-08	Quidnick Brook	41.69067777780	-71.66835277780
Flat River	FL-09	Trib to Flat River Reservoir	41.68848055560	-71.62158055560
Wood River	**WD-REF**	**Wood River**	**41.54444444444**	**-71.70583333333**
	ESS-09	Tucker Brook	41.98763611111	-71.63031666667
	ESS-15	Bailey Brook	41.52335833333	-71.29608611111
	ESS-20	Lawton Brook	41.56731111111	-71.28168888889
Maidford River	ESS-21	Maidford River	41.50196944444	-71.26830555556
	ESS-43	Bucks Horn Brook	41.69508055556	-71.75699166667
Adamsville Brook	**ESS-45**	**Adamsville Brook**	**41.57706666667**	**-71.13821111111**

†Italicized sites will be sampled only for water quality.
‡Sites in bold are references sites.