Appendix B

Standard Operating Procedures

Contents

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SOP GEN-01
FIELD DOCUMENTATION

The integrity of each sample from the time of collection to the point of data reporting must be maintained throughout the study. Proper record keeping will be implemented in the field to allow samples to be traced from collection to final disposition. All information relevant to field operations must be properly documented to ensure that activities are accounted for and can be reconstructed from written records. Several types of field documents and sample tracking information will be used for this purpose and should be consistently used by field personnel.

FIELD LOGBOOKS

During field sampling events, field logbooks are used to record all daily field activities. The purpose of the field logbook is to document events that occur and record data measured in the field to the extent that someone not present at the site can reconstruct the activity without relying on the memory of the field crew.

A bound, waterproof field logbook with consecutively numbered pages will be completed using indelible ink for each sampling event. All daily field activities will be documented in indelible ink in this logbook and no erasures will be made. All corrections should consist of a single line-out deletion, followed by the sampler's initials and the date. The sampler will initial and date each page of the field logbook. The sampler will sign and date the last page at the end of each day, and a line will be drawn through the remainder of the page.

The project name, site name and location (city and state), Exponent contract number, and the dates (i.e., duration) of sampling activity should be written on the cover of the field logbook. If more than one logbook is used during a single sampling event, then the upper right hand corner of the logbook will be annotated (e.g., 1 of 2, 2 of 2) to indicate the number of logbooks used during the field event.

Field logbooks will be stored in a secure manner when not in use in the field. At a minimum, the sampler will record the following information in the field logbook:

- Project name, project location, and project number
- Purpose and description of the field task
- Project start date and end date
- Date and time of entry (24-hour clock)

- Time and duration of daily sampling activities
- Weather conditions at the beginning of the field work and any changes that occur throughout the day, including the approximate time of the change (e.g., wind speed and direction, wave action, current, tide, vessel traffic, temperature of both the air and water, thickness of ice if present)
- Name of person making entries and other field personnel and their duties, including the times that they are present
- Level of personal protection being used
- Onsite visitors, if any, including the times that they are present
- The name, agency, and telephone number of any field contacts
- Notation of the system used to determine the station location information
- The sample identifier and analysis code for each sample to be submitted for laboratory analysis
- All field measurements made (or reference to specific field data sheets used for this purpose), including the time that the measurement was collected and the date of calibration, if appropriate
- The sampling location name, date, gear, water depth (if applicable), and sampling location coordinates
- The type of vessel used (e.g., size, power, type of engine) (for aquatic sampling only)
- The location and description of the work area, including sketches and map references, if appropriate
- Specific information on each type of sampling activity
- The sample type (i.e., groundwater, soil, surface sediment), sample number, and sample tag number
- Preservatives used, if any
- Sample storage methods
- Cross-references of numbers for duplicate samples
- A description of the sample (source and appearance, such as soil or sediment type, color, texture, consistency, presence of biota or debris, presence of oily sheen, changes in sample characteristics with depth, presence/location/ thickness of the redox potential discontinuity (RPD) layer, and odor) and penetration depth

- Estimate of length and appearance of recovered cores
- Photographs (uniquely identified) taken at the sampling location, if any
- Variations, if any, from specified sampling protocols and reasons for deviation
- Details pertaining to unusual events which might have occurred during sample collection (e.g., possible sources of sample contamination, equipment failure, unusual appearance of sample integrity, control of vertical descent of the sampling equipment)
- References to other logbooks used to record information (e.g., field data sheets, health and safety log).
- The signature of the person making the entry.

Upon completion of the field sampling event, the field team leader will be responsible for submitting all field logbooks to be copied. A discussion of copy distribution is provided below.

FIELD DATA FORMS

Occasionally, additional field data forms are generated during a field sampling event (e.g., Station/Sample Log, Groundwater Monitoring Form, Sediment Core Profile Form) to record the relevant sample information collected during a sampling event. For instructions regarding the proper identification of field data forms, sampling personnel should consult the project-specific field sampling plan.

Upon completion of the field sampling event, the field team leader will be responsible for submitting all field data forms to be copied. A discussion of copy distribution is provided below.

PHOTOGRAPHS

In certain instances, photographs (print or digital) of sampling stations will be taken using a camera-lens system with a perspective similar to the naked eye. Photographs may also be taken of sample characteristics and routine sampling activities. Photographs should include a measured scale in the picture, when practical. Telephoto or wide-angle shots will not be used because they cannot be used in enforcement proceedings. The following items should be recorded in the field logbook for each photograph taken:

1. The photographer's name, the date, the time of the photograph, and the general direction faced
2. A brief description of the subject and the field work portrayed in the picture

3. The sequential number of the photograph (filename for digital) and the roll number (disk number for digital, if applicable) on which it is contained.

Upon completion of the field sampling event, the field team leader will be responsible for submitting all photographic materials to be developed (slides, prints) or to be copied (disks), as appropriate. The slides, prints, or disks (as appropriate) and associated negatives will be placed in the project files (at the Exponent Project Manager's location [project-specific]). Photo logs and any supporting documentation from the field logbooks will be photocopied and placed in the project files with the slides, prints, or disks.

SAMPLE LABELS

Exponent sample labels are designed to uniquely identify each sample container that is collected during a sampling event. Field crews will be provided with preprinted sample labels, which must be affixed to each sample container used. The labels should be filled out at the time the samples are collected and should consist of the following information:

1. Sample number
2. Site name or project number
3. Date and time sample is collected
4. Initials of the samplers
5. Preservatives used, if any
6. A unique number (commonly referred to as the "Tag Number") that is preprinted on the label consisting of six digits; used to identify individual containers.

SAMPLE TAGS

Exponent sample tags are designed to be affixed to each container that is used for a sample. Sample tags are only required for environmental samples collected in U.S. Environmental Protection Agency (EPA) Region 5. Field crews will be provided with preprinted sample tags. Sample tags must be attached to each individual sample container with a rubber band or wire through a reinforced hole in the tag. All sample tag entries will be made with indelible ink. The tags should be filled out at the time the samples are collected and should consist of the following information:

1. Sample number
2. Site name or project number

3. Date and time sample is collected
4. Initials of the samplers
5. Preservatives used, if any
6. Type of analysis.

A space for the laboratory sample number (provided by the laboratory at log-in) will also be provided on the sample tag.

INTERNAL SAMPLE LABELS

For benthic infaunal samples, the sediment is washed away from the sample and the remaining benthic infauna are collected into a sample container. A sample label as discussed above is affixed to the outside of the sample container. In addition, an internal sample label is placed inside the sample container. This internal sample label is made of water-proof paper and all internal sample label entries will be made with pencil. The internal sample labels should be filled out at the time the samples are collected and should consist of the following information:

1. Sample number
2. Site name or project number
3. Date and time sample is collected
4. Initials of the samplers
5. Preservative used (i.e., formalin).

CHAIN-OF-CUSTODY/SAMPLE ANALYSIS REQUEST FORMS

Exponent uses a combined chain-of-custody/sample analysis request (COC/SAR) form. The sample number and the unique number at the bottom of each sample label will be recorded on the COC/SAR form. The COC/SAR form will also identify the sample collection date and time, the type of sample, the project, and the field team leader. In addition, the COC/SAR form provides information on the preservative or other sample pretreatment applied in the field and the analyses to be conducted by referencing a list of specific analyses or the statement of work for the laboratory. The COC/SAR form will be sent to the laboratory along with the sample(s).

The COC/SAR form will be completed in triplicate and consists of three pages: a white sheet, which always remains with the samples; a yellow sheet, which remains with the samples when they are shipped to the laboratory; and a pink sheet, which is removed by field staff prior to shipping to the laboratory or prior to placing the samples into the sample archives. The white sheet and the yellow sheet will be placed into a plastic sealable bag and secured to the inside top

of each sample cooler. The pink sheet will be retained by the field staff for filing at the Exponent Project Manager's location (project-specific).

Exponent also uses computer-generated COC/SAR forms. If computer-generated forms are used, then the forms must be printed in triplicate and all three sheets signed so that two sheets can accompany the shipment to the laboratory and one sheet can be retained on file at the Exponent Project Manager's location (project-specific).

At the end of each sampling day and prior to shipping or storage, chain-of-custody entries will be made for all samples. Information on the labels and tags will be checked against filed logbook entries. Upon completion of the field sampling event, the field team leader will be responsible for submitting all COC/SAR forms to be copied. A discussion of copy distribution is provided below.

CUSTODY SEAL

As security against unauthorized handling of the samples during shipping, two custody seals will be affixed to each sample cooler (example provided in Attachment GEN-03-1). The custody seals will be placed across the opening of the cooler (front right and back left) prior to shipping. Be sure the seals are properly affixed to the cooler so they cannot be removed during shipping. Additional tape across the seal may be prudent.

SHIPPING AIRBILLS

When samples are shipped from the field to the testing laboratory via a commercial carrier (e.g., Federal Express, UPS), an airbill or receipt is provided by the shipper. Upon completion of the field sampling event, the field team leader will be responsible for submitting the sender's copy of all shipping airbills to be copied. A discussion of copy distribution is provided below. The airbill number (or tracking number) should be noted on the applicable COC/SAR forms or alternatively the applicable COC/SAR form number should be noted on the airbill to enable the tracking of samples if a cooler becomes lost.

ACKNOWLEDGMENT OF SAMPLE RECEIPT FORMS

In most cases, when samples are sent to a testing laboratory, an Acknowledgment of Sample Receipt form is faxed to the Exponent QA/QC coordinator the day the samples are received by the laboratory. It is the responsibility of the person receiving this form to review the form and make sure that all the samples that were sent to the laboratory were received by the laboratory and that the correct analyses were requested. If an error is found, the laboratory must be called immediately. Decisions made during the telephone conversation should be documented in writing on the Acknowledgment of Sample Receipt Form. In addition, corrections should be made to the COC/SAR form and the corrected version of the COC/SAR form should be faxed to the laboratory.

The Acknowledgment of Sample Receipt form (and any modified COC/SAR forms) will then be submitted to be copied. A discussion of copy distribution is provided below.

ARCHIVE RECORD FORMS

On rare occasions, samples are archived at an Exponent office. If samples are to be archived at Exponent, it is the responsibility of the project manager to complete an Archive Record form. This form is to be accompanied by a copy of the COC/SAR form for the samples, and will be placed in a locked file cabinet.

DISTRIBUTION OF COPIES

Two copies of all field logbooks, additional field data forms, COC/SAR forms, and Acknowledgement of Sample Receipt forms will be made at Exponent. The first copy will be stamped with a "COPY" stamp. This copy will be placed in the project file and will be available for general staff use. The second copy will be stamped with a "FILE" stamp. This copy will be placed in the data management file with the laboratory data packages and will be used by the data management and quality assurance staff only. The original field logbooks and forms will be placed in a locked file cabinet.

One copy of the shipping airbill will be made and placed in the project file. The original airbill will be given to the respective Exponent receptionist for filing and billing purposes.

Setup of Locking File Cabinet

Each project will have its own file folder in a locking file cabinet. The folder label will include the project name and charge number. As many as five kinds of files will be included in this folder for each project:

- Field logbook(s)
- Additional field data forms
- COC/SAR forms
- Acknowledgment of Sample Receipt forms
- Archive Record form (to be completed only if samples are archived at the Bellevue field storage facility or at the Boulder laboratory).

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SOP GEN-02
SAMPLE CUSTODY

A stringent, established program of sample chain-of-custody will be followed during sample storage and shipping activities to account for each sample. The procedure outlined herein will be used with SOP GEN-01, *Field Documentation*, and SOP GEN-03, *Sample Packaging and Shipping*. Chain-of-custody record/sample analysis request (COC/SAR) forms (Attachment GEN-03-1) ensure that samples are traceable from the time of collection through processing and analysis until final disposition. A sample is considered to be in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession
2. The sample is in the person's view after being in possession
3. The sample is in the person's possession and is being transferred to a designated secure area
4. The sample has been locked up to prevent tampering after it was in the person's possession.

At no time is it acceptable for samples to be outside of Exponent personnel's custody unless the samples have been transferred to a secure area (i.e., locked up). If the samples cannot be placed in a secure area, then an Exponent field team member must physically remain with the samples (e.g., at lunch time one team member must remain with the samples).

PROCEDURE

The chain-of-custody record portion of the COC/SAR form is the most critical because it documents sample possession from the time of collection through the final disposition of the sample. The sample analysis request portion of the form provides information to the laboratory regarding what analyses are to be performed on the samples that are shipped.

The COC/SAR form will be completed after each field collection activity and before the samples are shipped to the laboratory. Sampling personnel are responsible for the care and custody of the samples until they are shipped. When transferring possession of the samples, the individuals relinquishing and receiving the samples must sign the COC/SAR form(s), indicating the time and date that the transfer occurs. Copies of the forms will be made and kept by Exponent, and the originals will be included with the samples in the sample cooler. The following guidelines will be followed to ensure consistent shipping procedures and to maintain the integrity of the samples:

1. Each chain-of-custody record/sample analysis request form must be appropriately signed by the sampling personnel. The person who relinquishes custody of the samples must also sign this form.

2. The chain-of-custody record/sample analysis request form should not be signed until the information has been checked for inaccuracies by the field team leader. All changes should be made by drawing a single line through the incorrect entry and initialing and dating it. Revised entries should be made in the space below the entries. Any blank lines remaining on the COC/SAR form after corrections are made should be marked out with single lines. This procedure will preclude any unauthorized additions.

3. At the bottom of each COC/SAR form is a space for the signatures of the persons relinquishing and receiving the samples and the time and date that the transfer occurred. The time that the samples were relinquished should match exactly the time they were received by another party. Under no circumstances should there be any time when custody of the samples is undocumented.

4. If samples are sent by a commercial carrier not affiliated with the laboratory, such as Federal Express or UPS, the name of the carrier should be entered in the "received by" block. Any tracking numbers supplied by the carrier should be also entered in the "received by" block. The time of transfer should be as close to the actual drop-off time as possible. After the COC/SAR forms are signed and copied, they should be sealed inside the transfer container.

5. If errors are found after the shipment has left the custody of Exponent personnel, a corrected version of the forms must be made and sent to all relevant parties. Minor errors can be rectified by making the change on a copy of the original with a brief explanation and signature. Errors in the signature block may require a letter of explanation.

6. Samples that are archived internally at Exponent must be accompanied by a COC/SAR form and an Archive Record form (see SOP GEN-01).

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SOP GEN-03
SAMPLE PACKAGING AND SHIPPING

Specific requirements for sample packaging and shipping must be followed to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein.

EQUIPMENT REQUIRED

Specific equipment or supplies necessary to properly pack and ship environmental samples include the following:

- Ice in doubled, sealable bags (e.g., Ziplocs®), frozen Blue Ice®, or dry ice
- Sealable airtight bags (assorted sizes)
- Large plastic garbage bags
- Paper towels
- Coolers
- Bubble wrap
- Fiber reinforced packing tape
- Duct tape
- Clear plastic packing tape
- Scissors
- Chain-of-custody seals
- "Fragile," "This End Up," or "Handle With Care" labels
- Mailing labels
- Airbills for overnight shipment
- Chain-of-custody record/sample analysis request forms.

PROCEDURE

The logistics for sample packaging and shipping should be specifically tailored to each study. In some cases, samples may be transferred from the field to a local storage facility where they can be either frozen or refrigerated. Depending on the logistics of the operation, field personnel may transport samples to the laboratory themselves or utilize an overnight courier service. If a courier service is used, then Exponent field personnel need to be aware of any potentially limiting factors to timely shipping (e.g., availability of overnight service and weekend deliveries to specific areas of the country, shipping regulations "restricted articles" [e.g., dry ice, formalin]; see SOP HS-01) prior to shipping the samples. Federal Express service locations can be determined by calling 1-800-463-3339. United Parcel Service locations can be determined by calling 1-800-742-5877.

The following steps should be followed to ensure the proper transfer of samples from the field to the laboratories:

<u>At the sample collection site:</u>

1. Appropriately document all samples using a logbook (see SOP GEN-01), the required sample container identification (i.e., sample labels and sample tags), and a chain-of-custody record/sample analysis request (COC/SAR) form (example provided in Attachment GEN-03-1). Fill out the COC/SAR form as described in SOP GEN-02.

2. Make sure all applicable laboratory quality control sample designations have been made on the COC/SAR form. Samples that will be archived for future possible analysis should be clearly identified on the COC/SAR form by noting the following: "Do Not Analyze: Hold and archive for possible future analysis," as some laboratories interpret "archive" to mean continue holding the residual sample after analysis.

3. Clean the gross contamination from the outside of all dirty sample containers to remove any residual material that may lead to cross-contamination.

4. Store each sample container in an individual sealable plastic bag that allows the sample label (example provided in Attachment GEN-03-1) to be read. Volatile organic analyte (VOA) vials for a single sample must be encased in bubble wrap before being sealed in bags.

5. If the samples have a required storage temperature, place a sufficient amount of ice in the sample cooler to maintain the temperature inside the cooler (e.g., 4°C) throughout the sampling day.

<u>At the sample processing area (immediately after sample collection):</u>

1. If the samples have a required storage temperature, then the samples should be cooled to and maintained at that temperature prior to shipping. For example, a sufficient amount of ice must be present in each sample cooler to maintain the

temperature inside the cooler at 4°C until processing begins to ship the samples to the testing laboratory.

2. Be aware of holding time requirements for project-specific analytes and arrange the sample shipping schedule accordingly.

3. Samples will be placed in secure storage (i.e., locked room or vehicle) or remain in the possession of Exponent sampling personnel until they are shipped to maintain sample integrity and chain-of-custody requirements.

4. Samples should be stored in the dark (e.g., coolers kept shut).

At the sample processing area (just prior to shipping):

1. Check sample containers against the COC/SAR form to ensure all samples intended for shipment are accounted for.

2. Choose the appropriate size cooler (or coolers) and make sure that the outside and inside of the cooler is clean of gross contamination. If the cooler has a drain on the outside at the bottom of the cooler, the drain should be capped and thoroughly taped shut with duct tape to prevent leakage.

3. The cooler should be lined with bubble wrap and a large plastic bag should be opened and placed inside the cooler.

4. Individually wrap each glass container (which at the sample collection site had already been placed in an individual sealable plastic bag) in bubble wrap. Place the wrapped samples into the large plastic bag in the cooler; leaving sufficient room for ice to keep the samples cold (i.e., 4°C).

5. If the samples have a required storage temperature, add enough ice or Blue Ice® to keep the samples refrigerated during overnight shipping (i.e., 4°C). Always over-estimate the amount of ice that you think will be required. Ice should be enclosed in a sealable plastic bag and then placed in a second sealable plastic bag to prevent leakage. Avoid separating the samples from the ice with excess bubble wrap because it will insulate the containers from the ice. After all samples and ice have been added to the cooler, use bubble wrap to fill any empty space to keep the samples from shifting during transport.

6. If possible, consolidate all VOA samples in a single cooler and ship them with (a) trip blank(s) if the quality assurance project plan calls for one.

7. If temperature blanks have been provided by the testing laboratory, include one temperature blank in each sample cooler.

8. Sign, date, and include any tracking numbers provided by the shipper on the COC/SAR form. Remove the back copy of the original COC/SAR form and retain this copy for the project records.

9. Place the rest of the signed COC/SAR form in a sealable bag and tape the bag containing the form to the inside of the cooler lid. Each cooler should contain an individual COC/SAR form for the samples contained in each respective cooler. If time constraints impact sample shipping and it becomes necessary to combine all of the samples onto a single set of COC/SAR forms and the shipment contains multiple coolers, indicate on the outside of the respective cooler "Chain-of-Custody Inside."

10. After the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it shut with fiber-reinforced packing tape. The cooler should be taped shut around the opening between the lid and the bottom of the cooler and around the circumference of the cooler at both hinges.

11. As security against unauthorized handling of the samples, apply two chain-of-custody seals across the opening of the cooler lid (example provided in Attachment GEN-03-1). One seal should be placed on the front of the cooler and one seal should be placed on the side of the cooler opposite the first seal. Be sure the seals are properly affixed to the cooler so they are not removed during shipment. Additional tape across the seal may be necessary if the outside of the cooler is wet.

12. Use a mailing label and label the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," and "Handle With Care." If the shipment contains multiple coolers, indicate on the mailing label the number of coolers that the testing laboratory should expect to receive (e.g., 1 of 2; 2 of 2). Place clear tape over the mailing label to firmly affix it to the outside of the cooler and to protect it from the weather. This is a secondary label in case the airbill is lost during shipment.

13. If an overnight courier is used, fill out the airbill as required and fasten it to either the top of the cooler or to handle tags provided by the shipper. In addition to the adhesive backing on many airbills, the airbill and/or mailing label should also be taped to the lid, because tracking problems can occur if a sticker is removed during shipment.

14. If samples need to be frozen (–20°C) during shipping, then dry ice will need to be placed in the sample cooler. Be aware of any additional shipping, handling, and special labeling requirements that may be required by the shipper for these samples. Exponent has arranged with CHEM-TEL (813-248-0573) to provide advisory services (i.e., information on how to label, ship, and package chemicals) for "restricted articles" (e.g., dry ice).

15. Benthic infauna samples will need to be preserved with formalin in the field prior to shipping. Be aware of any additional shipping, handling, and special labeling requirements that may be required by the shipper for these samples. Exponent has arranged with CHEM-TEL (813-248-0573) to provide advisory services (i.e.,

information on how to label, ship, and package chemicals) for "restricted articles" (e.g., formalin).

16. If samples are shipped that contain "restricted articles" (e.g., dry ice, formalin), then Exponent personnel must provide a 24-hour emergency number to the shipper. Exponent has arranged with CHEM-TEL to provide a 24-hour emergency contact number for all chemical shipments. Before shipping chemicals (and listing the CHEM-TEL emergency number), Exponent personnel must FAX the shipping document (manifest, declaration of dangerous goods, etc.) to CHEM-TEL informing them of the shipment. The fax number is 813-248-0581.

    For any shipment (air, rail, sea, or ground) within the United States, Canada, Puerto Rico, and the U.S. Virgin Islands, the telephone number to include on the shipping form is 1-800-255-3924. Any shipment outside the North American continent should reference "813-248-0573 (use the AT&T collect call operator)" on the shipping document. On the shipping documents, remember to indicate that the phone number specified is an emergency response contact number.

17. Notify the laboratory contact and the Exponent project QA/QC coordinator that samples will be shipped and the estimated arrival date and time. All environmental samples that are shipped at 4°C or –20°C will be shipped overnight for next morning delivery. If possible, fax copies of all chain-of-custody record/sample analysis request forms to the Exponent QA/QC coordinator. **Note:** Prior to faxing, it may be necessary to Xerox the COC/SAR form on a slightly darker setting so that the form is readable after it has been faxed. Never leave the original COC/SAR form in the custody of non-Exponent staff.

ATTACHMENT GEN-03-1

Example Chain-of-Custody Record/Sample Analysis Request Form, and Label and Custody Seal

CHAIN OF CUSTODY RECORD/SAMPLE ANALYSIS REQUEST FORM

Page ____ of ____

Project:
(Name and Number)

Exponent

Exponent Contact: _____ Office: ____

Ship to: _____

_____

_____

Lab Contact/Phone: _____

Samplers:

Environmental Group

Bellevue, WA (425) 643-9803
Boulder, CO (303) 444-7270
Lake Oswego, OR (503) 636-4338
Los Angeles, CA (310) 823-2035
Natick, MA (508) 652-8500

Sample No.	Tag No.	Date	Time	Matrix	Analyses Requested						Extra Container	Archive	Remarks

Matrix Code: GW - Groundwater SL - Soil SD - Sediment SW - Surface water

OTHER - Please identify codes _____

Priority:
❑ Normal ❑ Rush Rush time period _____

Shipped via: ❑ FedEx/UPS ❑ Courier Other _____

Condition of Samples Upon Receipt: _____

Custody Seal Intact: ❑ Yes ❑ No ❑ None

Relinquished by: _____ Date/Time: _____ Received by: _____ Date/Time: _____
(Signature) *(Signature)*

Relinquished by: _____ Date/Time: _____ Received by: _____ Date/Time: _____
(Signature) *(Signature)*

Distribution: White and Yellow Copies - Accompany Shipment; Pink Copy - Project File

Chain-of-custody/sample analysis request form.

Exponent®

OFFICIAL SAMPLE SEAL

SAMPLE NO.	DATE
SIGNATURE	
PRINT NAME AND TITLE	

Exponent®

SAMPLE NO.

SITE NAME

DATE TIME

SAMPLER PRESERVATIVE

TAG NO. 25101

Example label and custody seal.

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SOP GEN-04
STATION POSITIONING USING THE TRIMBLE PATHFINDER™ PRO XRS

This SOP describes the use of Trimble's global positioning system (GPS) Pathfinder™ Pro XRS equipment used for positioning sampling vessels and locating sampling stations. The Pro XRS offers the sub-meter accuracy often required for documenting sampling station locations and for relocating previously sampled stations.

PRO XRS DESCRIPTION

The Pro XRS combines a high-performance GPS receiver and antenna, beacon differential receiver, and satellite differential receiver in one compact unit. With the Pro XRS, operators can gather GPS data of sub-meter accuracy using their choice of differential correction sources (i.e., free beacon differential signals [e.g., Coast Guard beacons] or real-time satellite differential signals from OmniSTAR) without establishing a reference station. Correction of data is required to gain sub-meter accuracy. Free beacon or base station signals allow differential corrections to be performed after data collection by using a nearby beacon or base station logging data files. (Note: Station must be within 300 miles of the data collection location.) For satellite-based signals, a built-in virtual base station allows for real-time data correction, eliminating the need for post-processing data in some cases. However, post-processing data corrections can obtain accuracies in the range of 30–50 cm. These accuracies are for the horizontal (northing and easting) component only. The vertical component (elevation) accuracy ranges from sub meter to three times larger than the horizontal accuracy.

The Pro XRS also includes Trimble's advanced Everest™ technology, which allows users to collect accurate position data near walls, water, vehicles, or other surfaces that reflect satellite signals. Reflected signals, also called multipath signals, make it difficult for GPS receivers to accurately determine position. Everest uses a patented technique to remove multipath signals before measurements are used to calculate position.

EQUIPMENT REQUIRED

GPS Pathfinder™ Pro XRS consists of the following:

- GPS receiver in backpack casing (with system batteries and cables)
- Hand-held data logger (TSC1) and cable

- Pro XRS antenna, range poles, and cable
- Compass and tape measure
- Spare 12-volt camcorder and 9-volt batteries (2 each) (use only Kodak, Duracell, or Energizer 9-volt batteries)
- Battery charger and power cord.

PRO XRS SETUP

Follow these procedures for the proper setup of the Pro XRS:

1. Ensure connections between batteries, receiver and data logger are correct and secure. The coaxial antenna cable connects from the GPS receiver port "ANT" to the base of the antenna. The TSC1 cable connects from the bottom or top of the TSC1 to the receiver port "B." The dual Y-clip cables should be connected from the batteries to the TSC1 cable via a "pig-tail"-type connector.
2. Screw the three long antenna poles together (the shorter pole may be added if necessary for taller users). Screw on the antenna and connect its cable.
3. Put backpack and shoulder strap on. The pouch for the data logger should be in place around the waist strap.
4. Place antenna in the side pouch of the back-pack. Wind cord around pole, and use Velcro on the shoulder strap to secure the antenna.

BASIC OPERATION OF THE PRO XRS

Recording a Feature

Before beginning field use, ensure that all GPS configurations and settings are set correctly for the particular use of the Pro XRS and that an appropriate data dictionary is loaded onto the TSC1 (See Attachments GEN-04-1 and GEN-04-2 for typical settings). These steps outline the basic use of the GPS to document a sample position or any other defined "feature." Note that the TSC1 has both hard-keys and soft-keys that allow for its operation. The hard-keys are all the keys (e.g., letters and numbers) on its surface. The soft-keys are the F1 through F5 hard-keys. The function of these changes depending upon the context. These keys will be referred to with arrows around them (<soft-key>).

1. Turn data logger on outside in an open area. Wait for antenna to receive satellite signals. The display will read "Recording Almanac," "Too few SVs," and "PDOP too high." Continue to wait until enough satellites (4) are acquired, and the PDOP is below 6.0.

2. Ensure that the OmniSTAR satellite in use is the correct one for your geographical location. There are three satellites that cover the United States—each covering approximately one-third of the width of the continental United States, with overlapping coverage on the periphery. This setting can be checked/changed by accessing the "Receiver Status" menu. (Press MENU, press <DGPS>, press <SETUP>, press <SETUP>.) The satellite setting in this menu should indicate the appropriate region: Eastern USA, Central USA, or Western USA.

3. Select DATA COLLECTION, and create a new rover file or open an existing file. This file should be named according to the format: mmddxxxn; where "mm" is the month; "dd" is the date; "xxx" is the user's initials; and "n" is a number to indicate different files on the same date, if necessary (e.g., 0219cnc1). This naming convention allows future users and GIS staff to track the individual responsible for the file. Note: If opening an existing file press <NEW> to access the "Antenna options" menu and "Start Feature" menu.

4. Enter the height of the antenna from the ground to the "Measurement Method" reference point shown in the "Antenna Options" menu and then press ENTER to bring up the "Start Feature" menu.

5. Pick the appropriate data dictionary to use with the rover file. Only one dictionary can be used with a rover file. The data dictionary entitled "General sampling," contains features with attributes common to many Exponent projects. It is very important to use a data dictionary and be familiar with its attributes before recording information in the field.

6. Move to the location of the first feature for which you want to record the GPS position. Select the appropriate feature and press ENTER to begin logging. Log data points in accordance with the feature type. Point features should have at least 10 points collected at a stationary location. Line features should be collected while moving. If movement is stopped, press the <PAUSE> key. When movement starts again, press the <RESUME> key. Area features should be collected with enough points to define the outline of the area (e.g., a square building would have four single points, collected on each corner, and the <PAUSE> key would be used between each of the points).

7. Depending on the setup of the data dictionary, each feature may have one or more feature attributes. An attribute is used to record additional data associated with the feature. For example, the attributes assigned to a sediment sampling station could be sample number, station ID, sampling gear, sediment color, odor, etc. (The <PAUSE> key should be used while

recording feature attributes to avoid too many data points being collected at one point feature. [Body movements while logging attributes for an extended time can decrease the accuracy of collection.] The <PAUSE> key must be used when recording attributes of a line or area feature because only one data point should be collected in a single location.) Once all attributes are entered and the feature data points are logged, press ENTER to complete and save the feature and move on to a new feature. Pressing ESC instead of ENTER will allow the user to abandon the logged feature without saving.

8. When all features in a given area have been recorded, from the "Start Feature" menu press ESC to exit data capture and then press <YES> to save the file. When the Pro XRS is not in use, it should be turned off. If you need to come back to the same rover file later in the day, the rover file may be reopened at that time. (When starting a new day, a new rover file must be created to allow easier post-processing of position information.)

9. At the end of each day, the rover file should be downloaded to a PC by using Pathfinder Office software.

Feature Collection Options

Offsets—The Pro XRS can collect a point or line feature while standing at a set distance away from the feature. This option may be necessary because of obstructions such as tree cover, buildings, or car traffic. For a point feature, measure the distance between the object you want recorded and the Pro XRS antenna. Use the compass to determine the bearing (e.g., west is 270°). The bearing is the direction the point should be moved for it to be located in the correct place (e.g., if you are due north of the feature, the bearing is south or 180°; i.e., the position you want recorded is south of where you are standing). Estimate the inclination from the feature to the GPS antenna (if altitude determination is critical, a clinometer should be used). The inclination is the degree angle up from the feature to the antenna (e.g., if the feature is 5° below the antenna position, –5° would be entered). During data capture, from within the feature, press the <OFFSET> button, and enter the distance, bearing, and inclination. Press OK to complete the feature.

Note: This procedure describes an offset of a single feature. A constant offset may be applied to all features collected as well.

Nesting—While recording a line feature or an area feature, a point feature may be collected to avoid backtracking. While recording the line or area feature, press <PAUSE> and then <NEST>. The Pro XRS will prompt for collection of a new feature. Move to the feature, and collect data as for any other point feature. When the feature is complete, press OK. The Pro XRS is ready to resume collecting data as part of the line/area feature: press <RESUME>.

(Remember to continue moving before pressing resume to avoid having multiple positions recorded in the same place in the line or area feature.)

Segmenting—While moving along a line feature, changing the attributes of that line may be necessary (e.g., because of a change in surface type from paved to dirt road). This change may be done without having to begin a new feature by pressing <PAUSE> and then . Change the appropriate attributes and then press <RESUME> to continue recording.

Repeat—The function allows the collection of a new feature with the same feature attributes as the previous feature. If features are not exactly the same, it also allows editing of the attributes.

Quickmark—Allows collection of point features while moving (e.g., from a car or a boat) by estimating the exact location. The use of this feature will not result in positionally accurate locations.

REVIEWING/EDITING FEATURES

It is possible to review or edit features collected in the field while still in the data capture mode. For example, it may be necessary to document the GPS location in the field logbook or to edit one of the feature's attributes.

Without exiting data capture, press <REVIEW>. (If data capture is already complete, just press REVIEW and then select the appropriate rover file.) This step will display a list of data points including each feature collected. Scroll to the appropriate feature, and follow the steps below depending on the required action:

- To view the GPS location (e.g., lat/lon), press <POS>
- To edit the attributes, press ENTER. Make any necessary edits to the attributes by scrolling through.
- To change or add an offset, press <POS>, then press <OFFSET>. Make any necessary changes.
- To delete a feature collected in error, press <DEL>.

NAVIGATING TO AN EXISTING LOCATION

Waypoints

To use the Pro XRS to navigate to a previously established position, this position must be loaded into the data logger as a waypoint, be present as a feature position in the data files, or must be generated in the field using the GPS unit. Waypoints may be entered into the TSC1 by:

- Manually entering coordinates
- Choosing previously recorded locations and importing them into the TSC1 by using Pathfinder Office
- Defining a location stored in a rover file saved to the TSC1 as a waypoint (see *Reviewing/Editing Features*, above)
- Creating a way point from the current position being shown by the operating GPS unit in the field.

Navigating

Usually the *Navigation* module (accessed by pressing MENU followed by Navigation) will be used to guide yourself to a target (waypoint or feature). You can also use the *Map* module (accessed by pressing MENU followed by Map) to:

- Orient yourself in the area you are working in
- Get a general indication of the location of a feature or waypoint that you want to find
- Find or select features or waypoints that you want to navigate to
- Plot a course from one place to another.

While in the Map screen, the GPS cursor x shows the current position reported by the receiver and is always shown on the Map screen (note: it may not always be within the visible part of the screen when panning or scrolling). The <OPTIONS> key can be used to hide or display the GPS trail (line of dots showing up to 60 previous positions), the heading showing the direction of travel, and other options on the map display.

A feature can be selected by pressing MENU, Data Collection to reach the "Start Feature" screen, and then REVIEW to access all features contained in the data file. The desired feature can then be highlighted and selected by pressing the <Target> key which adds a crossed flag to the feature. The Map screen can be re-accessed by selecting MENU, then Map, which will now show the highlighted feature with a crossed flag symbol on the Map screen. The user can then

start moving toward the feature and the current position (shown by the x) will move closer to the target position as the user approaches.

There are two graphical modes of navigation with the Pro XRS in the TSC1 *Navigation* module. On both modes text information appears on the right of the screen in the *Info* panels, which can be configured by the user. The graphic modes available are the *Directional Dial* screen or the *Road* screen, which can be toggled between using the <Mode> key.

To navigate you need to select a target and then a start position. Each of these positions can be features from an open data file or a waypoint. A list of available features or waypoints can be accessed by pressing <TARGET> or <START>. Once the item has been chosen as a target it will show the crossed flags symbol in the list. Once a target has been selected, the Distance to Go appears at the bottom of the Navigation screen, which indicates the distance from the current GPS position to the target. Select a start position (not required but useful for calculating cross-track error and other navigation information) by pressing <START>. A waypoint of the current GPS position can be created for use as the Start point by selecting <CREATE>. Once the Start position is selected, a flag symbol will appear next to the item in the list.

In the *Directional Dial* mode an arrow will appear that will always point at the target. This is the bearing to go (Note: you need to be moving for this to be accurate as it will lock if you are moving too slowly or are stopped). The triangle at the top represent the direction that you are going or heading. This triangle never moves, but by changing directions you can line up the arrow with the triangle. When the two are aligned you are heading in the direction of the target. When you are close to the target a bull's-eye (two concentric circles) will appear at the edge of the screen. This is warning you that the unit will be switching to the close up screen. A proximity alarm will sound and the directional arrow will be replaced by the bull's-eye on the close up screen. Your current position will be shown by an x and the target by the bull's-eye. Move so that the x is in the same location as the bull's-eye.

In the *Road* mode you navigate by walking down a road. Your position is shown by a stick figure and is always positioned in the center of the screen. The target (crossed flags) shows the point that you are navigating to. Your heading is shown by the top center of the screen and the bearing to go is shown by the direction of the road, which will rotate as you change your heading. Change your heading until the road is pointing at the top of the screen (Target is also at the top of the screen) and the edges are parallel to the sides of the screen. As you move toward the target the screen zooms in, so the road appears to get wider.

DOWNLOADING ROVER FILES

Upon returning to the office, all rover files should be downloaded from the TSC1 to a PC for post-processing. After downloading, all rover files and waypoints should be removed from the TSC1 to conserve memory. Rover files may be deleted from the File Manager menu.

1. Select MENU, File Manager, then delete file(s).
2. Select the rover file to be deleted, and press <ENTER>.
3. Confirm the deletion of this file by pressing <YES>.

Data dictionaries can be deleted in the same manner by selecting Data dictionaries from the File Manager menu. Waypoints may be deleted by selecting Utilities from the Main menu and then by selecting Waypoints followed by <DEL>.

ATTACHMENT GEN-04-1

Pro XRS Settings

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ATTACHMENT GEN-04-1
PRO XRS SETTINGS

The following are lists of menus that can be accessed through the TSC1 keypad. Please ensure that settings are correct before proceeding. Please do not make changes to the settings unless necessary. Each menu will list all available subheadings, the correct setting, and the available <soft-keys> to access additional menus. Comments are included only where necessary.

GPS ROVER OPTIONS

Access this menu by selecting Configuration from the main menu and then select GPS Rover Options.

Logging Options

	Setting	**Comment**
Logging intervals		
Point feature	1s	
Line/area feature	2s–5s	depending upon speed of movement
Not in feature	None	
Velocity	None	
Confirm end feature	No	
Minimum pos	10	
Carrier Mode	Off	
Carrier phase min time	10 min	
Dynamics code	Land	may be changed to sea or air, as appropriate
Audible click	Yes	
Log DOP data	Yes	
Log PPRT data	Yes	
Log QA/QC data	Yes	
Allow GPS update	Warn First	
Warning Distance	Any	
Position Mode	Manual 3D	
Elevation Mask	15°	Should not go below 13° (accuracy decreases)
SNR Mask	6.0	Can raise to 7 if multi-path filtering is poor
PDOP Mask	6.0	Can be raised up to 8 – reduces accuracy
PDOP Switch	6.0	

REAL-TIME INPUT OPTIONS

This menu can be accessed from the GPS Rover options menu by selecting real-time input.

	Setting	**Comment**
Preferred Correction Source		
Choice 1	Integrated Satellite	Can be changed to beacon if needed
<SETUP>		
Provider	Omnistar	
Satellite	Eastern USA	change to US logging area: Eastern, Central, Western
Frequency	(automatically updated by selection in satellite field)	
Data rate	(automatically updated by selection in satellite field)	
Choice 2	Use uncorrected GPS	
Correction age limit	20s	

ANTENNA OPTIONS

This menu can be accessed from the GPS Rover options menu by selecting Antenna Options.

	Setting	**Comment**
Height	6 ft	Enter correct user antenna height using measurement method indicated below
Measure	Uncorrected	
Type	Integrated GPS/Beacon/Satellite	
Confirm	Per file	Can be changed to “Per feature” if antenna height varies and elevation is critical
Part Number	33580-50	Auto selected based on TYPE selected
Measurement Method	Bottom of Antenna Mount	

ATTACHMENT GEN-04-2

Additional Settings for the Pro XRS

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ATTACHMENT GEN-04-2
ADDITIONAL SETTINGS FOR THE PRO XRS

Additional Pro XRS settings can be found in the configuration menu. Items of particular importance are indicated in italics.

CONFIGURATION

This menu can be accessed by selecting Configuration from the main menu.

	Description
GPS base station options	For using a land base station or beacon for real time corrections
NMEA/TSIP output	Consult manual
Coordinate system	Changes coordinate system among latitude/longitude, UTM, and other coordinate systems. System can be converted, if necessary, after data capture by using Pathfinder Office software.
Map Display options	Change layers, scale, background files and items shown on the TSC1 screen during data collection
Navigation options	Changes Navigation parameters
Units and display	Changes various units, for example: length (e.g., feet, meters), altitude reference (e.g., MSL), ***North reference*** (i.e., true or magnetic). Units can be converted, if necessary, after data capture by using Pathfinder Office software.
Time and date	Changes to ***local time***, 24 hour clock, date format, etc.
Quickmarks	Set-up parameters for use with quickmarks.
Constant offset	Set-up parameters for use with a constant offset.
External sensors	Connections with external sensors.
Hardware (TSC1)	TDC1 settings such as beep volume, contrast, ***internal and external battery status***, software version, free space.

CONTRAST AND BACKLIGHTING

The TDC1 display can be viewed in various light settings. Pressing FUNC, then L turns on the display backlight for viewing in dim lighting. In addition, the contrast can be adjusted by pressing FUNC, then E or F.

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SOP BI-01
DECONTAMINATION OF TISSUE SAMPLING EQUIPMENT

Whenever possible, it is best to have the analytical laboratory process the tissue sample under clean laboratory conditions to limit possible contamination from field processing. If, however, the tissue sample must be processed in the field, then the following decontamination procedures should be followed (see project-specific field sampling plan [FSP] to determine if field processing is required).

To prevent potential cross contamination of samples, all reusable field filleting and tissue processing equipment (e.g., knives, tweezers, spoons) will be decontaminated before each use (i.e., before processing begins and between each sample). The cutting board will be decontaminated before processing begins and a piece of clean, unused aluminum foil will be wrapped on top of the cutting board (dull side up) for each sample (i.e., the foil will be replaced after each sample has been processed). At the sample collection site, a decontamination area will be established in a clean location, upwind of the actual sample processing location, if possible. This is where all field filleting and tissue processing equipment will be cleaned. Decontaminated equipment will be stored away from areas that may cause recontamination. Rinsate blanks will be collected according to SOP BI-02, *Preparation of Field Quality Control Samples—Tissue*. When handling decontamination chemicals, field personnel will follow all relevant procedures and will wear protective clothing as stipulated in the site-specific health and safety plan.

This SOP describes procedures for decontaminating field filleting and tissue processing equipment contaminated by either inorganic or organic materials. Sampling equipment used for both can combine these procedures, following the order of a detergent wash, site water rinse, organic solvent rinses, and final distilled/deionized water rinse with an acid rinse of all stainless-steel equipment at the end of each tissue processing field day.

EQUIPMENT REQUIRED

Equipment required for decontamination includes the following:

- Plastic tub (to collect solvent rinsate)
- Plastic bucket(s)
- Tap water or site water
- Carboy, distilled/deionized water (analyte-free; received from testing laboratory or other reliable source)

- Properly labeled spray bottles
- Funnels
- Alconox®, Liquinox® equivalent detergent
- Pesticide-grade ethanol and heptane (consult the project-specific FSP as the solvents may vary by EPA region or state)
- 10 percent (v/v) normal nitric acid (trace metal grade) for inorganic contaminants
- Baking soda
- Hard-bristle scrub brush
- Plastic sheeting, garbage bags, and aluminum foil
- Core liner caps or plastic wrap and rubber bands
- Personal protective equipment as specified in the health and safety plan.

DECONTAMINATION PROCEDURES FOR FULL SUITE ANALYSIS (ORGANIC AND INORGANIC ANALYTES)

The specific procedures for decontaminating field filleting and tissue processing equipment are as follows:

1. Rinse the field filleting and tissue processing equipment thoroughly with tap or site water to remove most of the remaining gross solids. Pieces that do not need to be used again that day may be set aside and thoroughly cleaned in the field laboratory at the end of the day.
2. Pour a small amount (i.e., 0.5 teaspoon) of concentrated industrial detergent into a bucket and fill it with tap or site water. If the detergent is in crystal form, all crystals should be completely dissolved prior to use.
3. Scrub the equipment in the detergent solution using a brush with rigid bristles. Be sure to scrub with a back-and-forth motion.
4. Double rinse the equipment with tap or site water and set right-side-up on a stable surface to drain. Do not allow any surface that will come in contact with the tissue to touch any contaminated surface.
5. Carefully rinse the field filleting and tissue processing equipment with ethanol from a squirt bottle, and let the excess solvent drain into a waste container (which may need to be equipped with a funnel). Ethanol acts primarily as a drying agent, but it also works as a solvent for some organic

contamination. Set the equipment in a clean location and allow it to air dry. Use the ethanol sparingly and allow the ethanol to cascade down the surface of the equipment (i.e., the ethanol will "sheet" over the equipment surface).

6. Carefully rinse the air-dried field filleting and tissue processing equipment with heptane from a squirt bottle, and let the excess solvent drain into the waste container (which may need to be equipped with a funnel). The opening of the squirt bottle may need to be widened to allow enough solvent to run through the core liners without evaporating. Heptane acts as the primary organic solvent, but it is insoluble with water. If water beading occurs, it may mean that the equipment was not thoroughly rinsed with ethanol. When the equipment has been rinsed with heptane, set it in a clean location and allow the heptane to evaporate before using the equipment for tissue processing. Use the heptane sparingly and allow the heptane to cascade down the surface of the equipment (i.e., the heptane will "sheet" over the equipment surface).
7. Rinse the field filleting and tissue processing sampling collection with a final distilled/deionized water rinse.
8. If the decontaminated field filleting and tissue processing equipment is not to be used immediately, wrap them in aluminum foil (dull side facing the cleaned area).
9. If the field filleting and tissue processing equipment are cleaned at the field laboratory and transported to the site, then the decontaminated equipment will be wrapped in aluminum foil (dull side facing the cleaned area) and stored and transported in a clean plastic bag until ready for use, unless the project-specific FSP lists special handling procedures.
10. Rinse all stainless-steel equipment at the end of each sampling day with 10 percent (v/v) normal nitric acid solution.

After decontaminating all of the field filleting and tissue processing equipment, the disposable gloves and used foil will be placed in garbage bags and disposed of in a solid waste landfill. When not in use, keep the waste solvent container closed and store in a secure area. The waste should be transferred to empty solvent bottles and disposed of at a licensed facility per the procedures listed in the project-specific FSP. When not in use, keep the waste acid container closed and store in a secure area. The acid waste should be neutralized with baking soda and disposed of per the procedures listed in the project-specific FSP.

DECONTAMINATION PROCEDURES FOR INORGANIC ANALYTES ONLY

The specific procedures for decontaminating field filleting and tissue processing equipment are as follows:

1. Rinse the field filleting and tissue processing equipment thoroughly with tap or site water to remove most of the remaining (i.e., gross) solids. Pieces that do not need to be used again that day may be set aside and thoroughly cleaned in the field laboratory at the end of the day.
2. Pour a small amount (i.e., 0.5 teaspoon) of concentrated industrial detergent into a bucket and fill it with tap or site water. If the detergent is in crystal form, all crystals should be completely dissolved prior to use.
3. Scrub the equipment in the detergent solution using a brush with rigid bristles. Be sure to scrub with a back-and-forth motion.
4. Double rinse the equipment with tap or site water and set right-side-up on a stable surface to drain. Do not allow any surface that will come in contact with the tissue to touch any contaminated surface.
5. Carefully rinse stainless-steel field filleting and tissue processing equipment with a 10 percent (v/v) normal nitric acid solution from a squirt bottle, and let the excess acid drain into the waste container (which may need to be equipped with a funnel). Use the acid sparingly and allow the acid to cascade down the surface of the equipment (i.e., the acid will "sheet" over the equipment surface).
6. Rinse the field filleting and tissue processing equipment with a final distilled/deionized water rinse.
7. If the decontaminated field filleting and tissue processing equipment is not to be used immediately, wrap them in aluminum foil (dull side facing the cleaned area).
8. If the field filleting and tissue processing equipment are cleaned at the field laboratory and transported to the site, then the decontaminated equipment will be wrapped in aluminum foil (dull side facing the cleaned area) and stored and transported in a clean plastic bag until ready for use, unless the project-specific FSP lists special handling procedures.

After decontaminating all of the field filleting and tissue processing equipment, the disposable gloves and used foil will be placed in garbage bags and disposed of in a solid waste landfill. When not in use, keep the waste acid container closed and store in a secure area. The acid waste should be neutralized with baking soda and disposed of per the procedures listed in the project-specific FSP.

Note: SOPs GEN-02, GEN-03, and BI-03 cited within.

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SOP BI-02
PREPARATION OF FIELD QUALITY CONTROL SAMPLES—TISSUE

This SOP describes the purpose, preparation, and collection frequency of field replicate samples, matrix spike/matrix spike duplicates, equipment rinsate blanks, trip blanks, temperature blanks, and reference materials (i.e., a standard reference material, a certified reference material, or other reference material; for the purposes of this document the acronym SRM will be used for all types of reference materials) for tissue samples. Not all of the field quality control (QC) samples discussed in this SOP may be required for a given project. The specific field quality control samples will be identified in the project-specific field sampling and analysis plan (FSP) and quality assurance project plan (QAPP). For most projects, Exponent's recommended field QC samples are: an equipment rinsate blank, a field replicate, and trip blanks if volatile organic compounds (VOCs) are to be analyzed. Definitions of all potential QC samples are described below.

As part of the quality assurance/quality control (QA/QC) program, all field QC samples will be sent to the laboratories blind. To accomplish this, field QC samples will be prepared and labeled in the same manner as regular samples, with each QC sample being assigned a unique sample number that is consistent with the numbering for regular samples. All of the containers with preservatives that are required to complete the field QC sample for the applicable analyte list shall be labeled with the same sample number. The sample ID for field quality control samples should allow data management and data validation staff to identify them as such and should only be recorded in the field logbook. Under no circumstances should the laboratory be allowed to use reference materials, rinsate blanks, or trip blanks for laboratory QC analysis (i.e., laboratory duplicates, matrix spike, and matrix spike duplicates). To prevent this from happening, regular samples should be selected and marked on the chain-of-custody/sampling analysis request (COC/SAR) form or the laboratory should be instructed to contact the project QA/QC coordinator to select appropriate samples for each sample group.

All field quality control samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping*. Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*.

Field quality control samples will be prepared at least once per sampling event, and certain types will be prepared more often at predetermined frequencies. If the number of samples taken does not equal an integer multiple of the intervals specified in this SOP, the number of field quality control samples is specified by the next higher multiple. For example, if a frequency of 1 quality control sample per 20 is indicated and 28 samples are collected, 2 quality control samples will be prepared. The text below describes the preparation and frequency of field

quality control samples required for tissue sampling activities, and shall be followed, unless different frequency requirements are listed in the FSP and QAPP.

Table BI-02-1 lists the quality control sample types and suggested frequencies for tissue sampling programs. Because tissue quality control sampling may require assessment of site cross-contamination, additional blanks may be required. A detailed explanation of each quality control sample type with the required preparation follows.

TABLE BI-02-1. FIELD QUALITY CONTROL SAMPLE REQUIREMENTS FOR TISSUE SAMPLING

Quality Control sample Name	Abbre-viation	Preparation		Frequency[a]
		Location	Method	
Replicate	REP	Sampling site	Additional natural sample	One replicate per 20 samples.
Matrix spike/matrix spike duplicate	MS/MSD	Sampling site	Additional natural sample for laboratory quality control requirements	One per 20 samples.
Equipment rinsate blank	ER	Sampling site	Deionized water collected after pouring through and over decontaminated equipment	Minimum of one per sampling event per type of sampling equipment used and then 1:20 thereafter.
Trip blank	TB	Laboratory	Deionized water with preservative	One pair per each VOC sample cooler shipment.
Temperature blank	TMB	Laboratory	Deionized water	One per sample cooler.
Standard reference material	SRM	Field laboratory or Sampling site	SRM ampules or other containers for each analyte group	One set per 50 samples or one per episode.

[a] Frequencies provided here are general recommendations; specific frequencies should be provided in the project-specific FSP or QAPP.

FIELD REPLICATE SAMPLES

Field replicate samples are separate tissue samples collected from different organisms (e.g., fish, crayfish) collected at the same approximate location in an identical manner over a minimum period of time to provide a measure of the field and laboratory variance, including variance resulting from sample heterogeneity. Field replicates will be prepared by collecting two completely separate samples from the same station and submitting them for analysis as separate samples. Field replicates will be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. The actual number of field replicate samples collected during a sampling event will be determined on a case-by-case basis by the project

QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of field duplicate collection may vary by EPA region or state).

MATRIX SPIKE/MATRIX SPIKE DUPLICATES

The matrix spike/matrix spike duplicate (MS/MSD) analyses provide information about the effect of the sample matrix on the design and measurement methodology used by the laboratory. To account for the additional volume needed by the laboratory to perform the analyses, extra sample volumes may be required to be collected from designated biota stations. MS/MSDs may be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. The actual number of field duplicate samples collected during a sampling event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP as the requirements may vary by analyte group).

EQUIPMENT RINSATE BLANKS

If filleting occurs in the field, then equipment rinsate blanks will be used to help identify possible contamination from the sampling environment and/or from decontaminated filleting equipment (e.g., knives). Equipment rinsate blanks will be prepared by pouring or pumping laboratory distilled/deionized water through the decontaminated filleting equipment, then transferring the water to the appropriate sample containers and adding any necessary preservatives. Equipment rinsate blanks will be prepared for all inorganic, organic, and conventional analytes at least once per sampling event per the type of sampling equipment used. The actual number of equipment rinsate blanks prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of equipment rinsate blank collection may vary by EPA region or state).

TRIP BLANKS

Trip blanks will be used to help identify whether contaminants may have been introduced during the shipment of the tissue samples from the field to the laboratory for VOC analyses only. Trip blanks are prepared at the testing laboratory by pouring distilled/deionized water into two 40-mL VOC vials and tightly closing the lids. Each vial will be inverted and tapped lightly to ensure no air bubbles exist.

The trip blanks will be transported unopened to and from the field in the cooler with the VOC samples. A trip blank shall be labeled and placed inside the cooler that contains newly collected VOC samples and it shall remain in the cooler at all times. A trip blank must accompany samples at all times in the field. One trip blank (consisting of a pair of VOC vials) will be sent with each cooler of samples shipped to the testing laboratory for VOCs analysis.

TEMPERATURE BLANKS

Temperature blanks will be used by the laboratory to verify the temperature of the samples upon receipt at the testing laboratory. Temperature blanks will be prepared at the testing laboratory by pouring distilled/deionized water into a vial and tightly closing the lid. The blanks will be transported unopened to and from the field in the cooler with the sample containers. A temperature blank shall be included with each sample cooler shipped to the testing laboratory.

REFERENCE MATERIALS

Reference materials (i.e., a standard reference material, a certified reference material, or other reference material; for the purposes of this document the acronym SRM will be used for all types of reference materials) are samples containing known analytes at known concentrations that have been prepared by and obtained from EPA-approved sources. The SRMs have undergone multilaboratory analyses using a standard method which provides certified concentrations. When available for a specific analyte, SRM samples provide a measure of analytical performance and/or analytical method bias (i.e., accuracy) of the laboratory. Several SRMs may be required to cover all analytical parameters. For all analytes where available, one SRM will be analyzed at a frequency of one per 50 samples. The actual number of SRMs analyzed during a project will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of SRM analysis may vary by EPA region or state). Details on preparation of the standard reference materials can be found in SOP BI-03, *Preparation of Reference Materials—Tissue*.

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SOP BI-05
FISH COLLECTION PROCEDURES USING A SEINE NET

This SOP discusses the sampling of fishes by use of a seine net. The procedures for processing the fish captured with a seine are described in SOP BI-08, *Fish Processing Procedures*. The personnel performing the fish collection will wear protective clothing as specified in the site-specific health and safety plan.

SAMPLE COLLECTION USING A SEINE NET

A seine net is used as an active sampling device to capture fish along a segment of shallow shoreline by encircling them. Each encircling effort or sweep of shoreline with the net is referred to as a "haul." The number of hauls and number of fish collected in each haul can be documented to yield quantitative (i.e., catch-per-unit-effort) information as a standard method of reporting fisheries seine data. Sampling by seine net is generally most effective in areas with smooth substrate and few underwater obstructions. A seine net consists of a length of mesh fabric, usually made of nylon or polyester, vertically suspended between a float line on top and a weighted lead line at the bottom. Seine nets can be obtained from commercial net vendors in various dimensions and mesh sizes. Seine nets commonly used for fisheries work have mesh sizes that range from 1/16 in. to 4 in. Specific seine dimensions are selectively used by stream investigators depending on the needs of the fish survey, fish sizes, or life stages of the fish sought.

Each end of the net is fastened to a metal or wooden pole referred to as a braille. Seine nets can be constructed with an extended bag at the center that aids in the entrapment of fish during the seine haul.

Equipment Required

Equipment required for collecting samples with a seine net consists of the following:

- Seine net (see project-specific FSP for correct mesh size and dimension)
- Brailles
- Hip boots or chest waders
- Collection buckets or sample containers

- Boat (for difficult areas to access)
- Tape measure or hip chain.

Sampling Procedures

Collection of fishes by using the seine net will proceed as follows:

1. Mark off the segment of shoreline to be sampled.
2. Hold the inner end of the seine at the beginning of the shoreline sampling segment.
3. Carry the other end of the seine into the water perpendicular to the shore (a second person is needed to complete this task). When sampling areas are difficult or dangerous to wade in, or when a very long seine (e.g., for seining an ocean beach) is deployed, a boat can be used to manipulate the outer end of the seine. When using a boat, one person should hold the seine pole while a second person rows the boat. Alternatively, the shoreward end of the seine can be tethered to a fixed object on the shore while the boat maneuvers the outer end of the seine.
4. Extend the seine away from shore until it is fully extended or until the water becomes too deep to maneuver the outer end of the net. Ideally, the water depth to be sampled is no deeper than the mesh wall on the seine net. If an extra bag is sewn into the seine net, make sure the bag is extended out behind the seine.
5. With the first person pulling the inner seine pole from shore and the second person pulling the outer pole in the water, drag the seine parallel to the shoreline for the length of the sampling segment. Make sure the lead line drags along the substrate so that fish cannot escape under the net.
6. If necessary, a third person can follow behind the seine as it is being pulled to free the net from any snags that are encountered.
7. When the end of the sampling segment is reached, swing the outer end of the seine shoreward and continue moving (sweeping) the seine toward shore until both ends meet at the shoreline.
8. Pull the remainder of the seine toward shore, making sure that the lead line drags along the substrate. It is important to keep the seine net in motion during the entire process so as not to lose fish from the net. The net tends not to entangle fish, therefore, they can easily swim out of the net if forward motion is paused.
9. Check the net for fish after the entire seine is brought onto the shore.

10. Transfer the captured individuals to collection buckets.

11. Process the fish in accordance with study design specifications (see project-specific FSP) and SOP BI-08, *Fish Processing Procedures*.

12. If replicate shoreline segments are to be sampled, repeat Steps 1–10 for each replicate segment.

13. If a quantitative analysis of the fish community is being conducted (i.e., catch-per-unit-effort, total enumeration, or mark-recapture), it is recommended that the upper and lower boundaries of the stream segment be blocked by nets of the same mesh as the seine net. These nets should be strung across the channel, ensuring that the bottom of the net contacts the sediments so fish cannot move out of the stream segment being sampled.

RECORD KEEPING

In addition to the items presented in SOP GEN-01, *Field Documentation*, the following information should always be recorded in the field logbook for <u>each</u> sampling segment:

- Seine mesh size and dimension used
- Length of the segment of shoreline that was sampled
- Water depth along the sampling segment
- Presence of debris (e.g., roots, boulders) that may have impaired seining ability along the sampling segment
- Presence of sheen on surface of the water
- Physical/habitat quality of each sampling segment (use EPA nationally standardized method; U.S. EPA 1999) if required by project-specific FSP
- Number of individual fish collected and their respective species each fish's length and weight, and if there are any physical anomalies (e.g., eroded fins, missing eyes, scoliosis or other body or mouth deformities, or skin lesions). If species identification is not definitive, save one specimen in a sample jar with site water (add preservative if available) for later confirmation by a second fisheries biologist.

SAMPLE CUSTODY AND SAMPLE SHIPPING

Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*. All samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping*.

FIELD QUALITY CONTROL SAMPLES

Details on collection of field quality control samples (e.g., replicate shoreline segments, replicate fish within a shoreline segment) will be specified in the project-specific FSP. Details on specific field quality control samples can be found in SOP BI-02, *Preparation of Field Quality Control Samples—Tissue*. Not all of the field quality control samples discussed in this SOP may be required for a given project. The specific field quality control samples will be identified in the project-specific field sampling plan (FSP) and quality assurance project plan (QAPP).

FIELD MEASUREMENTS

Depending on the specific project objectives, it may be necessary to perform field measurements of the *in situ* environment. Possible field measurements include concentration of dissolved oxygen, salinity, or conductivity in the overlying water. Details on collection of field measurements can be found in SOP SW-13, *Field Measurements for Surface Water.* The specific field measurements, if any, will be identified in the project-specific FSP.

DOCUMENTATION OF STATION LOCATIONS

The location of each seine net placement will either be well documented in the field logbook (including map of each seine net placement) or be determined using a differential global positioning system (DGPS), which is capable of providing latitude and longitude coordinates with an accuracy of approximately 2 m. The DGPS consists of two satellite receivers linked to each other by a VHF telemetry radio system. The receiver will be on the sampling vessel. Details on collection of field station coordinates can be found in SOP GEN-04, *Station Positioning Using the Trimble Pathfinder Pro XRS*. The specific kind of station location documentation used for a given project will be identified in the project-specific FSP.

REFERENCES AND OTHER SOURCES

Hayes, M.L. 1983. Active fish capture methods. pp. 123–145. In: Fisheries Techniques. L.A. Nielsen and D.L. Johnson (eds). Publication of the American Fisheries Society, Bethesda, MD.

U.S. EPA. 1999. Rapid bioassessment protocols for use in streams and wadable rivers: periphyton, benthic macroinvertebrates and fish. Second Ed. EPA 841-B-99-002. Prepared by M.T. Barbour, J. Gerritsen, B.D. Snyder, and J.B. Stribling. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

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SOP BI-07
FISH COLLECTION PROCEDURES USING FISH TRAPS

This SOP discusses the sampling of fishes by use of traps including trap nets, hoop nets, and minnow traps. The procedures for processing fish captured by traps are described in SOP BI-08, *Fish Processing Procedures*. The personnel performing the fish collection will wear protective clothing as specified in the site-specific health and safety plan.

SAMPLE COLLECTION USING A TRAP NET OR HOOP NET

Trap nets and hoop nets are used as passive sampling devices to capture fish as they swim along the shoreline. The nets can be set in different configurations to sample deeper, open waters. Trap nets are particularly effective in capturing several migratory species. A trap net consists of a leader (wall of mesh fabric) and a series of hoops or compartments that entrap fish after they pass through a series of funnels or openings. Panels of mesh referred to as "wings" can be added to either side of the openings on these traps and serve to guide otherwise passing fishes into the net funnels. The net is commonly set perpendicular to the shore with its mouth facing the shoreline. When fish encounter the leader or wings, they are directed into the mouth of the net. As fish move through the series of hoops or compartments, escape becomes increasingly difficult. Fish may be attracted to the net by other fish that are already captured in it. Bait may be added to trap nets and hoop nets to attract species such as catfish.

Equipment Required

Equipment required for collecting samples with a trap net or hoop net consists of the following:

- Trap net or hoop net
- Buoys
- Anchors (traditional, bricks, or concrete blocks, etc.)
- Line
- Boat hook
- Collection buckets
- Bait
- Boat.

Setting the Net

The net will be set as follows:

1. Bait the inside of the last compartment of the net if catfish or other bottom feeders are desired.
2. Anchor the shoreward end of the leader near the shoreline, or attach it to the shoreline by tying it to a fixed object onshore (e.g., a tree, a root, etc.).
3. Extend the leader line out into the water and perpendicular to shore until it is taut.
4. Extend each wing at a 45–90° angle to the leader line. This step can be done either by boat or by wading, depending on water depth and substrate characteristics.
5. Anchor the lower ends of both wings with anchors, and attach buoys to the upper ends of the wings. Adjust the buoy lines so that the buoys are floating and the lines are relatively taut.
6. Extend the hoops of the trap away from shore in line with the leader line, and pull on the end of the net until all of the hoops are upright.
7. Close the back end (cod end) of the net with a piece of line.
8. Attach an anchor to the end of the net to keep it submerged, and attach a buoy to the anchor to mark the location of the end of the net. It is helpful to estimate the length of line needed for the buoys before starting to set nets by using a depth finder or bathymetric map.
9. Allow the net to soak for the prescribed sampling period (e.g., 24–48 hours).

Retrieving the Net

The net will be retrieved and the fishes collected as follows:

1. Arrive at the buoy at the end of the net, snag the buoy line with a boat hook, and pull the buoy and its anchor into the boat.
2. Retrieve the hoops in sequence while moving toward shore.
3. Starting at the mouth of the net, shake the captured fish into the closed end of the net.
4. Once all captured fish are in the back end of the net, empty them into the collection buckets.

5. Process the fish according to study design specifications (see project-specific FSP) and SOP BI-08, *Fish Processing Procedures*.

6. If sampling will continue at the collection site, reset the net according to Steps 5–8 of the above procedures for setting a net.

7. If processing must be delayed and the FSP delineates stations or zones for fish capture, keep fish from separate stations in different buckets that have been marked with the station or zone identifier (e.g., station number) until they can be processed.

SAMPLE COLLECTION USING A MINNOW TRAP

A minnow trap is used as a passive sampling device to capture juvenile fish as well as the adult individuals of small fish species. Minnow traps can also be effective in capturing crayfish and tadpoles. Fish are captured when they swim into the trap through a funnel-shaped opening that makes escape difficult. The trap is generally set in shallow nearshore areas and should have a buoy attached to facilitate retrieval. Multiple traps can also be strung together with line to facilitate retrieval. The trap can be deployed with or without bait inside to attract fish. Fish may be attracted to the trap by other fish that are already captured in it.

Equipment Required

Equipment required for collecting samples with a minnow trap consists of the following:

- Minnow trap(s)
- Buoy(s) or surveyor flagging
- Line
- Boat hook
- Bait
- Boat.

Setting the Minnow Trap

The minnow trap will be set as follows:

1. Attach a buoy to the trap with enough line to ensure that the line will remain slack at the highest water level expected for the period of deployment. If sufficient line is not used, the buoy can reduce the negative buoyancy of the

trap, allowing the trap to be moved by waves or currents. The use of an excessive length of line should also be avoided because it will increase the probability of the line becoming snagged as it is moved around by waves or currents.

2. Assemble the trap. If bait will be used, the trap can be baited at this time.

3. Deploy the trap at the sampling station by lowering it over the side of the boat, making sure that it does not get tangled in the buoy line. If a string of traps will be deployed, attach the trap to the next one in the sequence before deploying it. Buoys do not need to be attached to any of the additional traps.

4. After the trap is placed on the bottom, adjust the length of the buoy line on the basis of the considerations discussed in Step 1. If a string of traps is used, move the boat to the prescribed location of each additional trap in sequence, and deploy each of those traps.

5. Allow the trap to soak for the prescribed sampling period (e.g., 24–48 hours).

6. If the minnow traps are being set from the shoreline, tie a long piece of rope onto the trap, and lower the minnow trap out into the stream channel, or place it at the edge of habitat along the shoreline or adjacent to habitat structure (e.g., a downed tree limb).

7. Secure the end of the line to a structure on the shoreline, and use surveyor flagging to mark where the line is tied.

8. If motorized boats are expected to traverse the channel, fasten a buoy to the trap with a length of line sufficient to allow the buoy to float above the trap. Ensure a sufficient amount of line is attached to keep the buoy afloat during high water conditions.

Retrieving the Minnow Trap

The minnow trap will be retrieved and the fishes collected as follows:

1. Arrive at the buoy attached to the trap, and snag the buoy line by using a boat hook or similar device.

2. Pull the trap to the water surface by using the buoy line, and bring the trap onboard the boat.

3. Open the trap, and transfer the captured fish to the collection buckets. If a string of traps is used, proceed to the next trap in sequence, and follow Steps 2 and 3.

4. Process the fish according to study design specifications (see project-specific FSP) and SOP BI-08, *Fish Processing Procedures*.

5. If sampling will continue at the collection site, reset the trap according to Steps 3–5 of the above procedures for setting a minnow trap.

6. In habitats influenced by tidal flux, check minnow traps before low tide is reached because the trap may become exposed during low tides, leading to mortality of the organisms in the trap or serving as an attractant to other wildlife.

RECORD KEEPING

In addition to the items presented in SOP GEN-01, *Field Documentation*, the following information should always be recorded in the field logbook for each sampling location:

- Net mesh size or size of trap used
- Location of trap in the water body sampled
- Water depth where the trap was placed
- The length of time the trap was in place, plus the number of fish collected during that period
- Information on any tidal cycles that occurred while the trap was in place (if applicable)
- Presence of sheen on surface of the water
- Physical/habitat quality of each sampling location (use EPA nationally standardized method; U.S. EPA 1999) if required by project-specific FSP
- Number of individual fish collected and their respective species, each fish's length and weight, and if there are any physical anomalies (e.g., eroded fins, missing eyes, scoliosis or other body or mouth deformities, or skin lesions). If species identification is not definitive, save one specimen in a sample jar with site water (add preservative if available) for later confirmation by a second fisheries biologist.

SAMPLE CUSTODY AND SAMPLE SHIPPING

Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*. All samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping*.

FIELD QUALITY CONTROL SAMPLES

Details on collection of field quality control samples (e.g., replicate trap placements, replicate fish within a trap) will be identified in the project-specific FSP. Details on specific field quality control samples can be found in SOP BI-02, *Preparation of Field Quality Control Samples—Tissue*. Not all of the field quality control samples discussed in this SOP may be required for a given project. The specific field quality control samples will be identified in the project-specific field sampling plan (FSP) and quality assurance project plan (QAPP).

FIELD MEASUREMENTS

Depending on the specific project objectives, it may be necessary to perform field measurements of the *in situ* environment. Possible field measurements include concentration of dissolved oxygen, salinity, or conductivity in the overlying water. Details on collection of field measurements can be found in SOP SW-13, *Field Measurements for Surface Water.* The specific field measurements, if any, will be identified in the project-specific FSP.

DOCUMENTATION OF STATION LOCATIONS

The location of each trap placement will either be well documented in the field logbook (including map of each trap placement) or be determined using a differential global positioning system (DGPS), which is capable of providing latitude and longitude coordinates with an accuracy of approximately 2 m. The DGPS consists of two satellite receivers linked to each other by a VHF telemetry radio system. The receiver will be on the sampling vessel. Details on collection of field station coordinates can be found in SOP GEN-04, *Station Positioning Using the Trimble Pathfinder Pro XRS*. The specific kind of station location documentation used for a given project will be identified in the project-specific FSP.

REFERENCES AND OTHER SOURCES

Hubert, W.A. 1983. Passive capture techniques. pp. 95–111. In: Fisheries Techniques. L.A. Nielsen and D.L. Johnson (eds). Publication of the American Fisheries Society, Bethesda, MD.

U.S. EPA. 1999. Rapid bioassessment protocols for use in streams and wadable rivers: periphyton, benthic macroinvertebrates and fish. Second Ed. EPA 841-B-99-002. Prepared by M.T. Barbour, J. Gerritsen, B.D. Snyder, and J.B. Stribling. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Note: *SOPs GEN-01, -02, -03; and BI-01 cited within.*

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SOP BI-08
FISH PROCESSING PROCEDURES

This SOP discusses the procedures for making biological measurements of individual fish and for resecting fillets from individual fish for analysis of chemical concentrations in edible muscle tissue.

All fish samples will be packaged and shipped in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping*. Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*. Field activities will be recorded in accordance with procedures outlined in SOP GEN-01, *Field Documentation*.

BIOLOGICAL MEASUREMENTS/OBSERVATIONS

The biological measurements and observations commonly made of individual fish include length, weight, gender, reproductive condition, presence or absence of physical anomalies, parasites, or disease, and age determined by using scales or hard body parts.

Equipment Required

Equipment required for making biological measurements and resecting fish fillets consists of the following:

- Measuring board
- Analytical balance (and calibrated taring weight, if required)
- Stainless-steel filleting knife
- Skinning pliers (if needed for removing catfish skins)
- Blunt-point forceps
- Fish scale-remover (“scaler”)
- Fillet board
- Microprojector (for aging, if required)
- Coin envelopes (for scale collection, if required)

- Aluminum foil (consult the project-specific field sampling plan [FSP] as the foil requirements may vary by EPA region or state)
- Ziploc® bags
- Collection buckets.

Length and Weight Measurements and Other Observations

Length and weight measurements should be made on unpreserved fish as soon as possible after collection. Preservation techniques such as freezing and fixation with formalin and ethanol can alter length and weight measurements relative to the values that would be found for unpreserved individuals immediately after capture. The procedure described below for measuring length addresses total length (i.e., the distance from the most anterior part of the fish to the tip of the longest caudal fin ray):

1. Examine each fish for signs of physical anomalies, disease, or external parasites. Examples of physical anomalies include eroded fins, missing eyes, scoliosis or other body or mouth deformities, and skin lesions. Examples of disease symptoms include hemorrhagic sores, skin fungi, or grossly undernourished body condition. Examples of external parasites include attached leeches or worms, or cysts embedded in the skin or fin membranes, or inside the gills. Detailed observations should be noted on appropriate data sheets for each fish examined. Note the location of the anomalies (i.e., caudal fin, left mandible).
2. Place each fish on the measuring board, with its head touching the wall of the board and its side resting along the ruler of the board. Do not squeeze the head of the fish against the wall of the board.
3. Push the caudal fin together, and record the measurement for the longest part of the fin to the specified accuracy (e.g., the nearest 1.0 mm).
4. Place the balance tray on the analytical balance, and press TARE. Wait for a reading of 0.0 g.
5. Place the fish in the balance tray.
6. Allow the weight reading to stabilize, and record the weight to the specified accuracy (e.g., 1.0 g).

Fish Filleting Procedures

Fish are commonly filleted to resect edible muscle tissue for analysis of chemical concentrations. The filleting process is the same one used by fishermen to remove edible

muscle tissue from fish. The results of the chemical analyses are therefore directly related to the tissue that is frequently consumed by humans. Filleting should occur after length and weight measurements and other observations have been recorded for each fish, as follows:

1. Decontaminate all filleting equipment (filleting knife, scaler, fillet board) using the procedures provided in SOP BI-01, *Decontamination of Equipment—Tissue*.
2. Cover the cutting board with a piece of aluminum foil, dull side facing up.
3. Place each fish on its side on the fillet board.
4. Remove all scales from the caudal fin to the head. Do not remove the skin from fish that are commonly eaten with the skin attached to the fillet. For species that are commonly skinned before eating (e.g., catfish), remove the skin from the entire fish by cutting the skin around the head and peeling it off with pliers.
5. Make a cut along the ventral midline of the fish from the vent to the base of the jaw.
6. Make a diagonal cut from the base of the cranium, following just behind the gill to the ventral side just behind the pectoral fin.
7. Remove the flesh and rib cage from each side of the fish by cutting from the cranium along the spine and dorsal fin to the caudal fin. Leave the ribs attached to the main fillet. When removing the fillet, it is common to leave the fatty "belly" meat on the fish carcass. Consult the project-specific FSP and quality assurance project plan (QAPP) regarding inclusion of belly meat or rib bones with the fillet portions, because this procedural requirement may vary among agencies.
8. If necessary (see project-specific FSP), wrap the fillets in aluminum foil with the dull side facing the tissue.
9. Label the wrapped sample according to the instructions provided in the project-specific FSP.
10. Place the labeled, wrapped sample in a labeled Ziploc® bag, and preserve as indicated in the project-specific FSP and QAPP.

Determination of Gender and Reproductive State

Gender and reproductive state will be determined as follows:

1. After filleting each fish, examine the gonads, and determine whether they are ovaries or testes. Record the gender of the fish.

2. Identify the reproductive state of the gonads according to the following scale:

   - **Stage I—**Ovaries are wine-colored and shaped like torpedoes, and no eggs are visible; testes are small, flat, whitish in color, and cling closely to the spine.

   - **Stage II—**Ovaries resemble those in Stage I, except that small black (but color may vary) eggs are visible to the naked eye; testes are swollen and milky in appearance.

   - **Stage III—**Ovaries are somewhat swollen and yellowish in color; testes are large, lobed, and freely emit a milky liquid.

   - **Stage IV—**Ovaries are greatly swollen, their texture resembles tapioca, and the largest eggs are transparent and more than 1 mm in diameter; testes are slack and contain an abundance of connective tissue.

   - **Stage V—**Ovaries are slack and contain only a matrix and a few residual eggs.

Age Determination

The age of fish is commonly determined by counting the number of annual check marks (i.e., annuli) on hard structures such as scales, spines, otoliths, vertebrae, and opercular bones. The procedures described below are based on the use of scales for age determination. If otoliths, opercular bones, or vertebrae are required for age analysis, follow procedures specified in Nielson et al. (1983) or as otherwise indicated in the project-specific FSP.

1. Only personnel experienced in the process of fish-scale age determinations should be assigned to this task. At least one experienced peer should validate age determinations.

2. Before collecting scales for age determinations, remove mucous, dirt, and epidermis from the area by gently wiping the side of the fish in the direction of the tail with a blunt-edged knife.

3. Remove about 20 scales from the left side of each fish from areas suitable for the particular species being aged. Consult standardized methods manuals or experienced fisheries workers to obtain this information. Removal must be done carefully. Blunt forceps or a knife tip may be very useful for this task. Be careful not to break the margins of the scales or scratch the surfaces. Scales that are broken or irregularly shaped should be discarded.

4. Transfer fish scales to a labeled coin envelope for later age determination. For bullheads and catfishes, remove the dorsal spine for age determination instead of the scales. If otoliths, opercular bones, or vertebrae are required

for age analysis, follow procedures specified in Nielson et al. (1983) or as otherwise indicated in the project-specific work plan.

5. A scale sample number should be included on the coin envelope for each fish sampled. The sample number should cross reference vital data for each fish including information such as species, length, weight, sex, date, location, and project number.

6. Scales should be inspected and cleaned before mounting them for microscopic viewing. If mucus, skin pigments, or dirt is present on the scale, soak them in water for about two hours, and scrub off any remaining deposits with a small brush or piece of cloth after the soaking period. Retain the best 5 to 10 scales for mounting and viewing.

7. Mount the viewing scales between two microscope slides, making sure that the scales do not overlap.

8. Project the mounted scales with a microprojector (microfiche reader) and identify the scale(s) that have a complete set of rings emanating outward from their center. The microprojector should provide an enlarged image to about 50 times the natural size of the scale.

9. The number of annual rings (annuli) on each scale are counted. Each "true" annulus represents one year of growth. Care must be taken not to misinterpret "false" annuli, "split" annuli, checks, crowded annuli, or accessory rings. An important consideration for aging fish via scale marks is to understand the time of annulus formation which can vary with latitude, spawning, migration, and feeding habits of the sampled fish population as well as with environmental data and water temperature range.

10. Scale and age data are recorded on a Scale Analysis Summary Sheet (Attachment 115-1). The scale analyst must sign and date the sample control sheet.

REFERENCES AND OTHER SOURCES

Nielson, L.A., D.L. Johnson, and S.S Lampton. 1983. Fisheries techniques. American Fisheries Society, Bethesda, MD.

NYSDEC. Fish preparation procedures for contaminant analysis. New York State Department of Environmental Conservation, Albany, NY.

ATTACHMENT BI-08-1

Scale Analysis Summary Sheet

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Scale Analysis Summary Sheet

Project Name:_____

Project Number:_____

Water Body:_____

Sample No.	Date Collected	Location	Species	Length (mm)	Weight (g)	Sex	Age	Remark

Analyst:_____ Date:_____

Witness:_____ Date:_____

Note: SOPs GEN-01, -02, -03; HS-01; SD-04, -05, and -06 cited within.

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SOP BI-12
BENTHIC MACROINVERTEBRATE SAMPLING USING A GRAB SAMPLER

This standard operating procedure (SOP) describes the procedures used to sample benthic macroinvertebrate assemblages by using a grab sampler (e.g., modified van Veen, Ekman, Ponar). Benthic assemblages are typically analyzed for the abundances and biomass of various species and major taxa. The project-specific field sampling plan (FSP) should stipulate the number of replicate samples (i.e., individual grabs) that need to be collected at each station. The personnel performing the benthic macroinvertebrate collection and sample processing will wear protective clothing as specified in the site-specific health and safety plan.

All benthic macroinvertebrate samples will be packaged and shipped in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping* with consideration of information provided in SOP HS-01, *Restricted Article Shipment*. Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*. Field activities will be recorded in accordance with procedures outlined in SOP GEN-01, *Field Documentation*.

The grab sampler used for benthic infauna studies should be capable of collecting acceptable samples from a variety of substrates, including mud, sand, gravel, and pebbles (APHA 1989). The procedures for sampling benthic macroinvertebrate assemblages by using a grab sampler are described below.

EQUIPMENT REQUIRED

Equipment required for benthic macroinvertebrate sampling includes the following:

- Grab sampler (e.g., modified van Veen, Ekman, Ponar)
- If grab sampler is of considerable weight, then a winch and hydrowire (with load capacities ≥3 times the weight of a full sampler)
- Sample collection table (if vessel deck space allows)
- Sample collection tub
- Ruler
- Sieve(s) (typically with a 0.595-mm mesh for freshwater studies or a 1.0-mm mesh for marine studies; consult project-specific FSP for correct sieve size);

multiple sieves can be stacked on top of each other to capture different size fractions of benthic macroinvertebrates that will be processed separately; consult project-specific FSP for correct number of sieves

- Scoop (for transferring sediment sample aliquots to the sieve)
- Sample containers (clean, 1-L wide mouth plastic jars with plastic screw-on lids)
- Internal labels
- 10 percent buffered formalin
- Rose bengal (depending on study objectives, rose bengal stain may or may not be added; consult project-specific FSP)
- Scrub brush and soft-bristle nylon brush or tooth brush
- If necessary, socket and crescent wrenches (for adding or removing the detachable weights of the van Veen grab sampler)
- Water pump and hose (for sieving samples and for rinsing the grab sampler, sample collection tub, and sample collection table).

GRAB SAMPLER DEPLOYMENT

1. Prior to deployment, clean the inside of the grab sampler with a scrub brush and site water.
2. Depending on the sampling environment and substrate, consult either SOP SD-04 *Surface Sediment Sampling Using a Modified van Veen Grab Sampler*, SOP SD-05, *Surface Sediment Sampling Using an Ekman Grab Sampler*, or SOP SD-06, *Surface Sediment Sampling Using a Ponar Grab Sampler* for the correct deployment techniques for the appropriate grab sampler.
3. Lower the sampler through the water column at a slow and steady speed (e.g., 30 cm/second).

Allow the grab sampler to contact the bottom gently, with only its weight being used to force it into the sediments. The sampler should never be allowed to "free fall" to the bottom because this may result in premature triggering, or improper orientation upon contact with the bottom.

GRAB RETRIEVAL

1. After the grab sampler has rested on the bottom for approximately 5 seconds, begin retrieving it at a slow and steady rate (e.g., 30 cm/second).
2. Ensure that the sampling vessel is not headed into any waves before the sampler breaks the water surface to minimize vessel rolling and potential sample disturbance.
3. After the grab sampler breaks the water surface and is raised to the height of the sample collection table or sample collection tub, rinse away any sediments adhering to the outside of the grab sampler (it is essential that the sediments adhering to the outside of the grab are removed because those sediments and any associated benthic macroinvertebrates are not part of the sample).
4. After rinsing is finished, raise the grab sampler above the height of the collection table or sample collection tub, swing it inboard, and gently lower it into the sample collection tub on the sample collection table while maintaining tension on the hydrowire to prevent the grab sampler from rolling when it contacts the bottom of the tub.
5. When the grab sampler contacts the bottom of the table or tub, insert wedges under both jaws, if necessary, so that the grab sampler will be held in an upright position.
6. Open the doors on the top of the grab sampler, and inspect the sample for acceptability. The following acceptability criteria should be satisfied:

   – The sampler is not overfilled with sample to the point that the sediment surface presses against the top of the sampler or is extruded through the top of the sampler (organisms may have been lost)

   – Overlying water is present (indicating minimal leakage)

   – The overlying water is not excessively turbid (indicating minimal disturbance or winnowing)

   – The sediment surface is relatively undisturbed; the sediment-water interface is intact and relatively flat with no sign of channelling or sample washout

   – The desired penetration depth is achieved (see project-specific FSP); the following penetration depths should be achieved at a minimum:

   – 4–5 cm for medium-coarse sand

   – 6–7 cm for fine sand

   – >10 cm for silty sediment

- There is no sign of sediment loss (incomplete closure of the sampler, penetration at an angle, or tilting upon retrieval).

If a sample fails to meet the above criteria, it will be rejected and discarded away from the station. The location of consecutive attempts should be as close to the original attempt as possible, and if sampling on a river or stream, consecutive attempts should be located in the "upstream" direction of any existing current. Rejected sediment samples should be discarded in a manner that will not affect subsequent samples at that station or other possible sampling stations.

Penetration depth should be determined by placing a ruler against the center of the inside edge of the opening on the top of one side of the grab sampler and extending it into the grab sampler until it contacts the top of the sample. The penetration depth is determined by the difference between that measurement and the total depth of the grab sampler.

SAMPLE REMOVAL AND PROCESSING

1. For each acceptable sample, characterize the sample as specified in the study design. Characteristics that are often recorded include the following:
   - Sediment type (e.g., silt, sand)
   - Texture (e.g., fine-grain, coarse, poorly sorted sand)
   - Color
   - Biological structures (e.g., chironomids, tubes, macrophytes)
   - Approximate percentage of biological structures
   - Presence of debris (e.g., twigs, leaves, wood chips, wood fibers, manmade debris)
   - Approximate percentage of organic debris
   - Presence of shells
   - Approximate percentage of shells
   - Presence of a sheen
   - Odor (e.g., hydrogen sulfide, oil, creosote)
   - Changes is sediment characteristics
   - Presence and depth of redox potential discontinuity layer (if visible)
   - Maximum penetration depth

- Comments relative to sample quality (i.e., leakage, winnowing, disturbance).

2. After the sample is characterized, open the jaws of the grab sampler so that its contents (i.e., sediments and overlying water) are released into the sample collection tub.

3. Rinse any remaining sediment inside the grab into the collection tub, being careful not to overfill the tub with water.

4. Before each sample is sieved, all sieves will be examined for damage and wear. Look for rips in the mesh, irregular mesh spacing, and sand grains caught in the mesh. Use water pressure or a soft nylon brush to dislodge sand. DO NOT use sharp objects or stiff brushes, as the mesh may be damaged or torn.

5. After the entire sample has been collected in the sample collection tub, carefully transfer aliquots of the sample to the sieve by using a scoop.

6. Sieve each sample aliquot by rotating the sieve (in an up-and-down, not swirling, motion) in a bucket of water or by passing a gentle stream of water through the sieve from above or washed using a combination of these techniques. For all methods, it is imperative that the samples be washed gently to minimize specimen damage.

7. After each aliquot has been sieved, carefully rinse all of the retained material into a sample container, and carefully check the sieve to ensure that no organisms are trapped in its mesh (do not fill any sample container more than three-quarters full to ensure that a sufficient amount of space is available for the fixative).

8. If an organism is found to be trapped in the sieve, dislodge it with a gentle stream of water or by using forceps, and transfer it to the sample container.

9. Continue sieving aliquots of the sample until all of the sample has been processed.

10. Any large stones or other debris in the sample too large to fit in the sample jar should be thoroughly and carefully rinsed-off into the sieve, removed, and discarded under the supervision of the field team leader and noted on the field logbook.

11. After the entire sample has been sieved, clean the sieve by turning it over and back-washing it with a high-pressure spray to dislodge any sediment grains or detritus that are lodged in the mesh.

12. Fix each sample by filling each sample container with a 10–15 percent solution of borax-buffered formalin and inverting the container at least five times to ensure that the fixative penetrates all parts of the sample.

13. Depending on the sampling environment and the preferences of the taxonomic laboratory, the samples may be dyed with rose bengal (see project-specific FSP). If required, rose bengal should be added to the formalin solution prior to fixing the samples.

14. Label each sample container (both internal and external labels are required; see below), and store it in a protective container.

INTERNAL LABELS

In addition to the label on the outside of the sample container (i.e., external label, see SOP GEN-01, *Field Documentation*), a complete label must be placed inside each sample container. The internal label must be preprinted and should be made of at least 100 percent waterproof rag paper. The internal labels should be filled out using a pencil (i.e., no ink).

SAMPLE CONTAINERS

Samples can be stored in various containers including glass or plastic jars, and plastic bags. Exponent prefers that plastic jars with plastic screw-on lids (formalin corrodes metal) be used to store benthic macroinvertebrates samples. The use of this kind of sampling container lessens the possibility of formalin leakage during shipping and the breaking or tearing of the sample container. In general, a single 1- or 2-qt container is large enough to hold a sieved sample from a van Veen grab sampler and 1-L container is large enough to hold a sieved sample from a Ekman or Ponar grab sampler. If the sample volume exceeds one half of the container volume, more than one container should be used. Use of multiple containers for single replicates should be recorded in the field logbook.

After the buffered formalin has been added to a sample container, it is critical that the contents be mixed adequately. This usually can be accomplished by inverting the container several times (make sure that the lid is tightly screwed on). After mixing, sample container should be placed in protective containers for storage and transport o the laboratory. After being stored for approximately 1 hour, samples should be inverted several times again to ensure adequate mixing. Onboard the sampling vessel, samples should be stored so as to minimize exposure to sunlight and temperature extremes. They should also be stored in a stable part of the ship to minimize agitation.

BUFFERED FORMALIN PREPARATION

The fixative most commonly used for benthic macroinvertebrate samples is formalin, an aqueous solution of formaldehyde gas. Under no circumstances should ethyl or isopropyl alcohol be used as a preservative in place of the formalin. Penetration of the alcohol into body tissues is too slow to prevent decomposition of the specimens.

Solutions of 10–15 percent buffered formalin are most commonly used. However, samples containing large amounts of organic debris (e.g., peat, woody plant material) may require higher concentrations. The volume of fixative should be at least twice the volume occupied by the sample. If possible, the formalin solution should be added to the sample container until it is completely filled. This will minimize abrasion during shipping and handling. It is recommended that at least 2 L of diluted formalin solution be on hand for each replicate van Veen grab collected and at least 0.75 L of diluted formalin solution be on hand for each replicate Ekman or Ponar grab collected. The formalin solution should always be buffered to reduce acidity. Failure to buffer may result in decalcification of molluscs and echinoderms. Ideally, pH should be at least 8.2, as calcium carbonate dissolves in more acidic solutions. Borax (sodium borate) should be used as the buffer because other buffering agents may hinder identification by leaving a precipitate on body tissues.

To prepare a 10-percent buffered formalin solution, add 4 oz of borax to each gallon of concentrated formalin (i.e., a 40-percent solution of formaldehyde in water). This amount will be in excess, so use the clear supernatant when making seawater dilutions. Dilute the concentrate to a ratio of one part concentrated formalin to nine parts site water (sea water or tap water). If seawater is used, it will further buffer the solution. Fresh buffered formalin should be made prior to each sampling event, because formalin will eventually consume all of the buffering capacity of the borax.

If staining is used (see project-specific FSP), rose bengal is often added to the buffered formalin to facilitate sorting by staining the benthic organisms. The stain colors most infauna and thereby enhances their contrast with the debris from which they are sorted. Taxa that do not always stain adequately include ostracods and gastropods. **BE CAREFUL** when adding rose bengal to the buffered formalin solution. Add only a **VERY SMALL AMOUNT** of rose bengal; a little rose bengal goes a very long way. **REMEMBER**, you can always add more stain to the buffered formalin if you need to, but you can not remove the rose bengal once it has been added.

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SOP BI-13
VEGETATION SAMPLING

This SOP describes the methodology for vegetation sampling and outlines procedures for determining the following vegetation measurements:

- Species richness
- Cover
- Frequency
- Biomass production
- Plant tissue analysis.

As used in this procedure, the term vegetation refers to terrestrial vascular plants unless otherwise specified. The methods in this SOP apply primarily to herbaceous plant communities and are not specifically directed at woody plant communities. Study design and data analysis are project specific and are not addressed in this SOP, but may be found in the project sampling and analysis plan (SAP). For each of the methods outlined below, random location of the samples is desired, and details related to locating samples will be provided in the SAP with the study design. Some modification of these procedures may be required depending on health and safety issues and the specific objectives outlined in the SAP.

For all vegetation fieldwork, voucher specimens should be made of all plant species not readily identifiable or known in the field. Voucher specimens should have the appropriate structures needed for laboratory identification (i.e., roots, stems, leaves, flowers, flower color, fruits, etc.). Specimens should be placed within individual labeled, folded sheets of newspaper and pressed by using proper botanical technique. Specific plant information on each collected voucher specimen should be recorded in the field notebook or the collector's plant collection notebook.

SPECIES RICHNESS DATA COLLECTION

Species richness can be determined through the use of relevé surveys, belt transects, point-intercept transects, or quadrats (plots). The specific method to be used on a project will be specified in the SAP.

Relevé Surveys

The relevé survey is conducted by compiling a comprehensive species list for each community or area of interest as specified in the SAP. The area to be surveyed is delineated and thoroughly walked through. During the walkthrough, all plant species observed in the area are identified and recorded on the datasheet. Abundance categories (Braun-Blanquet cover-abundance scale; Bonham 1989) may be assigned to each species if desired.

Belt Transects

The belt transect survey is conducted along a transect line. A transect line is laid out with a tape measure following the specific guidelines for length and transect location provided in the SAP and/or based on site-specific restrictions. Transect endpoints should be permanently marked and labeled to aid in relocation. Using the tape as a center line, identify and record on the data sheets all plant species rooted within one meter on either side of the tape (for the entire length of the transect). A 2-m long rod with the center point marked can be used to determine whether species near the edge are located within the 1-m outer boundary.

Point-Intercept Transects

The method for this type of transect is detailed in the section on cover. However, species richness is determined from the list of species for which foliar vegetation hits are recorded. The use of this method alone for species richness determination is not generally recommended, however, because the number of species encountered will be fewer than would be found by using the other methods listed here, and many of the less frequent occurring species will be missed.

Quadrats (Plots)

Quadrat or plot sampling for species richness consists of compiling a list of species found within a delineated area of specified size. Quadrats are generally square or rectangular in shape, although circular plots are also used. Common sizes for rangeland or herbaceous vegetation vary from 0.25 to 2 m^2. Quadrat size, the number of quadrats to sample, and the method for randomly locating quadrats for a given project are specified in the SAP. Species richness is determined by identifying and recording on the datasheet all plant species rooted within the quadrat.

COVER DATA COLLECTION

Cover is determined through the use of an optical point-intercept method or with the use of quadrats. The specific method to be used on a project will be specified in the SAP.

Optical Point-Intercept

The optical point-intercept method consists of evaluating what is encountered along a transect through the cross-hairs of an optical siting device. A transect is laid out with a tape, and sampling points are established at 0.5-m intervals along the transect line. Transect endpoints should be permanently marked and labeled to aid in relocation. The tripod with the optical siting device is positioned over the sample point on the transect line, and the optical device is positioned to the right of the transect. Observations are recorded on the datasheet as "hits" for each of the different cover categories, which include bare soil, litter, rock, lichen, moss, or vegetation. Hits on vegetation are recorded on the basis of species. Individual hits are considered to be indicative of the amount of cover provided by each of the cover categories. For example, if 100 points are evaluated along a transect, each hit is equivalent to 1 percent of the cover along the transect (1/100 of the total number of possible hits, or 1 percent). This method has an advantage over quadrat sampling in that it is more repeatable and consistent among different observers. The only decisions that need to be made are related to what appears in the cross-hairs of the siting device.

The number of transects to be sampled at each sampling area and the length of the transects are specified in the SAP. In some cases, however, the number and length of transects may depend on the size of available sampling area. Transect length can be adjusted to accommodate sample area size. However, as a general rule, 500 or more hits are recommended as a minimum to characterize an area. The number of transects and/or the linear distance between hits along the transect may be adjusted to properly characterize an area.

Quadrats (Plots)

See the discussion under *Species Richness Data Collection for Quadrats* for information on determining the size of and how to locate quadrats. Quadrat or plot sampling for cover consists of compiling a list of species found within a delineated area of specified size (i.e., a quadrat) and estimating the amount of coverage for each species. This information is recorded on the datasheet. Cover estimates are made for each species in the quadrat by using either the Braun-Blanquet cover-abundance scale (Bonham 1989) or the Daubenmire cover scale (Bonham 1989). The quadrat size, number of quadrats to sample, how to randomly locate the quadrats, and the abundance scale to use on a given project will be specified in the SAP.

This method provides a coarse estimate of cover and is not as repeatable as the optical point-intercept method. The first choice for estimating vegetation cover should be the optical point-intercept, but this method is provided for special situations in which that method is not desirable or feasible. As a general rule a minimum of 10 quadrats, but preferably 25–30 quadrats, is the best number for characterizing an area.

FREQUENCY

Species frequency information is obtained primarily from species richness or cover collection methods. Frequency provides an estimate of how often a species is encountered in an area given a specific quadrat size. Frequency is defined as how many times a species is encountered out of the total number of possible observations made (i.e., 20 quadrats out of 30 sampled). Often the final value is converted to a percentage (67 percent in this case). Values will vary depending on the actual method used to gather the species information (i.e., quadrats vs. point-intercept vs. belt transect). Therefore, using a consistent method when collecting data for frequency measurements is important for making valid comparisons. Quadrats can be added to a sampling protocol if specific frequency information is required and it cannot be adequately obtained from other data being collected. See quadrat sampling in the *Species Richness* and *Cover Data Collection* sections for more information.

BIOMASS DATA COLLECTION

Estimates of biomass production will be obtained through the use of clip plots. Usually 0.25-m^2 or 0.5-m^2 quadrats are used for clip plots. The specific size and how to randomly locate the quadrats in the sample area will be provided in the SAP. A list of all species found rooted within the quadrat is recorded on the datasheet. All of the current years' growth of herbaceous species is clipped at ground level (<1 cm), sorted by species, placed into individual paper bags, and labeled with the species and sample number. The previous years' growth is considered litter, even though it may still be standing erect. No cacti or woody vegetation are used to obtain biomass data. If needed, a list of species not to be included (i.e., semiwoody species) can be developed to ensure the consistency of the biomass collection. If specified in the SAP, the plant litter from each quadrat can also be collected and placed into individually labeled paper bags. Bags should be stored in a dry, cool location.

In the laboratory, a drying curve should be established to determine the length of drying time (at 65°C) necessary to obtain constant weights (i.e., so no further water loss occurs). The clipped materials (still in the paper bags) should be oven dried at 65°C, and then the weight of the clipped vegetation should be determined. The total bag weight minus the empty bag weight equals the plant biomass. Weights should be determined to the nearest 0.1 gram and recorded on the datasheet.

PLANT TISSUE DATA COLLECTION

Collection of plant material for tissue analysis is conducted like that for biomass data collection with some notable differences. Generally, specific plant species are collected for tissue analysis. The list of species to be collected and the plant organs to be collected (i.e., roots, stems, flowers, fruits, seeds, or entire plant), along with the amounts of each type of material needed for analysis, will be specified in the SAP. This SOP assumes that only aboveground biomass is to be collected.

Co-location of biomass and plant tissue for sampling is important for interpretation of results. Species collected for tissue analysis should come from the area surrounding the quadrat used for biomass sampling. Plant tissue of the species of interest is clipped off at ground level (< 1cm) in concentric circles of increasing size around the biomass quadrat. If the SAP specifies that only seeds are to be collected, then the whole plant need not be clipped, but seeds would be collected from increasing concentric circles around the biomass quadrat. Seeds are generally collected by hand. However, plastic sheets may be spread under mature seed bearing plants, which are then beaten, causing the seeds to fall on the plastic sheeting, where they may easily be collected. Collection of material continues in concentric circles of increasing distance from the biomass quadrat until sufficient material for analysis is collected. Collected material is placed into labeled, appropriate bags or containers as specified in the SAP. It may be necessary to use specific types of gloves or to have special types of containers for storing the plant tissues, depending on what is being analyzed for. These details should be specified in the SAP. Collected material should be stored in ice chests with re-freezable ice packs in the field until it can be transferred to more permanent cooler storage at the field laboratory. All samples will be kept at 4°C until sent to the laboratory.

REFERENCES AND OTHER SOURCES

Bonham, C.D. 1989. Measurements for terrestrial vegetation. John Wiley & Sons, New York, NY.

Brower, J.E., and J.H. Zar. 1977. Field and laboratory methods for general ecology. Wm. C. Brown Publishers, Dubuque, IA.

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SOP BI-14
TERRESTRIAL INVERTEBRATE SAMPLING

This procedure is applicable for the capture of aboveground terrestrial arthropods.

PITFALL TRAPS

Pitfall traps are used for sampling active arthropods that tend to be strictly ground-dwellers, including many beetles and spiders. Pitfall traps are containers sunk into the ground so the open end of the container is flush with the ground surface. The size of the containers varies with the size of the organism targeted for capture. Pitfall traps for invertebrates are typically the size of waxed Dixie® cups. These cups, glass jars, or other suitable containers can be used as pitfall traps. If containers are reused, they should be thoroughly decontaminated between sampling events.

Depending on the goal of the study, pitfall traps can be arrayed in a grid, along a linear trap line, or adjacent to particular locations (e.g., soil sampling stations). The array of pitfall traps must be clearly identified in the project sampling and analysis plan (SAP). "Wings" made from lumber or garden edging can also be used to guide ground-dwelling insects to the pitfall traps.

Traps should be emptied at regular intervals. The length of the interval may vary depending on the weather and the sampling goals. Sampling for volatile contaminants in hot weather may require checking on a daily basis. Sampling for metals in cool weather may only require checking pitfall traps at two or three day intervals. If containers much larger than a quart jar are used, pitfall traps should be checked daily because small mammals and other nontarget animals may be captured.

After emptying pitfall traps, invertebrates should be sorted in the field into the lowest desired taxonomic level that is practical. Sorted samples should be placed in plastic bags with labels with assigned sample numbers that clearly identify the station (trap) location, date, and other pertinent information (see SOP GEN-01, *Field Documentation*). Samples that are being retained for chemical analyses should be placed on ice in ice chests until returned to the field laboratory, at which point the sample bags should be placed in a freezer. Invertebrates destined for chemical analyses should not be killed by using chemicals. Many commonly used chemicals may cause regurgitation and/ or defecation, which may result in the loss of an analyte and therefore lead to underestimation of contamination. Freezing is therefore recommended for killing invertebrates.

COVER BOARDS

Cover boards are used for capturing what have been called "cryptozoa." These are invertebrates that seek a microclimate refuge from otherwise harsh conditions. Typical types of organisms found under cover boards may include crickets, slugs, wood lice, certain beetles, and spiders. The surface of the flipped cover board should also be checked for organisms clinging to its surface. The sampler should be prepared to capture swiftly moving organisms in bottles or other containers. NOTE: Cover boards are also refuges for creatures such as venomous reptiles, scorpions, centipedes, or spiders. Personnel should never lift a cover board with unprotected fingers. If poisonous snakes are a potential problem, a cover board should always be lifted with a long-handled instrument. If a problem snake or other unwanted organism is encountered, the sampler should not try to remove it. If possible, the cover board should be removed, and personnel should leave the immediate area. The disappearance of the microclimate should lead to the disappearance of the snake. The site health and safety plan should be followed at all times.

Cover boards are conveniently and inexpensively made from 2 ft × 2 ft squares of untreated 0.75-in. plywood. Cover boards can be arrayed in grids, trap lines, opportunistically, or at particular locations (e.g., soil sampling stations) as desired. The SAP should specify the trapping design. Cover boards can also be used with pitfall traps to gain additional taxa, especially when pitfall traps cannot be checked regularly. Use boards that are wider than the pitfall trap, and suspend the board above the top of the trap with four small (0.5- to 1-in. thick) blocks of wood.

Time between sample collections is not critical for cover boards because the invertebrates are free to move about between intervals. Thus, this parameter is a matter of convenience and logistics. Invertebrates should be collected and processed in the same manner as described under *Pitfall Traps*.

Invertebrates should be sorted in the field into the lowest desired taxonomic level that is practical. Sorted samples should be placed in plastic bags with labels with assigned sample numbers that clearly identify the station (trap) location, date, and other pertinent information (see SOP GEN-01). Samples that are being retained for chemical analyses should be placed on ice in ice chests until returned to the field laboratory, at which point the sample bags should be placed in a freezer. Invertebrates destined for chemical analyses should not be killed by using chemicals. Many commonly used materials may cause regurgitation and/or defecation, which may result in the loss of an analyte. For invertebrate samples destined for use in ecological risk assessments, this may result in an underestimate of contamination.

MALAISE TRAP

Malaise traps are used to collect flying or emerging arthropods, such as wasps, flies, and moths. These traps are designed to intercept arthropods flying in any direction. They are tent-like structures made of netting, which funnel flying insects into a collection jar located at the top of the tent. For best results, the trap should be placed where wind currents are common or where

natural travel corridors exist. Examples of such areas include along a ridge top or along a stream stretch. These traps can be used to inventory rare or elusive insects and are not typically used in tissue collection studies.

SWEEP NETTING

Sweep netting is used to capture flying insects or insects that live on bushes, high grasses, or low trees. Insect groups readily captured by sweepnetting include many grasshoppers, butterflies, flies, bees, and wasps.

Sweep nets come in two basic designs. Lighter butterfly nets are designed to be easily moved about in pursuit of an active single prey that is capable of effective evasive action. Heavier nets are used to sweep through vegetation, capturing all insects that are present. Both methods are effective, and the choice of nets depends on the targeted group of arthropods.

The net is swept quickly in an arc through the vegetation or to capture a targeted insect (e.g., a butterfly), and the netting is then flipped quickly over the mouth of the net so the insects can not escape. The net is then maneuvered to place the insect in a jar or plastic bag (special care is taken with bees and wasps).

Samples can be taken along transects and the results reported in captures per unit of time. Because this method of reporting is highly variable among individuals, sampling should be done by the same individuals at all stations. Alternatively, formulas can be used to estimate the volume of a sweep net, and results can be reported in those terms. The area should be sampled for 30 minutes unless there is an abundance of invertebrates, in which case 15 minutes should be sufficient. The amount of time spent sweep netting is noted on the data sheet and in the field log book.

BEATING TRAYS

Areas too lush for sweep netting, such as woody plant communities, can be sampled by using beating trays. This method takes advantage of the response of some insects dropping from vegetation when disturbed. The beating tray or sheet is held under the vegetation while the vegetation is beaten or shaken. A number of trays can be used together to sample a larger area. Typically, a time interval is used to standardize sampling. In this manner, captures can be reported per unit of time.

SORTING

Invertebrates should be sorted in the field into the lowest desired taxonomic level that is practical. Sorted samples should be placed in plastic bags with labels with assigned sample numbers that clearly identify the station (trap) location, date, and other pertinent information (see SOP GEN-01). Samples that are being retained for chemical analyses should be placed on

ice in ice chests until returned to the field laboratory, at which point the sample bags should be placed in a freezer. Invertebrates destined for chemical analyses should not be killed by using chemicals. Many commonly used materials may cause regurgitation and/or defecation, which may result in the loss of an analyte. For invertebrate samples destined for use in ecological risk assessments, this may result in an underestimate of contamination.

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SOP BI-15
SMALL MAMMAL TRAPPING PROCEDURE

This SOP describes procedures for collecting small mammals for population analysis or tissue collection. These techniques are generally useful for the collection of mammals ranging in body size from a shrew to an adult raccoon. The methods described in this SOP include both live-collection and kill-collection techniques. The SOP discusses the use of live traps, snap traps, and pitfall traps.

EQUIPMENT

The following is a list of typical equipment used for the collection of small mammals:

- Sherman live traps (or equivalent)
- Museum special snap traps (or equivalent)
- Tomahawk live traps (or equivalent)
- Drift fences (e.g., metal or plastic sheeting)
- Pitfall traps (e.g., metal cones, metal or plastic buckets)
- Rifle or pistol (e.g., .177-caliber pellet gun or .22-caliber rifle)
- Shotgun (e.g., 12-gauge shotgun)
- Bait balls (peanut butter, rolled oats, and sunflower seeds and/or corn meal)
- Brightly colored wire flags or wooden stakes (1 × 2 × 24 in. or 1 × 2 × 36 in.)
- Clipboard and data sheets
- Small mammal identification book
- Keys to identification, sex, and age
- Copy of applicable trapping and salvage permits and scientific collection permits
- Research site map with grid overlay

- Pesola scales:
  - 0–10 g for shrews
  - 100 g for most rodents
  - 300 g for *Sigmodon*, large *Microtus*, rats (i.e., *Neotoma*, *Rattus*)
  - 1.5–2.5 kg for ground squirrels, tree squirrels, and rabbits
- Weighing bag or Ziploc® bags
- Extra 4 × 4 in. waxed paper squares
- Markers (e.g., dissecting scissors for pelage clipping, paint, fingernail polish) or PIT tags
- Appropriate safety equipment (Tyvek® suits and respirators) as required by the health and safety plan.

The following equipment is optional:

- Polyester fiberfill (or similar nonabsorbent material)—during cold or inclement weather
- Flashlights/headlamps.

PROCEDURES

Personnel

Only personnel trained to use small mammal traps, and whose names are listed on the appropriate permits, are authorized to capture and handle small mammals. All required research protocols, federal regulations, and other applicable regulatory guidelines should be studied before initiating trapping operations. Personnel without previous experience should be under the guidance and direct supervision of an experienced trapper.

Collection Methods and Trap Types

The choice of collection method will be specific to the size of the animals being sought and the objectives of the sampling and analysis plan (SAP). If animals are to be captured, marked, and released, Sherman live traps or their equivalent (i.e., Longworth traps, Havahart traps) should be used. The 3 × 3.5 × 9 in. traps will capture most small mammal species, including most species of shrews and most species of microtine, cricetid, and heteromyid rodents. The traps are also capable of capturing young rabbits, young opossums, young raccoons, and adult squirrels.

If it is necessary to collect animals for analyses, museum special snap traps or their equivalent (i.e., Victor traps) may be used for rodents up to small ground squirrel size. For kill-trapping of large squirrels, rats, and mammals up to the size of small rabbits, Victor rat traps or their equivalent should be used. For larger animals, a .22-caliber rifle or shotgun is necessary. However, live traps can be used when a specific species or sex of animals is needed for analysis. Once the desired animals are captured, animals can be dispatched by cervical dislocation or by placing them in a cloth bag in a cooler of dry ice. Specific collection methods should be detailed in the SAP.

Grids vs. Trap Lines

The trapping method used (grids, trap lines, or randomly placed traps) is determined from the SAP. Whenever possible, traps should be set in a single habitat type, not overlapping habitat types. If density information is sought, grids should be used whenever possible. The approach recommended by White et al. (1982) requires a sufficient grid size to contain at least three, preferably four, nested subgrids for use in density estimation models, with the subgrids preferably separated by two rings of traps. Density estimation lines may also be used with trapping grids. Analysis with density estimation lines is more complex and should only be performed after consultation with a statistician to ensure an adequate study trapping design. It is also necessary for density estimation to uniquely mark individuals so that capture histories and capture probabilities of individuals can be calculated. Finally, the grid method has a high trapping success. Grids may be square or rectangular, with one, two, or three traps set at each grid intersection. Thus, a 10×10 m grid would contain 100 grid intersections. One trap per grid intersection requires placement of 100 traps. If all traps were left open for one 24-hour day, the total trapping effort would be 100 trapnights, less any correction for sprung traps. More traps per station are required in habitats with greater densities of small mammals, where competition for the traps (as shelter) or the food resources within (bait) is likely to occur.

If the habitats to be sampled are too small to permit use of grids, randomly placed trap lines or individual traps may be used. If the study objectives require only a general description or assessment of the small mammal fauna (indices of relative frequency or relative abundance), randomly placed trap lines or individual traps may be preferable. The number of trap lines per habitat type, length of trap lines, and number of traps per station will be specified in the SAP and be dependent on the extent of area to be sampled and features of the habitat.

The distance between adjacent trap stations, adjacent trap lines, or grid lines will also be stated in the SAP. If the study objectives require an assessment of a single species, trap spacing and traps per station should be based on the home range size of the species being studied, with a minimum of three trap stations within each animal's home range (White et al. 1982). If a multispecies habitat assessment is required, traps are generally set at a spacing of 5.0 m, 7.5 m, 10.0 m, 15.0 m, or 22.5 m. If multiple traps are placed per station, they should be approximately equidistant and within 1.0–1.5 m of the station center.

Grid/Trap Line Marking

Individual traps at a station should be placed in locations that sample various microhabitat features because microhabitat differences have been shown to influence small mammal occurrence. For example, traps should be set at the bases of trees and shrubs, at the edge of the shrub canopy, in the open, in microtine runways, alongside fallen trees, in short and tall grass, and in disturbed areas of forbs and shrubs.

The beginning and end of trap lines, the corners of grids, and individual stations should be marked whenever possible. Generally, the fewer markers the better to avoid attracting predators (ground and aerial) that may cue on the markers, which would thereby increase mortality in the trapping area and influence the density/abundance/occurrence estimations. If wire flags are used, the flag should be trimmed to a 1-in. width to reduce flapping. A color visible to humans but not readily visible (and therefore an attractant) to wildlife should also be used. An alternative to the use of wire flags is to use painted wooden stakes, willow stems, or rebar driven into the ground to mark the station center, with only the top few inches painted. In wooded habitats, surveyor flagging may be tied to the vegetation to mark the station center. All grid and trap line locations should be marked on field site maps to aid relocation and provide a permanent record of where trapping occurred and what trapping method was used. If a global positioning system unit is available, readings of the beginning and end markers of a trapline or the corners of the grid should be logged.

Trap Functioning

Each trap should be cleaned and checked for proper functioning before placing it in the field. When trapping is being conducted to address small mammal tissue contamination or bioaccumulation, or where the hantavirus is of concern, all traps should be cleaned and disinfected before placement at a station or before moving to a different station. Disinfection of traps is discussed in the health and safety plan. All urine and fecal materials should be washed off. Traps may be disassembled for cleaning beneath the treadle mechanism by removing the wires from selected trap sides, permitting easy access to the trap interior.

Treadles on live traps should release doors with only very light fingertip pressure on the treadle or a light tap on the top of the trap. Sensitivity of the mammal trap is varied by pulling forward or pushing back the treadle lock mechanism.

Snap traps should be checked to ensure that all parts are securely fastened so that when the trap is sprung, the trap does not disassemble. Trap sensitivity is adjustable on all snap traps. To adjust the sensitivity of museum special snap traps, bow (i.e., bend) or straighten the holding bar that passes across the snap bar and inserts into the bait treadle (bowing the holding bar increases sensitivity, straightening the holding bar decreases sensitivity). On Victor snap traps (mouse or rat size), push the metal bait treadle holder to the sides of the trap to increase or decrease sensitivity.

Pitfall traps cannot be adjusted and can fill with water, either from groundwater seepage, percolation from the surrounding soil, or rainfall entering the trap. Animals will drown in water-filled pitfalls if a dry refuge is not provided. Holes can be punched in pitfalls to allow water to drain out, although in some habitats and soil types, this step may cause the pitfall to fill with water more quickly. In conical pitfalls, synthetic batting (i.e., dacron) or rocks can be placed in the bottom to keep the animals out of the water. In flat-bottomed pitfalls (e.g., buckets or cans), a rock or brick can be placed in the bottom to provide a dry resting area for captured animals.

Bait

Dry baits are readily available and easy to use. Rolled oats or horse feeds, such as Purina Omelene, make good dry baits. Dry baits may not be as effective as moist baits, but this may be advantageous depending on study objectives. Care should be taken when using live traps to ensure that dry bait does not prevent the treadle from working properly.

Bait balls are very attractive to a wide variety of small mammals ranging from shrews to raccoons. Bait balls are made by mixing peanut butter, rolled oats, and sunflower seeds and/or cornmeal. Peanut butter should first be warmed until easily stirred, then the remaining ingredients should be added. This mixture is then allowed to cool. A small amount of the peanut butter mixture (approximately the size of an M&M® Peanut candy) is spooned into the middle of a 4 × 4 in., waxed paper square. The waxed paper is folded around the bait ball and the ends are twisted (so that the bait ball looks like a Hershey's® Kiss).

Snap traps can be baited with the mixture above or with pure peanut butter. In some instances (e.g., tundra areas in Alaska), it may not be necessary to apply any bait because many of the species are herbivores and thus unlikely to be attracted to bait. These species will be caught as they encounter traps through their daily movements (i.e., if the trap is in the runway or an area in which the animal is foraging). Pitfalls are not typically baited, although a bait such as sardines that provide an attractant for some species (i.e., shrews) may be considered.

Trap Placement

The following procedures should be used to place traps:

1. Clear the immediate area where each trap will be placed of grass and other ground clutter so that each trap sets firmly on the ground. You may level the ground, but do not disturb an area much larger than the size of the trap.
2. Check to be sure that when the door of a live trap is set open, there is no wobble as the animals step into the entrance of the trap. For snap traps, ensure that the entire platform sits firmly on the ground. If the trap moves when a small mammal begins to enter, it may retreat and thereafter avoid the trap.

3. If wind or a steep slope causes trap instability, anchor each trap with a U-shaped piece of #12 wire, open-end down, that straddles the center of each trap. Force the wire ends into the ground to prevent each trap from being moved. For large snap traps (i.e., rat traps), attach a small screw eye to the back edge of the trap, attach a length of wire or rope (i.e., 12–18 in.), and attach the second end to a large nail or spike. The nail or spike is driven into the ground to secure the trap in the event the animal is caught but not immediately killed and attempts to escape.

4. If using dry bait, place a handful of bait inside the trap, turn the trap upside down, and shake it so that the bait is on the opposite side of the treadle, then quickly turn the trap right side up. The dry bait should now be on the treadle. Be sure the bait is on the treadle and not under it. Too much bait under the treadle will hamper operation of the trap. If using bait balls to bait traps, determine which is the front end of the trap by pressing open each door in turn and looking inside. The front of the trap is the end that has the metal door catch on the floor of the trap. Then hold the twisted ends of a bait ball, and push the ball through the top of the back door. Once it is inside the trap, pull the ball back toward you. The bait ball will catch the inside the trap door and pull it shut.

5. If temperatures below 5°C are expected or extended periods of rain are anticipated, place a wad of bedding material (polyester fiberfill or similar nonabsorbent material) in each trap to serve as nesting material. This step will help insulate animals from potentially fatal cold weather.

6. For pitfalls, use a shovel, post-hole digger, or sharp metal rod to create a hole in the soil of sufficient depth to hold the pitfall. The pitfall is placed correctly if the lip of the pitfall is slightly below the level of the surrounding soil or duff.

Trap Checking

If traps are left open all day, they should be checked at least twice daily. Heavy rain, cold, or extreme heat can kill trapped animals; trap checks should be performed as expeditiously as possible. Pitfalls may need to be checked more frequently. Pitfalls are the most successful method for capturing shrews, and shrews will tend to eat any other animals in the trap, including other shrews. Extra bait should be carried during trap checks. Soiled bedding material should be replaced as needed.

The suspension of trapping due to inclement weather will be at the discretion of designated field personnel. Any time trapping efforts are suspended, entrance doors on live traps should be shut and snap traps deactivated. All traps should be closed or deactivated before any scheduled days off. Pitfalls should be covered, either with a board, a lid, or some type of plug placed into the container when not in use.

Field personnel must immediately capture and relocate predators that begin preying on trapped animals and killing captured small mammals. Mammalian predators can be caught in larger live traps and released several miles from the research sites. Predators may be destroyed only if the proper permits have been obtained. Additionally, some states have regulations regarding the relocation of predators. Be sure to learn about these regulations before relocating animals.

COLLECTION BY FIREARMS

Larger-bodied animals that are unable to be caught in live traps must be collected by using a firearm. Preferred types are a .177-caliber pellet gun for smaller animals, .22-caliber rifle for animals the size of ground squirrels and rabbits, and a shotgun for animals the size of a raccoon. Extreme care must be exercised at all times in transporting and handling a firearm. Only people experienced with firearm use and authorized by the health and safety officer should use this type of equipment. Anyone collecting samples by using this method should have completed a firearm safety course.

Animal Handling

Review the health and safety plan for specific protective requirements before handling animals.

The Pesola scale should be tared to the weight of the capture bag, or the bag should be weighed before being used to weigh any small mammals captured in the field.

The following procedures are used to remove and weigh captured animals:

1. A shut door may indicate a capture. To check, hold the trap with the baited end of the trap facing the ground. Gently press the front door open only as far as necessary to determine if an animal is inside.
2. If you have captured an animal, press the front door open further, adjusting the trigger mechanism slightly with a finger of the hand that is holding the trap so that the door remains open. Shield the opening of the trap with the other hand to prevent escape by the animal.
3. Once the door is secure, place the capture bag over the mouth of the trap, gathering any loose edges.
4. Turn the trap upside down. If the animal does not readily fall out, gently shake the trap.
5. Once the animal is in the bag, make sure it is not near the open end, quickly close the bag, and set the trap down.

6. Remove any foreign objects that have fallen into the trap with the animal (e.g., bait, bedding, sticks).
7. Weigh the bag. If the scale is not pre-tared, subtract the weight of the bag from the weight of the bag and the animal.
8. Record the weight.
9. Live animals in pitfalls should be removed by personnel wearing heavy leather gloves to avoid being bitten.
10. Removing larger animals in Tomahawk and Havahart traps requires particular caution. Tip the trap up on its end, and carefully reach in a gloved hand to grasp the animal. An alternative is to lock the door open and shake the animal out of the trap into a cloth holding bag (e.g., a pillow-case type of bag).

Other Measurements

Measurements in addition to weight can be helpful if the identification of the animal is in question. Measurements that are often used for identification are the total length (including the tail), tail length, hind foot length, and ear length. These measurements require use of a specific method to ensure proper identification. Refer to the field sampling plan, field guides, or mammalogy laboratory books for the proper method.

Sexing Animals

Experience is necessary for sexing small mammals. Males and females may be differentiated by using the following guidelines:

- **Males**—Check for the presence of testes (only visible during periods of reproductive activity). The penis is directed anteriorly and may be covered with a sheath. The distance between the papillae and the anus is greater in males than in females.
- **Females—**Check for the presence of mammae, a vaginal opening, and a clitoral sheath. The distance between the papillae and the anus is shorter than in males.

Record sex information.

Aging Animals

The most accurate and cost-efficient method of aging small mammals currently in practice is the use of eye-lens weights, as described in Rowley et al. (1983) and Thomas and Bellis (1980). An approximation of age can be made in the field by using details of pelage coloration, body weight, and meristic measurements (i.e., length of hind foot or tail length). Local keys or field guides are moderately useful in aging animals. A good source for age characteristics, if available, is a small mammal collection maintained at a college, university, or natural history museum.

Trap Cleanup

Due to the risk of hantavirus in small mammal populations across the country, any traps that have been used should be treated as if they contain hantavirus. Risk of hantavirus is greatest in closed air environments. Therefore, traps should be transported in an open-air vehicle such as the back of a pickup truck or a trailer. If this is not possible, the traps should be bagged in large plastic bags, and care should be taken not to tear the bags while placing the traps in the vehicle. Alternatively, traps can be washed in the field provided a means of transporting wastewater is available.

Once traps are transported to an area for washing, all traps should be washed with soap and water, decontaminated with bleach, and rinsed thoroughly whether traps were used in a treated (e.g., contaminated) or an untreated area. Traps should then be allowed to air dry before they are packed away. Refer to the health and safety plan for further precautions regarding hantavirus and small mammal handling. Traps from treated sites should be washed with soap and water, decontaminated with bleach, air dried, and packed as described in the health and safety plan.

SAFETY PRECAUTIONS

1. All work, including the transfer of samples from bags into the blender and from the blender into sample bottles, will be performed inside a biological safety cabinet (BSC). The blender and utensils must be thoroughly disinfected before removal from the BSC.
2. Laboratory personnel performing the work will be trained in BSC use and made aware of biosafety hazards.
3. Disposable latex or nitrile gloves must be worn at all times when handling small mammals and/or samples.
4. Gloves must be disinfected before removal.
5. Hands must be washed after removing gloves.

6. Disinfect all surfaces coming in contact with samples after they are used. Suitable disinfectants include a bleach/water solution, alcohol, or commercial products such as Lysol®.

7. Spray or soak all trash, including plastic bags and gloves, with disinfectant, then double bag trash for disposal as solid waste.

8. Workers who become ill or who develop a febrile or respiratory illness within 45 days of the last potential exposure should immediately seek medical attention and inform the attending physician of the potential occupational risk of hantavirus infection. The physician should contact local health authorities promptly if hantavirus-associated illness is suspected. A blood sample should be obtained and forwarded through the state health department to the Centers for Disease Control for hantavirus antibody testing.

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Note: *SOP SD-02 cited within.*

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SOP SD-01
DECONTAMINATION OF EQUIPMENT—SEDIMENTS

To prevent potential cross contamination of samples, all reusable sediment sampling and processing equipment will be decontaminated before each use. At the sample collection site, a decontamination area will be established in a clean location, upwind of actual sampling locations, if possible. This is where all sediment sampling and processing equipment will be cleaned. Decontaminated equipment will be stored away from areas that may cause recontamination, and rinsate blanks will be collected according to SOP SD-02, *Preparation of Field Quality Control Samples—Sediment*. When handling decontamination chemicals, field personnel will follow all relevant procedures and will wear protective clothing as stipulated in the site-specific health and safety plan.

This SOP describes procedures for decontaminating sampling and processing equipment contaminated by either inorganic or organic materials. Sampling equipment (e.g., van Veen, Ekman, Ponar, core tubes) used for both analyte groups follow the decontamination order of a detergent wash, site water rinse, organic solvent rinses, and final site water rinse. Sample processing equipment (e.g., bowls, spoons) should have a final distilled/deionized water rinse instead of a site water rinse. If the surface of stainless steel equipment appears to be rusting (possibly due to prolonged contact with organic-rich sediment), it should be given an acid and site water rinse at the end of each sampling day to minimize corrosion.

EQUIPMENT REQUIRED

Equipment required for decontamination includes the following:

- Polyethylene or polypropylene tub (to collect solvent rinsate)
- Plastic bucket(s) (e.g., 5-gal- bucket)
- Tap water or site water
- Carboy, distilled/deionized water (analyte-free; received from testing laboratory or other reliable source)
- Properly labeled squirt bottles
- Funnels
- Alconox®, Liquinox®, or equivalent industrial detergent
- Pesticide-grade ethanol and heptane (consult the project-specific field sampling plan [FSP], as the solvents may vary by EPA region or state)

- 10 percent (v/v) nitric acid (reagent grade) for inorganic contaminants
- Baking soda
- Long handled, hard-bristle brushes
- Extension arm for cleaning core liners
- Plastic sheeting, garbage bags, and aluminum foil
- Core liner caps or plastic wrap and rubber bands
- Personal protective equipment as specified in the health and safety plan.

DECONTAMINATION PROCEDURES FOR FULL SUITE ANALYSIS (ORGANIC, METAL, AND CONVENTIONAL ANALYTES)

Two organic solvents are used in this procedure. The first is miscible with water (e.g., ethanol) and is intended to scavenge water from the surface of the sampling equipment and allow the equipment to dry quickly. This allows the second solvent to fully contact the surface of the sampler. Make sure that the solvent ordered is anhydrous or has a very low water content (i.e., < 1 percent). If ethanol is used, make sure that the denaturing agent in the alcohol is not an analyte in the samples. The second organic solvent is hydrophobic (e.g., heptane) and is intended to dissolve any organic chemicals that are on the surface of the equipment.

The exact solvents used for a given project may vary by EPA region or state (see project-specific FSP). Exponent uses ethanol and heptane as preferred solvents for equipment decontamination. If specified in the project-specific FSP, isopropanol and acetone can be substituted for ethanol, and hexane and methanol can be substituted for heptane in the decontamination sequence. The choice of solvents is also dependent on the kind of material from which the equipment is made (e.g., acetone cannot be used on polycarbonate), and the ambient temperature (e.g., hexane is too volatile in hot climates). In addition, although methanol and hexane are sometimes slightly more effective than other solvents, their use is discouraged due to toxicity to sampling personnel.

The specific procedures for decontaminating sediment sampling equipment and sediment compositing equipment are as follows:

1. Rinse the equipment thoroughly with tap or site water to remove visible sediment. This step should be performed onsite for all equipment, including core liners that will not be used again until the next day of sampling. After removing visible solids, sampling equipment that does not need to be used again that day may be set aside and thoroughly cleaned in the field laboratory at the end of the day.
2. Pour a small amount of concentrated laboratory detergent into a bucket (i.e., about 1–2 tablespoons per 5-gal bucket) and fill it halfway with tap or

site water. If the detergent is in crystal form, all crystals should be completely dissolved prior to use.

3. Scrub the equipment in the detergent solution using a long-handled brush with rigid bristles. For the polycarbonate core liners, use a round brush attached to an extension arm to reach the entire inside of the liners, scrubbing with a back-and-forth motion. Be sure to clean the outside of core liners, bowls, and other pieces that may be covered with sediment.
4. Double rinse the equipment with tap or site water and set right-side-up on a stable surface to drain. The more completely the equipment drains, the less solvent will be needed in the next step. Do not allow any surface that will come in contact with the sample to touch any contaminated surface.
5. If the surface of stainless steel equipment appears to be rusting (this will occur during prolonged use in anoxic marine sediments), the surface requires passivation. Otherwise skip to next step. Using a 10 percent (v/v) nitric acid solution, rinse using a squirt bottle, or wipe all surfaces using a saturated paper towel. Areas showing rust may require some rubbing with the paper towel. If using a squirt bottle, let the excess acid drain into the waste container (which may need to be equipped with a funnel). Double-rinse equipment with tap or site water and set right-side-up on a stable surface to drain thoroughly.
6. Carefully rinse the equipment with ethanol from a squirt bottle, and let the excess solvent drain into a waste container (which may need to be equipped with a funnel). These solvents act primarily as a drying agent by scavenging water from the equipment surface and carrying it away, but they also work as a solvent for some organic contamination. Core liners must be held over the waste container and turned slowly so the stream of solvent contacts all of the surface. The sample apparatus (e.g., grab sampler) may be turned on its side and opened to be washed more effectively. Set the equipment in a clean location and allow it to air dry. Use only enough solvent to scavenge all of the water and flow off the surface of the equipment (i.e., establish sheet flow) into the waste container. Allow equipment to drain as much as possible. Ideally, the equipment will be dry. The more thoroughly it drains, the less solvent will be needed in the next step.
7. Carefully rinse the drained or air-dried equipment with heptane from a squirt bottle, and let the excess solvent drain into the waste container (which may need to be equipped with a funnel). The opening of the squirt bottle may need to be widened to allow enough solvent to run through the core liners without evaporating. Heptane acts as the primary solvent of organic chemicals. Ethanol is soluble in heptane but water is not. If water beading occurs, it means that the equipment was not thoroughly rinsed with ethanol or that the ethanol that was purchased was not free of water. When the equipment has been rinsed with heptane, set it in a clean location and allow the heptane to evaporate before using the equipment for sampling. Use only

enough solvent to scavenge all of the ethanol and flow off the surface of the equipment (i.e., establish sheet flow) into the waste container.

8. The final rinse is with site water for the sampling equipment (i.e., van Veen, Ekman, Ponar, core tubes) and distilled/deionized water for processing equipment (i.e., stainless-steel bowls and spoons). Equipment does not need to be dried before use.
9. If the decontaminated sampling equipment is not to be used immediately, wrap small stainless-steel items in aluminum foil (dull side facing the cleaned area). Seal the polycarbonate core liners at both ends with either core caps or cellophane plastic and rubber bands. Close the jaws of the Ekman and Ponar grab samplers and wrap in aluminum foil.
10. If the sample collection or processing equipment is cleaned at the field laboratory and transported to the site, then the decontaminated equipment will be wrapped in aluminum foil (dull side facing the cleaned area) and stored and transported in a clean plastic bag (e.g., a trash bag) until ready for use, unless the project-specific FSP lists special handling procedures.
11. Rinse or wipe with a wetted paper towel all stainless-steel equipment at the end of each sampling day with 10 percent (v/v) normal nitric acid solution. Follow with a freshwater rinse (site water is okay as long as it is not brackish or salt water).

After decontaminating all of the sampling equipment, the disposable gloves and used foil will be placed in garbage bags and disposed of in a solid waste landfill. When not in use, keep the waste solvent container closed and store in a secure area. The waste should be transferred to empty solvent bottles and disposed of at a licensed facility per the procedures listed in the project-specific FSP. When not in use, keep the waste acid container closed and store in a secure area. The acid waste should be neutralized with baking soda and disposed of per the procedures listed in the project-specific FSP.

DECONTAMINATION PROCEDURES FOR METAL AND CONVENTIONAL ANALYTES ONLY

The specific procedures for decontaminating sediment sampling equipment and sediment processing equipment are as follows:

1. Rinse the equipment thoroughly with tap or site water to remove the visible sediment. This step should be performed onsite for all equipment, including core liners that will not be used again until the next day of sampling. Pieces that do not need to be used again that day may be set aside and thoroughly cleaned in the field laboratory at the end of the day.
2. Pour a small amount of concentrated laboratory detergent into a bucket (i.e., about 1–2 tablespoons per 5-gal bucket) and fill it halfway with tap

or site water. If the detergent is in crystal form, all crystals should be completely dissolved prior to use.

3. Scrub the equipment in the detergent solution using a long-handled brush with rigid bristles. For the polycarbonate core liners, use a round brush attached to an extension arm to reach the entire inside of the liners, scrubbing with a back-and-forth motion. Be sure to clean the outside of core liners, bowls, and other pieces that may be covered with sediment.
4. Double-rinse the equipment with tap or site water and set right-side-up on a stable surface to drain. Do not allow any surface that will come in contact with the sample to touch any contaminated surface.
5. If the surface of stainless steel equipment appears to be rusting (this will occur during prolonged use in anoxic marine sediments), the surface requires passivation. Using a 10 percent (v/v) nitric acid solution, rinse using a squirt bottle, or wipe all surfaces using a saturated paper towel. Areas showing rust may require some rubbing with the paper towel. If using a squirt bottle, let the excess acid drain into the waste container (which may need to be equipped with a funnel). Double-rinse sampling equipment with tap or site water and set right-side-up on a stable surface to drain. Double-rinse processing equipment with distilled/deionized water and allow to drain.
6. If the decontaminated sampling equipment is not to be used immediately, wrap small stainless-steel items in aluminum foil (dull side facing the cleaned area). Seal the polycarbonate core liners at both ends with either core caps or cellophane plastic and rubber bands. Close the jaws of the Ekman and Ponar grab samplers and wrap in aluminum foil.
7. If the sample collecting or processing equipment is cleaned at the field laboratory and transported to the site, then the decontaminated equipment will be wrapped in aluminum foil (dull side facing the cleaned area) and stored and transported in a clean plastic bag until ready for use, unless the project-specific FSP lists special handling procedures.

After decontaminating all of the sampling equipment, the disposable gloves and used foil will be placed in garbage bags and disposed of in a solid waste landfill. When not in use, keep the waste acid container closed and store in a secure area. The acid waste should be neutralized with baking soda and disposed of per the procedures listed in the project-specific FSP.

Note: *SOPs GEN-02, -03, -04; SD-01, -02, -03, and -11 cited within.*

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SOP SD-05
SURFACE SEDIMENT SAMPLING USING AN EKMAN GRAB SAMPLER

This SOP describes the procedures used to collect surface sediment with an Ekman grab sampler. For the purposes of this SOP, surface sediment is defined as the upper 10 cm of the sediment column, but may vary given the sampling interval specified in the study design. The specific sampling interval will be specified in the project-specific field sampling plan (FSP). Surface sediment is typically analyzed for various physical and chemical variables so the sampling equipment and sampling procedures must be compatible with all analyses.

A stainless-steel Ekman grab sampler is a light-weight sampler capable of collecting acceptable samples from a variety of soft substrates, such as silt, silt mixed with clay, and silt mixed with a little sand (U.S. EPA 2001). This sampler is effective in various environments (e.g., lakes, rivers, and streams). A quiescent environment is needed for optimal sampling in deeper water. In very soft sediment it can penetrate as much as 15 cm, but in most sediment it penetrates less than 10 cm unless auxiliary weights or driverods are used. The Ekman grab sampler has two doors on top to allow easy access to the sediment for visual characterization and removal of undisturbed surface sediments. The procedures for collecting surface sediment samples using the Ekman grab sampler are described below.

EQUIPMENT AND SUPPLIES REQUIRED

Equipment required for sediment sampling using the Ekman grab sampler includes the following:

- Stainless-steel Ekman grab sampler (typically 0.25 ft^2) and spare parts
- Rope of sufficient length to reach the sediment at the deepest station plus 10 ft, and of a diameter that will fit through the messenger (<0.25 in. OD)
- Messenger (it is preferable to have two messengers)
- Metal driverods for harder sediment in shallow water
- Weights that attach to the outside of the Ekman
- Teflon® or polyethylene siphon
- Flat-bottomed container (e.g., dish pan)

- Stainless-steel ruler
- Stainless-steel spoons
- Stainless-steel mixing bowl or pot.

DECONTAMINATION

To prevent potential cross-contamination of samples, all reusable sediment sampling equipment will be decontaminated. Before each station is sampled, decontaminate the inner surfaces of the grab sampler and all stainless-steel sample compositing equipment. Details on correct decontamination procedures can be found in SOP SD-01, *Decontamination of Equipment—Sediment*. The project-specific FSP should also be consulted to determine any project-specific decontamination procedures. The personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific health and safety plan.

All solvent rinsates (if used) will be collected into a bucket or tub and allowed to evaporate over the course of the day. Any rinsate that has not evaporated by the end of the sampling event will be containerized and disposed of in accordance with applicable regulations.

GRAB SAMPLER DEPLOYMENT

1. If the water depth is less than 9 ft and the sediment is relatively hard, attach the grab sampler to the metal driverods. If the water depth is greater than 9 ft, use the rope to deploy the grab sampler.
2. Place the decontaminated grab sampler on a clean surface and open it.
3. Ensure that the two release wires are securely placed around the release pins.
4. Lower the sampler through the water column at a slow and steady speed to reduce turbulence ahead of the sampler.
5. Allow the grab sampler to contact the bottom gently. In soft sediments allow only its weight to force it into the sediments. The sampler should never be allowed to "free fall" to the bottom because this may result in an excessive wake, or improper orientation upon contact with the bottom.
6. Release the messenger to close the doors on the bottom of the grab sampler.

GRAB RETRIEVAL

1. After the grab sampler has rested on the bottom for approximately 5 seconds, begin retrieving it at a slow and steady rate. This will avoid disturbing the sediment interface and loss of sediment from tilting or washout during retrieval.

2. After the grab sampler breaks the water surface, gently lower it into a clean, flat-bottomed container, while maintaining the grab sampler in an upright position. This will help retain an intact interface by reducing how much the overlying water sloshes back and forth. If the jaws are not completely closed, push them closed by hand.

3. As soon as the grab sampler is secured, open the doors on the top of the grab sampler, and inspect the sample for acceptability. The following acceptability criteria should be satisfied:

   - The sampler is not overfilled with sample to the point that the sediment surface presses against the top of the sampler or is extruded through the top of the sampler
   - Overlying water is present (indicating minimal leakage)
   - The overlying water is not excessively turbid (indicating minimal disturbance or winnowing)
   - The sediment surface is relatively undisturbed; the sediment-water interface is intact and relatively flat with no sign of channelling or sample washout
   - The desired penetration depth is achieved
   - There is no sign of sediment loss (incomplete closure of the sampler, penetration at an angle, or tilting upon retrieval).

If a sample fails to meet the above criteria, it will be rejected and discarded away from the station. The locations of consecutive attempts and replicate samples (if any) should be as close to the first sample as possible, and if sampling on a river or stream, samples should be located upstream of previous samples. Rejected sediment samples should be discarded in a manner that will not affect subsequent samples at that station or other possible sampling stations.

Penetration depth should be determined with a decontaminated stainless-steel ruler by measuring the distance from the top of the sampler to the sediment interface and subtracting this from the inside depth of the sampler. If the sample is fairly level inside the sampler, this measurement can be made at one edge. If the sample is uneven but has an intact interface, then measurements should be made on opposite edges of the sample and the average value used. This observation (i.e., that the sediment surface is slanted) and subsequent calculation of the average penetration depth should be recorded in the field logbook. If penetration depth is

inadequate, add auxiliary weights. If penetration is still too shallow, a Ponar or van Veen grab sampler may be necessary.

SAMPLE REMOVAL AND PROCESSING

1. For acceptable samples, remove the overlying water by slowly siphoning it off near one or more sides of the grab sampler. Ensure that the siphon does not contact the sediments or that fine-grained sediment is not entrained and siphoned off. If sediment is suspended in the overlying water, do not proceed with siphoning until the sediment is allowed sufficient time to settle.
2. After the overlying water is removed, characterize the sample as specified in the study design. Characteristics that are often recorded include:
   - Sediment type (e.g., silt, sand)
   - Texture (e.g., fine-grain, coarse, poorly sorted sand)
   - Color
   - Presence/location/thickness of the redox potential boundaries (a visual indication of black is often adequate for documenting anoxia)
   - Approximate percentage of water
   - Presence of biological structures (e.g., chironomids, tubes, macrophytes)
   - Approximate percentage of biological structures
   - Presence of debris (e.g., twigs, leaves)
   - Approximate percentage of organic debris
   - Presence of shells
   - Approximate percentage of shells
   - Stratification, if any
   - Presence of a sheen
   - Odor (e.g., hydrogen sulfide, oil, creosote).
3. After the sample is characterized, remove the top 10 cm using a stainless-steel spoon (see project-specific FSP for correct sampling interval) and place in a decontaminated stainless steel bowl. Unrepresentative material (e.g., large shells, stones, leaves, twigs) should be carefully removed without

touching the sediment sample under the supervision of the field team leader and noted in the field logbook.

4. Remove subsamples for analysis of unstable constituents (e.g., volatile organic compounds, acid-volatile sulfides), and place them directly into sample containers without homogenization. Sediment must be placed in these containers with no headspace and no entrapped bubbles (i.e., completely fill the sample container).

5. Transfer the remaining surface sediment to a stainless-steel mixing bowl or pot for homogenization. Additional grab samples may be required to collect the volume of sediment specified in the study design. If it is necessary to collect additional grab samples to meet the project-specific volume requirements, the mixing bowl or pot should be covered with aluminum foil (dull side down) to prevent sample contamination (e.g., from precipitation, splashing water, falling leaves) and placed out of the sun and away from heat.

6. After the surface sediment has been removed from the grab sampler, move away from the station, open the jaws of the grab sampler, and allow the remainder of the sediment to fall out of the grab sampler. Discard this material away from the station, and rinse away any sediment adhering to the inside of the grab sampler. This can be done by repeatedly dipping the sampler in the water. The grab sampler is now ready for additional sampling at the same station or decontamination before sampling at a new station.

7. After a sufficient volume of sediment is transferred to the mixing bowl or pot, homogenize the contents of the bowl or pot using stainless-steel spoons until the texture and color of the sediment appear to be uniform.

8. After the sample is homogenized, distribute subsamples to the various containers specified in the study design and preserve the samples as specified in the study design. The sediment in the mixing bowl or pot should be briefly stirred in between the transfer of sediment to each sample container.

9. After all sediment for testing has been placed in the sample containers, if it is suspected that there is a clay component to the sediment, a "ribbon test" should be performed on the sediment to confirm this suspicion. In this "texture-by-feel" test, a small piece of suspected clay is rolled between the fingers while wearing protective gloves. If the piece easily rolls into a ribbon it is clay; if it breaks apart, it is silt. This information should be noted in the field logbook.

FIELD QUALITY CONTROL SAMPLES

Details on collection of field quality control samples and preparation of the certified reference materials can be found in SOP SD-02, *Preparation of Field Quality Control Samples—Sediment*

and SOP SD-03, *Preparation of Reference Materials—Sediment*. Not all of the field quality control samples discussed in these SOPs may be required for a given project. The specific field quality control samples will be described in the project-specific FSP and quality assurance project plan (QAPP).

FIELD MEASUREMENTS

A water depth measurement must be collected at every sampling location. For sites where tides affect water depth, the time of collection and depth measurement must be recorded simultaneously. Depending on the specific project objectives, it may be necessary to perform field measurements of the *in situ* environment. Possible field measurements include temperature and pH of the sediment at the sediment-water interface and concentration of dissolved oxygen, salinity or conductivity in the overlying water. Details on collection of field measurements can be found in SOP SD-11, *Field Analyses for Sediment.* Required field measurements, if any, will be specified in the project-specific FSP.

STATION LOCATION COORDINATES

Station locations will be determined in accordance with the project-specific FSP. Generally, station locations are determined with a differential global positioning system (DGPS), which is capable of providing latitude and longitude coordinates with an accuracy of approximately 2 m. The DGPS consists of two satellite receivers linked to each other by a VHF telemetry radio system. The GPS receiver will be on the sampling vessel or carried by the sampling team if a vessel is not used. Details on collection of field station coordinates can be found in SOP GEN-04, *Station Positioning Using the Trimble Pathfinder Pro XRS*.

SAMPLE CUSTODY AND SAMPLE SHIPPING

Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*. All samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping*.

REFERENCE

U.S. EPA. 2001. Methods for collection, storage and manipulation of sediments for chemical and toxicological analyses: Technical Manual. EPA-823-B-01-002. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

Note: SOPs GEN-02, -03, -04; SD-01, -02, -03, and -11 cited within.

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SOP SD-06
SURFACE SEDIMENT SAMPLING USING A PONAR GRAB SAMPLER

This SOP describes the procedures used to collect surface sediment with a Ponar grab sampler. For the purposes of this SOP, surface sediment is defined as the upper 10 cm of the sediment column, but may vary given the sampling interval specified in the study design. The specific sampling interval will be specified in the project-specific field sampling plan (FSP). Surface sediment is typically analyzed for various physical and chemical variables so the sampling equipment and sampling procedures must be compatible with all analyses.

A Ponar grab sampler is capable of collecting acceptable samples from a variety of semi-soft substrates, such as silt mixed with clay, and silt mixed with some sand (U.S. EPA 2001). This sampler is effective in various environments (e.g., lakes, rivers, estuaries, and marine waters). Some older Ponar samplers are constructed of galvanized (zinc) or cadmium plated steel and their use should be restricted to investigations in which analysis of metals is not performed, or where presence of these metals will not affect subsequent tests (e.g., benthic invertebrate identification and enumeration). Stainless steel samplers are preferred. Ponar samplers do not allow access to the sample from the top, and require dumping the whole sample, which prevents visual inspection of the interface, measuring the depth of penetration, and subsampling different depth intervals. Exponent's petite Ponar grab sampler has been modified with two doors on top to allow access to the sediment for visual characterization and removal of undisturbed surface sediments. Unmodified Ponar grab samplers should never be used to collect surface sediment for chemical analysis. Unmodified Ponar grab samplers are suitable for collection of benthic infauna and qualitative sediment samples only. The procedures for collecting surface sediment samples using the Ponar grab sampler are described below.

EQUIPMENT AND SUPPLIES REQUIRED

Equipment required for sediment sampling using the Ponar grab sampler includes the following:

- Stainless-steel Ponar grab sampler (petite Ponar 0.25 ft^2, standard 0.54 ft^2) and spare parts
- Large-diameter rope that is easy to grab and of sufficient length to reach the sediment at the deepest station plus 10 ft
- Teflon® or polyethylene siphon
- Flat-bottomed container (e.g., dish pan)

- Stainless-steel ruler
- Stainless-steel spoons
- Stainless-steel mixing bowl or pot.

DECONTAMINATION

To prevent potential cross-contamination of samples, all reusable sediment sampling equipment will be decontaminated. Before each station is sampled, decontaminate the inner surfaces of the grab sampler and all stainless-steel sample compositing equipment. Details on correct decontamination procedures can be found in SOP SD-01, *Decontamination of Equipment—Sediment*. The project-specific FSP should also be consulted to determine any project-specific decontamination procedures. The personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific health and safety plan.

All solvent rinsates (if used) will be collected into a bucket or tub and allowed to evaporate over the course of the day. Any rinsate that has not evaporated by the end of the sampling event will be containerized and disposed of in accordance with applicable regulations.

GRAB SAMPLER DEPLOYMENT

1. Place the decontaminated grab sampler on a clean surface and open it.
2. Ensure that the release pin is securely placed and that the knot is tight and firm at the top of the grab sampler.
3. Lower the sampler through the water column at a slow and steady speed to prevent accidental triggering and reduce turbulence ahead of the sampler.
4. Allow the grab sampler to contact the bottom gently, with only its weight being used to force it into the sediments. The sampler should never be allowed to "free fall" to the bottom because this may result in premature triggering, an excessive wake, or improper orientation upon contact with the bottom.

GRAB RETRIEVAL

1. After the grab sampler has rested on the bottom for approximately 5 seconds, begin retrieving it at a slow and steady rate. This will avoid loss of fine-grained surface sediments, mixing of sediment layers upon impact, lack of sediment penetration, and loss of sediment from tilting or washout during retrieval.

2. After the grab sampler breaks the water surface, gently lower it into a clean, flat-bottomed container, while maintaining the grab sampler in an upright position. This will reduce help retain an intact interface by reducing how much the overlying water sloshes back and forth.

3. As soon as the grab sampler is secured, open the doors on the top of the grab sampler, and inspect the sample for acceptability. The following acceptability criteria should be satisfied:

   - The sampler is not overfilled with sample to the point that the sediment surface presses against the top of the sampler or is extruded through the top of the sampler
   - Overlying water is present (indicating minimal leakage)
   - The overlying water is not excessively turbid (indicating minimal disturbance or winnowing)
   - The sediment surface is relatively undisturbed; the sediment-water interface is intact and relatively flat with no sign of channelling or sample washout
   - The desired penetration depth is achieved
   - There is no sign of sediment loss (incomplete closure of the sampler, penetration at an angle, or tilting upon retrieval).

If a sample fails to meet the above criteria, it will be rejected and discarded away from the station. The locations of consecutive attempts and replicate samples (if any) should be as close to the first sample as possible, and if sampling on a river or stream, samples should be located upstream of previous samples. Rejected sediment samples should be discarded in a manner that will not affect subsequent samples at that station or other possible sampling stations.

Penetration depth should be determined with a decontaminated stainless-steel ruler by measuring the distance from the top of the sampler to the sediment interface and subtracting this from the inside depth of the sampler. If the sample is fairly level inside the sampler, this measurement can be made at one edge. If the sample is uneven but has an intact interface, then measurements should be made on opposite edges of the sample and the average value used. This observation (i.e., that the sediment surface is slanted) and subsequent calculation of the average penetration depth should be recorded in the field logbook.

SAMPLE REMOVAL AND PROCESSING

1. For acceptable samples, remove the overlying water by slowly siphoning it off near one or more sides of the grab sampler. Ensure that the siphon does not contact the sediments or that fine-grained sediment is not entrained and

siphoned off. If sediment is suspended in the overlying water, do not proceed with siphoning until the sediment is allowed sufficient time to settle.

2. After the overlying water is removed, characterize the sample as specified in the study design. Characteristics that are often recorded include:

   - Sediment type (e.g., silt, sand)
   - Texture (e.g., fine-grain, coarse, poorly sorted sand)
   - Color
   - Presence/location/thickness of the redox potential boundaries (a visual indication of black is often adequate for documenting anoxia)
   - Approximate percentage of water
   - Presence of biological structures (e.g., chironomids, tubes, macrophytes)
   - Approximate percentage of biological structures
   - Presence of debris (e.g., twigs, leaves)
   - Approximate percentage of organic debris
   - Presence of shells
   - Approximate percentage of shells
   - Stratification, if any
   - Presence of a sheen
   - Odor (e.g., hydrogen sulfide, oil, creosote).

3. After the sample is characterized, remove the top 10 cm using a stainless-steel spoon (see project-specific FSP for correct sampling interval) and place in a decontaminated stainless steel bowl. Unrepresentative material (e.g., large shells, stones, leaves, twigs) should be carefully removed without touching the sediment sample under the supervision of the field team leader and noted in the field logbook.

4. Remove subsamples for analysis of unstable constituents (e.g., volatile organic compounds, acid-volatile sulfides), and place them directly into sample containers without homogenization. Sediment must be placed in these containers with no headspace and no entrapped bubbles (i.e., completely fill the sample container).

5. Transfer the remaining surface sediment to a stainless-steel mixing bowl or pot for homogenization. Additional grab samples may be required to collect

the volume of sediment specified in the study design. If it is necessary to collect additional grab samples to meet the project-specific volume requirements, the mixing bowl or pot should be covered with aluminum foil (dull side down) to prevent sample contamination (e.g., from precipitation, splashing water, falling leaves) and placed out of the sun and away from heat.

6. After the surface sediment has been removed from the grab sampler, move away from the station, open the jaws of the grab sampler, and allow the remainder of the sediment to fall out of the grab sampler. Discard this material away from the station, and rinse away any sediment adhering to the inside of the grab sampler. This can be done by repeatedly dipping the sampler in the water. The grab sampler is now ready for additional sampling at the same station or decontamination before sampling at a new station.

7. After a sufficient volume of sediment is transferred to the mixing bowl or pot, homogenize the contents of the bowl or pot using stainless-steel spoons until the texture and color of the sediment appears to be uniform.

8. After the sample is homogenized, distribute subsamples to the various containers specified in the study design and preserve the samples as specified in the study design. The sediment in the mixing bowl or pot should be briefls stirred in between the transfer of sediment to each sample container.

9. After all sediment for testing has been placed in the sample containers, if it is suspected that there is a clay component to the sediment, a "ribbon test" should be performed on the sediment to confirm this suspicion. In this "texture-by-feel" test, a small piece of suspected clay is rolled between the fingers while wearing protective gloves. If the piece easily rolls into a ribbon it is clay; if it breaks apart, it is silt. This information should be noted in the field logbook.

FIELD QUALITY CONTROL SAMPLES

Details on collection of field quality control samples and preparation of the certified reference materials can be found in SOP SD-02, *Preparation of Field Quality Control Samples—Sediment* and SOP SD-03, *Preparation of Reference Materials—Sediment*. Not all of the field quality control samples discussed in these SOPs may be required for a given project. The specific field quality control samples will be described in the project-specific FSP and quality assurance project plan (QAPP).

FIELD MEASUREMENTS

A water depth measurement must be collected at every sampling location. For sites where tides affect water depth, the time of collection and depth measurement must be recorded

simultaneously. Depending on the specific project objectives, it may be necessary to perform field measurements of the *in situ* environment. Possible field measurements include temperature and pH of the sediment at the sediment-water interface and concentration of dissolved oxygen, salinity, or conductivity in the overlying water. Details on collection of field measurements can be found in SOP SD-11, *Field Analyses for Sediment.* Required field measurements, if any, will be specified in the project-specific FSP.

STATION LOCATION COORDINATES

Station locations will be determined in accordance with the project-specific FSP. Generally, station locations are determined with a differential global positioning system (DGPS), which is capable of providing latitude and longitude coordinates with an accuracy of approximately 2 m. The DGPS consists of two satellite receivers linked to each other by a VHF telemetry radio system. The GPS receiver will be on the sampling vessel or carried by the sampling team if a vessel is not used. Details on collecting station coordinates can be found in SOP GEN-04, *Station Positioning Using the Trimble Pathfinder Pro XRS*.

SAMPLE CUSTODY AND SAMPLE SHIPPING

Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*. All samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping*.

REFERENCE

U.S. EPA. 2001. Methods for collection, storage and manipulation of sediments for chemical and toxicological analyses: Technical Manual. EPA-823-B-01-002. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC.

Note: SOPs GEN-02, -03, -04; SD-01, -02, -03, -08, and -11 cited within.

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SOP SD-10
SEDIMENT CORING USING A DRIVE ROD CHECK VALVE CORER

This standard operating procedure (SOP) describes the procedure for collecting sediment core samples using a drive rod check valve corer. The drive rod check valve corer is designed for collecting short cores (<60 cm) in water less than about 30 ft deep. The corer is lowered through the water column and then driven into the sediment using drive rods. This corer has the advantage over gravity corers in that the drive rods allow up to 200 lb of driving force to be used without having to handle or lift a heavy weight.

The sample is held in the core tube with the suction provided by a check valve at the top of the corer. Unlike free-floating check valves, this valve is actuated from the boat using a cord. As the corer is lowered, the valve is held open so water flows freely through the corer as it approaches the sediment, thus reducing the wake that can disrupt the surficial sediments. Because it is not a piston-type corer, some bypass/compaction of the sample will occur depending on the sediment type and core length. The internal cross-sectional area of the 3-in. diameter corer is 39 cm^2, which yields about 2 g of dry solids per centimeter of sample thickness at a porosity of 98 percent and about 15 g of solids per centimeter of thickness at a porosity of 85 percent.

There are five basic steps to collecting sediment with this corer:

1. Prepare the corer
2. Measure the water depth
3. Drive the corer
4. Retrieve the corer
5. Remove the core.

When reading instructions, refer to Figures SD-10-1 through SD-10-4.

PRELIMINARY CONSIDERATIONS

It is best to work from a platform that is anchored and will not drift. This setup helps to prevent collecting a poor quality sample and damaging the equipment. A platform with a low free-board, such as a pontoon boat, is best.

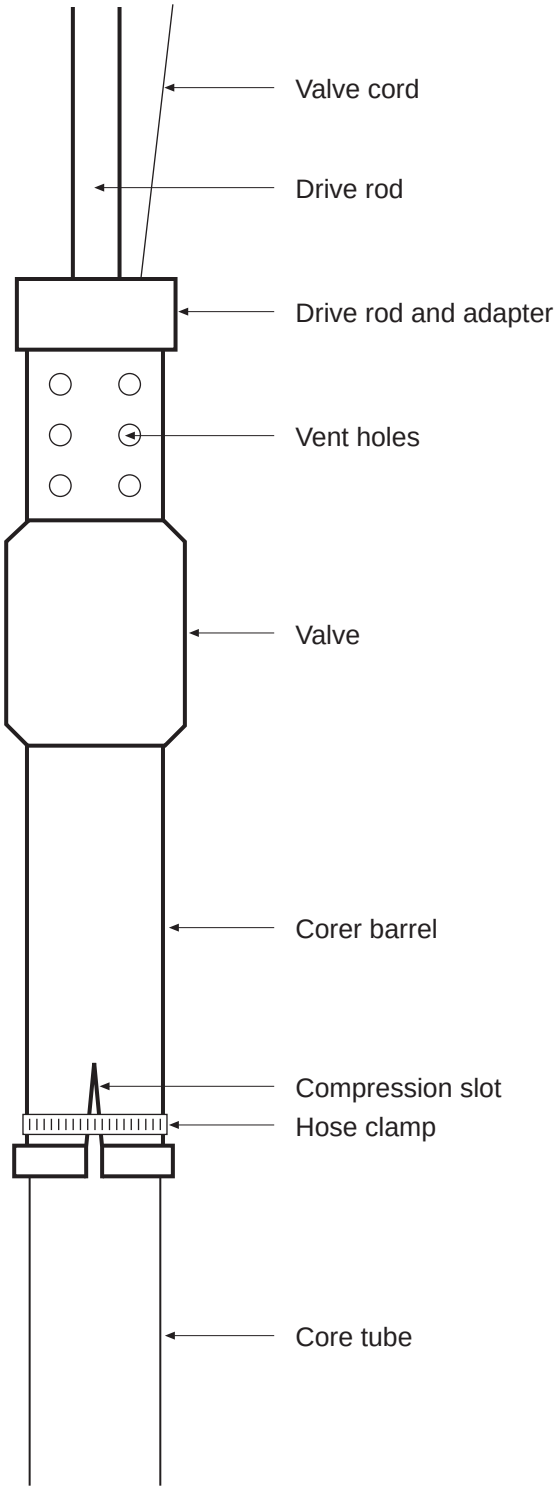

Figure SD-10-1. Drive rod check valve corer.

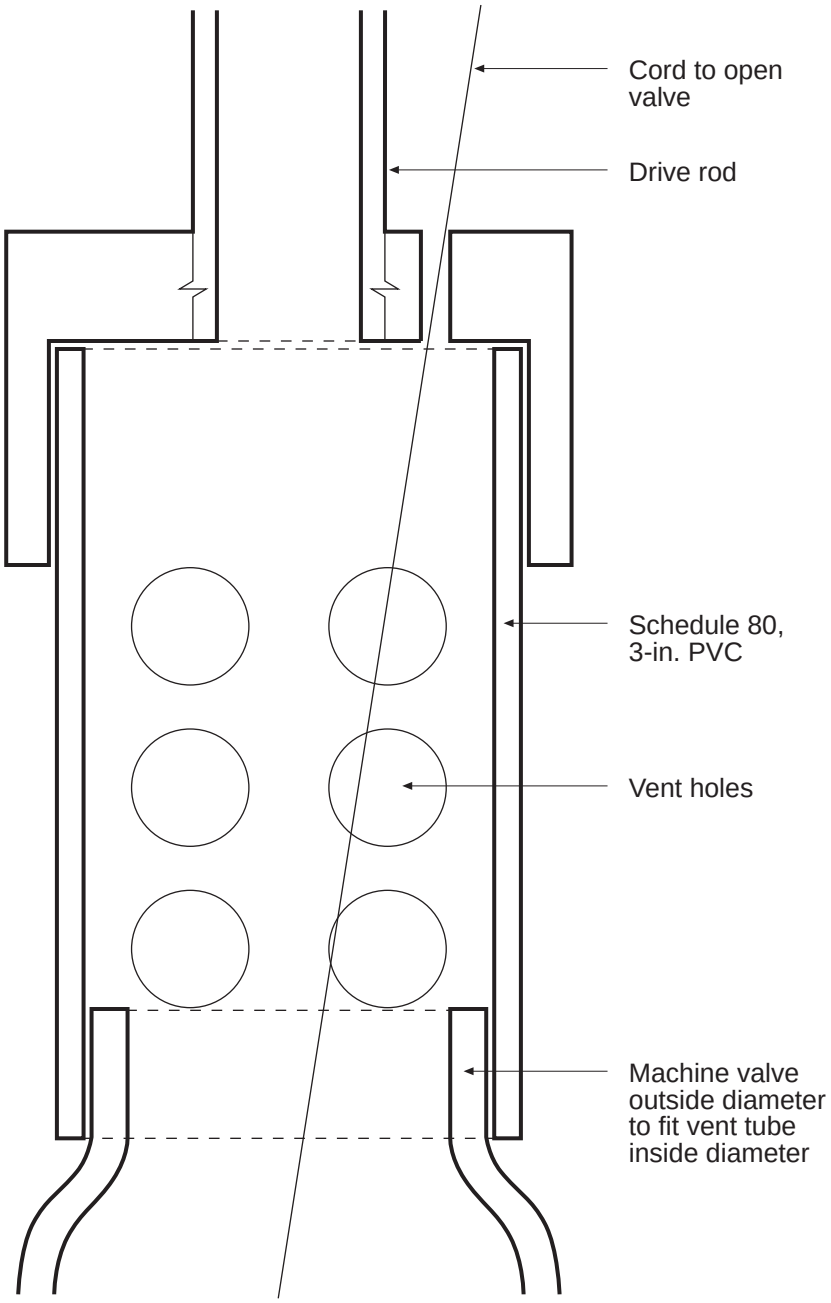

Figure SD-10-2. Detail of vent tube.

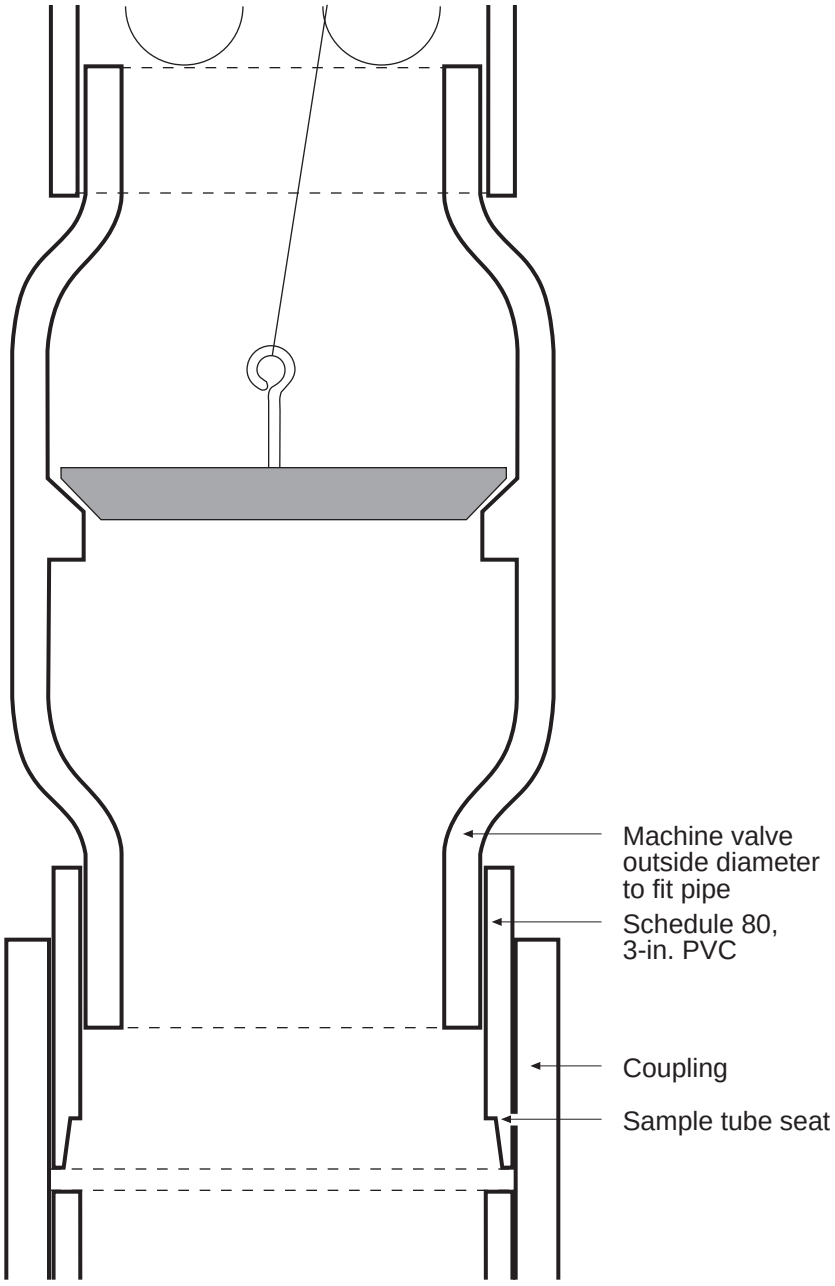

Figure SD-10-3. Detail of valve.

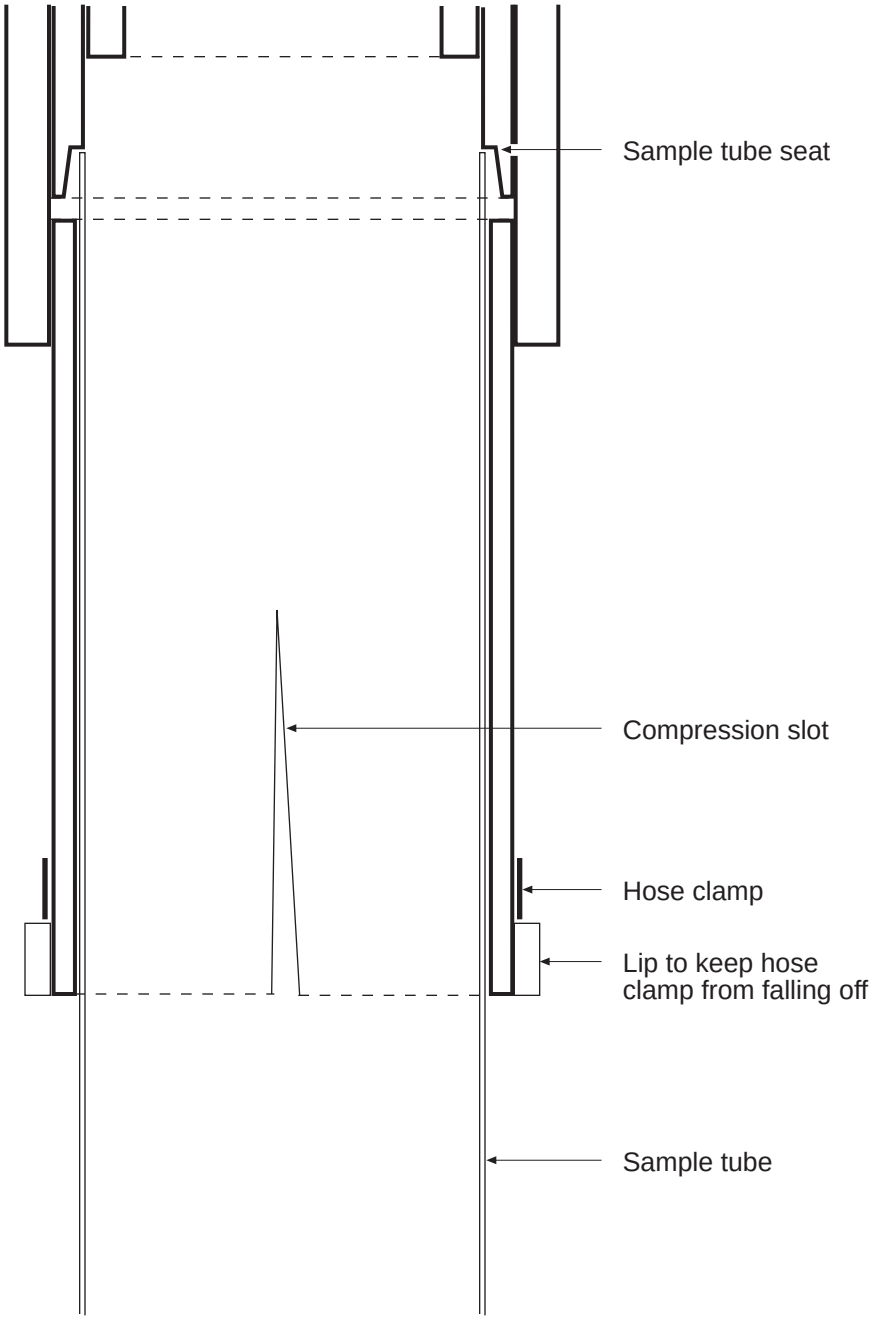

Figure SD-10-4. Detail of sample tube holder.

Core tubes can vary in length from about 70 to 200 cm. The core tube should be about 50 cm longer than the sample length needed to provide for overlying water and errors in the depth driven. It is desirable to have about 20 to 30 cm of water overlying the sediment in the core tube. The overlying water provides a buffer that reduces agitation of the surfical sediments when handling the core tube.

The corer should be pushed into the sediments deeper than the length of core needed. If the sediments are soft, it is possible to over penetrate and run the sediment–water interface up into the valve. A long core tube will help prevent such an occurrence. For the tube to retain the sample, the minimum sample length is about 3 to 4 times the diameter depending on the sediment type.

DECONTAMINATION

To prevent potential cross-contamination of samples, all reusable sediment sampling equipment will be decontaminated. Before each station is sampled, decontaminate the inner surfaces of the corer or core tube liner and all stainless-steel sample compositing equipment. Details on correct decontamination procedures can be found in SOP SD-01, *Decontamination of Equipment—Sediments.* The project-specific field sampling plan (FSP) should also be consulted to determine any project-specific decontamination procedures. The personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific health and safety plan.

All solvent rinsates (if used) will be collected into a bucket or tub and allowed to evaporate over the course of the day. Any rinsate that has not evaporated by the end of the sampling event will be containerized and disposed of in accordance with federal regulations.

INSTRUCTIONS

1. **Prepare the Corer—**Before using the corer, inspect it for worn or broken parts, and repair as necessary.

    1.1 Clean the corer; sandy material in particular can foul the valve and other seals. If the corer has been used in a sandy area, sand caught on the seat might prevent the valve from sealing. To clean the valve, run or spray water through it while repeatedly opening and closing the valve. Test the valve for leaks by releasing the valve cord and pouring water into the top of the corer and watching for leakage. No more than about 1 mL per minute should leak.

    1.2 Insert a core tube into the corer barrel and push it in until you feel the top end of the tube contact the sealing ring at the top of the corer barrel. To seat the tube, push it hard for about a tenth of an inch; you will feel it seat into position. If the bottom edge of the core tube is

beveled to improve cutting action, make sure the tube is not upside down. Tighten the hose clamp at the bottom of the barrel so that the core tube cannot be rotated by hand within the corer barrel. Make sure that the drive rod is tightly screwed into the adapter.

2. **Measure the Water Depth—**Measure the water depth to within about a foot of the true depth, using a weighted measuring tape or sonar.

   You will need to know the depth so you can attach the correct length drive rods and so you can determine how close the corer is to the sediment as it is being lowered.

3. **Drive the Corer**

   3.1 While keeping the valve open with the valve line, lower the corer and keep adding drive rods until the corer is near the sediment. Only a couple pounds of lifting force is required to keep the valve open, so do not lift too hard on the valve line. With the corer and drive rods hanging vertically, lower the corer slowly until you feel it contact the sediment, and then with one smooth motion, push the corer into the sediment. Be careful to push vertically on the corer. If the platform moves laterally and the drive rods are at an angle, attempting to drive the corer may damage it.

   3.2 After the corer is driven to the desired depth, release the valve cord so the valve closes.

4. **Retrieve the Corer—**After the valve is closed, the corer can be retrieved; retrieval is best done with two people.

   4.1 Lift steadily on the drive rods until you feel the corer break loose from the sediments. As the corer approaches the water surface, have a rubber stopper ready to place in the bottom of the core tube. If the sediments are sandy and the samples tend to erode from the bottom of the tube as it is lifted through the water column, it may be necessary to keep the corer submerged just below the surface while another person reaches underwater and places the stopper in the tube. If sampling is performed from a large boat that has a lot of free-board, it may be necessary to have someone near the water level on a skiff to insert the stopper. While the corer is being lifted onboard, support the rubber stopper so that it and the sample do not fall out.

   4.2 After the corer is onboard, seat the stopper so it is entirely inside the core tube by placing a second stopper on the deck and pushing the corer down on top of it. Keep the corer vertical at all times to prevent the sample from shifting, and avoid rapid movements that can disrupt the interface.

5. **Remove the Core**

   5.1 As a second person holds the corer vertical and keeps the valve open, loosen the hose clamp at the bottom of the core barrel and hold the bottom of the core tube firmly against the deck.

   5.2 While holding the core tube, have the second person lift the corer off the tube. If the tube is seated very firmly in the barrel from the force of driving the corer, twist the barrel slightly while lifting it off the tube to break it loose. It is best to rotate the barrel, not the core tube, because when it breaks loose, the rapid rotation of the core tube may disrupt the sediment–water interface. As the core barrel is lifted off the tube, the water in the valve assembly will spill. Before moving or lifting the core tube, seal the top of the core tube with a test plug.

   5.3 Inspect the sample for acceptability. The following acceptability criteria should be satisfied:

   - The sampler is not overfilled with sample so that the sediment surface presses against the top of the sampler or is extruded through the top of the sampler
   - Overlying water is present
   - The overlying water is not excessively turbid (indicates minimal disturbance)
   - The desired penetration depth is achieved (see project-specific FSP for required penetration depth)

   5.4 If possible, extrude and section the sample immediately in accordance with SOP SD-08, *Sediment Coring Procedures Using Slide-Hammer and Gravity Corers*. Immediate extrusion and sectioning is essential if the sample is to be analyzed for redox-sensitive elements. Oxygen diffuses through the polycarbonate core tube and oxidizes ferrous iron in the pore water. This process is fairly rapid, and an orange iron oxide precipitate will visibly form on the inside walls of the core tube within a day. There is some evidence that this oxidation does not extend more than a couple millimeters into the sample. If the sample cannot be extruded immediately, keep it cool and out of the sun by refrigerating it or wrapping it with aluminum foil.

SAMPLE REMOVAL AND PROCESSING

1. For acceptable samples, remove the overlying water by slowly siphoning it off near one or more sides of the corer. Ensure that the siphon does not contact the sediments or that fine-grained suspended sediment is not siphoned

off. If sediment is suspended in the overlying water, do not proceed with siphoning until the sediment is allowed sufficient time to settle.

2. After the overlying water is removed, characterize each sampling interval as specified in the study design. Characteristics that are often recorded in the field logbook include:

   - Sediment type (e.g., silt, sand)
   - Texture (e.g., fine-grain, coarse, poorly sorted sand)
   - Color
   - Presence/location/thickness of the redox potential discontinuity layer (a visual indication of black is often adequate for documenting anoxia)
   - Approximate percentage of water
   - Presence of biological structures (e.g., chironomids, tubes, macrophytes)
   - Presence and approximate percentage of biological structures, organic debris
   - Stratification, if any
   - Presence of a sheen
   - Odor (e.g., hydrogen sulfide, oil, creosote).

3. After the sample is characterized, remove the specified sampling interval using a stainless-steel spatula or spoon (see project-specific FSP for correct sampling interval). Unrepresentative material (e.g., large shells, stones) should be carefully removed without touching the sediment sample under the supervision of the field team leader and noted in the field logbook.

4. Remove subsamples for analysis of unstable constituents (e.g., volatile organic compounds, acid-volatile sulfides), and place them directly into sample containers without homogenization. Sediment must be placed in these containers with no headspace and no entrapped bubbles (i.e., completely fill the sample container).

5. Transfer the remaining surface sediment to a stainless-steel mixing bowl or pot for homogenization. Additional sediment may be required to collect the volume of sediment specified in the project-specific FSP. If it is necessary to collect multiple cores at a station to meet the project-specific volume requirements, then the mixing bowl or pot should be covered with aluminum foil (dull side down) to prevent sample contamination (e.g., from precipitation, splashing water).

6. After removing the sediment from the corer, move the sampling vessel away from the station and discard this material away from the station, and rinse away any sediment adhering to the inside of the corer. The corer is now ready for additional sampling at the same station or decontamination before sampling at a new station.

7. After a sufficient volume of sediment is transferred to the mixing bowl or pot, homogenize the contents of the bowl or pot using stainless-steel spoons until the texture and color of the sediment appears to be uniform.

8. After the sample is homogenized, distribute subsamples to the various containers specified in the study design and preserve the samples as specified in the study design. The sediment in the mixing bowl or pot should be briefly stirred in between each spoon transfer to the sample containers.

9. After all sediment for testing has been placed in the sample containers, if it is suspected that there is a clay component to the layer of sediment, a "ribbon test" should be performed on the sediment collected from this layer to confirm this suspicion. In this "texture-by-feel" test, a small piece of suspected clay is rolled between the fingers while wearing protective gloves. If the piece easily rolls into a ribbon it is clay; if it breaks apart, it is silt. This information should be noted in the field logbook.

FIELD QUALITY CONTROL SAMPLES

Details on collection of field quality control samples (e.g., field duplicates) will be specified in the project-specific FSP. Details on collection of field quality control samples and preparation of the certified reference materials can be found in SOP SD-02, *Preparation of Field Quality Control Samples—Sediment* and SOP SD-03, *Preparation of Reference Materials—Sediment*. Not all of the field quality control samples discussed in this SOP may be required for a given project. The specific field quality control samples will be described in the project-specific FSP and quality assurance project plan (QAPP).

FIELD MEASUREMENTS

A water depth measurement must be collected at every sampling location. Depending on the specific project objectives, it may be necessary to perform field measurements of the *in situ* environment. Possible field measurements include temperature and pH of the sediment at the sediment-water interface and concentration of dissolved oxygen, salinity, or conductivity in the overlying water. Details on collection of field measurements can be found in SOP SD-11, *Field Analyses for Sediment.* The specific field measurements, if any, will be specified in the project-specific FSP.

STATION LOCATION COORDINATES

At a minimum, station locations for all field sampling will be determined using a differential global positioning system (DGPS), which is capable of providing latitude and longitude coordinates with an accuracy of approximately 3 m. More accurate determination of position may be required by the project FSP. Details on collection of field station coordinates can be found in SOP GEN-04, *Station Positioning Using the Trimble Pathfinder Pro XRS*.

SAMPLE CUSTODY AND SAMPLE SHIPPING

Sample custody will be maintained in accordance with procedures outlined in SOP GEN-02, *Sample Custody*. All samples will be packaged and shipped with other samples in accordance with procedures outlined in SOP GEN-03, *Sample Packaging and Shipping*.

TROUBLESHOOTING

Problem 1: The Corer Is Not Retaining the Sample

There are two possible causes for this problem. One is that the sediments are sandy and not cohesive so they do not stick to the core tube walls or themselves. As a result, the core erodes from the bottom as it is lifted through the water. This problem can be solved in several ways.

- Drive the corer deeper into the sediments, where there may be a more cohesive layer. It is not unusual for a fine-grained cohesive layer to lie below coarser layers.
- Place a stopper in the bottom of the tube as soon as possible using one of two methods: 1) use a rod that holds the stopper in the correct position, maneuver the rod below the tube, and lift it up to insert the stopper, or 2) have a diver insert the stopper.
- Use a smaller diameter corer so there is relatively more cohesion of the sediment with the walls.

The second possible cause is a leak in the suction of the corer that allows the whole core to start slipping out of the core tube. There are two places where the suction can be lost: the valve, and the seat between the core barrel and the core tube. Inspect and clean both the valve and the seat, and check to be sure that the valve is not stuck in the open position.

Problem 2: The Sediment Interface Is Not Distinct

There are several possible causes for this problem. One is that the bottom end of the core tube was moving horizontally when it first contacted the sediments. Further evidence of this cause is if the sediment interface is tilted. In this case, make sure the platform is not moving and that the corer and drive rods are allowed to hang vertically just before driving the corer. Another common cause is the formation of gas bubbles in the sediments of productive or eutrophic systems. When a corer is pushed into this type of sediment, bubbles are released that entrain and resuspend sediment. There is no easy solution to this problem other than to let the resuspended sediment settle before processing the sample. Another possible cause is rough handling of the sample.

Problem 3: The Core Recovery Is Low

Little can be done to prevent bypass/compaction other than to use a piston corer. However, the amount of bypass/compaction can be quantified. One easy method is to apply Velcro® tape to the outside of the corer barrel and determine the depth of penetration by noting where sediment is caught in the Velcro®.

Note: *SOP SD-18 cited within.*

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SOP SD-19
FIELD CLASSIFICATION OF SEDIMENT

This SOP presents the field classification of sediments to be used by Exponent field staff. Sediment descriptions should be precise and comprehensive without being verbose. Assumptions and personal comments should not be included in the sediment descriptions. These descriptions will be used to interpret environmental conditions and other potential properties, rather than the exact mineralogy or tectonic environment.

Sediment descriptions should be recorded in either the observing scientist's field logbook, or if subsurface sediment is collected, then the sediment description column of the Field Sediment Core Form (see SOP SD-18, *Logging of Sediment Cores*; Attachment SD-18-1) should be completed for each core collected. If no difference between consecutive sediment samples exists, subsequent descriptions can be noted as "same as above," or minor changes such as "increasing sand" or "becomes dark brown" can be added.

After the overlying water is removed, characterize the sediment. Sediment characteristics that are often recorded in the field logbook or the Field Sediment Core Form (see SOP SD-18; Attachment SD-18-1) if subsurface sediment is collected, include:

- Sediment type (e.g., silt, sand)
- Texture (e.g., fine-grain, coarse, poorly sorted sand)
- Color
- Presence/location/thickness of the redox potential discontinuity layer (a visual indication of black is often adequate for documenting anoxia)
- Approximate percentage of moisture
- Presence of biological structures (e.g., chironomids, tubes, macrophytes) and the approximate percentage of these structures
- Presence of organic debris (e.g., twigs, leaves) and the approximate percentage of debris
- Presence of shells and the approximate percentage of shells
- Stratification, if any
- Presence of a sheen
- Odor (e.g., hydrogen sulfide, oil, creosote).

In addition, the project-specific field sampling plan should be reviewed to determine if there are any project-specific reporting requirements.

In general, the similarities of consecutive sediment samples should be noted. Examples of surface sediment descriptions are provided in Table SD-19-1. The minimum elements of the sediment descriptions are discussed below. The format of sediment descriptions for each sample should be consistent throughout the logbook.

Table SD-19-1. Example of surface sediment sample descriptions

Station No.	Grab No.	Example Descriptions
SW01	1	SILT, mottled dark gray (10YR 4/1) with thin layer < 1 cm of very pale brown (10YR 7/4) on surface. Occasional roots, some twigs, and leaves on surface. Slight reducing odor. Sheen on overlying water in grab.
SW02	1	Sandy SILT, fine sand, dark gray (10YR 4/1) throughout grab, with 10 percent medium to coarse sand, trace woody debris. Chironomid on surface.
SW02	2	Same description as first grab at Station SW02.
SW02	3	Same description as first grab at Station SW02, but no sand (SILT only) and color is very dark gray (10YR 3/1) with no chironomid present.

DEFINITIONS OF SEDIMENT TYPES

Fine-grained sediments are classified as either silts or clays. Field determinations of silts and clays are based on observations of dry strength, dilatancy, toughness, and plasticity. Field procedures for these tests are included in ASTM D-2488-84. If these tests are used, the results should be included in the sediment description. Sediments with high plasticity can be emphasized by describing them as "silty CLAY with high plasticity." Plasticity is an important descriptor because a sediment can be dilatant/nonplastic and serve as a transport pathway, or it can be highly plastic and very impervious.

Coarse-grained sediments are classified as predominantly sand. The gradation of a coarse-grained sediment is included in the specific sediment name (i.e., fine to medium SAND with silt). Estimating the percentage of size ranges following the group name is encouraged for mixtures of silty sand and sand. If applicable, use the modifiers "poorly graded" or "well graded" when describing the sand component of the sediment.

COLOR

The basic color of a sediment, such as brown or gray, must be provided in the description. The color term can be modified by adjectives such as light, dark, or very dark. Especially note streaking or mottling. The color chart designations provided in *EarthColors: A Guide for Soil and Earthtone Colors* is the Exponent color standard for sediment. If *EarthColors* is not available, then a Munsell color guide can be used.

MOISTURE CONTENT

The degree of moisture present in the sediment should be defined as moist, wet, or very wet. The percent moisture content should be estimated.

OTHER COMPONENTS

Other components, such as organic debris and shell fragments, should be preceded by the appropriate adjective reflecting relative percentages: trace (0–5 percent), few (5–10 percent), little (15–25 percent), and some (30–45 percent). The word "occasional" can be applied to random particles of a larger size than the general sediment matrix (i.e., occasional stone, large piece of wood).

ADDITIONAL DESCRIPTIONS

Features such as sloped surface in the grab, root holes, odor, and sheen should be noted if they are observed. Anything unusual should be noted. Additional sediment descriptions may be made at the discretion of the project manager or as the field conditions warrant.

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SOP SL-09
FIELD CLASSIFICATION OF SOIL

This SOP presents the field classification of soils to be used by Exponent field staff, which has been adopted from ASTM D-2488-84 (see SOP SL-10, *Logging of Soil Boreholes*, Attachment SL-10-2). ASTM D-2488-84 uses the Universal Soil Classification (USC) system for naming soils. Field personnel are encouraged to study these procedures. Soil descriptions should be precise and comprehensive without being verbose. The overall impression of the soil should not be distorted by excessive emphasis on minor constituents. In general, the similarities of consecutive soil samples should be emphasized and minor differences de-emphasized. These descriptions will be used to interpret aquifer properties and other potential contaminant transport properties, rather than the exact mineralogy or tectonic environment.

Soil descriptions should be provided in the Soil Description column of the Field Borehole Log Form (Attachment SL-10-1) for each sample collected. If no difference between consecutive soil samples exists, subsequent descriptions can be noted as "same as above," or minor changes such as "increasing sand" or "becomes dark brown" can be added.

The format of soil descriptions for each sample or identified stratigraphic layer/soil horizon should be as follows:

1. Group symbol—The group symbol should be placed in the Unified Symbol column
2. USC group name—The USC name should be identical to the ASTM D-2488-84 Group Name with the appropriate modifiers
3. Minor components
4. Color
5. Moisture
6. Additional descriptions.

Examples of soil descriptions are provided in Table SL-09-1. The minimum elements of the soil descriptions are discussed below.

TABLE SL-09-1. EXAMPLE OF SOIL SAMPLE DESCRIPTIONS

SM	Silty fine to medium SAND, with trace fine gravel, and occasional roots, very dark gray, moist to wet
SW-SM	Fine to coarse SAND with silt, some fine gravel, mottled dark gray and tan, moist. Sand consists of 20 percent biotite flakes, no bedding observed
ML	Sandy SILT, fine sand, dark gray, moist. Fractures predominantly vertical, at 1–3-in. spacing.
GW	Fine to coarse GRAVEL with 10 percent medium to coarse sand, trace woody debris, gray, moist to wet. Reddish brown staining noted within 2 ft of water table. Gravel is rounded and flat. River deposits.

DEFINITIONS OF SOIL TYPES

Table SL-09-2 presents the USC system. The USC system is an engineering properties system that uses grain size to classify soils. The first major distinction is between fine-grained soils (more than 50 percent passing through the No. 200 sieve [75 μm/0.029 in.]) and coarse-grained soils (more than 50 percent retained by the No. 200 sieve).

TABLE SL-09-2. SOIL CLASSIFICATION SYSTEM

Major Divisions			Group Symbol	Group Name
Coarse-Grained Soils	**Gravel**	Clean	GW	Well-graded gravel, fine to coarse gravel
	More than 50 percent of	Gravel	GP	Poorly graded gravel
	coarse fraction retained on	Gravel with	GM	Silty gravel
More than	No. 4 sieve	Fines	GC	Clayey gravel
50 percent	**Sand**	Clean	SW	Well-graded sand, fine to coarse sand
retained by	More than 50 percent of	Sand	SP	Poorly graded sand
No. 200 sieve	coarse fraction passes	Sand with	SM	Silty sand
	No. 4 sieve	Fines	SC	Clayey sand
Fine-Grained Soils	**Silt and Clay**	Inorganic	ML	Silt
			CL	Clay
	Liquid limit <50	Organic	OL	Organic silt, organic clay
More than 50	**Silt and Clay**	Inorganic	MH	Silt of high plasticity, elastic silt
percent passes			CH	Clay of high plasticity, fat clay
No. 200 sieve	Liquid limit ≥50	Organic	OH	Organic clay, organic silt
Highly organic soils			PT	Peat

Note: Field classification is based on visual examination of soil in general accordance with ASTM D-2488-84.

Soil classification using laboratory tests is based on ASTM D-2487-83.

Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

Liquid limit is the water content of soil-water where the consistency changed from plastic to liquid.

Fine-grained soils are classified as either silts or clays. Field determinations of silts and clays are based on observations of dry strength, dilatancy, toughness, and plasticity. Field procedures

for these tests are included in ASTM D-2488-84. If these tests are used, the results should be included in the soil description. At least one complete round of field tests should be performed for a site if these fine-grained materials are encountered, preferably at the beginning of the field investigation. The modifiers "fat" and "lean" are used by ASTM to describe soils of high and low plasticity. The soil group symbols (e.g., CL, MH) already indicate plasticity characteristics, and these modifiers are not necessary in the description. Soils with high plasticity can be emphasized by describing them as "silty CLAY with high plasticity." Plasticity is an important descriptor because it is often used to interpret whether an ML soil is acting as either a leaky or competent aquitard. For example, an ML soil can be dilatant/nonplastic and serve as a transport pathway, or it can be highly plastic and very impervious.

Coarse-grained soils are classified as either predominantly gravel or sand, with the No. 4 sieve (4.75 mm/0.19 in.) being the division. Modifiers are used to describe the relative amounts of fine-grained soil in a sample, as noted below:

Description	Percent Fines	Group Symbol
Gravel (sand)	<5 percent	GW, GP (SW, SP)
Gravel (sand) with silt (clay)	5–15 percent	Hyphenated names
Silt (clayey) with gravel (sand)	>15 percent	GM, GC (SM, SC)

The gradation of a coarse-grained soil is included in the specific soil name (i.e., fine to medium SAND with silt). Estimating the percentage of size ranges following the group name is encouraged for mixtures of silty sand and gravel. Use of the modifiers "poorly graded" or "well graded" is not necessary because they are indicated by the group symbol.

A borderline symbol is shown with a slash (GM/SM). This symbol should be used when the soil cannot be distinctly placed in either soil group. A borderline symbol should also be used when describing interbedded soils of two or more soil group names when the thicknesses of the beds are approximately equal, such as "interbedded lenses and layers of fine sand and silt." The borderline symbol should not be used indiscriminately. Every effort should be made to place the soil into a single group.

MINOR COMPONENTS

Minor components, such as cobbles, roots, and construction debris, should be preceded by the appropriate adjective reflecting relative percentages: trace (0–5 percent), few (5–10 percent), little (15–25 percent), and some (30–45 percent). The word "occasional" can be applied to random particles of a larger size than the general soil matrix (i.e., occasional cobbles, occasional brick fragments). The term "with" indicates definite characteristics regarding the percentage of secondary particle size in the soil name. It will not be used to describe minor components. If a non-soil component exceeds 50 percent of an interval, it should be stated in place of the group name.

COLOR

The basic color of a soil, such as brown, gray, or red, must be given. The color term can be modified by adjectives such as light, dark, or mottled. Especially note staining or mottling. This information may be useful to establish water table fluctuations or contamination. The Munsell soil color chart designation is the Exponent color standard. All color designations must be accompanied by a description of the moisture content of the soil when the color designation was made. It is generally preferable to determine color on moist samples; water may be added to the soil to achieve this moisture content.

MOISTURE CONTENT

The degree of moisture present in the soil should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed in Table 3 of ASTM D-2488-84.

ADDITIONAL DESCRIPTIONS

Features such as discontinuities, inclusions, joints, fissures, slickensides, bedding, laminations, root holes, soil animals, and major mineralogical components should be noted if they are observed. Anything unusual should be noted. Additional soil descriptions may be made at the discretion of the project manager or as the field conditions warrant. The Field Borehole Log Form lists some optional descriptions, as does Table 13 of the ASTM standard. The reader is referred to the ASTM standard for procedures for these descriptions.

CONTACTS BETWEEN SOIL TYPES

The contact between two soil types must clearly be marked on the soil borehole log because it is very difficult to interpret borehole logs where soil sample descriptions change over a 5- or 10-ft sample interval if there is no indication of where this change occurred. If the contact is obvious and sharp, draw it in with a straight line. If it is gradational, a slanted line over the interval is appropriate. In the case where it is unclear, a dashed line over the most likely interval is used.

Note: SOPs GW-07 and SW-15 cited within.

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SOP SL-15
FIELD LABORATORY MEASUREMENT OF SOIL SLURRY pH AND CONDUCTIVITY

FIELD LABORATORY PROCEDURES

1. Maintain pH and conductivity meters under appropriate conditions, as specified by the manufacturers.
2. If appropriate, allow meters to warm up before taking measurements.
3. Weigh out 20 g of field-moist soil sample. Place the sample in a 100-mL beaker.
4. Add 20 mL of distilled water from a 50-mL graduate cylinder, or weigh 20 g of distilled water, and add to sample.
5. Work water into soil using a glass stirring rod or rubber spatula. Disperse clumps and stir vigorously for 1 minute.
6. Allow mixture to settle for 30 minutes.
7. Measure temperature of supernatant. Adjust pH meter temperature compensator as appropriate.
8. Measure pH of supernatant to nearest 0.1 unit. Remove pH probe.
9. Immediately rinse solids from pH electrodes with a stream of distilled water.
10. Measure conductivity of supernatant, record to nearest 10 μm.
11. Rinse conductivity probe several times with distilled water.

INSTRUMENT CALIBRATION

1. Calibrate pH meter with two buffers before measuring each batch of slurries in accordance with SOP GW-07, *Field Measurements for Groundwater*.
2. Calibrate conductivity meter with standard KCl solution before measuring a batch of samples in accordance with SOP SW-15, *Field Measurement of Specific Conductance*.

Exponent®

SOP SW-13
FIELD ANALYSES FOR WATER

Several physical and chemical water parameters are best measured in the field because of the unstable nature of the parameter or because the information is needed to direct further sampling. It is frequently preferable to perform these analyses in the field, especially if the samples will not be immediately transported to the analytical laboratory (pH, in particular, should be measured in the field, if feasible). In addition, measurements of temperature and transparency can only be collected accurately in the field. Five parameter measurements for water are described in this SOP.

TEMPERATURE

Water temperature may be measured with either an alcohol or digital thermometer. It is recommended that mercury thermometers not be used to avoid possible breakage and introduction of mercury into the environment and to remove a source of possible contamination to samples collected for the analysis of mercury. Temperature should be measured as soon as the sample is collected to obtain a measurement that is an accurate representation of the *in situ* sample temperature. All instruments used to measure temperature should be traceable to a NIST temperature reference. In the case of digital thermometers, if there is a calibration procedure recommended by the manufacturer, it should be followed.

DISSOLVED OXYGEN

Dissolved oxygen may be measured in the field by either a dissolved oxygen meter and probe or by a field-portable Winkler titration kit. Samples should be protected from absorbing oxygen from the atmosphere by using a low or zero-headspace container. In using a meter and probe, the system should be calibrated according to the manufacturer's procedure prior to use with a zero oxygen standard and a second standard of known oxygen content. The second standard should be checked by performing a Winkler titration. When measuring dissolved oxygen with a meter and probe, the sample should be swirled or stirred constantly until the reading stabilizes and the measurement is recorded.

pH

The pH of a water column sample may be measured in the field using a pH meter. The meter should be calibrated according to manufacturer's specifications with at least two standards of known pH. The pH of these standards should bracket the expected pH at the sampling site. For example, if the pH at the sampling site is expected to be basic (pH 7 to 14), standards of pH 7.00

and 10.00 should be used to calibrate the meter. If pH measurements at the sampling site do not fall within the initial calibration range, the meter should be recalibrated with appropriate standards and sample pH remeasured for those samples that fell outside the calibration range. For more detailed procedures, see discussion in *Standard Methods for the Examination of Water and Wastewater* (APHA 1989).

TRANSPARENCY

Water column transparency is measured with a Secchi disk, which is a weighted, black-and-white or all-white disk that is lowered into the water body on a calibrated rope or line. Measurement should be performed from the side of the boat that faces away from the sun. The disk is lowered slowly until it is no longer visible and then raised until it is visible again. The depth, measured from the water surface, is recorded in feet or meters. The all-white disk may be preferable when the water transparency is high. Either disk, however, is acceptable to use.

TURBIDITY

Turbidity may be measured in the field with a field-portable nephelometer (turbidity meter). The meter should be calibrated prior to use with at least two standards of different but known turbidity (in nephelometric turbidity units or NTUs). The two standards should bracket the range of turbidity measurements expected at the sampling site. When performing field analysis for turbidity, samples should be analyzed as soon as possible after collection. If immediate analysis is not possible, the sample should be agitated prior to analysis to resuspend any settled solid material. If the sample temperature increases, air bubbles may form and cause erroneous values. For more detailed procedures, see APHA (1989).

SALINITY OR CONDUCTIVITY

Salinity may be measured in the field with a salinometer, and conductivity with a conductivity meter. The meter should be calibrated prior to use according to the manufacturer's directions using a standard of known salinity (in parts per thousand) or conductivity. The salinity or conductivity of the standard should be close to the expected value at the sampling site. When measuring a sample for salinity or conductivity, the sample should be swirled or stirred until the meter is stabilized and a measurement is recorded. Salinity may also be calculated from the measured conductivity and temperature of a sample according to Standard Method 2520B (APHA 1989). Gross salinity measurements may also be taken with a field-portable refractometer. This instrument will provide salinity measurements with an accuracy of 1 to 2 parts per thousand. For more detailed procedures, see APHA (1989).

REFERENCE

APHA. 1989. Standard methods for the examination of water and wastewater. 17th Edition. L.S. Clesceri, A.E. Greenberg, and R.R. Trussell (eds). American Public Health Association, Washington, DC.