AOS PROTOCOL AND PROCEDURE: STABLE ISOTOPE SAMPLING IN SURFACE AND GROUND WATERS

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	11/21/2014	ECO-02430	Initial release
B	01/22/2015	ECO-02632	Migration to new protocol template
C	09/03/2015	ECO-03164	Aligning lake sampling with water chemistry protocol
D	01/21/2016	ECO-03423	Updates following FOPS review
E	02/07/2017	ECO-04367	2016 updates following FOPS training and reviews; updated template; Updated field replicate strategy; River stationID changed to 'c0', no longer 'rs'; Updated shipping info and data entry.
F	01/10/2018	ECO-05285	Clarified replicate wording to match updated SWC. Updated wording on lake inlet and outlet sampling to indicate only lakes with permanently flowing inflows and outflows will be sampled as inlet and outlet locations. Lakes without permanent inflows and outflows will only be sampled at buoy location. Updated shipping of H2O samples to every 2 months per CLA schedule, added barcode language

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1 OVERVIEW

1.1 Background

The following protocol outlines field sampling of stable isotope chemistry in aquatic environments (e.g., stream, rivers, ponds, lakes, and groundwater). Naturally occurring stable isotopes are useful ecological research tools. Isotopes are forms of the same element, differing in the number of neutrons in the nucleus. These different forms have similar chemical reactivity, but the different number of neutrons affects the weight of the element. While these elements have similar chemical reactions, the extra weight of the neutron can result in slower reactions than observed in the lighter isotope, resulting in a changing ratio of heavy to light isotope. This is known as fractionation.

Isotopes are measured as the fractional amount of heavy isotope (^{H}F) over the light (^{L}F) isotope, relative to a standard.

$$\delta = [(R_{sample}/R_{standard} - 1)] * 1000,$$

where $R = {}^{H}F/{}^{L}F$.

Common stable isotopes of ecological interest include nitrogen, carbon, oxygen, hydrogen and sulfur, which are useful in studying elemental cycling, food web dynamics, nutrient transfer and hydrological modeling (Fry 2008).

1.2 Scope

This document provides a change-controlled version of Observatory protocols and procedures. Documentation of content changes (i.e. changes in particular tasks or safety practices) will occur via this change-controlled document, not through field manuals or training materials.

1.2.1 NEON Science Requirements and Data Products

This protocol fulfills Observatory science requirements that reside in NEON's Dynamic Object-Oriented Requirements System (DOORS). Copies of approved science requirements have been exported from DOORS and are available in NEON's document repository, or upon request.

Execution of this protocol procures samples and/or generates raw data satisfying NEON Observatory scientific requirements. These data and samples are used to create NEON data products, and are documented in the NEON Scientific Data Products Catalog (RD[03]).

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain higher-level information that is implemented in the current document. Examples include designs, plans, or standards.

AD[01]	NEON.DOC.004300	EHS Safety Policy and Program Manual
AD[02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD[03]	NEON.DOC.000724	Domain Chemical Hygiene Plan and Biosafety Manual
AD[04]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[05]	NEON.DOC.004104	NEON Science Performance QA/QC Plan

2.2 Reference Documents

Reference documents contain information that supports or complements the current document. Examples include related protocols, datasheets, or general-information references.

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.002652	NEON Level 1, Level 2 and Level 3 Data Products Catalog
RD[04]	NEON.DOC.001271	NEON Protocol and Procedure: Manual Data Transcription
RD[05]	NEON.DOC. 002211	Datasheets for AOS Protocol and Procedure: Stable Isotope Sampling in Surface and Ground Waters
RD[06]	NEON.DOC.001646	General AQU Field Metadata Sheet
RD[07]	NEON.DOC.001152	NEON Aquatic Sample Strategy Document
RD[08]	NEON.DOC.002905	AOS Protocol and Procedure: Water Chemistry Sampling in Surface Waters and Groundwater
RD[09]	NEON.DOC.002494	Datasheets for AOS Shipping Inventory
RD[10]	NEON.DCO.004257	All Systems Standard Operating Procedure: Decontamination of Sensors, Field Equipment, and Field Vehicles

2.3 Acronyms

Acronym	Definition
Ah	Amp Hours
°C	Degrees Celsius
Cm	centimeter
DI	De-ionized
GF/F	Glass fiber filter
POM	Particulate Organic Matter
L	Liter
m	meter
mph	Miles per hour
mL	milliliter
	millimeter

um	micrometer
NEON	National Ecological Observatory Network

2.4 Definitions

Epilimnion: Top layer of water of a stratified lake, denoted by highest temperatures and least dense water in the summer.

Headspace: A gaseous space above a closed liquid sample.

Hydrograph: A diagram depicting the change in discharge (m^3/s) over a given time(s).

Hypolimnion: The dense bottom layer of a stratified lake that sits below the thermocline. This layer is denoted by cooler summer temperatures and slightly warmer winter temperatures relative to the epilimnion.

Isotope: An atom with the same number of electrons and protons, but different numbers of neutrons.

Stable isotope: Isotopes (i.e., atomic species) that do not undergo spontaneous radioactive decay.

Thalweg: The deepest part of a stream channel.

Thermocline: The vertical section of the lake where the rate of decrease in temperature with increasing depth is greatest. The denser and cooler layer below the thermocline is defined by the hypolimnion. The warmer upper layer is termed the epilimnion.

3 METHOD

The following protocol describes the collection, processing, storage and shipping of the stable isotopes $^{15}N/^{14}N$, $^{13}C/^{12}C$ of Particulate Organic Matter (POM) and $^{2}H/^{1}H$, $^{18}O/^{16}O$ of water samples from aquatic environments, including streams, rivers, and lakes. $^{2}H/^{1}H$, $^{18}O/^{16}O$ of water will also be sampled from groundwater.

Disruption of the sediments by walking or by sampling too close to the stream and lake bottom can contaminate samples. Thus, always sample upstream from wading activity and minimize the suspension of sediments when sampling. If sediments are disrupted, wait until the area has cleared before sampling.

In **wadeable and non-wadeable streams**, samples are collected in the deepest part of the channel (A.K.A. thalweg, the line of least resistance to water flow), where it is assumed that the stream channel is well mixed. The stream sampling location is located away from, or upstream of, any major local disturbances and other areas where NEON sampling activities commonly occur. Stable Isotope samples should be collected with water chemistry samples immediately downstream of Sensor Set 2 in **wadeable streams** and just downstream of the only sensor set (Sensor Set 1) in **non-wadeable streams** (Figure 1).

In streams with a shallow water column, technicians must be cautious not to disturb the benthic sediments when sampling.

In lakes, sample collection depends on lake depth and stratification, as detailed below (**Figure 3**). For all lakes, one sample is taken at 0.5 m (Kemmerer sampler should be placed with top at 0.25 m and bottom at 0.75 m) below the surface of the water from the buoy location. If the lake is stratified at the time of sampling, an additional sample will be collected from the hypolimnion at the buoy location (4 total samples). In lakes with **very** shallow hypolimnions (hypolimnion thickness <2 m) do not collect a hypolimnion sample. In lakes with shallow hypolimnions (hypolimnion thickness 2-4 m), the sample is collected from the mid-point of the hypolimnion. In lakes with deep (i.e thick) hypolimnions (hypolimnion thickness >4 m) an integrated sample is collected as described in the water chemistry protocol (RD[08], **Figure 3**). Note that if inlet and outlet streams are present, samples are collected just downstream of the inlet and outlet infrastructure, following the wadeable stream sampling design.

Groundwater well samples should be collected to align in space and time with the groundwater water chemistry samples (RD[08]). Groundwater samples are only sampled for H2O isotopes, no POM isotopes are collected from groundwater wells.

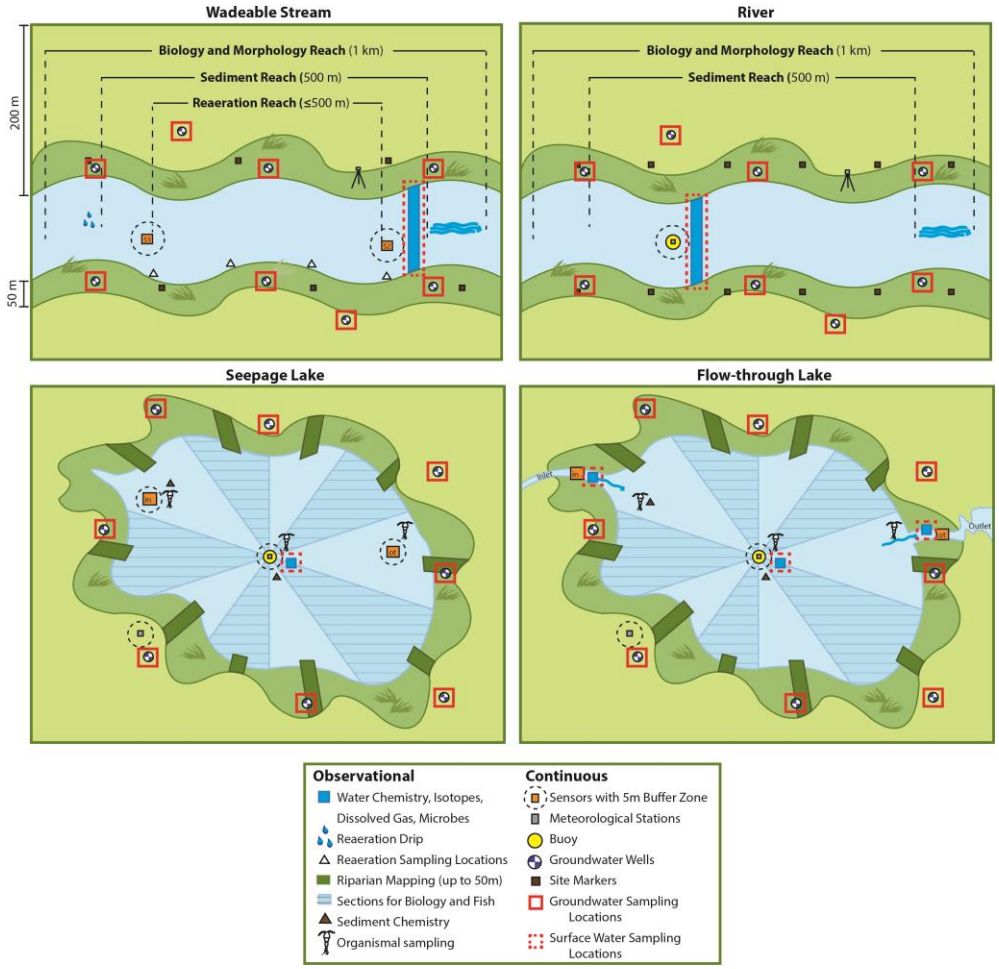


Figure 1. Generic site layouts for wadeable streams, rivers (AKA non-wadeable streams) and lakes surface water and groundwater sampling locations. Seepage lakes are lakes with no true inlet and outlet, while flow-through lakes have a true inlet and outlet.

Standard Operating Procedures (SOPs), in Section 7 of this document, provide detailed step-by-step directions, contingency plans, sampling tips, and best practices for implementing this sampling procedure. To properly collect and process samples, field technicians **must** follow the protocol and associated SOPs. Use NEON's problem reporting system to resolve any field issues associated with implementing this protocol.

The value of NEON data hinges on consistent implementation of this protocol across all NEON domains, for the life of the project. It is therefore essential that field personnel carry out this protocol as outlined in this document. In the event that local conditions create uncertainty about carrying out these steps, it is critical that technicians document the problem and enter it in NEON's problem tracking system. The procedures described in this protocol will be audited according to the Field Audit Plan (AD[05]).

During Operations, NEON will quantify measurement uncertainty on H2O samples (POM replicates are included in standard operating procedures) by collecting two (2) additional replicate H2O samples (total

of 3 samples) for external analysis on a minimum of 10% of samples. All sites (lakes, streams, and river) should conduct 3 replicate sampling events per year, for 6 additional H2O samples per year (10 additional samples in stratified lakes). In other words, during 3 sample bouts per year, 2 additional H2O samples will be collected at each sampling station. Replicates do not need to be collected on the same day as water chem replicates. Replicate sampleID convention for replicate H2O samples should be site.station.YYYYMMDD.H2O.2 and site.station.YYYYMMDD.H2O.3.

For lakes, only collect replicate samples at buoy stations. No replicates will be collected on groundwater samples. If your lake is stratified, replicates should be collected at c1 and c2, as these layers have very different environmental variability.

Quality assurance will be performed on data collected via these procedures according to the NEON Science QA/QC Plan (AD[06]).

4 SAMPLING SCHEDULE

4.1 Sampling Frequency and Timing

Isotope samples should be collected in conjunction with water chemistry samples. Science Operations will provide sample timing annually.

4.1.1 Wadeable and Non-wadeable Streams

In wadeable and non-wadeable streams and rivers, aquatic stable isotope sampling occurs up to 26 times per year. Standard recurrent stream and river sampling should take place one Tuesday per month (e.g., 12 times per year) in coordination with 'co-located' NEON atmospheric wet deposition chemistry sampling. The remaining 14 sampling dates are site specific and based on the cumulative discharge of the stream representing the increasing and decreasing periods of annual peak flow. Science Operations will provide sample-timing windows in domain specific sample strategy documents.

4.1.2 Lakes

In lakes, aquatic stable isotope sampling shall occur up to 12 times per year. Other than event based sampling, chemistry samples should be collected on Tuesday to coincide with other national chemistry sampling efforts (RD[07]). For lakes, the number of samples will vary with season, and depends on the timing of thermal stratification.

4.1.3 Groundwater Wells

For groundwater wells, a total of 8 samples per year per site will be sampled. Due to the limited number of samples available it is anticipated that a subset of wells will be sampled at multiple times per year (e.g., 4 wells sampled 2 times per year). This will allow for evaluation of seasonal responses in groundwater constituent concentrations (RD[08]). Sample timing will be site-specific, but in general, samples are targeted for the early spring and late fall (See Section 4.2 for detailed explanation on sampling criteria).

4.2 Criteria for Determining Onset and Cessation of Sampling

Stable isotope chemistry sampling occurs in conjunction with water chemistry sampling in streams, lakes and groundwater environment (RD[08]). The timing of sampling allows researchers to assess aquatic biogeochemical cycles, and therefore timing depends on the dominant driver(s) of nutrient flux and cycling within each system. Timing of sampling is site-specific and determined by rules developed using historical discharge for streams and environmental data for both streams and lakes (RD[07]). For example, streams with little or no flow during the summer dry-season or streams that are frozen during the winter are sampled more intensively during other periods that have more flow. Systems that have a snowmelt-dominated or storm-dominated flow regime are sampled more intensively during elevated flows, on both the rising and falling limb of the hydrograph (i.e., time periods when the majority of the nutrients are moving through the system), and sampled sporadically during times of baseflow (RD[07]). Stream systems that are heavily influenced by winter rains are sampled more frequently during the winter. Samples in lakes will be taken approximately monthly, with several samples being taken to capture major events such as ice-off, major storm, turnover and stratification.

Groundwater sampling dates are guided by the hydrologic cycle of the system that the site is located in. Samples are targeted for the early spring when the dominate precipitation events begin to increase the groundwater flow rate towards the aquatic system (stream, river, or lake); and for late fall when the production of surface constituents have had sufficient time to infiltrate into the groundwater. The timing of these seasons is site dependent, and the quantification mechanism is unique to the aquatic system. Sample timing will be defined by the cumulative discharge curve for streams and rivers, with the first sample occurring when the discharge is between 20-30%, and the second sample when the discharge is between 70-80% of the predicted annual cumulative discharge based on historic discharge data, when available. Sample timing for lakes will be similar to that of streams and rivers, but due to the lack of a discharge curve, the groundwater around the lakes will be sampled based on the lake level. The historic trends in annual lake level fluctuations, when available, will be used to define when the samples shall be collected. The first sample shall be obtained when the lake is 20-30% from its seasonal high level, and the second set of samples shall be collected when the lake level has reduced between 70-80% from its high level towards its seasonal low water level. When historical lake level data is not available, sample timing shall occur near the first and third biology sampling bouts, and will be coupled with the surface water chemistry sampling bouts. The timeframe for collecting samples will range from a 2-week to a 2-month window of time within which to align a groundwater chemistry sampling event with a surface water sampling event. This range is dependent on the discharge characteristics unique to each aquatic system.

4.3 Timing for Laboratory Processing and Analysis

Samples should be stored on ice (4°C) immediately after collection. Process (filter and store appropriately) surface and subsurface isotope samples as soon as possible, and within 4 hours of sample collection. For storage and shipping timelines see SOP F.

4.4 Sampling Timing Contingencies

Table 1. Contingent decisions for streams and lakes

Delay/ Situation	Action	Outcome for Data Products
Hours	If the stream water chemistry sampling location is too shallow to obtain a sample, sample upstream in a flowing section of the stream (always sample in the thalweg, if possible) and note this change on field sheet.	No adverse outcome.
	If no streamflow exists, sample in a nearby pool where the water is deep enough to obtain a clean, sediment free sample, and be sure to note this change in the field sheet as a "non-flowing sample."	No adverse outcome.
	If the stream is entirely dry or frozen solid, note that on the field sheet.	No adverse outcome.
	If the stream is ice-covered, but is still flowing, the ice should be broken so the stream can be sampled (following a few minute period to allow the water to clear).	No adverse outcome.
	If the lake is frozen only on the surface and safe to walk on (minimum of 15 cm thickness for walking and 20 cm thickness for use of UTV/snowmobiles, etc.) make a hole in the ice and proceed with sampling. The thickness of the ice shall be tested on the nearshore environment prior to walking on the lake, by drilling a hole in the ice and measuring the ice thickness and consistency (RD[08]).	No adverse outcome.
	If lake surface is frozen, and the lake has in-lake inlet and outlet sampling locations, only sample at buoy location. Lakes with inlet and outlet streams should follow stream ice recommendations for inlet and outlet locations.	No adverse outcome.
	If sampling stirred up sediments or added chemical constituents to the water within the past hour, allow the water to clear and disturbance to pass or sample in a different location.	No adverse outcome.
	If weather conditions deteriorate and the lake/non-wadeable stream becomes too windy (>20 mph) and has unsafe wave heights (>1 m) to hold the boat stationary over a sampling point, return to shore and wait in a safe location for 30 minutes. If wind subsides, resume sampling, if not, return to the Domain Support Facility and sample at another time.	No adverse outcome.

Table 2. Contingent decisions for groundwater

Delay/ Situation	Action	Outcome for Data Products
Hours	If temperatures are below freezing and water in the pump discharge line is freezing, stop sampling and reinitialize the sampling effort when ambient temperatures are above freezing. Since groundwater well sampling occurs at most twice a year, the events should be timed with above freezing weather conditions.	No adverse outcome.
	Should time become limited during chemistry sampling, collect water samples in 4-L jugs and return the samples on ice to the designated sample processing location to filter.	No adverse outcome.
	If water samples cannot be processed in situ, the filtration and preservation must be completed within 4 hours of sample collection. Samples must be kept cold (~4°C) to reduce nutrient transformation. Water jugs must be shaken before filtration to re-suspend particulates and homogenize water.	No adverse outcome.
	If when sampling a well following the low flow method, the well goes dry, turn off the pump and wait for groundwater to return to the well, then restart the pumping and collect groundwater for sampling.	No adverse outcome.
	Though wells are generally sited for slightly elevated locations, times will occur when standing water surrounds the base of the well. In this condition postpone sampling until the ground near the base of the well is free of standing water.	No adverse outcome.
Days – Months	If site conditions dictate that stream sampling is not possible due to the stream being dry, then postpone the groundwater sampling event until flow returns in the stream.	No adverse outcome.
	If a well goes dry, postpone the sampling event until the selected well has water again. If the well goes dry for an extended period of time, and the stream maintains flowing water, submit a trouble ticket so we can evaluate switching the selected well to a different well.	No adverse outcome
	In some locations, the groundwater level will drop below the bottom of the well either seasonally (e.g., Taiga and Tundra sites) or in periods of drought, which are likely to occur at some point during the life of the Observatory. Under these conditions sampling of groundwater is not possible.	No adverse outcome.
	For sites that have the “generation” of groundwater resulting from seasonal thawing of permafrost, sampling is targeted for times when the permafrost is sufficiently thawed to allow for collection of groundwater samples.	No adverse outcome.

4.5 Criteria for Permanent Reallocation of Sampling Within a Site

Aquatic stable isotope sampling will occur on the schedule described above at 1 (streams/rivers) and 3-4 (lakes) sampling stations per site. Ideally, sampling will occur at these sampling locations for the lifetime of the Observatory (core sites) or the duration of the site's affiliation with the NEON project (relocatable sites). However, circumstances may arise requiring that sampling within a site be shifted from one particular location to another. In general, sampling is considered to be compromised when sampling at a location becomes so limited that data quality is significantly reduced. If sampling at a given station becomes compromised, a problem ticket should be submitted by Field Operations to Science.

There are two main pathways by which sampling can be compromised. Sampling stations can become inappropriately suited to answer meaningful biological questions (e.g., a terrestrial sampling plot becomes permanently flooded or a stream moves after a flood and the location is no longer within the stream channel). Alternatively, sampling locations may be located in areas that are logistically impossible to sample on a schedule that that is biologically meaningful.

4.6 Sampling Specific Concerns

A groundwater chemistry sampling event must occur within a 2-week to a 2-month window of time to align with a stream sampling event. This range is dependent on the discharge characteristics unique to each stream. Groundwater well sampling can be time consuming; therefore, extending the groundwater chemistry sampling event over two days is acceptable. However, efforts should be taken to complete the sampling in one day. If site conditions dictate that stream sampling is not possible due to the stream being dry, then postpone the groundwater sampling event until flow returns in the stream. Additional information on Groundwater Sampling contingency planning can be found in the Groundwater Chemistry Sampling From Observation Wells (RD[08]).

Samples should be processed (filtered and/or frozen) as soon as possible. If necessary, surface water may be collected in a large container, kept on ice at 4℃, and filtered and/or preserved within 4 hours at a base camp or Domain Lab (i.e., if weather or other safety considerations dictate the need to get out of the field immediately and/or stream discharge is increasing quickly). Sample collection time and processing time must be recorded on the Aquatic Isotope Sampling Data Sheet (RD[05]).

Table 3. Sampling specific contingent decisions

Delay/ Situation	Action	Outcome for Data Products
If a groundwater well is damaged (i.e., casing is broken internally) or bent	Do not try to sample this well. It is likely that the pump may get stuck inside the well due to the limited tolerance between the pump and well casing. If this condition is observed submit a trouble ticket for a new well to be selected for sampling.	No adverse outcome.

5 SAFETY

This document identifies procedure-specific safety hazards and associated safety requirements. It does not describe general safety practices or site-specific safety practices.
Personnel working at a NEON site must be compliant with safe field work practices as outlined in the Operations Field Safety and Security Plan (AD[02]) and EHS Safety Policy and Program Manual (AD[01]). Additional safety issues associated with this field procedure are outlined below. The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop their work in unsafe conditions.

Activities in streams should only be performed when flow conditions are safe. Do not attempt to wade a stream where velocity x depth is ≥ 10 ft^2/s (0.93 m^2/s) (AD[02]). When working around ice, refer to (AD[02], Section 10.3 Winter Water Safety. Do not attempt to walk on frozen lake is depth of ice is less than 6" (+15cm) or operate UTV or snowmobile on frozen lake if depth of ice is less than 8" (20cm). Use caution and good judgment to carefully evaluate site conditions including ice strength. Local guidelines from natural resource officials, property owners or hosts, and domain managers should be consulted regarding work on ice, prior to deploying employees and equipment. Do not continue if the risk is too great.

In addition to standard safety training provided by NEON, the following safety requirements are applicable:

1. Due to site-specific hazards that may be encountered, technicians may perform GPS positioning around the lake, and measurements for inflow and outflow, without dismounting from the vessel. In addition, technicians are required not to put hands and feet in waters where alligators are present and to make sure a safe distance from hazards is maintained.
2. All personnel must be wearing a personal flotation device prior to entering the boat, and in wadeable streams when conditions are approaching the allowed wading limit (AD[02]).
3. All employees shall have access to a form of communication with other team members such as a two-way radio.
4. Technicians should be aware of any site-specific water hazards of that particular location (i.e., current status, tidal charts, etc.).
5. If personnel or loads will be on ice while performing their task for greater than 2 hours, all loads should be multiplied by 2 to determine safe ice thickness.
6. Access to Safety Data Sheet shall be available for work with chemicals (including Dry Ice) associated with this protocol.

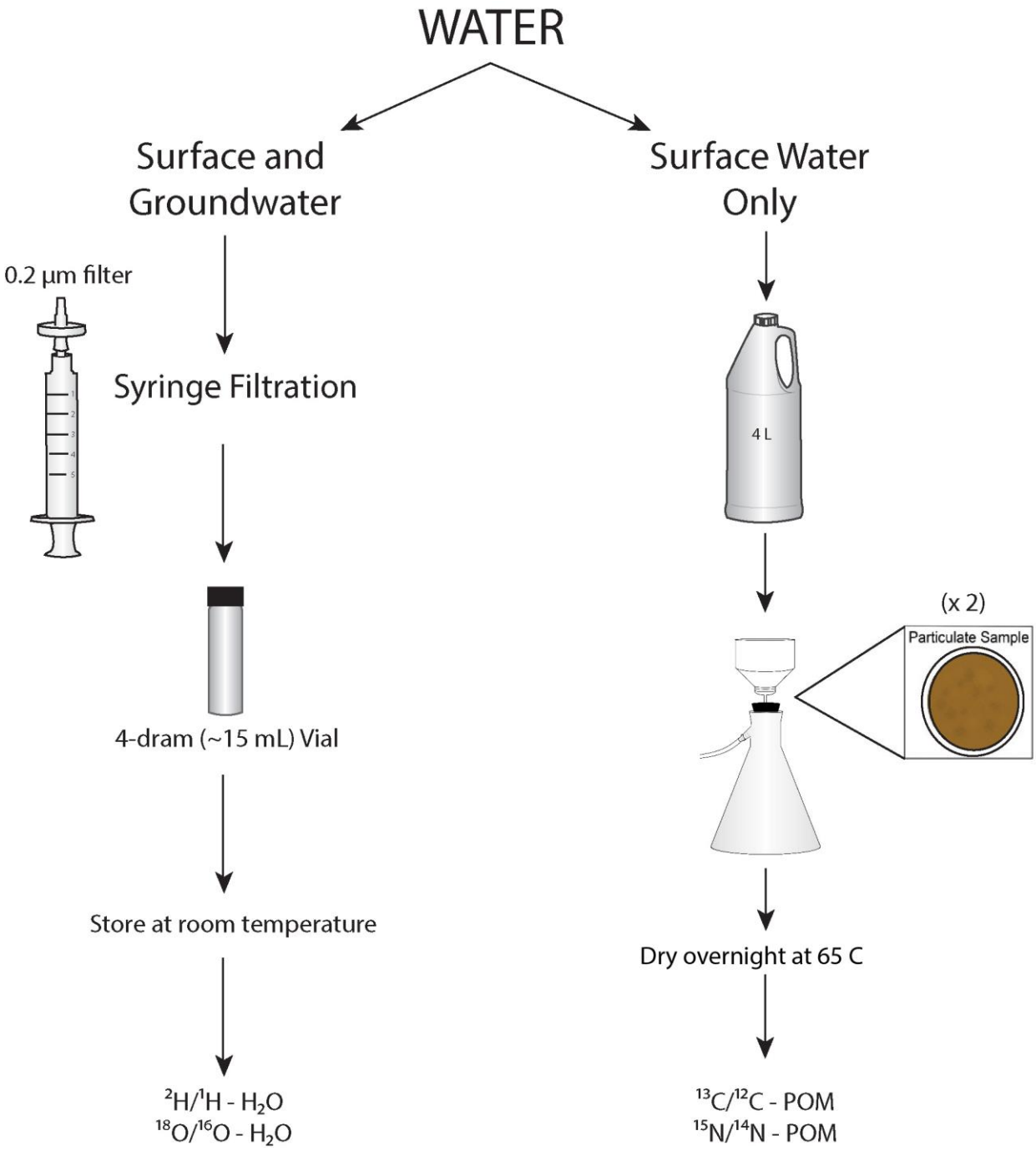


Figure 2. Diagram of isotope sample collection and equipment required per station. H2O sample should be ~90% full to prevent breakage from freezing during winter shipping. 2 filters are collected at each station per collection event. Note, lakes have multiple stations per collection event. For Groundwater well sampling, only the H2O sample is collected, no POM samples are collected from groundwater wells.

6 PERSONNEL AND EQUIPMENT

6.1 Equipment

The following equipment is needed to implement the procedures in this document. Equipment lists are organized by task. They do not include standard field and laboratory supplies such as charging stations, first aid kits, drying ovens, ultra-low refrigerators, etc.

Table 4. Equipment list – Surface and subsurface (groundwater) water isotope sampling

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
MX111388	CDW-G	4452963	R	Mobile data entry tablet, fully charged and synced before field work	Field data entry	1	N
MX100554	Thomas Scientific, Inc.	8939D81	R	60 mL syringe (numbers covered with clear packing tape)	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	1	N
MX106261	Thomas Scientific, Inc. Fisher Scientific Company, LLC	1227H00 14823220	R	5 mL syringe (numbers covered with clear packing tape)	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	1	N
GB08760000			R	Vacuum-pump filter manifold assembly, pre-made	Filtering samples	1	N
Part of GB08760000			R	Filter Unit and 25 mm, 200 mL funnel	Filtering samples – part of filter manifold assembly	1	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
				(Part #: 0341440000)			
Part of GB08760000			R	1 L Polypropylene vacuum flask (Part #: 0341520000)	Filtering samples – part of filter manifold assembly		N
Part of GB08760000			R	2 L Polypropylene vacuum flask (Part #: 0342980000)	Filtering samples – part of filter manifold assembly		N
MX111134	Amazon Capital Services Inc.	MV8510	R	Vacuum hand pump – back up to filtering manifold, metal handle	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering –	1	N
MX111135	Amazon Capital Services Inc.	MVM8900	S	Vacuum Hand Pump replacement parts	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1	N
MX100387	Fisher Scientific Company, LLC	975350	R	Filter forceps (flat ends)	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1	N
MX100391	Fisher Scientific Company, LLC	300742	R	Graduated cylinder, 250mL	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1	N
MX105571	Cole-Parmer Fisher Scientific Company, LLC Thomas Scientific, Inc.	EW0608953 0343814B 1212W94	R	Collection jug, 4L	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	1 per station	N
MX104512	Recreation Equipment Inc.	113008	R	First Aid Kit		1	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Consumable items							
MX108274	Fisher Scientific Company, LLC Thomas Scientific, Inc.	033433G 1231B94	R	Vial, 16 mL, 21 Dia. x 73 mm H., Black Phenolic Cap, 14B Rubber Liner Material, Clear, Glass; VWR or Equivalent	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	1	N
MX109591	Fisher Scientific Company, LLC	9719006	R	Syringe Filter, non-sterile, nylon, 0.2 µm pore size, 33 mm diameter	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	1* per station	N
MX100691	Fisher Scientific Company, LLC	1337412	R	Plastic Paraffin film (e.g., Parafilm)	$^{18}O/^{16}O$, $^{2}H/^{1}H$ of H_2O Collection	As needed	N
MX106350	Fisher Scientific Company, LLC	987464	R	GF/F filters (25 mm diameter, pre-ashed)	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	2 per station	N
MX100589	Grainger, W.W.	6CHG5	R	Aluminum foil squares (~4" X 4")	$^{15}N/^{14}N$, $^{13}C/^{12}C$ of POM Filtering	2	N
MX106268	Grainger, W.W. Amazon Capital Services Inc. Arrow SameDay	5NHH1 B00006IBUV 5520	R	Isotope waterproof labels (1" x 2 $^{5}/_{8}$"), pre-printed adhesive labels	Labeling samples, human readable	As needed	N
			S	Adhesive barcode labels	Labeling sample bottles	1	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
					with barcode-readable	sheet	
MX102002			R	Permanent markers	Labeling samples	1	N

R/S=Required/Suggested
* May require more than 1 per sample in turbid waters

Table 5. Equipment list – Additional equipment and consumables for surface water isotope sampling in lakes and rivers

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
MX100393	Fisher Scientific Company, LLC	EW0548610	R	Kemmerer sampler	Collecting samples	1	N
MX100364	Thomas Scientific, Inc. Cole-Parmer Fisher Scientific Company, LLC	1207W05 EW0640776 14171212	S	Tubing (1/8” ID)	Sample transfer from Kemmerer to syringe for H2O sample	1	N
MX108938			R	Ice auger	Drilling a hole in the ice	1	N
			R	Boat		1	Y

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
MX107097	Amazon Capital Services Inc.	B003ZZG5EM	R	Anchor with rope		2	N
MX100457			R	Oars		2	N
MX100458	West Marine Products, Inc.	13487178	R	Trolling Electric Motor		1	Y
MX100899	Grainger, W.W.	2UKJ5	R	Battery (12 volt)		1	Y
MX100435	Amazon Capital Services Inc.	B003QKQ4V0	R	Safety kit for boat (e.g., flares, bailer, float with rope)		1	Y
			R	Personal Flotation Devices (PFDs)		1 per person	N
			R	Waders or boots		1 pair per person	N
Consumable items							
				(none)			

R/S=Required/Suggested

Table 6. Equipment list – Additional equipment and consumables for sampling isotopes in groundwater

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
MX110049	In-Situ, Inc.	73310	R	Water level tape	Measuring water level	1	N
MX101740	Uline	S-7914	R	Clean 5 Gallon Bucket	Pumping sample water	1	N
MX105571	Cole-Parmer Fisher Scientific Company, LLC Thomas Scientific, Inc.	EW0608953 0343814B 1212W94	R	4-L jug	Collecting sample water	1 per well sampled	N
318830003	QED Environmental Systems	MPSP4P	R	QED Sample Pro Pump	Pumping sample water	1	N
318830001	QED Environmental Systems	MP50	R	QED MP-50 Compressor / Controller	Pumping sample water	1	N
			R	Key	Unlocking well	1	N
MX100899	Grainger, W.W.	2UKJ5	R	Battery (12V, minimum of 3.6 Ah)	Pumping sample water	2*	N
318830002	QED Environmental Systems	DTTP4B	R	Bucket of ¼" x ¼" dual bonded tubing (250 feet of tubing in each bucket). Tubing will be dedicated per each well for the	Pumping sample water	1 per site, required for 1st	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
				duration of the sampling events.		sampling event.	
318830002	QED Environmental Systems	DTTP4B	R	Dedicated tubing for wells (in 1-gallon bags). Make sure to get the tubing identified for the well that will be sampled. The sealable bags shall be labeled with the Well ID.	Pumping sample water	1 dedicated piece of tubing per well sampled (after 1st sampling event)	N
Consumable items							
				(none)			

R/S=Required/Suggested *Always take Extra batteries into field

Table 7. Equipment list – Sample field storage and shipping

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
Durable items							
			R	Shipping cooler	Shipping samples	1	N
			R	Dry ice shipping container	Shipping filters	1	N
Consumable items							
			R	Cardboard box	Shipping H_2O Glass Vials	As needed	N
			R	Packing material	Filling up extra space and adding absorbent material	As needed	N
MX104844	Grainger, W.W.	5LH30	R	Resealable plastic bags (gallon and quart size)	Separately enclosing the shipping labels, ice packs and samples	1	N
MX105088	Fisher Scientific Company, LLC	3532100	R	Ice or ice packs	Keeping the samples cool in field	As needed	N
MX105587	Grainger, W.W.	15F814 31HJ31	R	Clear Packing tape, roll	Labeling shipment	1	N
			R	Shipping labels	Labeling shipment and cooler return	2	N

Item No.	Supplier	Supplier ID	R/S	Description	Purpose	Quantity	Special Handling
MX100212			R	Dry ice	Shipping filters	1 lb.	Y

R/S=Required/Suggested

6.2 Training Requirements

All technicians must complete required safety training, and technicians must complete protocol-specific training for safety and implementation of this protocol as required in Field Operations Job Instruction Training Plan (AD[04]).

All personnel required to operate a boat shall be trained through a NEON Safety approved program (AD[02]). All others shall be aware of boating safety procedures.

6.3 Specialized Skills

Where applicable, personnel will be licensed to operate a boat and able to safely handle a motor and drive a boat safely.

6.4 Estimated Time

The time required to implement a protocol will vary depending on a number of factors, such as skill level, system diversity, environmental conditions, and distance between sample plots. The timeframe provided below is an estimate based on completion of a task by a skilled two-person team (i.e., not the time it takes at the beginning of the field season). Use this estimate as framework for assessing progress. If a task is taking significantly longer than the estimated time, a problem ticket should be submitted.

We estimate sampling requires 1-2 technicians for 1-2 hours each surface water sampling day plus travel to and from the site. We estimate 1 technician for 4-16 hours for groundwater wells (depending on the number of wells sampled during each bout).

7 STANDARD OPERATING PROCEDURES

SOP A Selecting Sampling Depth in Lakes

1. Take one sample at a 0.5-meter depth at buoy station.
2. Is the lake thermally stratified at buoy station?
   a. If NO, do not take any more samples.
   b. If YES, calculate the depth of the **hypolimnion** section (i.e. hypolimnion thickness) at the buoy. Ensure you are calculating the hypolimnion section depth (i.e. hypolimnion thickness), NOT the maximum lake depth and NOT the depth that the hypolimnion starts (**Figure 3**).
      1) If hypolimnion section depth (i.e. hypolimnion thickness) is <2 m, do not take any more samples.
      2) If hypolimnion depth/thickness > or = 2 m but < or = 4 m, then collect a sample from the midsection of the hypolimnion depth.
      3) If hypolimnion depth/thickness >4 m, then divide the hypolimnion depth by 2 and collect a sample in the midsection of both those layers. Integrate the samples from the hypolimnion into 1 sample.
3. Is there a true inlet and/or outlet to the lake (**Figure 1**a)?
   a. If No, do not take any more samples
   b. If Yes, collect samples just downstream of the inlet and/or outlet infrastructure, following the wadeable stream protocol.

In lakes, care must be taken to avoid contaminating the sample with re-suspended bed sediment. Such contamination may be minimized by anchoring the boat upwind (or upstream) of the sampling site, and using an anchor line 2-3 times as long as the depth of the lake or stream. Ensure that when anchoring in non-wadeable streams, the anchor and boat are within the permitted reach. If sediments are disrupted, wait until the area has cleared before sampling (~15 mins).

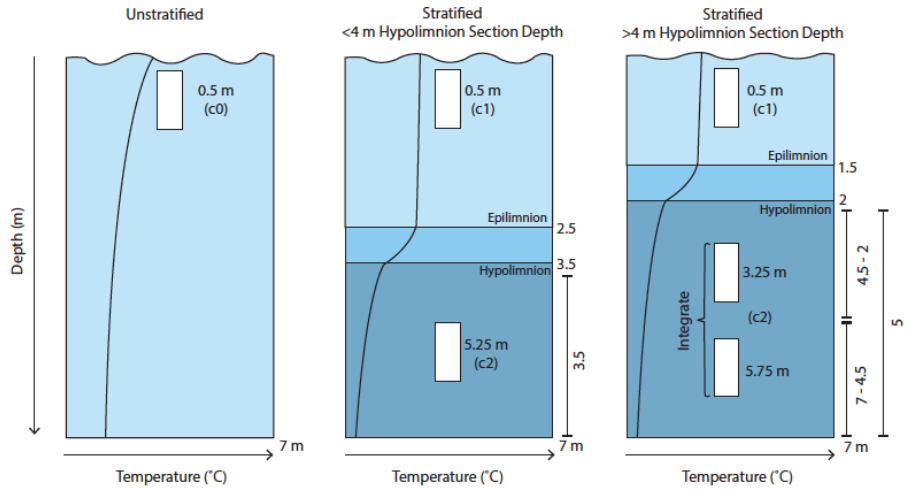


Figure 3. Examples of unstratified and stratified lake water column sampling depths with placement of thermocline. Note, hypolimnion sampling is determined by the hypolimnion section depth (i.e. thickness). If hypolimnion thickness is < 4m, collect one sample at midpoint of hypolimnion. if hypolimnion thickness is > 4 m collect an integrated sample.

SOP B Preparing for Sampling

B.1 Preparing for Data Capture

Mobile applications are the preferred mechanism for data entry. Mobile devices should be fully charged at the beginning of each field day, whenever possible. For detailed instructions on protocol specific data entry into mobile devices, see the NEON Internal Sampling Support Library (SSL).

However, given the potential for mobile devices to fail under field conditions, it is imperative that paper datasheets are always available to record data. Paper datasheets should be carried along with the mobile devices to sampling locations at all times.

B.2 Preparing for Sampling

1. Pre-ash GF/F filters:
   a. Place layers of 25 mm GF/F filters on aluminum foil. Use multiple layers of foil if needed, filters can be touching and placed on top of one another but should not be stacked more than 3 filters deep.
   b. Place in muffle furnace (500 °C) for at least 6 hours.

c. After the furnace has cooled, remove from the furnace and stack filters using filter forceps, and place in original box.
d. Label box with permanent marker to read “ASHED, Your Name, Date”.
e. Place box in in sealed zip-top bag.
f. Ashed filter may be stored indefinitely, as long as they remain in the box and stay dry.

2. Check the aquatic isotope field sampling kit to make sure all supplies are packed.
3. **Labels are waterproof but should be filled out before getting wet to ensure ink will stick to the labels.**
4. Attach pre-printed labels (**Error! Reference source not found.Error! Reference source not found.**).
5. SampleID: **site.stationID.YYYYMMDD.sampleType.Rep**. *siteID* is the 4-digit side code. *StationID* is the 2-digit station code where sample was taken (i.e., Station ID for streams ="ss", non-wadeable streams/rivers = 'c0'; in Lakes, inlet="in", outlet="ot", center="c0", if center is stratified: "c1", "c2", "c3" with “c1” being the top layer; "w1"-"w8" for groundwater wells). *sampleType* is the 3-letter sample code (H2O or POM), do NOT include isotope numbers (i.e. 2H,18O or 15N13C) to sampleID. *Rep* is replicate #.
   a. For regular H2O collections without replicates, rep is always “.1” See example:
      1) Ex.) **PRIN.ss.20151013.H2O.1**
   b. Use a printer and/or sharpie to fill out labels before going into the field.

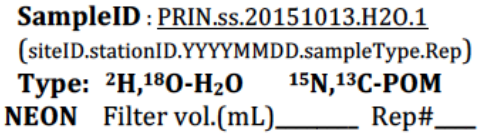


Figure 4. NEON aquatics stable isotope chemistry labels example.

6. When the system is available, adhesive barcode labels will be added to the sample containers and scanned by the mobile app (**Figure 5**). Add adhesive labels to vials prior to going in the field.
   a. Keep a human-readable label on each bottle with a minimum of the sample ID printed to assist with organization and shipping.

Figure 5. Example of adhesive barcode labels.

SOP C Field Sampling

NOTE: Be cautious when sampling. Items can easily fall into the water while bending to sample.

1. In the field, complete the General AQU Field Metadata and the Water Chemistry Application on the mobile data recorder. You only need to fill out one General Field Metadata Application per site per day.
   a. Always make note of any weather or stream conditions that could influence chemistry, including but not limited to wind, activities in the surrounding watershed, prior flood or rain events, ice, and changes in sampling locations (RD[06]). For lakes, also record new Global Positioning System (GPS) coordinates (accuracy is <4 m) and total depth of the water column sampled with the water chemistry protocol (RD[08]).
2. Collect samples according to water chemistry sampling protocol (RD[08]) in streams, rivers and lakes, or groundwater wells, as appropriate. Samples should be collected at the same depth as the water chemistry samples are collected. Samples for isotopes should be collected out of the same sampler and collection jug as water chemistry, if possible.
3. Station ID is the 2-digit station code where sample was taken (i.e., Station ID for streams ="ss", non-wadeable streams/rivers = 'c0'; in Lakes, inlet="in", outlet="ot", center="c0", if center is stratified: "c1", "c2", "c3" with “c1” being the top layer; "w1"-"w8" for groundwater wells).

C.1 Wadeable Streams (Follow RD[08]):

Isotope sampling in wadeable streams will be completed in the same location as surface water chemistry, immediately downstream of Sensor Set 2 (RD[08]) and upstream of any stream disruption and in a flowing area of the stream, if possible.

1. Collect stream isotope samples and metadata following the Water Chemistry Sampling in Surface Waters and Groundwater Protocol (RD[08]).
2. ALWAYS sample in the THALWEG (the deepest location in the stream cross-section) and 5-10 cm below the surface (to avoid sampling floating material or surface film). If the usual location is too shallow select another location within the stream reach that is deep enough, preferably in the thalweg. Personnel can step into the stream, but be sure to take samples upstream from the standing location.
3. Proceed to SOP D, Sample Collection and Processing.

C.2 Lakes and Rivers (Non-wadeable streams) (Follow RD[08]):

Isotope sampling in lakes and rivers will follow the Water Chemistry Sampling in Surface Waters and Groundwater Protocol (RD[08]).

1. Collect river and lake water samples and metadata following the Water Chemistry Sampling in Surface Waters and Groundwater Protocol (RD[08]).
   a. Move to the sampling station and note the station ID in the mobile recorder (on the field sheet, if necessary) (RD[08]; SOP B.2).
   b. Determine the depths for sampling according to Secchi Application.
   c. Sample using the Kemmerer bottle (Figure 6, RD[08]; SOP B.2). Depth should be measured from the bottom of the Kemmerer.
2. Proceed to SOP D, Sample Collection and Processing.

Figure 6. Image of Kemmerer Sampler.

C.3 Groundwater Wells (Follow RD[08]; SOP B.3):

Groundwater wells are only sampled for H2O, no POM samples are collected. Groundwater isotope H2O sampling will be completed in the same location/assigned wells as water chemistry sampling occurs.

1. Collect groundwater sample water and associated metadata from selected wells following the Groundwater Chemistry Sampling Protocol (RD[08], SOP B.3).
   a. Locate well and measure water depth.
   b. Remove groundwater well sensor from the well.
   c. Extract groundwater from well, using appropriate pump method.
   d. Collect water samples for H2O. No POM samples are collected for GW.
2. Proceed to SOP D, Sample Collection and Processing.

SOP D Sample Collection and Processing

1. Process (filter and store appropriately) surface and subsurface isotope samples within 4 hours of sample collection. If samples are not processed immediately, water should be stored on ice and in the dark to reduce biological activity prior to sample processing.
2. SampleID: **site.stationID.YYYYMMDD.sampleType.Rep**. *siteID* is the 4-digit side code. *StationID* is the 2-digit station code where sample was taken (i.e., Station ID for streams ="ss", non-wadeable streams/rivers = 'c0'; in Lakes, inlet="in", outlet="ot", center="c0", if center is stratified: "c1", "c2", "c3" with “c1” being the top layer; "w1"-"w8" for groundwater wells). *sampleType* is the 3-letter sample code (H2O or POM), do NOT include isotope numbers (i.e. 2H,18O or 15N13C) to sampleID. *Rep* is replicate #.
   a. For regular H2O collections without replicates, rep is always “.1” See example:
      1) Ex.) **PRIN.ss.20151013.H2O.1**

D.1 $^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples from Surface and Ground Water

1. Rinse a 5 mL or 60 mL syringe 3 times with source water. Discard rinse water downstream or on the bank.
2. Attach a 0.2 µm syringe filter.
3. Rinse collection bottle (15 mL glass vial with rubber closure) with filtered sample water 3 times. To rinse: filter at least 1-3 mLs of sample water into vial, recap (you may just hold cap on with your hand instead of rescrewing cap each rinse), and shake to ensure water touches all parts of the bottle and cap.
4. Collect sample in a 15 mL glass bottle (**Figure 2**). Sample bottle should be **~90% full** to minimize evaporation, but should have enough headspace to ensure bottle will not be broken if freezing occurs.
5. Securely attach lid and **wrap plastic paraffin film** around the lid and vial to secure the lid and to reduce air movement.
6. Record data in the mobile app.
   1) If available, scan the barcode label with the tablet (**Figure 7**).
   2) Ensure that the human-readable sample ID matches the sample ID generated by the mobile app.

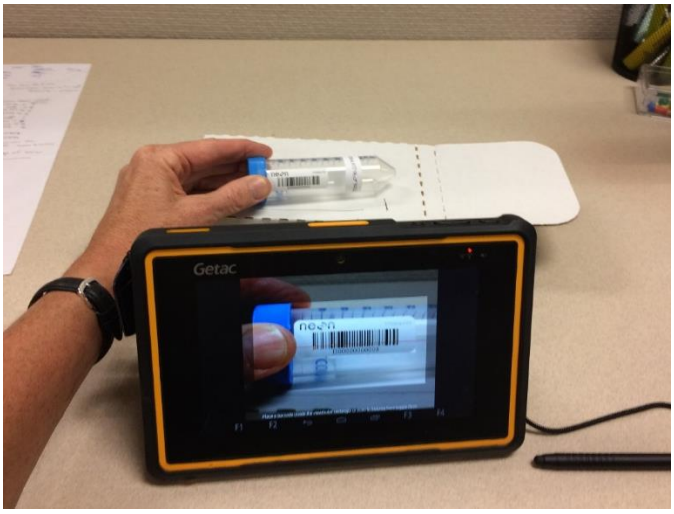


Figure 7. Barcode label scanning.

7. No additional preservation or special shipping is required.

D.2 $^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM from Surface Waters

1. Collect water using a 4 L jug to be filtered within 4 hours. In shallow streams, you may need to use the peristaltic pump to get the water out of the stream and into the 4 L jug.
   a. To reduce biological activity, keep jug on ice and in the dark until you are able to process the sample.
2. Set up filter funnel, filter flask, and vacuum pump (Figure 8).
   a. Connect flexible tubing from vacuum pump to hose connection on filter flask.
   b. Make sure filter stem is inserted into the hole in the rubber stopper.
   c. Insert rubber stopper into the top of the filter flask. Push in tightly.
   d. Attach top of filter funnel to filter stem. This may be a magnetic connection or a screw-in connection.

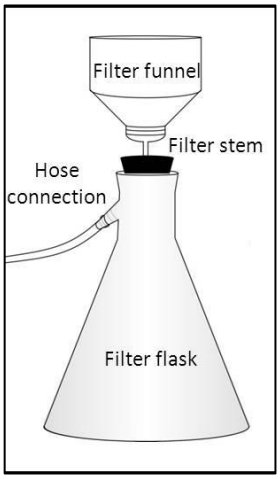


Figure 8. Filter apparatus setup

3. Rinse the filter funnel and stem with de-ionized (DI) water.
4. Remove the top of funnel.
5. Place pre-ashed GF/F filter on top of the filter stem (Figure 8).
   a. Place filter so that the **grid side is down**.
6. Re-attach the top of funnel.
7. Rinse the filter with DI water. Use the vacuum pump to create suction in the flask and draw the DI water through the filter.
8. Shake sample bottle vigorously for ~30 seconds to mix sample.
   a. Filter known volume of sample.
      1) Measure using a graduated cylinder. Pour sample slowly in ≤200 mL increments into filter funnel.
   b. Do not pour more sample into funnel than will pass through the filter. All water in the filter funnel must pass through the filter, if filter becomes clogged while there is still sample water in the funnel, discard sample and filter and start again.

9. **Keep track of the volume of sample filtered on the Mobile Data Recorder**
10. Draw suction on filter apparatus using the hand vacuum pump (or vacuum manifold, if available). Do not exceed 15 inches of mercury (in Hg) vacuum on the pump dial. High pressure ruptures cells and causes chlorophyll and other compounds to dissolve and pass through the filter.
    a. If you have added too much sample and the filter appears to be clogged, you may discard the contents of the filter funnel and the filter and start over. **If you decant water from the filter funnel, you must discard the filter and start over.**

11. Check the filter, if it still appears white, filter more sample. If the filter appears green or yellow tinged, proceed to next step.
    a. **Record the volume of sample filtered for each Replicate on the mobile recorder.**

b. Filter as much as possible (should be >500 mL, if possible). If unable to filter the minimum amount, filter as much sample as possible and record volume.

12. Rinse inside walls of funnel using wash bottle of DI.
    a. Do not include DI rinse water in the volume of sample filtered.
13. Continue to draw suction on the filter until there is no water left in the funnel and there is no excess water on top of the filter.
14. Remove top of filter funnel, release suction by turning the valve on the manifold. If using the hand pump, you may need to remove stopper.
    a. You may wish to remove the stopper entirely form the flask or manifold to reduce pressure on filter. This will make removing the filter easier.
15. Carefully remove the filter from the stem using filter forceps (forceps with flat ends). Take care not to touch the filter with your fingers.
    a. Fold filter in half and place on a clean square of aluminum foil (~4x4“). Alternatively, you may find if it easier to place the non-folded filter on the foil and then fold the foil and filter in one movement (To make this easier, pre-crease a foil sheet and fold the filter while closing the foil around it). **Use caution** when transferring an unfolded filter, to not lose any of the sample on the filter or you will need to resample.
    b. Fold foil securely around the filter to form a packet.
    c. Label foil packet with adhesive sample label (1 x 2 $^{5}/_{8}$”) (**Error! Reference source not found.**.
16. Rinse funnel with DI and wipe filter forceps with kimwipes.
17. Repeat above steps until you have 2 replicate filters from the same sample.
    a. Two (2) ^{13}C, ^{15}N POM isotope filters
18. Record data in the mobile app.
        1) If available, scan the barcode label with the tablet (**Figure 7**).
        2) Ensure that the human-readable sample ID matches the sample ID generated by the mobile app.
19. Place all foil packets from one site inside a resealable bag. Using a permanent marker, label the outside of the resealable bag with Domain, Site, Date, and the “lab type” ($^{13}C/^{15}N$).
    a. Place all dried filters in a desiccator until shipping.

D.3 Ending the Day

1. Refreshing the sampling kit
    a. Restock the sampling kit (shipping cooler) with new isotope chemistry sampling bottles with new labels attached, filters, resealable plastic bags, etc. Refer to 9.2 Equipment and Materials.
2. Equipment maintenance, cleaning and storage
    a. Peristaltic Pump:
        1) Run clean water through the peristaltic pump to rinse tubing. Make sure to pump all water out of tubing before storage.
        2) Charge batteries.

b. Rinse Filter Funnel apparatus with DI

SOP E Data Entry and Verification

Mobile applications are the preferred mechanism for data entry. Data should be entered into the protocol-specific application as they are being collected, whenever possible, to minimize data transcription and improve data quality. For detailed instructions on protocol specific data entry into mobile devices, see the NEON Internal Sampling Support Library (SSL). Mobile devices should be synced at the end of each field day, where possible; alternatively, devices should be synced immediately upon return to the Domain Support Facility.

However, given the potential for mobile devices to fail under field conditions, it is imperative that paper datasheets are always available to record data. Paper datasheets should be carried along with the mobile devices to sampling locations at all times. As a best practice, field data collected on paper datasheets should be digitally transcribed within 7 days of collection or the end of a sampling bout (where applicable). However, given logistical constraints, the maximum timeline for entering data is within 14 days of collection or the end of a sampling bout (where applicable). See RD[04] for complete instructions regarding manual data transcription.

SOP F Sample Shipment

Information included in this SOP conveys science-based packaging, shipping, and handling requirements, not lab-specific or logistical demands. For that information, reference the CLA shipping document on CLA's NEON intranet site.

Shipments are to have a hardcopy of the "per Sample" tab of the shipping inventory (RD[09]) sent in each box as well as an electronic shipping inventory that is emailed to the receiving laboratory and to the contact in NEON Collections and Laboratory Analysis at the time of shipment. ShipmentID **must** be included in the electronic version of the shipping inventory (be sure to fill it out in the 'per sample' tab too), but is not necessary for the hard copy. Also include the shipment tracking # in the email.

Shipment files should be named: *DXX_ASI_ShippingInventory_YYYYMMDD*, where YYYYMMDD is the date shipped. If multiple shipments are sent on the same day:
DXX_ASI_ShippingInventory_YYYYMMDD_#of#

F.1 Handling Hazardous Material

N/A

F.2 Supplies/Containers

1. $^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples
   a. Samples will be shipped every two months on a schedule set by CLA for each domain.
   b. Ensure you have wrapped plastic paraffin film around the lids to keep them secure during shipping.
   c. Pack glass bottles for **$^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples in** liquid absorbent packing material for protection from breaking and leakage. After bottles have absorbent material packed securely around them, any remaining space can be filled with regular packing material.
   d. Glass bottles can be packaged and shipped in a secure box to isotope lab. "Up" arrows can be affixed to the secure box.
   e. Prepare a shipping inventory detailing the contents of the shipment, using the protocol-specific templates found on CLA's NEON intranet site. Include a printed copy of the inventory in the shipment box. Place 'per sample' tab of AOS shipping inventory (RD[09]) in a resealable plastic bag and tape to the inside top of cooler.
   f. Save the inventory with the following naming convention:
      "**DXX_MOD_ShippingInventory_YYYYMMDD**" ex) D02_ASI_ShippingInventory_20151015
      1) If multiple shipments are sent on the same day:
         DXX_ASI_ShippingInventory_YYYYMMDD_#of#
   g. Complete packing slip, address shipment, and ship ground to the destination(s) specified in the CLA "Shipping Information for External Facilities" document.

h. Email an electronic copy of the shipping manifest and tracking number to the email addresses listed in the CLA "Shipping Information for External Facilities" document.
i. Include the shipment tracking # (Shipment ID) in the email body, as well as the electronic copy of shipping manifest.

2. Filters ($^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM)
   a. Filters are shipped as you would ship for Algal chemistry. Filters are shipped with Algal chemistry or every 2 months, whichever comes first.
   b. Prepare a shipping inventory detailing the contents of the shipment, using the protocol-specific templates found on CLA's NEON intranet site. Include a printed copy of the inventory in the shipment box. Place 'per sample' tab of AOS shipping inventory (RD[09]) in a resealable plastic bag and tape to the inside top of cooler.
   c. Tape and label containers appropriately for shipping on dry ice and ship to algae chemistry lab.
   d. Save the inventory with the following naming convention: "**DXX_MOD_ShippingInventory_YYYYMMDD**"
   e. Complete packing slip, address shipment, and ship ground to the destination(s) specified in the CLA "Shipping Information for External Facilities" document.
   f. Email an electronic copy of the shipping manifest and tracking number to the email addresses listed in the CLA "Shipping Information for External Facilities" document.
   g. Include the shipment tracking # (Shipment ID) in the email body, as well as the electronic copy of shipping manifest.

F.3 Timelines and Conditions

1. $^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples.
   a. Samples should be shipped Ground every 2 months per CLA schedule.
2. Filters ($^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM)
   a. Filters shall be shipped in batches every 2 months or at the same time as the biology bout shipment. Filters shall be stored in a desiccator until shipped.

F.4 Grouping/Splitting Samples

Organize by Site ID, if applicable.

F.5 Return of Materials or Containers

Include return shipping label with WBS code if any shipping materials need to be returned to the domain support facility (e.g., cooler for POM filters).

F.6 Shipping Inventory

Fill out the AOS Sample Shipping Inventory (RD[09]). Each box sent should have a copy of the 'per sample' tab of the shipping inventory of its contents. The 'Shipment ID' does not need to be filled out on the hardcopy. The electronic shipping inventory that includes ShipmentIDs and IDs of all samples shipped should be emailed to the appropriate contact at the receiving analytical laboratory as well as the NEON CLA contact on the day that samples ship. Include shipping IDs and estimated arrival date(s)/time(s) in the email as well.

F.7 Laboratory Contact Information and Shipping/Receipt Days

See the 'CLA shipping document' on CLA's NEON intranet site (Sharepoint).

8 REFERENCES

Fry, B. 2008. *Stable Isotope Ecology.* 308 p. Springer.

Gandhi, H. T.N. Wiegner, P.H. Ostrom, L.A. Kaplan, and N.E. Ostrom. 2004. Isotopic (^{13}C) analysis of dissolved organic carbon in stream water using an elemental analyzer coupled to a stable isotope ratio mass spectrometer. Rapid Communications in Mass Spectrometry 18:903-906

APPENDIX A DATASHEETS

The following datasheets are associated with this protocol:

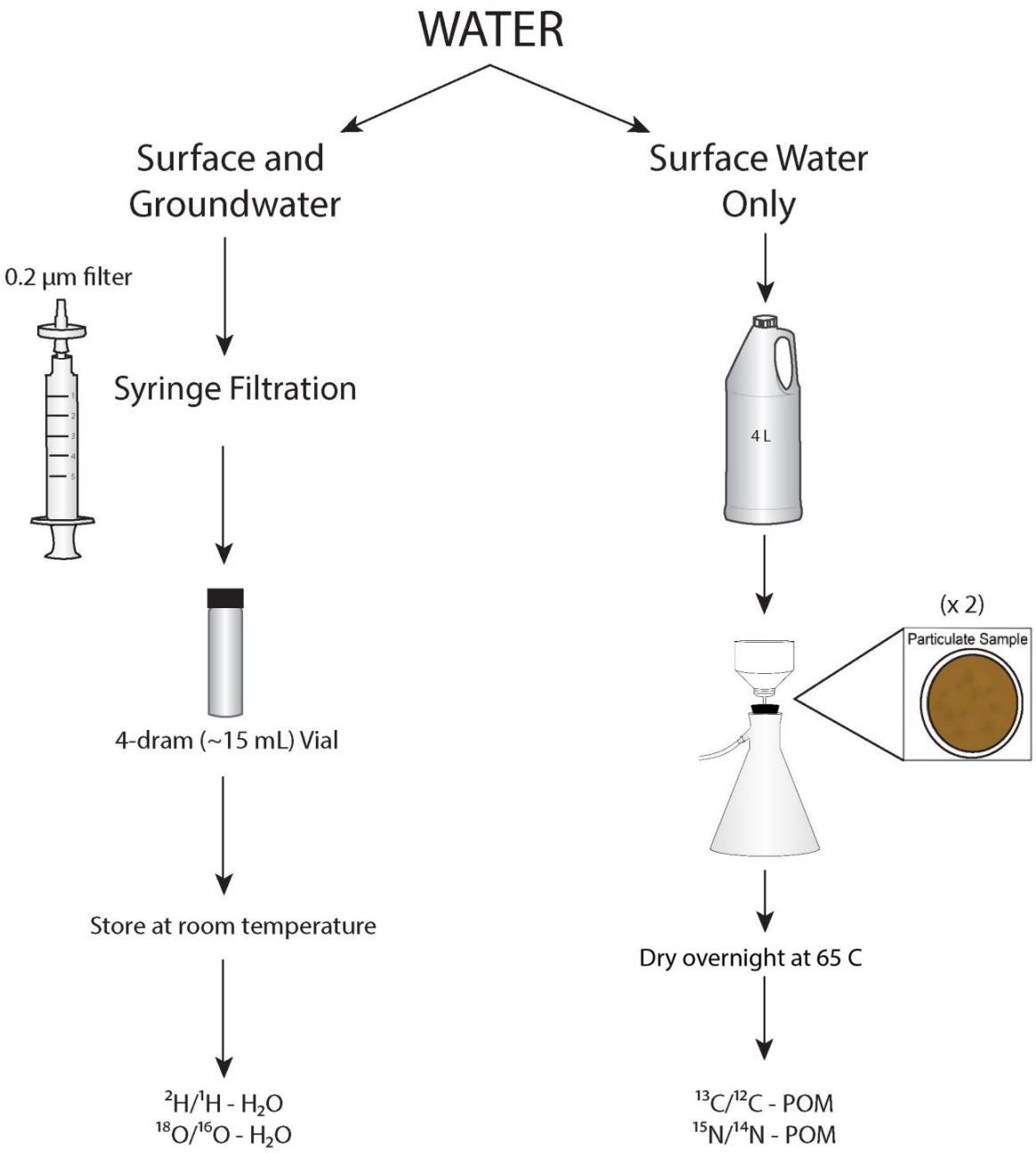
Table 8. Datasheets associated with this protocol

NEON Doc. #	Title	Mobile Application
NEON.DOC. 002211	Datasheets for AOS Protocol and Procedure: Stable Isotope Sampling in Surface and Ground Waters	(AOS) SWC [PROD]
NEON.DOC.001646	General AQU Field Metadata Sheet	(AOS) Field Metadata and Gauge Height [PROD]
NEON.DOC.002494	Datasheets for AOS Shipping Inventory	Shipping App [PROD]

These datasheets can be found in Agile or the NEON Document Warehouse, user guides for mobile applications may be found in NEON's internal sampling support library.

APPENDIX B QUICK REFERENCES

B.1 Flowchart of Sample Collection and Filtration



B.2 Steps for Sample Collection and Filtration

Step 1 – Pre-ash filters.

Step 2 – Check the isotope field sampling kit to make sure all supplies are packed.

Step 3 – Prepare labels (1 x 2 $^{5}/_{8''}$)

SampleID : PRIN.ss.20151013.H2O.1
(siteID.stationID.YYYYMMDD.sampleType.Rep)
Type: $^{2}H,^{18}O\text{-}H_2O$ $^{15}N,^{13}C\text{-POM}$
NEON Filter vol.(mL)_____ Rep#___

Step 4 – Ensure the General AQU Field Metadata Sheet (RD[06]) is completed per field site visit.

Step 5 – Wadeable streams: Collect isotope samples in the thalweg following the Water Chemistry Sampling in Surface Waters and Groundwater protocol (RD[08]).

Step 6 – Lakes and non-wadeable streams: Collect isotope samples following the Water Chemistry Sampling in Surface Waters and Groundwater protocol (RD[08]). Select sampling depth and collect samples using the Kemmerer.

Step 7 – Groundwater wells: Collect isotope samples from selected wells following the Water Chemistry Sampling in Surface Waters and Groundwater protocol (RD[08]).

1. Locate well and measure water depth.
2. Remove groundwater well sensor from the well.
3. Extract groundwater from well, using appropriate pump method.
4. Collect water samples.

Step 8 – Process (filter and store appropriately) surface and subsurface isotope samples within 4 hours of sample collection:

1. $^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples from Surface and Ground Water:
   a. Filter using a 0.2 µm filter with syringe into sample vials
2. $^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM from Surface Waters (2 filters):
   a. Filter with a vacuum pump and ashed GF/F filters

Step 9 – Ship samples:

1. $^{18}O/^{16}O$ and $^{2}H/^{1}H$ of H_2O samples: Ship samples Ground every 2 months per CLA schedule.
2. Filters ($^{13}C/^{12}C$ and $^{15}N/^{14}N$ of POM): Ship filters every 2 months or at the same time as the biology bout shipment. Filters shall be dried at 65C and stored in a desiccator until shipped.

APPENDIX C REMINDERS

Before heading into the field: Make sure you…

- ☑ Collect and prepare all equipment including labels.
- ☑ Pre-print labels on waterproof adhesive labels.
- ☑ Fill out the labels before they get wet.

Sample collection: Be sure to…

- ☑ Not sample anywhere you or other field technicians have walked, or locations that appear recently disturbed. Wait for disturbance to pass.
- ☑ Avoid contaminating the sample with re-suspended bed sediment.
- ☑ Use caution when sampling as items can easily fall into water while sampling.
- ☑ ALWAYS sample in the THALWEG in wadeable and non-wadeable streams.

Sample filtering: Be sure to…

- ☑ Keep track of the volume of sample filtered on the mobile data recorder or paper Data Sheet (RD[05]).
- ☑ If you decant water from the filter funnel, you must discard the filter and start over.
- ☑ DO NOT add more water into the filter tower than you can filter.

APPENDIX D ESTIMATED DATES FOR ONSET AND CESSATION OF SAMPLING

See the Site Specific Sampling Strategy Document on AQU's NEON intranet site.

APPENDIX E SITE-SPECIFIC INFORMATION

See the Site Specific Sampling Strategy Document on AQU's NEON intranet site.