TOS STANDARD OPERATING PROCEDURE: Minimizing Site Disturbance During Aquatic and Terrestrial Observation System Sampling

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	08/26/2016	ECO-04051	Initial release
B	03/21/2017	ECO-04518	• Removed most of the content related to invasive species as that is to be covered in another SOP • Updated formatting to be more consistent, mostly using bullets instead of numbers, as appropriate.

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1 DESCRIPTION

1.1 Purpose

Activities associated with the logistics and measurements of the Aquatic Observation System (AOS) and Terrestrial Observation System (TOS) have the potential to damage natural, urban, and agricultural landscapes. This impact can affect the information obtained from long-term observations made by NEON and other scientific investigations, damage natural resources and associated management goals, and compromise NEON's relationship with landholders and the scientific community. This document identifies some of these impacts and describes practices that can and should be followed by NEON staff in an effort to mitigate damage that occurs as a result of NEON's OS sampling activities.

1.2 Scope

This document provides a change-controlled version of an Observatory procedure. 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.

1.3 Applies To

The procedure described in this document is used in the following protocols:

Doc #	Title
NEON.DOC.001025	TOS Protocol and Procedure: Plot Establishment
NEON.DOC.014037	TOS Protocol and Procedure: Measurement of Herbaceous Biomass
NEON.DOC.000987	TOS Protocol and Procedure: Measurement of Vegetation Structure
NEON.DOC.001710	TOS Protocol and Procedure: Litterfall and Fine Woody Debris
NEON.DOC.001709	TOS Protocol and Procedure: Bryophyte Productivity
NEON.DOC.001711	TOS Protocol and Procedure: Coarse Downed Wood
NEON.DOC.014040	TOS Protocol and Procedure: Plant Phenology
NEON.DOC.014039	TOS Protocol and Procedure: Leaf Area Index
NEON.DOC.014042	TOS Protocol and Procedure: Plant Diversity
NEON.DOC.014038	TOS Protocol and Procedure: Root Biomass
NEON.DOC.001710	TOS Protocol and Procedure: Plant Litter
NEON.DOC.001024	TOS Protocol and Procedure: Canopy Foliage
NEON.DOC.014048	TOS Protocol and Procedure: Soil
NEON.DOC.014050	TOS Protocol and Procedure: Beetles
NEON.DOC.014045	TOS Protocol and Procedure: Ticks
NEON.DOC.000481	TOS Protocol and Procedure: Small Mammal Sampling
NEON.DOC.014041	TOS Protocol and Procedure: Breeding Landbird Sampling
NEON.DOC.003046	AOS Protocol and Procedure: Aquatic Macroinvertebrate Sampling
NEON.DOC.003045	AOS Protocol and Procedure: Periphyton, Seston, and Phytoplankton Sampling
NEON.DOC.003039	AOS Protocol and Procedure: Aquatic Plant, Bryophyte, Lichen, and Macroalgae

	Sampling
NEON.DOC.003044	AOS Protocol and Procedure: Aquatic Microbial Sampling
NEON.DOC.001194	AOS Protocol and Procedure: Zooplankton Sampling in Lakes
NEON.DOC.001295	AOS Protocol and Procedure: Fish Sampling in Wadeable Streams
NEON.DOC.001296	AOS Protocol and Procedure: Fish Sampling in Lakes
NEON.DOC.002905	AOS Protocol and Procedure: Water Chemistry Sampling in Surface Waters and Groundwater
NEON.DOC.001886	AOS Protocol and Procedure: Stable Isotope Sampling in Surface and Ground Waters
NEON.DOC.001199	AOS Protocol and Procedure: Surface Water Dissolved Gas Sampling
NEON.DOC.001193	AOS Protocol and Procedure: Sediment Chemistry Sampling in Wadeable Streams
NEON.DOC.001191	AOS Protocol and Procedure: Sediment Chemistry Sampling in Lakes and Non-Wadeable Streams
NEON.DOC.000693	AOS Protocol and Procedure: Reaeration
NEON.DOC.001196	AOS Protocol and Procedure: Riparian Habitat Assessment in Wadeable Streams
NEON.DOC.001195	AOS Protocol and Procedure: Riparian Habitat Assessment in Lakes and Non-Wadeable Streams
NEON.DOC.001085	AOS Protocol and Procedure: Stream Discharge
NEON.DOC.001197	AOS Protocol and Procedure: Bathymetry and Morphology of Lakes and Non-Wadeable Streams
NEON.DOC.003162	AOS Protocol and Procedure: Wadeable Stream Morphology

1.4 Acknowledgments

This document was produced through collaboration between NEON Science and Field Operations staff.

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.001155	NEON Training Plan
AD[04]	NEON.DOC.050005	Field Operations Job Instruction Training 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.001025	TOS Protocol and Procedure: Plot Establishment
RD[05]	NEON.DOC.014037	TOS Protocol and Procedure: Measurement of Herbaceous Biomass
RD[06]	NEON.DOC.000987	TOS Protocol and Procedure: Measurement of Vegetation Structure
RD[07]	NEON.DOC.001710	TOS Protocol and Procedure: Litterfall and Fine Woody Debris
RD[08]	NEON.DOC.001709	TOS Protocol and Procedure: Bryophyte Productivity
RD[09]	NEON.DOC.001711	TOS Protocol and Procedure: Coarse Downed Wood
RD[10]	NEON.DOC.001154	AOS Protocol and Procedure: Aquatic Decontamination
RD[11]	NEON.DOC.004257	All Systems Standard Operating Procedure: Decontamination of Sensors, Field Equipment, and Field Vehicles

2.3 Acronyms

All acronyms used in this document are defined in RD[01].

2.4 Definitions

N/A

3 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.

4 PERSONNEL AND EQUIPMENT

4.1 Equipment

There is no specific equipment for this SOP.

4.2 Training Requirements

All technicians must complete required safety training as defined in the NEON Training Plan (AD[04]). Additionally, technicians must complete procedure-specific training for safety and implementation of this procedure as required in Field Operations Job Instruction Training Plan (AD[05]).

All NEON staff are required to minimize impacts to sites where NEON has established sites. This document provides guidance for minimizing vehicle, foot, and other impacts.

4.3 Specialized Skills

No specialized skills are required to implement this Standard Operating Procedure.

5 CONTINGENCIES AND NOTES

N/A

6 STANDARD OPERATING PROCEDURES

The act of collecting observational samples at NEON sites is going to have an impact on the sites themselves. Trails will be created; plants will be trampled and even removed. This SOP describes practices designed to minimize that damage. Adhering to these guidelines initially and then developing new techniques through time will reduce the impact of disturbance on NEON data and help preserve the landscapes NEON has adopted as sites for long-term study.

While some practices and guidelines will be universally applicable across all NEON sites, the diversity of sites with respect to climate, soil, topography, vegetation, wildness, management, and traffic and congestion of non-NEON staff will require a diversity of techniques for minimizing damage. One approach will not always work across such a range of conditions, and different approaches may be necessary at terrestrial and aquatics sites. There may also be site-specific constraints such as rules, regulations, or requests stipulated by the site host or land owner that direct travel and work at a site that might contradict and override guidelines provided in this document.

This document is broken into two SOPs. SOP A describes techniques to minimize damage to sites while traveling to sample locations at AOS and TOS sites. SOP B describes steps for minimizing damage caused by sampling points, grids, and plots at TOS sites. SOP C describes steps for minimizing damage specific to sampling at AOS sites (streams, lakes, and rivers).

SOP A MINIMIZING SITE-SCALE DAMAGE AT AOS AND TOS SITES

Spatially distributed observations across sites require a combination of travel by vehicle and on foot. While techniques and tips for reducing NEON's impact are broken into corresponding sections below, a site-specific, holistic planning exercise that considers the workflow of all protocols and the spatial

distribution of sampling will reduce impacts and increase sampling efficiency. For example, if two plots are relatively close in space, it might be possible to travel between the locations without returning to a vehicle, reducing travel time and the frequency of visits on a path between a single plot and parking area.

A.1 Vehicle travel

The power to carry weight and move at high speeds; the attributes that make trucks and other vehicles critical to NEON sampling can also cause damage to sites. Considerate and careful driving can help reduce these impacts. Please refer to any guidelines that might be established in the site permit and develop best practices for vehicle travel. General best practices include:

- Drive slowly. Reducing speed while driving the small and circuitous roads that exist at most NEON sites will reduce dust that can be damaging to the surrounding landscape and science infrastructure, reduce the likelihood of the accidents such as collisions with wildlife, livestock, and other users of the site, and reduce the impact to sandy or dirt roads. Some site hosts (e.g. Ordway Swisher Biological Station and Yellowstone National Park) have very strict speed limits. In most cases, speed limits will not be posted within sites and Field Operations staff should develop driving practices or internal rules that ensure safety and integrity of the site.

- Pay attention to weather. Roads at some sites are vulnerable when wet, such as the access route to Rio Cupeyes. If possible, particularly at sites with dirt, clay or sandy roads, do not drive during or immediately following significant rain events. Driving under these conditions can cause deep ruts or trenches and increase the likelihood of getting stuck, which often results in further damage to roadways.

- Drive and Park consciously. NEON is a long-term project; sampling locations will be revisited regularly and for many years. Do not create new roads to ease access to plots. The location where vehicles are parked prior to traveling on foot is going to be vulnerable to damage. Many site hosts will have specific instructions about how and where vehicles should be parked to protect vegetation and ensure roads remain open to travel. Follow these rules. When possible, park in established pull-outs or parking lots, avoid parking on vegetation and if appropriate, equip vehicles with spark arrestors, ensure the vehicle has a fully functional fire extinguisher, and consider marking approved parking lots with GPS or physical material. Consider solutions that involve a driver who drops equipment and/or a crew at the side of the road before driving the car to an acceptable parking location. At sites with limited guidance from site hosts or defined parking places, make conscious decisions. Parking in the same place every time will concentrate impact, which might be appropriate at sites with sensitive soils, such as Moab. Varying the location might reduce the impact and could be appropriate at more resilient sites, such as the Central Plains Experimental Range.

A.2 Travel by foot

After a vehicle is parked, most plots will require some travel by foot. The impact of this travel can be handled in two primary ways: concentrating the impact by repeatedly traveling the same route or dispersing the impact by making a concerted effort to walk a different path each time a sampling location (point/plot/grid) is visited. It is up to the Domain staff at each site to determine, in consultation with the site host, which approach is preferred.

- Concentrate the impact. At most sites there will be small trails created with repeated travel by foot to sampling locations. It will be easier and faster to travel to plots on these trails, and in many cases repeatedly walking the same path and concentrating the impact will be preferable to dispersed impact. If appropriate, mark the start of trails. A straight line from the vehicle to the sampling location will often not be the fastest, most efficient, or result in the least impact. Consider contouring or avoiding steep slopes that might be vulnerable to erosion and altered drainage patterns; the expeditious and least destructive path may not be a straight line to a plot. Cover types that are particularly sensitive to trails, such as wetlands, should be avoided. As with all procedures, please check with site hosts regarding preferences and regulations regarding travel throughout the site.

- Disperse the impact. In some cases it will be preferable, and even required, that NEON avoid the creation of foot paths when traveling to sampling locations. In this case, a different route should be followed each time a sampling location is visited. The members of the crew visiting the location should spread out, traveling several meters apart, when possible, as opposed to in a single line. If possible, vehicles should be parked at different locations through time so that the point of origin is not the same with every visit. A GPS unit can track routes by visit to ensure variation across bouts and years.

- Find other alternatives. Some sites will be sensitive to trailing – primarily tundra sites in Alaska and particularly mesic sites – such that all or part of access to a plot/point/grid will need to be accessed by boardwalk. This will be particularly true of locations sampled by protocols that require larger crews and frequent visits throughout a field season (e.g. mammal, beetle, tick, and mosquito modules, water chemistry). The need for boardwalks at sites should be communicated to Domain managers and Field Operations management.

A.3 Other site-scale impacts

- Avoid spread of invasive species. Invasions are variable in space, and different parts of each site will have various levels of vulnerability to invasion. More details can be found in the Decontamination SOP (RD[11]).

- "Leave No Trace" (https://lnt.org/). Practices that seek to minimize the impact at the site should be followed.

SOP B MINIMIZING IMPACTS AT THE SCALE OF POINT, GRID, AND SAMPLING PLOT (TOS)

Similar to the site-scale, damaging TOS points, grids and plots by sampling them is unavoidable. However, damage should be minimized to facilitate an understanding of pattern and process at large spatial scales; the intent is not to measure the impact of sampling. The methods for mitigating these impacts will depend on variation across sites, but attention to plot selection, patterns of movement while sampling, and staging sampling efforts will help at most sites.

B.1 Selection of plots and grids

Every plot provided to NEON Field Operations for plot establishment has remotely been vetted and reviewed by NEON Science staff. Aerial imagery and digital elevation maps provide only a cursory understanding of the conditions on the ground. While NEON would like to sample such that inference can be made to entire sites, some features make the landscape particularly vulnerable to erosion and other damage when sampled repeatedly through time. If the impact of sampling cannot be mitigated without reasonable infrastructure and equipment, these plots should not be included in the NEON effort.

- Do not sample excessively steep plots. The definition of steep, the threshold beyond which plots should not be sampled, will depend on the resilience of the site. The durability of a site is likely linked to vegetation, soil, precipitation, and the protocols implemented at the location. A slope of 35 degrees with anchoring boulders and dense shrubby vegetation at Niwot Ridge (D13) may not be particular vulnerable to sampling that occurs within a base plot (i.e. plant diversity and productivity). However, a 30-degree slope in a deciduous forest with little understory vegetation and a dense, moist litter layer might quickly develop slippery and muddy trails when a mammal grid is repeatedly sampled. A plot or areas adjacent to plots , even those with slopes less than 30 degrees, with crumbly, rocky soils in an arid environment can be highly erosive, damaging to vegetation, and dangerous for those collecting data. Generally slopes greater that 35-40 degrees seem to be particularly vulnerable to excessive damage and should not be sampled.

- Develop plans for sensitive soils. Biological soil crusts are vulnerable to trampling but are an important part of ecological systems at some sites in the arid West. While small sections of boardwalk or other protection might be appropriate in some places, installation has the potential to cause significant damage to crusts. In such cases it might be most practical to establish trails within and around plots from which observations area made. Trails can be marked with flagging or other appropriate material as needed.

B.2 Staging sampling efforts

Spend a minimal amount of time in a plot. When approaching a plot on foot, be conscious of the plot, look for plot markers and/or track the distance to the plot on the GPS, and navigate to a corner point, not the plot centroid. Also be aware of collocated plots. For example, don't walk through a base plot on route to a mammal grid. It is imperative that traffic through tick plots is minimized to avoid influencing observations of tick diversity and abundance. Keep equipment, food, water, and other material outside the plot and take only what is needed for data collection into the plot. Processing of material such as soil, bycatch, mammals, and unknown plant species should occur outside the plot or grid. Similarly, all breaks for food and water should occur outside the plot or grid. In some cases it may be appropriate to store plot-specific protections (e.g., 1-2 sections of geoblock) outside a plot for staging activities and breaks to mitigate damage to the site outside of plots.

B.3 Sampling points, grids, and plots

Efforts to minimize damage to points, grids, and plots should be prioritized. Efforts to minimize excessive damage to the area immediately around these areas should also be considered, but creation of a path around a grid or plot is preferable to a path within the plot. Approaches for minimizing impacts will depend on sampling and infrastructure.

- Phenology Plots. The frequency of observation required to describe phenological transitions will result in trails at most sites. Make every effort to walk the same route with each sampling bout. If possible, make observations of tagged individuals from this trail and/or have the recorder stay on the trail while observations are made at an individual plant species. If this is not possible, (smaller) paths may be needed to access individuals. Phenology plots are located in close proximity to the NEON tower and frequently intersect other TOS Tower Plots. The trails developed along the perimeter of the primary phenology plot (i.e. the phenology transect), those made to access individuals, or those made to access phenology Plots should avoid all other NEON plots, even if this requires a circuitous path.

- Base Plots (Tower and Distributed). Base Plots support numerous protocols and are vulnerable to damage from the sampling effort. Make every effort to minimize this damage. Plots should be marked with permanent markers at point 31 to eliminate the need to access the center of the plot to confirm location. Do not go inside the plot, particularly the inner 20m x 20m plot unless observations are being made as directed by a protocol. At most sites it will be appropriate to concentrate inevitable impact in specific parts of the plot – primarily on the central N-S and E-W axes of the plot - so as to reduce the impact on observations being made.

    - Beetle sampling. Beetle pitfall traps are located at the very edge of Base Plots, approximately 40m in each cardinal direction from the center of the plot. Walk around the outside 40m x 40m plot to complete the beetle sampling protocol, not through the

plot. This will take more time, but given the frequency of beetle sampling it will greatly reduce the impact to the actual plot.

- Plant diversity sampling. When stretching tapes to delineate the plot, walk outside the 20m x 20m inner plot. Similarly, make as many observations as possible from outside the 20m x 20m plot. Many of the nested 1 and 10m^2 subplots are located at the perimeter of this 400m^2 area, species and associated cover estimates should be made from the outside of the plot. To access the nested subplots near the center of the plot (point 41), walk along the axes of the plot, taking care to avoid trampling the 1m^2 subplots. Searching the 100-m^2 subplots will require foot traffic through the plot. Be gentle. Take care to avoid stepping on plants and disturbing soil with scuffing feet, being conscious of the impact of this activity will significantly reduce the cumulative impact over time. While making observations within the plot, be aware that standing in one place for an extended period of time can cause damage. Do not sit in the plot and consider carrying a piece of geoblock or similar protection on which to stand while observations are being made.

- Vegetation structure. As much as possible, stem mapping should prioritize mapping from corner points to avoid impacts to the part of the plot sampled for plant diversity. When mapping stems inside the inner 20m x 20m plot (mapping from points 31, 33, 49, and 51), be cognizant of the plant diversity subplots at these corners and stand outside the inner 20m x 20m plot. Mapping stems at the center of the plot (point 41) should be done only when stems can be viewed from no other location. This will reduce traffic to the center of the plot.

- Leaf area index. Tread lightly. First visit the plots in regular light conditions to better understand access points and how to best avoid the phenology look and trampling other Tower Plots. Make every effort to walk the lines along the cardinal directions within the plot. Please avoid stepping in the 1m^2 subplots designed for plant diversity sampling.

- Herbaceous biomass. Kneeling and the consistent impact in one area is difficult to avoid. Make every attempt to avoid dragging knees and feet and consider working from a gently-placed geoblock to reduce disturbance.

- Mat forming bryophytes. Avoid trampling the vegetation as much as possible. Avoid walking across plot to extent possible. Walk along edges of plot, and along edges of clip strip as it is being delineated. Do not walk inside clip strip being delineated.

- Soil biogeochemistry and microbiota. Stage sampling equipment outside of the 40m x 40m plot. Take the shortest route possible to approach the sample location. Walk on rocks as much as possible. While sampling, reduce trampling within the plot by locating

one sample location at a time and completing sampling at that location prior to moving to the next location.

- Mammal Grids. Always walk the traplines along the N-S axis, except when moving to the next trapline. This will constrain disturbance to narrow trails within the grids over time. Consistency is the key; E-W travel can be used if strongly preferable for a given plot. At most sites, small trails will develop along the primary axes of travel within the mammal grids. Stage all activities outside the grid in an effort to minimize the impact of frequent foot travel in the grids. The vegetation and hydrology of some sites will be particularly vulnerable to trails and even wet trenches during sampling. Site-specific strategies for protecting the landscape should be discussed with the NEON vertebrate ecologist.

- Mosquito Points. Mosquitoes are sampled near roads. Be sure to park the vehicle in a safe place, but also be aware of impacts to vegetation and soil. If possible stage sampling activities at the vehicle and take minimal equipment to trap. If the trap is placed on a tree or other natural structure, take care to be particularly gentle with that individual.

- Tick Plots. While a small trail will likely develop on the tick plot over the life of the Observatory, make every attempt to minimize impact to vegetation. Avoid smashing shrubs and try to step around, or over, bunch grasses and other vegetation.

B.4 Extra protection for sampling locations

Some sites and/or specific cover types at sites will be particularly vulnerable to excessive damage from even minimal traffic. Tundra in Alaska is easily destroyed. Trails quickly turn to water-filled trenches, which can result in melting of permafrost. Specific parts of the Domain 05 core site are covered in vegetation with standing water that are particularly vulnerable to damage from sampling activities. At sites such as these, there will be a need for site-appropriate measures to protect the resources at the site. Examples range from construction of boardwalks to use of more primitive (and less expensive and expansive) boardwalks, to various forms of protective matting. In some cases there will be a need for this infrastructure around and through Base Plots on cardinal directions. In other cases, just parts of a plot might require these protections. It should be noted that this type of infrastructure may not be appropriate for mammal grids due to the likelihood that animal behavior will be altered. Please communicate all needs for site and plot-specific protections that require infrastructure to Field Operations management.

SOP C MINIMIZING IMPACTS IN AND AROUND LAKES, RIVERS, AND STREAMS (AOS)

Riparian areas around streams are often moist and sensitive to repeated travel and high-use. Accidental removal or trampling of vegetation on stream banks from over-use and technician travel can make

riparian areas more sensitive to erosion. Depending on the site host(s) preference, refraining from using the same path to enter the stream may be preferable to using an established path. At sensitive sites, with frequent site visits, high-use areas may benefit from a raised staging area, such as a foot plank or other platform.

- Boating in lakes and rivers: At lake and river sites, boating and field decontamination may cause additional site disturbance. Technicians should take care to only drive trailers over approved boat launch areas, and pump or drain bilge water or remove aquatic plants from boat and/or trailer only at boat launches. When running the boat motor in shallow areas do not uproot aquatic vegetation. If the need to access the shore arises, take care when landing the boat to prevent disturbing or damaging habitat structure including woody debris, overhanging banks, or vegetation.

- Sensor Maintenance, Water Chemistry, and Stream Discharge: Sensor locations in streams are visited frequently (about every 2 weeks). Care should be taken to avoid over-use of entry locations to streams, particularly at the stream sensor locations and water chemistry station, as these will be visited the most frequently. Avoid over-use by using more than one entrance point to the stream. In areas where erosion of stream banks is a major concern, such as in the Southern Plains (Domain 11), steps or erosion-control paths should be installed. Please communicate all needs for site and plot-specific protections that require infrastructure to Domain managers and Field Operations management.

- Reaeration: Walking between reaeration stations should be done slightly away from the stream channel, where slopes are flatter and soils are more stable, or on access paths or roads running along the stream channel. Do not walk in the stream or on the immediate stream banks, as these areas are more sensitive to disturbance. A raised staging area, plank or other platform may be used at the injection location to minimize impact of heavy equipment to the site. A platform will also help level the work surface and make using the equipment easier. The use of a raised staging area in sensitive areas should be discussed between Domain managers and the site host.

- Sediment Chemistry: While collecting sediments from NEON streams and the nearshore environment of lakes care should be taken to avoid walking through sediment deposition zones and disturbing fine streambed material. Avoid trampling aquatic plants and algae or disturbing physical habitat including large woody debris. When walking longer distance to another deposition zone or between stations use the shoreline instead of the stream or lake to avoid impacting aquatic habitat and organisms.

- Riparian Habitat Assessment: In wadeable streams, this protocol involves positioning the observer along 10 transects within the stream at mid, left, and right bank locations. Lake and non-wadeable riparian observations are made via boat. Enter and exit the transect

perpendicular to the stream bank. Avoid trampling aquatic organisms and habitat. Do not move habitat such as large woody debris to improve visibility at the transect. Instead, slightly shift your observation location a step or two to the side to get a better view. Do not knock down riparian vegetation to get a better view into the transect.

- Fish Sampling: This protocol requires up to four technicians to wade into the stream or lake shore to actively capture fish using a backpack electrofisher unit. Fish sampling and capturing fish with the electroshocker or passive net set up (gill, fyke, or minnow nets) is a very intrusive protocol which inevitably requires several people to walk throughout the stream reaches or lake shorelines being surveyed. These impacts can be minimized by following a few precautions. In streams, the sampling approach is to begin at the most downstream reach and work upstream to minimize suspending sediments which can impact sampling success by making fish and habitat difficult to see. This allows the sampler to have a better view of stream habitat and reduces the risk of trampling habitat. While wading within the nearshore at lake sites make deliberate steps and ensure secure footing to avoid shuffle stepping which can lead to an increase in suspended sediments and streambed disturbance. Keep in mind also that lake electrofishing occurs during non-daylight hours (evening – early morning) making it more important to avoid disturbing sediments and decreasing visibility. Again, minimizing the suspension of sediments allows for improved visibility and an avoidance of disturbing sensitive habitat. Use the anode pole to draw fish out of cover habitat instead of walking up to it and possibly trampling habitat structure.

- Aquatic Benthic Sampling: Benthic sampling in streams, lakes, and rivers includes periphyton, benthic microbes, macroinvertebrate, and aquatic plant sampling. Benthic sampling is inherently destructive to the stream bed or lake/river bottom as it requires removal of material. Site disturbance may be mitigated by limiting wading activities in the stream, lake, or river, choosing sampling locations carefully and not oversampling (i.e., collecting multiple samples and discarding), approaching sampling locations from downstream, and accessing the site via approved pathways or haphazard routes, depending on the preference of the site host(s). Technicians should choose field processing locations that limit riparian destruction, such as using the boat at the lake or river, or finding a cobble bar in a stream.

- Rapid Habitat Assessment and Stream Morphology: The rapid habitat assessment and stream morphology protocols require a great deal of wading within the stream channel, as well as travel on the stream bank. Care should be taken to avoid repeated travel in soft, marshy areas that are typically more prone to trampling.

- Groundwater Wells: The groundwater well network is spread across the site and requires relatively infrequent visits for sensor maintenance (~ 1x per month) and measurement of groundwater chemistry (~ 2x per year). In general the wells tend to be positioned in relatively stable dry ground, however care should be taken to avoid passing through soft, marshy areas

when moving from one well to the next. At each well location, care should be taken to not trample all the vegetation near the well during routine sampling or maintenance events.

7 REFERENCES

N/A

APPENDIX A QUICK REFERENCES

N/A

APPENDIX B REMINDERS

N/A