Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 1

Preparations for the Field Season and Equipment Needed

Version 1.01 (November 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	11/2011	D. Witwicki	Clarify terminology for headpins / transect ends; remove species richness	Unclear in previous version; no longer sampled	1.01

This SOP describes how to prepare for the field season, including a list of field equipment and tasks that are performed before each field trip.

1. Before the Field Season

The following tasks should be completed by the project manager or field crew leader well before the arrival of seasonal field crew members.

1. Post positions for seasonal employees or student interns 3-4 months prior to scheduled field work. Riparian monitoring requires four field crew members for vegetation sampling and three field crew members for surveying and well installation. Hiring must be completed at least six weeks prior to the beginning of the field season to allow time for federal background check procedures.
2. Review the entire protocol. Understand the goals and procedures of the monitoring program before beginning other preparations. Discuss any proposed or recent changes to the sampling design or protocol with appropriate I&M personnel. If a change has been implemented since the last field season, make sure that all field forms, databases, and relevant SOPs have been updated.
3. Compile a list of reaches that will be monitored. Discuss the season's objectives with appropriate I&M personnel to develop a field schedule.
4. Schedule field work. Use the guidelines below to develop a field schedule that meets the objectives for the field season and maintains some flexibility for unforeseen events.

   Seasonality of sampling
   Vegetation is sampled during the growing season, typically between June and September. Sampling visits should be scheduled to optimize phenology for the group of NCPN park units included in riparian monitoring. Park units should be visited at approximately the same time each year to maximize repeatability.

Stream channels are surveyed when riparian vegetation is leafless, generally late fall or early spring. The relative timing of surveying and vegetation sampling should be scheduled to minimize the possibility of flooding between sampling events. Well installation can occur at any time the ground is not frozen, but will likely occur in spring or fall to avoid weather extremes.

Field crew schedule
Crew members typically work 8 consecutive 10-hour days, followed by 6 days off, especially when working at distant park units or in the backcountry. Field work that does not require travel and camping has more flexibility. Office work at the beginning and end of the field season is scheduled for 8 hour days Monday through Friday, and additional office days throughout the field season may be scheduled for trainings, field preparation, or data management.

5. Request research permits. Begin the process at least 10 weeks before the start of the field season to allow ample time for processing.
6. Coordinate with the appropriate park staff to make sure that the proper compliance is followed before installing monitoring wells and rebar. It could take several months from the time paper work is submitted until our proposed installations are cleared.
7. Plan travel logistics. Notify appropriate park personnel of the dates the riparian field crew will be in their park unit. Discuss housing availability and needs with appropriate parks, and acquire backcountry camping permits.
8. Organize and check all equipment. Equipment is usually tested and inventoried at the end of the field season. Review this list to make sure that you have adequate supplies and that all replacement equipment is ordered and will be available before the field season begins. Tables 1-4 list equipment needed for each SOP.
9. Review plant species lists for each park unit, and update them with new species detected in the previous field season. Print additional copies, if necessary, so that each 2-person team has a copy for the field. Review the species most likely to be encountered in each park and assemble relevant flora, keys, and field herbaria.

2. A few weeks before each field visit

The following tasks should be completed by the field crew leader in the weeks before a scheduled field visit.

1. Review existing maps for each park, and request additional maps from the GIS technician if necessary. Make sure that the locations of existing benchmarks are added to maps for surveying trips.
2. Pack and review relevant information for each reach.

All visits

Access document – contains useful information for navigating to remotes areas of park units.

Trip reports - from the previous field season. At the end of each field trip, the crew leader writes a brief report describing general field conditions, access issues, logistical challenges, safety concerns, equipment problems, and suggestions for improving efficiency.

Monument photos – photos used to help relocate each headpin, total station instrument setup, or reference mark for surveying.

Vegetation sampling

Revisit data sheets – provides directions to the reach, coordinates of headpins, and any other specific information from the previous visit.

Reach species list - list of species detected during previous monitoring visits.

Surveying

Field notes – a copy of notes from the previous survey.

Hydrologic sampling

Well measurements – review distance between top and bottom of each well (TOC-BW) from Well Installation data sheet, and record these values on the Well Revisit data sheet for comparison with field measurements.

3. Print and copy the field data sheets. Print all greenline and pebble count data sheets and at least 1/4 of the other data sheets on Rite-in-the-Rain© paper. Copies of each form are found at the end of the appropriate SOP. Data sheets for field measures are listed below with the minimum number needed to sample a reach.

   Vegetation sampling

   Reach establishment or re-visit – 1
   Photos – 2
   Point-intercept – 14
   Greenline – 7 (perennial streams only)
   Canopy closure and exotic frequency - 7
   5-m belt – 7
   Reach census – 4
   Unknown Plants – 10
   Pebble count – 2
   Site assessment – 1

   Hydrologic sampling

   Well installation or re-visit– 1
   Flow measurement – 1

4. Coordinate with the GIS technician to reserve GPS units and load UTM coordinates for the reaches to be sampled.
5. Load data from the previous total station survey on the datalogger.
6. Contact parks and provide detailed trip information. Contact the resource staff and chief ranger and provide dates the crew will be working in the park, names of field crew members, vehicle descriptions, and approximate locations of monitoring activity.
7. Check stream flows and weather forecasts. Stream flows can be referenced at usgs.waterdata.gov. Applicable gages include:

   09404900 East Fork Virgin River near Springdale, UT for ZION
   09330000 Fremont River near Bicknell, UT, for CARE, and
   09330230 Fremont River near Caineville, UT for CARE.

Storm activity should be carefully monitored for its potential impact on crew safety and sampling. Due to high flash flood potential, fieldwork should never be scheduled at NABR during an active storm period. Do not sample during flood events.

8. Prepare decontamination solution. Wear protective eyewear and gloves while mixing the 5% quaternary ammonium solution.

   Use the following measures to properly dilute the solution:

Volume of tap water	**Volume of *Quat128*®**	**Volume of *Sparquat 256*®**
100 mL water	4.63 mL	3.00 mL
1 gallon water	6.35 liquid oz.	4.12 liquid oz.
1 gallon water	12.7 tbsp	8.2 tbsp
1 gallon water	0.79 cups	0.51 cups
100 gallons water	4.96 gallons	3.22 gallons
1000 gallons water	49.6 gallons	32.2 gallons

3. Immediately before each field visit

The following tasks should be completed by the field crew leader immediately before each field visit.

1. File a backcountry safety plan. The day the crew leaves for a multi-day field trip, the crew leader should fax a backcountry safety plan to Glen Canyon dispatch. Crew leaders should review the NCPN Backcountry Safety Plan for specific procedures.
2. Check for satellite phone availability using the Globalstar Call Times Tool at http://calltimes.globalstarusa.com/.
3. Perform a vehicle safety inspection and replace any necessary fluids.
4. Check out cameras, GPS units, and satellite phones to crew members. Depending on the type of field trip, also check out lasers, total station, data logger, water level meter, peristaltic pump, PDA, field laptop, and/or cordless drill. **Make sure that the batteries are fully charged for all rechargeable equipment.**
5. Before each use, test the diluted decontamination solution with “Quat Chek” Test Paper. Match up the color of the paper with the ppm’s on the color chart. For optimal disinfection, the diluted solution should have a concentration between 600 and 800 ppm. If it is too diluted, dispose of properly and make a new cleaning solution.

Table 1. Equipment needed for all integrated riparian sampling.

Item	Number needed	Description	Notes
General Equipment - *necessary for all SOPs*			
GPS with extra batteries	2	Trimble GeoXM or more accurate	main unit and backup
GPS car charger	1		
Digital camera	2		transect headpins and mid-channel, survey monuments and reference marks, wells and piezometers
Extra battery for digital camera	2		
Inverter	1	plugs into vehicle	charge electronic equipment
Permit	2 per vehicle		one on dashboard, one with crew
Maps	1 per 2 people		
Data sheets	variable		at least 25% on rite-in-the-rain paper
SOPs	1 per 2 people		
Clipboard	1 per 2 people	lightweight with interior storage	
Field notebook	variable	small, Rite-in-the-Rain©	field notes
Pencils	5 - 10		
Waders	1 per person	3 mm neoprene	optional during hot weather
Safety Equipment - *necessary for all SOPs*			
First aid kit	1 per 2 people		content list in NCPN Backcountry Safety Plan
Satellite phone	1 per 2 people		
Satellite phone charger	1 per phone		
NCPN Backcountry Safety Plan	1 per 2 people		
NCPN Accident Report Logs	1 per 2 people		found in NCPN Backcountry Safety Plan
NCPN Medical Information Forms	1 per person		found in NCPN Backcountry Safety Plan
Pump Sprayer	1	2- gallon herbicide pump sprayer	decontaminate equipment and personal items
Protective eyewear	1		use while mixing Quat solution
Quaternary ammonium	Pre-diluted	Quat128	decontaminate equipment and personal items
Quat-Chek test paper	1		test dilution of decontamination solution
Scouring brush	1		decontaminate equipment and personal items
Rubber gloves	10		protect hands during decontamination

Item	Number needed	Description	Notes
Throw bag	1		
Personal Equipment - *necessary for all SOPs, provided by observers*			
Insect repellent			
Sunscreen			
Water bottles			
Sunhat or baseball hat			
Shoes for wading			
Transect Set-up - SOP #4, *Necessary for all visits except hydrologic monitoring revisits.*			
100-m Kevlar taglines	2	Kevlar string with meter markings	set up transects through dense vegetation
Rebar	min. 4	3/8" diameter cut into 18" lengths	secure taglines
100-m transect tapes	2	fiberglass reel tapes	cross-section transects
Chaining pins	min. 6	striped metal pins	secure tapes
Transect relocation photos	R - 2	reference photos taken during establishment	

Table 2. Equipment needed for riparian vegetation sampling by a four-person crew. Some equipment is used for more than one activity but is listed under the most appropriate activity in this table.

Item	Number needed	Description	Notes
Reach Establishment and Re-visits - SOP #4, *Necessary for all visits unless noted with an E = establishment or R = re-visit.*			
Compass	2	with declination setting	set declination, take transect bearings
Rangefinder	E -1	short-range	measure riparian zone widths
Pin flags	min. 21	narrow steel pins with flag top	mark locations
Rebar	E -min. 18	3/8" diameter cut into 18" lengths	permanent headpins and temporary markers to secure taglines
Sledgehammer	2		drive in rebar
Rebar caps	E - 14	1 1/2" pre-stamped with NCPN	label rebar and cover top for safety
Leather piece	E - 1	piece of old belt or glove	protects rebar cap when pounding
2-way radios	4		crew communication
Extra radio batteries	min. 12	AA alkaline	radios require 3 per unit
Point-Intercept Sampling - SOP #6, *Necessary for all visits.*			
Point-intercept lasers	3		includes spare
Laser monopods	2		mount lasers

Item	Number needed	Description	Notes
Extra laser batteries	min. 6	1.5V silver oxide watch batteries	lasers take 3 per unit
Densitometer	2	periscope canopy instrument	point-intercept of tall shrub canopy
Screwdriver	1	small Phillips head	change laser batteries
10-m transect tapes	2	fiberglass reel tapes	greenline transects and pebble counts
Chaining pins	10	striped metal pins	secure greenline transect tapes
Reach species list	2	species previously recorded at reach	
Exotics and canopy closure - SOP #6, *Necessary for all visits.*			
Folding ruler	2		delineate exotic frequency quadrats
Spherical densiometer	2	modified concave	canopy closure
5-m Belt Transects - SOP #6, *Necessary for all visits.*			
2.5-m poles	2	made of 1.25-m PVC lengths with coupler	delineate 5-m belt boundaries
15-cm DBH calipers	2	diameter calipers in cm	measure sapling
DBH tape	2	diameter tape in cm	measure trees; also used for reach tree census
Reach Tree Census - SOP #6, *Necessary for all visits.*			
Tree tags	E - min. 200, R - min. 50	pre-stamped 1-1000 round aluminum	tree tags; use a different series for adding trees during re-visits
Nails	E - min. 200, R - min. 50	6d 2" galvanized steel	
Clawhammer	2		
Tool pouch	2		holds equipment
List of previously tagged trees	R - 2		
Plant Identification and Unknown Plants - SOP #6, *Necessary for all visits.*			
Hand lenses	2		
2-gallon resealable plastic bags	min. 6	2- gallon or larger	collect plants
Masking tape	2		label plant collections
Permanent marker	2		label plant collections
Trowel	2	small garden tool	extract specimen roots
Plant press	1	field press with card, blotter, and paper	store plant collections for identification
Relevant floras and park species lists		various by park	
Photographs - SOP #5, *Necessary for all visits.*			
Chalkboard	2	5 x 7"	label photos
Chalk	2		
Pebble Count - SOP #7, *Necessary for all visits.*			

Item	Number needed	Description	Notes
Metric rulers	2	stiff, with engraved or raised markings	measure pebbles
Site Assessment - SOP #8, *Necessary for all visits.*			
Stopwatch	2		time exotic plant search

Table 3. Equipment needed for stream channel surveys by a three-person crew.

Item	Number needed	Description	Notes
Stream Channel Surveying - SOP #9, *Necessary for all visits unless noted with an I = initial survey or R = re-visit.*			
Total station with 2 batteries	1		make sure batteries are fully charged before leaving
Charger for total station	1		use when electricity is available
Datalogger with Survey Pro software	1		make sure batteries are fully charged before leaving
Charger for datalogger	1		use when electricity is available
12-volt battery with inverter	1		charging equipment in the backcountry
Tripod	1	with 5/8" screw-mount and adjustable legs	mounting total station
Backsight tripod and tribrach	1		mounting backsight
Prism	3	identical	for rods and backsight
Metric surveying rod with level	2	identical, telescoping to 5 m	
10-m engineer's tape	1		measure instrument and rod heights
2-way radios	3		crew communication
Extra radio batteries	many	AA alkaline, 3 per radio	1.5 sets per radio per day
Ear piece with microphone	1	compatible with radios	for person running total station
Rebar	I - min. 12, R - 4	3/8" diameter cut in 0.5 m lengths	permanent and temporary markers; secure taglines
Stamped aluminum rebar caps	I - 12	1 1/2" pre-stamped with NCPN	label rebar and cover top for safety
Hammer/mallet	1		
Screwdriver, pliers, and wrench set	1		attach prisms, troubleshoot equipment
Pin flags	30	narrow steel pins with flag top	mark locations
Flagging	1 roll	brightly colored	mark locations
100-m Kevlar taglines (2)	2	Kevlar string with meter markings	set up transects through dense vegetation

Item	Number needed	Description	Notes
GPS	1	Survey grade with horizontal accuracy < 0.1 m	
Field notes from previous survey			

Table 4. Equipment needed for well installation and hydrologic monitoring.

Item	Number needed	Description	Notes
Well Installation - SOP #10			
Well points	3	1.25” I.D. x 3’ length, 60 Gauze (Campbell)	
Galvanized pipe	min. 36 ft.	1.25” x 4’ lengths, threaded on both ends	for riparian piezometers
Screened riser	1	1.25” I.D. x 2.5’ length 60 Gauze well point (Campbell) without point	for instream well
Drilled riser	1	1.25” I.D. x 2.5’ length of galvanized pipe with holes pre-drilled	backup for instream well
Fence post driver	1	large diameter, heavy-weight	drive in wells
Drive caps	4	1.25” I.D.	
Drive couplings	12	1.25” I.D.	
Sacrifice pipe	3	1.25” x 8” length, threaded on both ends	
Teflon tape	3 rolls		protect threads while installing pipe
Ear protection	3	ear-muff style	safety
Padded gloves	3 sets		safety
Bubble level	1		level pipe during installation
Shovel	1		prepare hole for well
Rope	1	min. 15 ft.	guide casing during installation
Bentonite pellets	6 shovels worth		seal space around well
Small bucket or water bottle	1		
Pressure transducers	3	non-vented (Solinst)	records water stage
Barometric logger	1	Solinst	records atmospheric pressure
Kevlar rope	min. 45 ft.	1/8” braided (U.S. Rope & Cable)	install pressure transducers
Eye bolt	3	3/16” x 2”	install pressure transducers

Small hex-head cable clamp	6	1/16”	prevent the end of the Kevlar rope from unraveling
Cordless power drill	1		vent piezometer
Drill bit	2	1/8” split point	vent piezometer
Filter fabric	1	2 ft. x 6 ft. section of landscaping grade fabric	wrap around exposed section of instream well if holes were manually drilled
Hose clamps	4	1”- 1.5” hex-head and/or flat head screw driver adjust	affix filter fabric to well
Permanent marker	1		mark alignment for water level meter
Hydrological monitoring *(all visits)* - SOP #10 *Necessary for all visits unless noted with an R = re-visit.*			
Pipe wrenches	2		tighten fittings, open and close wells
Water level meter	1	Solinst	measure depth to water in wells
Flow-meter and associated equipment	1	Pygmy (Rickly), Flume, or Weir depending on stream size	measure stream flow
Inertial lift pump	1	semi-rigid tubing (HDPE) with footvalve (Waterra)	remove fine sediments
Peristaltic pump	1	Geotech Geopump 2	purge well
Flexible tubing	min. 25 ft.	Masterflex	used with peristaltic pump
PDA and interface cable	R - 1	Solinst Levelloader and cable specific to the PDA	download pressure transducer and barometric logger data
Field laptop and cable	1	with Solinst software and optical interface USB cable is specific to pressure transducer /barometric logger	download pressure transducer and barometric logger data; reprogram instruments

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 2

Hiring and Training Observers

Version 1.00 (March 2010)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP explains the qualifications needed for permanent and seasonal field personnel and procedures for training vegetation sampling technicians. Accurate, consistent data collection begins with the hiring process, followed by a rigorous training program. Technicians must also be prepared, both mentally and physically, for the extreme weather and difficult terrain of NCPN parks.

Hiring Field Technicians

Staffing requirements

Integrated riparian monitoring requires hydrologic, geomorphic, and vegetation expertise. A permanent or term subject-to-furlough hydrologic technician (minimum GS-6) installs and maintains all hydrologic equipment and coordinates collection of hydrologic data. A permanent or term subject-to-furlough biological or physical science technician (minimum GS-6) leads a crew responsible for vegetation and geomorphology sampling. Three seasonal crew members (NPS, volunteer, intern, or cooperator) comprise the riparian vegetation crew. Two of these seasonal technicians will also assist with geomorphology sampling.

Qualifications and attributes

In addition to the technical skills, experience, and knowledge listed below, certain qualities are necessary for all NCPN field personnel. To maintain data quality, all staff should have the ability to successfully engage in repetitive, detail-oriented work. Technicians must be in excellent physical condition and able to thrive in difficult field conditions. Certification as a Wilderness First Responder (or Wilderness First Aid) and CPR is also an asset. Employees should expect to travel to remote parks and work away from home for periods of up to 8 consecutive days and, in many instances, to camp in backcountry situations.

Technical Skills, Experience, and Knowledge

The Riparian Crew Leader can be either a Biological or Physical Science Technician. Since it is unlikely that NCPN will be able to recruit a candidate with the technical expertise needed for both vegetation and geomorphology sampling, NCPN is committed to train the selected candidate in the skill that they are lacking. The technical skills, experience, and knowledge required for all integrated riparian field positions is detailed below.

Lead Biological Science Technician (Crew Leader)

- Ability to identify common riparian genera and species.
- Ability to key plants to species using floras and technical keys.
- Experience leading a field crew to collect biological data in remote field settings.

Lead Physical Science Technician (Crew Leader)

- Experience using a total station and post processing total station data.
- Ability to identify bankfull and channel thalweg.
- Experience leading a field crew to collect physical data in remote field settings.

Hydrological Technician

- Experience installing and maintaining instream monitoring wells and piezometers.
- Ability to identify channel thalweg.
- Ability to work independently in remote field settings.

Seasonal Biological Science Technicians (or interns or volunteers)

The most essential element for the collection of quality data is well-trained, experienced field crews. Given the variability of plant community types across NCPN parks, it is necessary to hire highly skilled botanists with experience working throughout the region. The importance of hiring and training well-qualified observers cannot be overemphasized. In order to accurately detect trend across sampling periods, it is imperative that observers record vegetation and geomorphology data using the same methods and level of precision year after year. While not imperative, experience conducting quantitative vegetation sampling is a valuable skill in any employee. During the applicant review process, it will be important to give priority to those candidates with considerable experience conducting vegetation surveys and, secondly, to candidates with (1) experience conducting any type of field work that involves data collection, (2) extensive experience backpacking and hiking, and/or (3) an academic degree related to vegetation or ecology. Particular attention should be paid to the experience of the observer, his/her ability to learn new plants, physical abilities to withstand difficult field conditions, and overall attitude. NCPN will train biological science technicians in geomorphology survey techniques.

Training Seasonal Vegetation Observers

To promote accuracy and consistency in data collection among data collectors, training should be designed to calibrate data collectors so that they have comparable skills in identifying species and are recording data in a consistent format. For data collectors who are already competent at identifying plants by sight and taxonomic keying, the need for training in plant identification may be minimal. If the program is fortunate enough to hire all experienced personnel for a season, then the proposed training program will improve their skills. No data collector is exempt from the training program.

1. Prepare for the training program. The project manager or crew leader acts as the primary instructor; however, experts in various aspects of the protocol (such as First Aid/CPR) should be scheduled to assist in training as necessary. The instructor must prepare training materials, itineraries, and field gear before the training program begins.

2. Issue field gear before training begins. See SOP #1 for a list of field equipment. Provide a copy of this protocol to all trainees, along with a list of recommended personal field and camping equipment, before training begins. Ensure that observers examine the list of necessary personal gear (see SOP #1) and that they have all the appropriate equipment by the time field work starts. Make sure that trainees are informed and prepared for the training and survey events. Have the field technicians read the relevant riparian SOPs prior to field training.

3. Have all vegetation crew members participate in Riparian Vegetation Reach Establishment, Navigation, and Safety training. The project manager and field crew leader provide several days of instruction covering all field-based procedures. All field SOPs should be thoroughly reviewed prior to field exercises so they can be used as references during training. Crew members will practice plant identification skills, navigation techniques, and data collection methods on a test transect before sampling a real transect. All procedures will be exercised to the full extent, including actual recording of observations on data sheets.

Crew members from previous seasons normally do not need as much training as new crew members; however, all data collectors must attend the entire training each year. For returning crew members, it is especially important to point out changes to the protocol, review any issues with data quality from the previous year, and recommend methods for improving data quality, if necessary. Experienced crew members can assist with training less-experienced field crew members.

It is important that all crew members calibrate their measurement techniques with each other before collecting data at monitoring reaches. This will ensure that measurements are as consistent as possible among crew members. Crew members should rotate partners often during training so that they can identify discrepancies in data collection techniques and remedy any issues before actual data collection.

4. Focus on navigation and reach set-up. Training should be given in both general navigation techniques using traditional maps and compass, as well as handheld GPS units. All technicians should practice recording spatial data using a GPS unit.

5. Emphasize field safety procedures and issues. Training includes a one-day CPR/First Aid course, review of the NCPN Backcountry Safety Plan and first aid kits, and Job Hazard Analysis. Discuss important safety issues for the NCPN region, notably, flooding, heat/cold exposure, hiking safety, and fatigue. Review proper use and care of government vehicles, vehicle inspection, tire changing, defensive driving, and safety on 4WD roads. The crew leader or project manager will also review low impact camping procedures.

6. Review dominant plant species. Training consists of field-based identification of plants likely to be observed during the field season, with emphasis on difficult-to-identify species. Additionally, field crews are instructed on the use of available taxonomic keys and reference

materials. The field crew leader provides tips for making quality plant collections, documenting unknown species, and vouchering new species. Since the northern Colorado Plateau is ecologically diverse, the field crew leader also provides plant species training throughout the field season at each new park unit, including guided plant walks and a review of field herbaria.

7. Conduct additional training at reaches that are easily accessible.
Training continues throughout the 1st field trip to actual reaches. Sampling should occur in a park that is easily accessible to account for slower data collection while new crew members are learning. Field partners should also be rotated frequently to continue calibration of field measurement techniques.

Suggested topics for training:

Program overview – introduction to NCPN goals and projects

Administrative responsibilities and policies – timesheets, travel, work hours, leave policies, and equipment care

Safety – NCPN Backcountry Safety Plan, Job Hazard Analysis, first aid kits, satellite phone use, specific safety concerns

Government vehicles – proper use and care, vehicle inspection, tire changing

Park etiquette – biological soil crust, visitor interactions, low impact practices

GPS – navigation, logging points, data dictionaries

Reach establishment – measuring active riparian zone width, identifying the channel thalweg, taking bearings using a compass, transect set up

Vegetation measures – Includes all methods in SOP #6. Pay particular attention to training observers in identifying the greenline, tagging trees, and measuring DBH.

Pebble count – identifying scoured channel, measuring b-axis

Photos – taking good reference photos, appropriate camera orientations for monitoring photos, checking time and date settings

Plant identification – making plant collections, using available plant references, review of common species with particular attention to difficult groups including grasses, sedges, rushes and willows, plant walks in the field

Geomorphology surveys – proper extension of the rod and positioning of the prism, identifying geomorphic surface breaks, identifying bankfull and channel thalweg

Riparian Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 3

Using Global Positioning System (GPS) Units

Version 1.03 (January 2012)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	12/2010	A. Wight	Added instructions for recording census trees and unmonumented transect ends	Protocol change; clarification	1.01
1.01	6/9/2011	A. Wight	Added instructions for offsetting a feature and adding UTMs	Clarification	1.02
1.02	1/9/2012	K. Lund, D. Witwicki, A. Wight	Clarified terminology, updated TerraSync screen captures	Confusion between headpins and transect end points	1.03

This SOP explains the procedures and considerations that all observers should follow when navigating to and/or collecting geospatial data at riparian monitoring reaches. It assumes that each observer is familiar with the operation and function of the GPS unit to be used for this project. This SOP is intended to complement, not replace, the operations manual accompanying the GPS unit.

This SOP is divided into two main sections: 1) Riparian Site Characterization and Riparian Reach Establishment, and 2) Riparian Site Revisit. Each main section contains minimum GPS receiver requirements, followed by brand-specific instructions. The intent is to maintain a high quality of GPS spatial accuracy and collection capabilities. This SOP does not require the use of a specific brand of GPS unit; however, the unit must meet the minimum standards listed below.

1. Definitions and Acronyms

NPS	National Park Service
NCPN	Northern Colorado Plateau Network
I&M	Inventory & Monitoring Program of the National Park Service
SOP	Standard Operating Procedure
GIS	Geographic Information Systems – A computerized system used to input, manage, manipulate, analyze and display geographic data in digital form.
GPS	Global Positioning System (unit/receiver/datalogger) – A three part system of 1) 25+ Department of Defense satellites, 2) Control segment, 3) Users with receivers

Coordinate system	Any three-dimensional reference frame that locates objects in space.
FGDC	Federal Geographic Data Committee, the interagency committee that promotes the coordinated development, use, sharing, and dissemination of geographic data.
Feature	A physical object or location of an event. A feature can be a point, line, or polygon (area).
Data Dictionary	Information (data) that describes features that will be located in the field.
Tabular dataset	A dataset organized in a table or group of tables where each column and row has a specific interpretation; often produced by Microsoft (MS) Excel, MS Access, database, or statistical software, and managed as text, spreadsheet, or relational databases.
Spatial dataset	A dataset that is natively read by mapping software; often produced by mapping software, such as ESRI ArcMap and ArcInfo; also includes georeferenced imagery, geodatabases, as well as hardcopy aerial photographs, satellite imagery, and maps.
Raw data	Data that have not been subjected to either quality control or documentation procedures; includes data recorded by hand on hard-copy forms, digital files from handheld devices, GPS receivers, telemetry data loggers, etc.
Certified data	Finalized project data, i.e., data that have undergone thorough quality assurance and screening as well as complete documentation.
Working database	A project-specific database for entering and processing data for the current season (or other logical period of time). This might be the only database for short-term projects where there is no need to distinguish working data for the current season from the full set of validated project data.
Master database	Project-specific database for storing the full project data set, used for viewing, summarizing, and analysis. Only used to store certified data.

2. Site Verification and Reach Establishment

The project manager predetermines the centroids of riparian monitoring reaches (specific XY coordinates in UTM NAD83). NCPN requires the use of a mapping grade GPS unit to record any locations in a reach.

2.1 Minimum GPS Receiver Requirements

- Capable of uploading pre-determined riparian monitoring locations
- Capable of utilizing data dictionary utilities (NCPN Riparian Data Dictionary, see section 2.3)
- Capable of utilizing park-specific background GIS data layers
- Capable of navigation
- Capable of maintaining 4 or more satellites
- Capable of maintaining horizontal errors of less than 5 meters (PDOP (or equivalent error reading) of less than 6)
- Capable of post data collection correction (differential correction)
- Capable of storing date, time, elevation, and coordinates of features collected (in addition to data dictionary items)
- Capable of exporting features collected to a GIS data format

2.2 GPS Unit Setup

The NCPN currently uses the Trimble line of mapping grade GPS units and TerraSync software to capture the spatial data for the riparian monitoring reach locations. The requirements should be transferable to other mapping grade GPS receivers (such as Leica etc.).

Positional accuracy can be affected by several factors which mapping-grade GPS units can track and to some extent, compensate for. Table 1 lists these functions, their definitions, and the standard settings.

Table 1. Minimum GPS receiver settings standards.

Name	Definition	Standard
Almanac	GPS unit collects data containing estimated position of satellites, time corrections, and atmospheric delay parameters.	The unit will automatically collect the almanac. Acquire within 10 days prior to data collection or navigating, download to computer.
Altitude reference	Ellipsoid model	Height Above Ellipsoid (HAE)
Antenna heights	GPS unit height above the ground (average).	1.0 meter
Coordinate System	A reference system consisting of a set of points, lines, and/or surfaces, and a set of rules, used to define the positions of points in space in either two or three dimensions.	Universal Transverse Mercator (UTM)
Datum	Geodetic model designed to fit a point on the earth's surface to the ellipsoid.	NAD 1983 (Conus)
Elevation mask	The minimum angle at which a GPS receiver will track satellite vehicles.	15 degrees
Logging intervals	Time interval between positions gathered.	Point: 1 second Line and Polygon: 5 seconds
Minimum number of positions for a point feature	Number of positions received then averaged to create a point feature.	10
Mode	2-Dimensional or 3-Dimensional	3-Dimensional (4 satellites)
PDOP Mask	Positional Dilution of Precision is a measurement of the geometry of the satellites.	6.0 or less
Satellite vehicles	Number of satellites, currently a constellation of 28 DOD satellites.	4
SNR Mask	Signal-to-Noise Ratio is a measure of the strength of the satellite signal relative to background noise.	4.0
Unit of Measure	Units of measure.	Meters
Zone	In UTM coordinate system, the globe is divided into 60 north-south zones.	Zone 12 North (N)* *Black Canyon & Curecanti are Zone 13 N

2.3 Data Dictionary

A data dictionary should be utilized to facilitate field data collection as well as to assure necessary data items are correctly collected. The minimum elements necessary for the riparian data dictionary are shown below. Once the project manager has given the GIS technician all potential riparian points for a given park in a given year, those points are then imported with the Riparian data dictionary (using Pathfinder Office), creating a data file for Reach Establishment (*PARK*_Riparian). All point features in the Riparian Data Dictionary should have the default feature settings of:

Logging Interval	Time = 1 second
Minimum Positions	3
Accuracy	Code
Label 1	ReachID

The following data dictionary digital file (.ddf) can be obtained by contacting the NCPN Data Management staff.

Reach Establishment Center Point Feature

The reach establishment point should be used to locate the center point of the riparian monitoring reach. Once the location has been evaluated as an acceptable or rejected riparian monitoring reach (see SOP #4), fill in the S_Action as "Accept" or "Reject."

EstPlotCenter Attributes	Attribute Explanation	Entry	Type
ReachID	Numeric unique ID from Project Manager	Entry **not** permitted in the field	Numeric
S_Action*	• Accept – decision to accept the site as an acceptable riparian monitoring location • Reject – decision to reject the site as an acceptable riparian monitoring location	Entry permitted in the field	Menu
Comments	Any comments regarding the reach	Entry permitted in the field	Text – Optional

*will only be included in the data dictionary during years of initial riparian set up, this will not be needed after reaches have been established.

Headpin Points Feature

A riparian monitoring reach has seven transects, and each transect is monumented with two headpins. When possible, headpins are located at transect end points. Often a headpin cannot be located precisely at the beginning or end of a transect because it falls on bedrock, in the channel, or in some other unstable situation. In such cases, the headpin is placed at a stable point along the transect in the general vicinity of the transect end (see SOP #4). Identify and GPS the location of each headpin. Record the location of the headpin along the transect to the nearest 0.1 m in the "Headpin_m" attribute in the data dictionary.

Headpin Attributes	Attribute Explanation	Entry	Type
ReachID	Numeric unique ID from Project Manager	Entry permitted in the field	Numeric
HeadpinPt	• T1_Left (Transect 1, river Left headpin) • T1_Right (Transect 1, river Right headpin) • T2_Left (Transect 2, river Left headpin) • T2_Right (Transect 2, river Right headpin) • T3_Left (Transect 3, river Left headpin) • T3_Right (Transect 3, river Right headpin) • T4_Left (Transect 4, river Left headpin) • T4_Right (Transect 4, river Right headpin) • T5_Left (Transect 5, river Left headpin) • T5_Right (Transect 5, river Right headpin) • T6_Left (Transect 6, river Left headpin) • T6_Right (Transect 6, river Right headpin) • T7_Left (Transect 7, river Left headpin) • T7_Right (Transect 7, river Right headpin)	Entry **required** in the field	Menu
Headpin_m	Distance, in meters, along the transect where the headpin is located. Normally Right = 0 and Left = transect end, but often shifted due to bedrock or unstable surfaces.	Entry permitted in the field	Numeric
Comments	Any comments regarding the headpin location (“under TAMCHI” or “beside boulder”, for example).	Entry permitted in the field	Text – Optional

Transect Start or End Points Feature

GPS the location of each transect beginning or end point. Record a right and left end point for each transect, even if you already recorded the same point under the headpin point feature. GPSing transect start and end points is a lower priority than GPSing headpins, but should be completed whenever possible.

Transect Attributes	Attribute Explanation	Entry	Type
ReachID	Numeric unique ID from Project Manager	Entry permitted in the field	Numeric
TransPoint	• T1_Left (Transect 1, river Left) • T1_Right (Transect 1, river Right) • T2_Left (Transect 2, river Left) • T2_Right (Transect 2, river Right) • T3_Left (Transect 3, river Left) • T3_Right (Transect 3, river Right) • T4_Left (Transect 4, river Left) • T4_Right (Transect 4, river Right) • T5_Left (Transect 5, river Left) • T5_Right (Transect 5, river Right) • T6_Left (Transect 6, river Left) • T6_Right (Transect 6, river Right) • T7_Left (Transect 7, river Left) • T7_Right (Transect 7, river Right)	Entry **required** in the field	Menu
Location	Distance, in meters, along the transect where the start or end occurs. Right = 0 and Left = transect end.	Entry permitted in the field	Numeric

Comments	Any comments regarding the transect location ends (for example "on slickrock").	Entry permitted in the field	Text – Optional

Tree Census Points Feature

Individual or small groups of trees may be mapped during the reach census (see SOP #6) in order to help future crews relocate trees. For each tree/tree group that is GPSed, record the tree tag number(s) and ReachID in the data dictionary.

CensusTree Attributes	Attribute Explanation	Entry	Type
TreeTagNum	Tree tag number(s)	Entry **required** in the field	Text
ReachID	Numeric unique ID from Project Manager	Entry permitted in the field	Numeric
Comments	Any comments regarding the tree(s).	Entry permitted in the field	Text – Optional

Cultural Feature

This point feature is available for your use should you encounter a cultural site of some type.

CulturalSite Attributes	Attribute Explanation	Entry	Type
Type	• Structure • Lithic Scatter • Potsherds • Cowboy camp • Fence • Pictograph • Petroglyph • Other	Entry permitted in the field	Menu
Comment	Incidental site observation comment	Entry permitted in the field	Text – Optional
Comment2	Incidental site observation comment	Entry permitted in the field	Text – Optional

Other Optional Point Feature

This point feature is for incidental observations the monitoring crews may encounter. For example, you may find an invasive exotic plant community or want to mark where you parked your car or left a trail. You can mark that location with this point feature, briefly commenting why you marked the location.

OtherPt Attributes	Attribute Explanation	Entry	Type
Comment	Incidental observation comment	Entry permitted in the field	Text – Optional
Comment2	Incidental observation comment	Entry permitted in the field	Text – Optional

Routes to Reaches
This line feature is for mapping routes to riparian monitoring reaches that seem somewhat difficult to locate and/or navigate to. Once all data collection is complete, on the hike out from the reach, this feature can create a route or trail for future field crews to easily locate the monitoring reach.

Route Attributes	Attribute Explanation	Entry	Type
ReachID	unique ReachID	Entry permitted in the field	Text – Optional
Comments	Incidental observation comment	Entry permitted in the field	Text – Optional

All other data required from the GPS unit can be automatically downloaded from the GPS unit (see section 2.6).

2.4 Uploading possible monitoring locations

Mapping grade GPS units have the ability to upload data points to be used in concert with the data dictionary. The riparian monitoring reach locations are imported with the Riparian Data Dictionary by the NCPN GIS technician. Importing points (then uploading) to the GPS unit eliminates possible reach mis-identification in the field and allows the user to navigate more easily to a riparian reach and headpins.

Also, background data layers can be used to assist with navigation. The two GIS data layers found most useful as background layers have been 1) roads and trails and 2) hydrography, both combined with the park boundary.

2.5 Collecting data

Once you've navigated to the reach (or potential reach), it's time to collect the necessary GPS locations. Appendix A contains detailed instructions for using the Riparian data dictionary and various files. Open the necessary file, and begin logging the point and any required data. Each point collected should be allowed to receive 10 positions before ending data collection and moving onto collecting another type of point. Given the challenging terrain of many of the riparian monitoring reaches (e.g., transect end points under an overhanging wall, next to a cliff, under trees, etc.), many locations may need to be GPSed using the offset feature (see pg. 18 for detailed instructions).

2.6 Downloading

When data collection is finished, the GPS data need to be downloaded. The NCPN GIS technician downloads the data from the GPS unit(s) after each field excursion, and then differentially corrects the data, using the appropriate (closest) base station. The corrected GPS

files are then exported to a GIS data format. Table 2 indicates the attributes to capture while exporting the corrected GPS data into a GIS data format (i.e., "turn on" in Pathfinder Office).

Table 2. GPS Auto-generated attributes to capture.

PDOP	Update Status	Height
Correction Status	Data File Name	Vertical Precision
Receiver Type	Total Positions	Horizontal Precision
Date Recorded	Filtered Positions	Standard Deviation
Time Recorded	Data Dictionary Name	Position

Data should be exported using the same coordinate system used in the field (UTM, NAD83 Conus, Zone 12, meters). Any notes from the field crew pertaining to the GPS data will be corrected/fixed/edited at this time.

2.7 Uploading to the master Riparian Database

Once the GPS field data are validated & verified (GPS points given a visual review, compared to Generalized Random Tessellation Stratified (GRTS) coordinates, transect plot ID attributes verified) in ArcMap, the data are ready to be uploaded into the working Riparian Database. The GPS data are exported from ArcMap into an Excel spreadsheet for importing into the Riparian Database (see SOP #13, section 3.1).

3. Riparian Reach Revisit

Once reaches are established, GPS units will be used primarily for relocation of and navigation to the riparian reaches and transects. This allows for the use of recreational grade GPS units (Garmins, Magellans, etc.) rather than the sometimes heavier and larger mapping grade GPS units. The use of mapping grade units is encouraged for navigation to plots ready to be revisited; however, the following steps allow for the use of a recreational GPS unit. Appendix B contains detailed instructions on using a Garmin 76 GPS unit.

If it becomes necessary to replace a headpin that has washed away or become buried, the field crew should relocate the headpin following instructions in SOP #4. GPS the location of the new headpin and transect end points with the GPS unit. The GIS technician will download the updated coordinates for the reach and forward them to the Data Manager to incorporate into the Riparian database.

3.1 Minimum GPS Receiver Requirements

- Capable of uploading previously visited riparian monitoring transect locations (XY points)
- Capable of storing date and coordinates of features collected.
- Capable of exporting features collected to a format that can be used by GIS
- Capable of maintaining an EHE (Estimate of Horizontal Error) of less than or equal to 12 meters. Maintaining an EHE (or EPE – Estimate of Positional Error) of 12 meters or less meets the National Map Accuracy Standard.

- Capable of tracking a minimum of 4 satellites
- Capable of collecting real-time differentially-corrected positions (DGPS)

3.2 GPS Unit Setup

The riparian monitoring reach transects which are to be revisited in a given year will be given to the NCPN GIS technician. These locations (XYs of the plot centroid as well as all fourteen headpin and transect locations) will then be uploaded into a GPS unit for relocation purposes. If using a Garmin GPS, data transfer is enhanced by utilitizing the freeware DNRGarmin (http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions.html). Background maps of the area(s) to be visited should be uploaded from Map Source as well. Once the data are transferred to the GPS unit, the GPS unit is ready for field use.

The GPS unit should be configured with the settings in Table 3.

Table 3. Minimum GPS receiver settings.

Name	Standard
Projection (displayed coordinates)	UTM
Datum	NAD 83
WAAS	Enabled (on)

Appendix A

File explanations:

Existing Data Files on GPSes:

- *Park_Riparian*– (Park Reach Establishment) This file will contain the reach center points, the headpins as well as the transect end points. This file may also contain potential center points (locations not yet reconned) of riparian monitoring reaches.

Background Layers (Files):

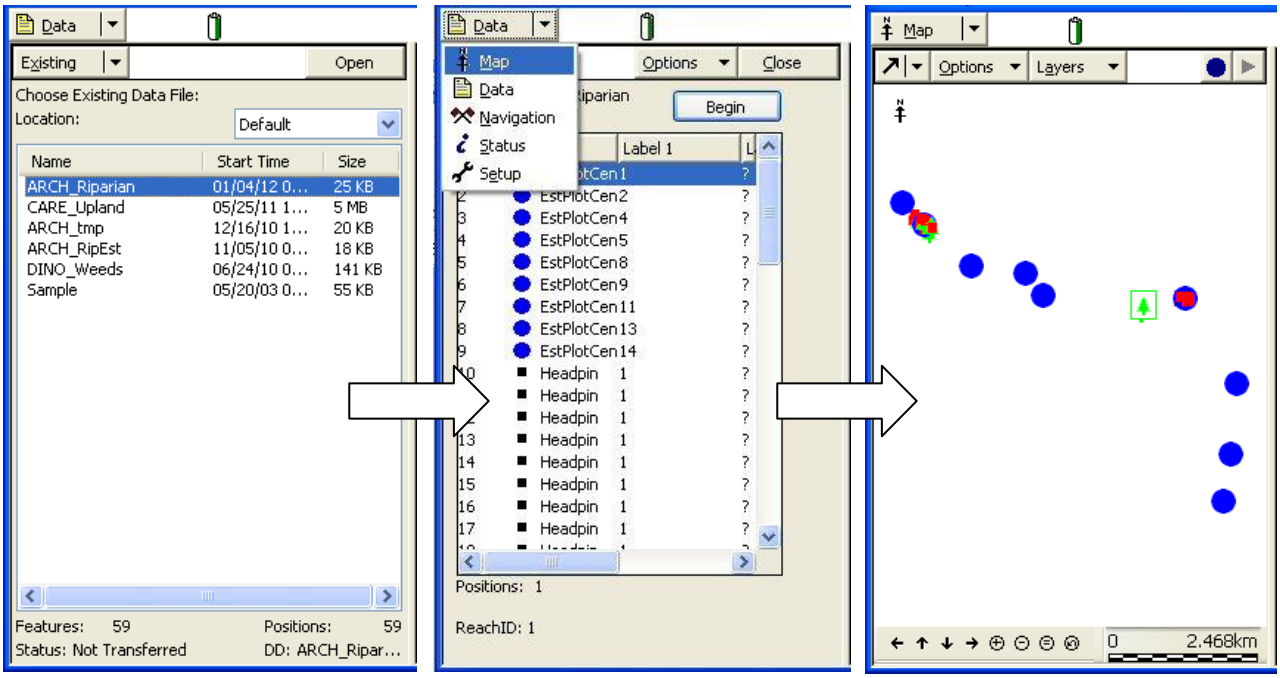
- *PARK*_RdsTrls – This file contains the roads and trails for [park], and the park boundary, as well as any previously GPSed route data to a reach.
- *PARK*_Strms – This file contains the "streams" (hydrography) for [park], and the park boundary.

Basic instructions:

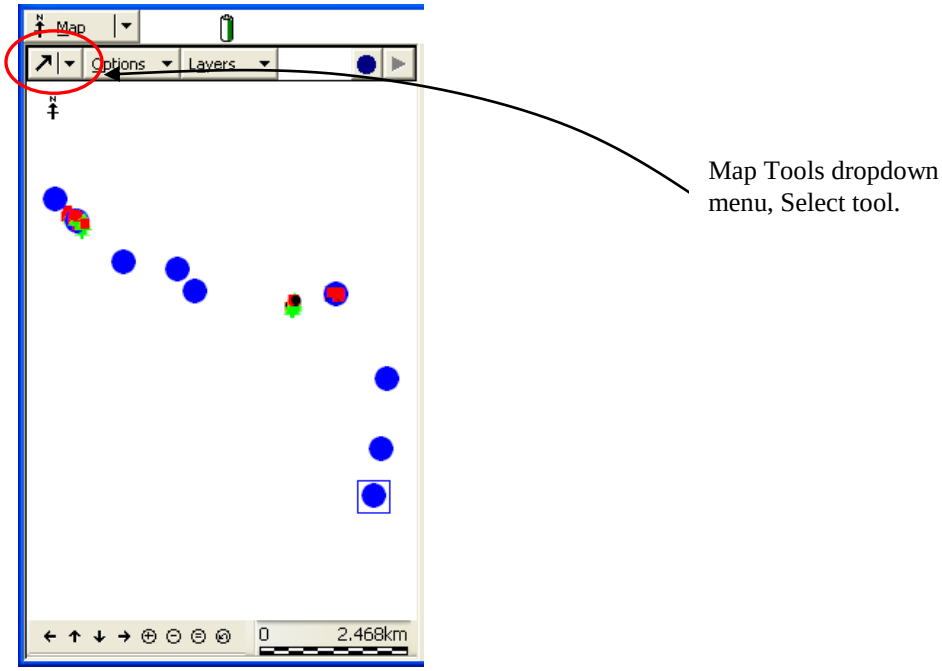
The following instructions are based on using a Trimble GPS unit with TerraSync Professional GPS software loaded. The directions below demonstrate one way of recording and navigating through the screens and options in TerraSync, not the only way to GPS the data needed for riparian monitoring points.

Navigation:

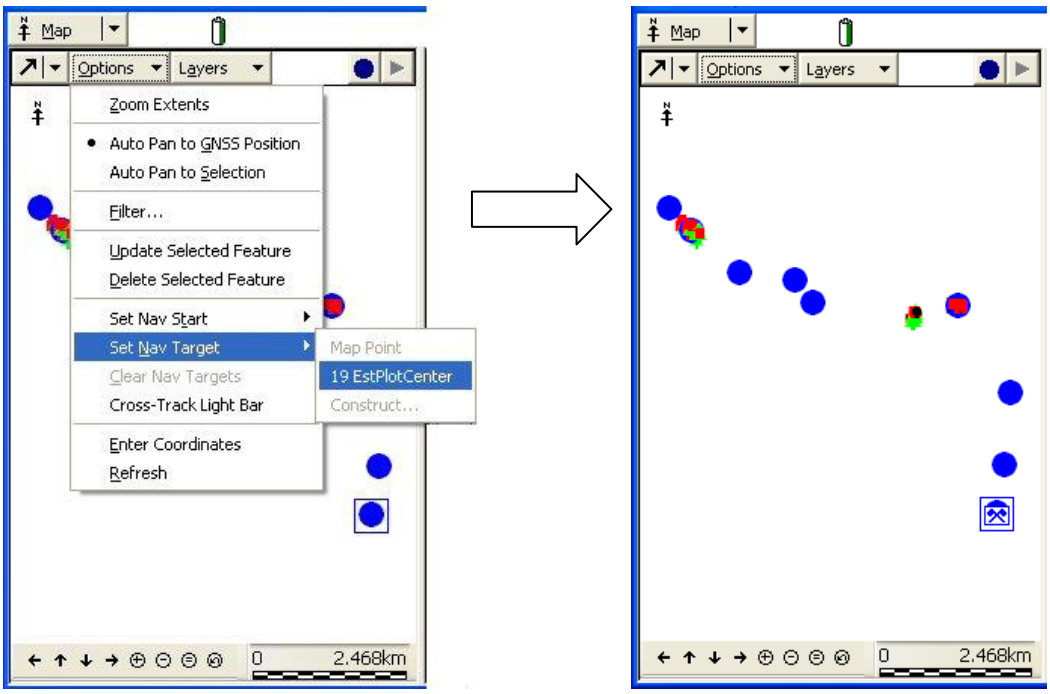
To navigate to a point, open the file which contains the point you want to update. Change the screen to the Map View (tap on the Data drop down, and choose Map).



Using the Map Tools (the drop down menu directly underneath Map), use the Select tool to select the point to which you wish to navigate. A box will display around the point.

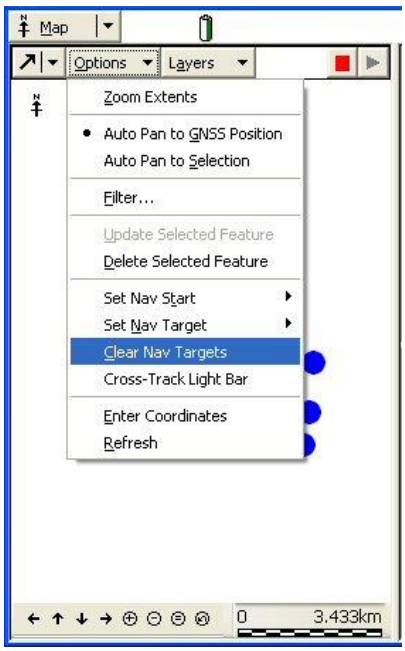


Click on the Options button, then Set Nav Target, then the point/file name. The selected point will then be displayed with the target icon (crossed flags).

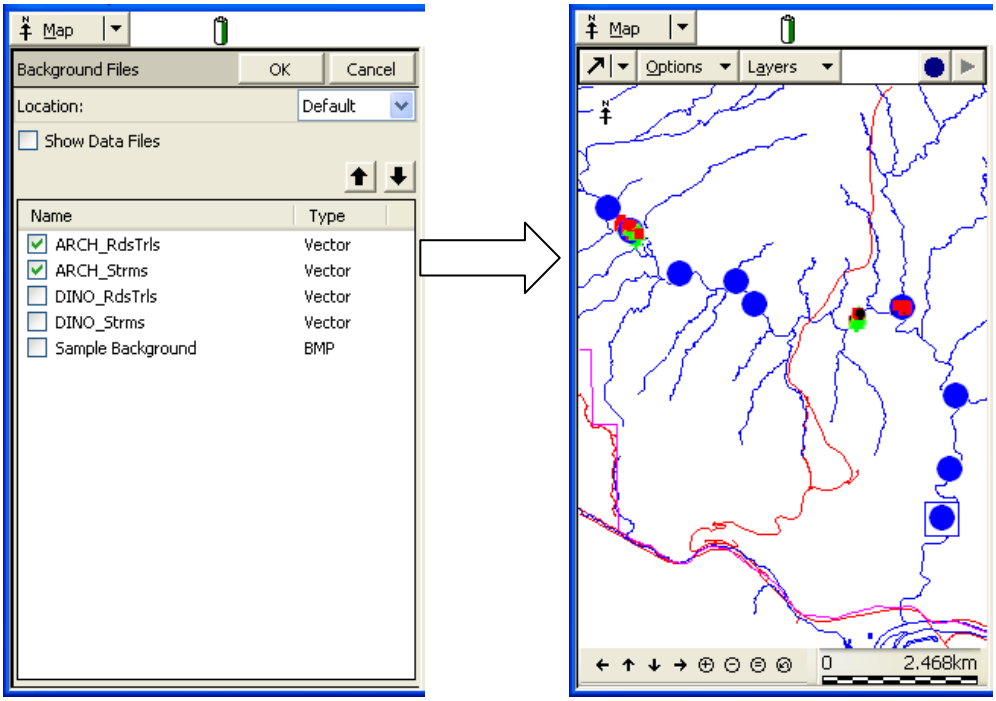


Open the Navigation section (click on Map and choose Navigation). This will open the navigation screen. As you move, this screen will display the information needed to navigate to the point.

When you've reached your point and/or no longer need to navigate, select the Map screen, then go to Options and select Clear Nav Targets.



To bring in some background layers, tap the Layers button, then choose Background Files. You can select one or more to display on the Map view (be aware that background files may display as one color). Tap OK. Also on the Layers button, make sure that Background is checked so the layers will draw.

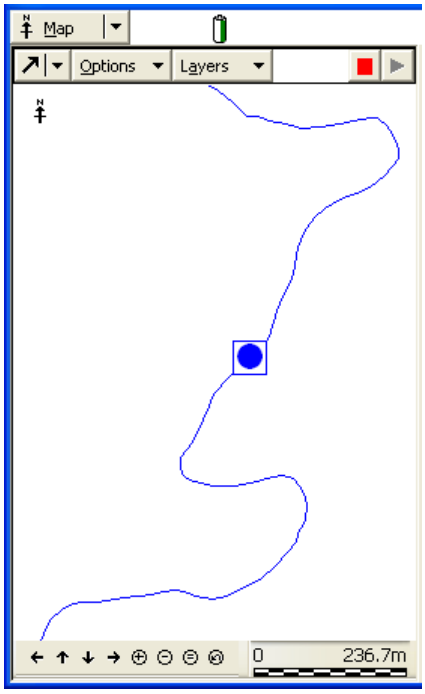


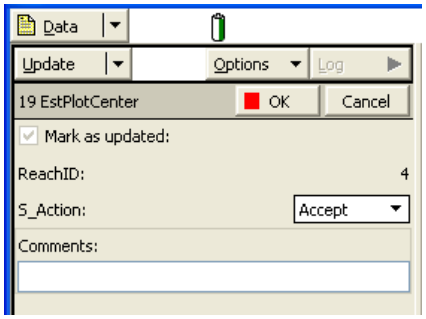
Tip – When navigating to a reach, use the reach centroid to navigate until you get fairly close to the plot, then switch to using one of the headpins or transect end points so you won't trample the transects getting to the reach.

Once you've found your riparian reach, if it hasn't previously been established, you'll need to GPS the centroid, each headpin, and each transect end point.

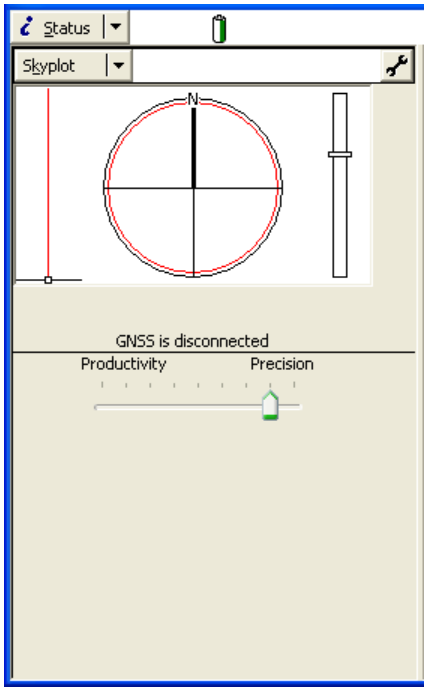
Log Data

To GPS (locationally update) the reach centroid (between T4_Left and T4_Right), merely double tap the reach center icon from the map screen, and the data dictionary fields for the point will open (EstPlotCenter). The only item needed for a reach center is the ReachID which is already there, so just let the GPS unit obtain 10 or so "hits" from the satellites, and tap OK.

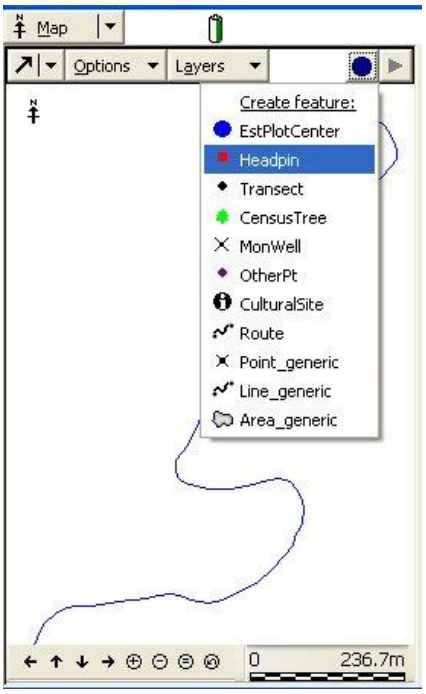


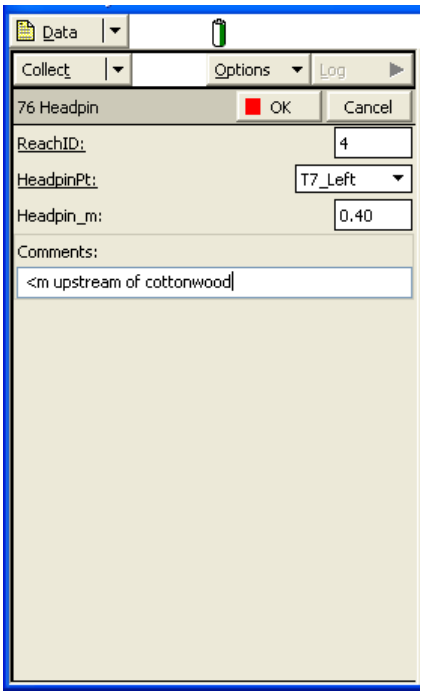


The location of the headpins of the riparian transects are important, as they are used in conjunction with the survey data. In order to get the best location possible, and if using a Trimble XM (fondly referred to as the "yellow bricks"), move the slider bar on the Status screen as far toward the Precision side as you can and still be able to log the location.

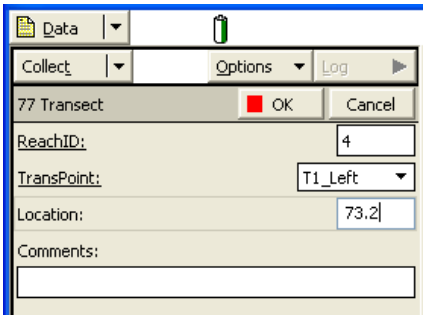


To GPS the headpins, select the blue dot at the top and right of the map screen, and choose Headpin. Fill in the ReachID and HeadpinPt at a minimum, Headpin_m and any comments if needed.

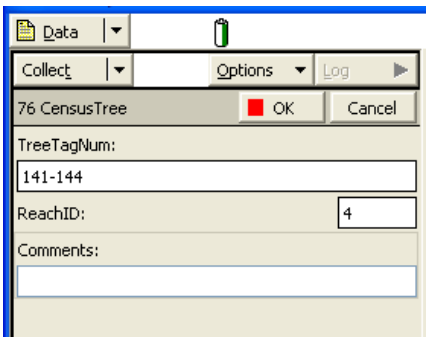




GPSing the Transect end points is nearly identical to GPSing the headpins; fill in the ReachID and TransPoint at a minimum, and Location and Comments if necessary. You may need to utilize the Offset feature, explained later on in this appendix.



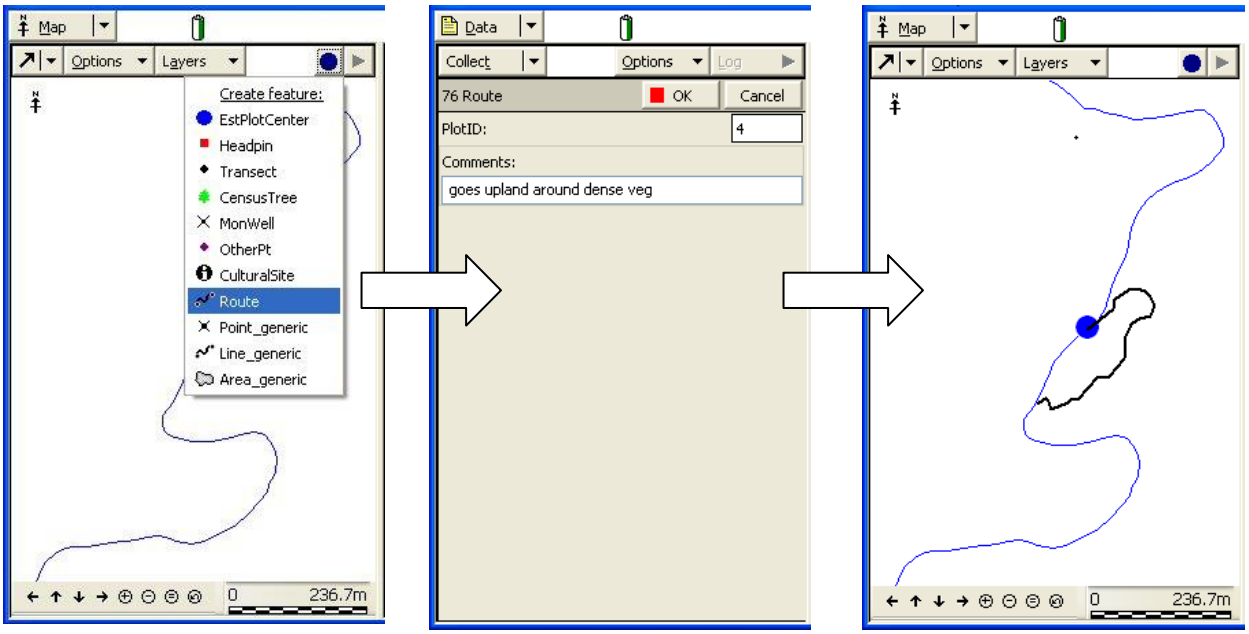
If there are a fair number of trees/tree clumps, and locations of those trees would be helpful in finding those trees in future years, use the CensusTree feature in the data dictionary, and include the tree tag number(s) and ReachID.



There are also two other point features, CulturalPt and Other. "CulturalPt" can be used to note the location of some type of cultural resource, while "Other" can be used to note the location of your vehicle, where you left a trail, or anything you want to record.

Creating Trails/Routes:
If you feel that the reach you've visited is difficult to navigate to and/or hard to find, you may want to GPS the route you take out. This route can then be shown to future field crews to enable them to get to the reach efficiently.

To map the route (trail) from the reach, click on Data/Collect and click on Route, which will bring up a field to fill in the ReachID and any brief comments you'd like to add.

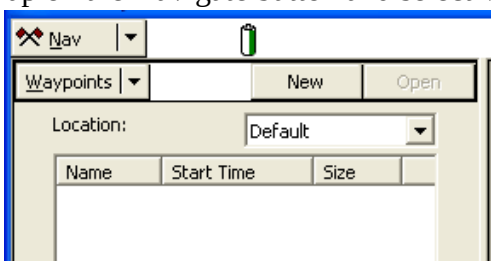


As you walk along, the GPS unit will collect a point every 3 seconds. You don't need to do anything until you get to the end of the route (i.e., back to the paved road or trail). At that point, just click OK to end, close, and save the feature.

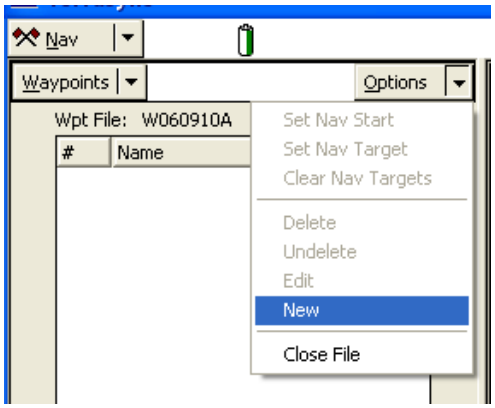
Creating a Waypoint from Coordinates

There may be times when you have a coordinate you need to get to that is not already loaded into the GPS unit. If you have the coordinates, you can create a waypoint, which then you can navigate to.

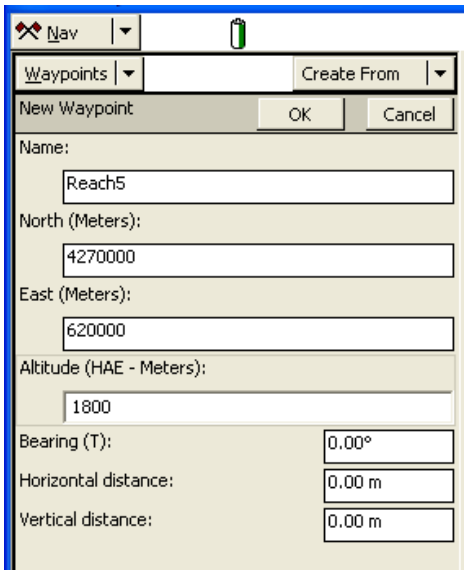
1. Go to the top left pulldown and select Navigation
2. Tap on the Navigate button and select Waypoints



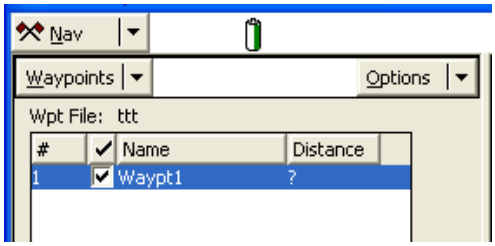
3. Create a new waypoint file by tapping the New button
4. You have the opportunity to name the file or use the default. Tap OK.
5. From the Options button, select New



6. Fill in the Name, North, East and Altitude fields (for elevation, enter a reasonable guess). Filling in the Bearing or Distance fields is not necessary. Tap OK.



7. Double click the point you just created, and it will automatically set it as the navigation target (note the checkmark)

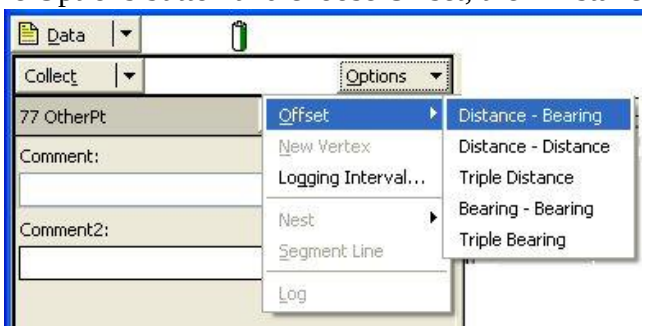


8. Tap on Waypoints dropdown menu, and choose Navigate. The Navigation screen will open, displaying the bearing and distance to the point you just entered. Now you are able to navigate to the location you just entered. The waypoint will also be displayed on the Map screen with the crossed flags icon.

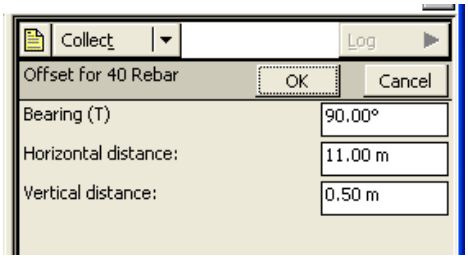
Offsetting a Point

If a location is next to a cliff or tree or something that is blocking satellite reception, you can still collect the location by using the Offset feature.

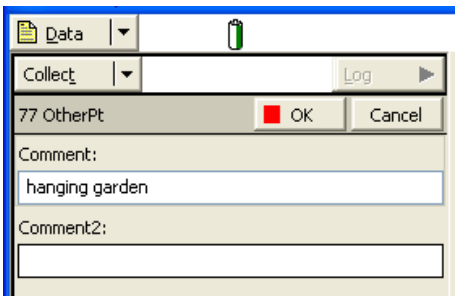
1. Select the feature to GPS from the data dictionary. Once the Data screen has opened, tap the Options button and choose Offset, then Distance – Bearing.



2. The Offset screen will appear. Fill in your bearing and horizontal distance (Vertical distance is optional) describing where the point is in relation to you, then tap OK.

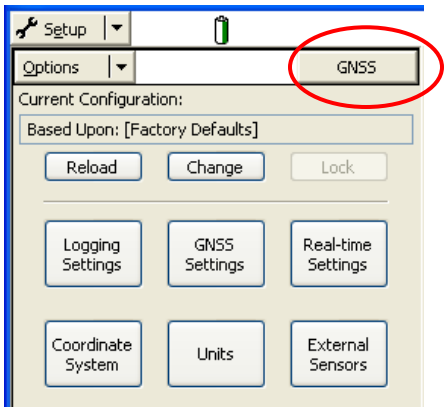


3. The data dictionary for that point feature will appear, allowing you to fill in the information necessary to collect the location. Tap OK when finished.



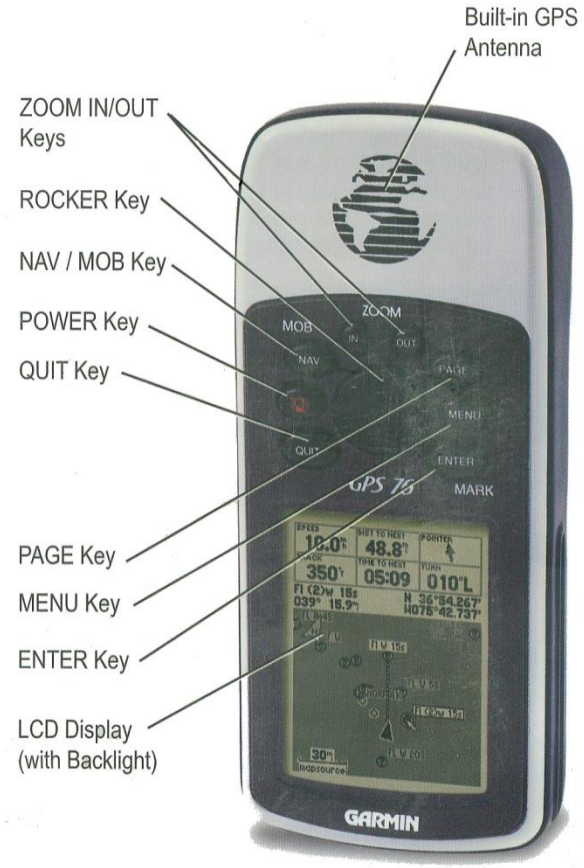
Hints for Trimble units:

- Log a point for a minimum of 10 (to 20) "hits" (about 10 seconds).
- At the end of the day (or end of needing the GPS), close the file in TerraSync (on the Data screen, Close is at the bottom right). Then close TerraSync (Data/Exit).
- Holding the power button down for 30 seconds will soft re-boot the XM GPS. Holding the power and reset button down for approximately 60 seconds will hard re-boot the XM GPS. Neither of these re-boots will lose any data, but you should recheck the coordinate system. You may need to reboot if the screen freezes or if TerraSync does not load.
- To re-boot the Junos, there is a little hole on the top left side (next to the expansion card). Push that with the tip of the stylus to re-boot the Juno.
- To conserve on battery life (generally 8 hours on XMs and 4+ hours on Junos), turn the unit off if you aren't using it to navigate. It is recommended that TerraSync be closed *prior* to turning off the unit.
- On the Juno ST GPS units, there is a sliding button near the power button. If it is slid down, this will "lock" the Juno off so it won't accidentally turn on while bouncing around in a backpack. Using this to turn the unit off (and on) seems to help conserve battery life (and allows TerraSync to be left open).
- If the GPS gets disconnected, go to the Setup screen and tap the GNSS button on the upper right side. A little connecting icon will appear as the unit reconnects to the GPS. A satellite icon will replace the connecting icon when TerraSync is reconnected to the GPS.



- As a general rule, if the battery life goes below 20% on the Junos, it's time to replace the battery. Close all files and exit TerraSync before switching batteries.
- The NCPN has a copy of the TerraSync Users Guide, which goes into more detail about the many functions of TerraSync. Please contact the GIS technician if you would like to take a look at it.
- Report any idiosyncrasies with the Trimble GPSes to the NCPN data management staff.

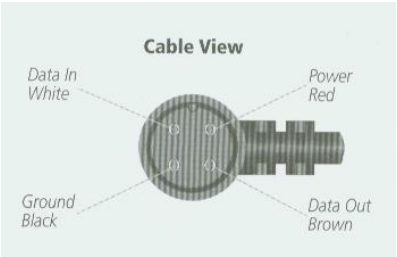
Appendix B



This graphic demonstrates the keys of a Garmin 76 GPS unit, and their functions. These keys are referred to in the following instructions.

1. To Connect GPS to Computer

- Either a serial or USB port cable will accompany the GPS unit. This is the cable that connects the GPS receiver to your workstation computer, allowing the uploading and downloading of waypoints.
- The serial or USB end of the cable attaches to your workstation computer. The other cable end (below) inserts into the Garmin GPS unit (lift bottom of black flap on the back of the GPS unit).



2. To change the displayed map projection:

- Turn on the unit by depressing the POWER key
- Set Projection
    1. Access the Main Menu (press the MENU key twice).
    2. Using the rocker key, scroll down to Setup and press the ENTER key
    3. There are several tabs listed (General, Time, Units, Location, Alarms & Interface) – using the rocker key, scroll over to the Location tab. Scroll down with the rocker key to Location Format and press the ENTER key.
    4. Scroll down the list of formats to UTM UPS, make sure this choice is highlighted, and press the ENTER key.
    5. Scroll down to Map Datum, press the ENTER key. Scroll down through the Map Datum choices, press the ENTER key when NAD 83 is highlighted.
    6. Press the PAGE key to get back to the "GPS Information" screen. (If the GPS Information screen is not showing, press the PAGE key; it will cycle through the screens). The bottom of the screen should now be displaying coordinates as UTM.

3. Set GPS to log differentially correct data

- If not already on, power up the GPS
- Enable WAAS
    1. Access the Main Menu (press the MENU key twice).
    2. Using the key, scroll down to Setup and press the ENTER key.
    3. There are several tabs listed (General, Time, Units, Location, Alarms & Interface) – using the rocker key, scroll over to the Location tab. Scroll down with the rocker key to General and press the ENTER key.
    4. Scroll down to WAAS, press ENTER, highlight Enabled, and press ENTER
    5. Press the PAGE key to exit Setup.

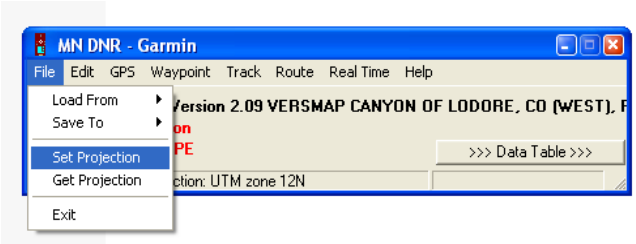
4. In the Field - optional

- Collect (or mark) a waypoint
    1. When at the observation location, check the GPS Information page for number of satellites (4 or more needed) and accuracy (12 meters or less)
    2. Press and hold the ENTER/MARK key until the Mark Waypoint Page is displayed.
    3. Using the Rocker key, change the waypoint ID.
    4. Using the Rocker key, highlight "OK" and press ENTER.
- Navigation
    1. Press the NAV key.
    2. Select 'Go To Point' then press the ENTER key.
    3. Select 'Waypoints' then press the ENTER key.
    4. Select 'your point' then press the ENTER key.
    5. Highlight the 'GoTo' button, press ENTER.
    6. As you start walking, the Pointer will point to your destination.

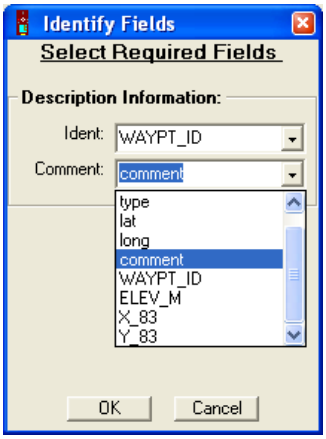
5. Upload Background Data

- Upload background maps from MapSource (proprietary software) if needed.

- Upload waypoints using MN DNR Garmin freeware.
    1. Connect GPS to the computer.
    2. Turn GPS on, then open DNR Garmin, it will connect to the computer.
    3. When the MN DNR – Garmin window opens, make sure that the projection is set to UTM, NAD 83, zone 12N (unless at CURE or BLCA, which are zone 13N). Go to File, then Set Projection to change projection.

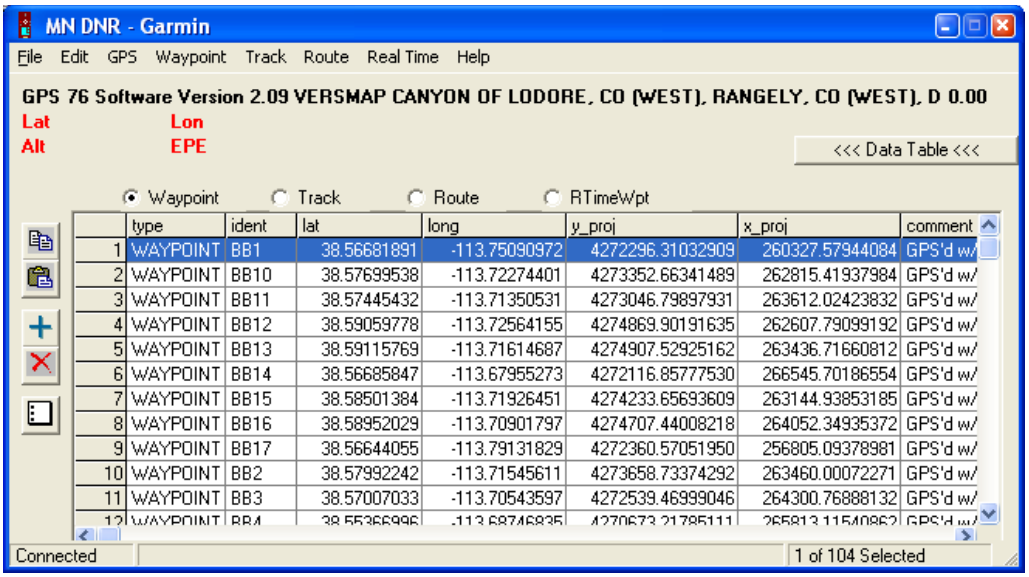


    4. Click on File, then Load From. You can upload a .txt file, .dbf file, or a shapefile. Navigate to the file you wish to upload and click Open.
    5. A window will open prompting you select description information. Choose appropriate fields for Ident (ID) and Comment and click OK.



    6. A window will open stating "File was loaded successfully from….". Click OK.

7. Points will be displayed in the MN DNR – Garmin window.

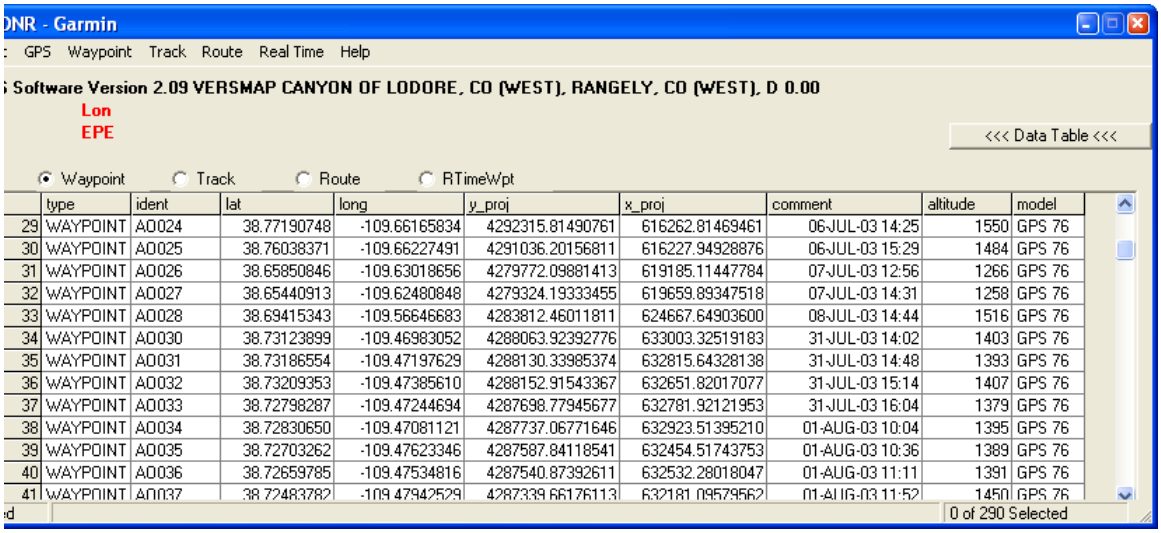


	type	ident	lat	long	y_proj	x_proj	comment
1	WAYPOINT	BB1	38.56681891	-113.75090972	4272296.31032909	260327.57944084	GPS'd w/
2	WAYPOINT	BB10	38.57699538	-113.72274401	4273352.66341489	262815.41937984	GPS'd w/
3	WAYPOINT	BB11	38.57445432	-113.71350531	4273046.79897931	263612.02423832	GPS'd w/
4	WAYPOINT	BB12	38.59059778	-113.72564155	4274869.90191635	262607.79099192	GPS'd w/
5	WAYPOINT	BB13	38.59115769	-113.71614687	4274907.52925162	263436.71660812	GPS'd w/
6	WAYPOINT	BB14	38.56685847	-113.67955273	4272116.85777530	266545.70186554	GPS'd w/
7	WAYPOINT	BB15	38.58501384	-113.71926451	4274233.65693609	263144.93853185	GPS'd w/
8	WAYPOINT	BB16	38.58952029	-113.70901797	4274707.44008218	264052.34935372	GPS'd w/
9	WAYPOINT	BB17	38.56644055	-113.79131829	4272360.57051950	256805.09378981	GPS'd w/
10	WAYPOINT	BB2	38.57992242	-113.71545611	4273658.73374292	263460.00072271	GPS'd w/
11	WAYPOINT	BB3	38.57007033	-113.70543597	4272539.46999046	264300.76888132	GPS'd w/
12	WAYPOINT	BB4	38.55366996	-113.68746835	4270673.21785111	265813.11540862	GPS'd w/

8. If the points are correct, click on WAYPOINT on the top menu, then Upload.
9. A window will pop up stating "Transfer Complete. # points uploaded".

6. Downloading Waypoints

- Download waypoints using MN DNR Garmin.
  1. Connect the GPS to the computer and turn on the GPS unit, then open the program DNR Garmin on the computer
  2. From the DNR Garmin main menu, click on Waypoint, then Download. Your data will appear in the MN DNR Garmin window. Elements to be included in the downloading process are: type, ident, lat, long, y_proj, x_proj, comment, altitude & model. These fields can be chosen by choosing Waypoint from the main menu, then Waypoint Properties and checking only those fields.



	type	ident	lat	long	y_proj	x_proj	comment	altitude	model
29	WAYPOINT	A0024	38.77190748	-109.66165834	4292315.81490761	616262.81469461	06-JUL-03 14:25	1550	GPS 76
30	WAYPOINT	A0025	38.76038371	-109.66227491	4291036.20156811	616227.94928876	06-JUL-03 15:29	1484	GPS 76
31	WAYPOINT	A0026	38.65850846	-109.63018656	4279772.09881413	619185.11447784	07-JUL-03 12:56	1266	GPS 76
32	WAYPOINT	A0027	38.65440913	-109.62480848	4279324.19333455	619659.89347518	07-JUL-03 14:31	1258	GPS 76
33	WAYPOINT	A0028	38.69415343	-109.56646683	4283812.46011811	624667.64903600	08-JUL-03 14:44	1516	GPS 76
34	WAYPOINT	A0030	38.73123899	-109.46983052	4288063.92392776	633003.32519183	31-JUL-03 14:02	1403	GPS 76
35	WAYPOINT	A0031	38.73186554	-109.47197629	4288130.33985374	632815.64328138	31-JUL-03 14:48	1393	GPS 76
36	WAYPOINT	A0032	38.73209353	-109.47385610	4288152.91543367	632651.82017077	31-JUL-03 15:14	1407	GPS 76
37	WAYPOINT	A0033	38.72798287	-109.47244694	4287698.77945677	632781.92121953	31-JUL-03 16:04	1379	GPS 76
38	WAYPOINT	A0034	38.72830650	-109.47081121	4287737.06771646	632923.51395210	01-AUG-03 10:04	1395	GPS 76
39	WAYPOINT	A0035	38.72703262	-109.47623346	4287587.84118541	632454.51743753	01-AUG-03 10:36	1389	GPS 76
40	WAYPOINT	A0036	38.72659785	-109.47534816	4287540.87392611	632532.28018047	01-AUG-03 11:11	1391	GPS 76
41	WAYPOINT	A0037	38.72483782	-109.47942529	4287339.66176113	632181.09579562	01-AUG-03 11:52	1450	GPS 76

3. Click on File, and then Save To. Navigate to the proper folder on the computer where GPS files are stored.
4. There are several file types which you can save the file as. The NCPN recommends saving the data as a projected shapefile (*.shp) file.
5. Name the file with the date of download in the file name (e.g., Riparian_June10_09.shp) and click the Save button. A window will display "File successfully written to …" .

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 4

Establishing the Reach and Setting up Transects

Version 1.01 (January 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	1/2012	K. Lund & D. Witwicki	Clarify wording; improve data sheet	Confusion between headpins and transect end points	1.01

This SOP describes the methods for (1) assessing the suitability of a new monitoring reach, (2) establishing a sampling reach, and (3) setting up and relocating transects for vegetation monitoring and surveying. A list of necessary equipment for these procedures can be found in SOP #1.

A minimum of a three-person team is needed to establish and set up the monitoring transects.

1. Reach Establishment

1.1 Assessing suitability of a new monitoring reach

Potential monitoring locations will be selected based on the length of the stream within park boundaries using GIS technology. Reaches of the stream that are confined by bedrock or colluvium, or that are affected by a major tributary, will be buffered out of the potential monitoring areas whenever possible. On longer streams, multiple random, spatially-balanced points will be generated using a Generalized Random Tessellation Stratified (GRTS) design. These points will be assigned sequential reach identification numbers and should be assessed in ascending order.

Locating the centroid

A. Use topographic maps, aerial photographs, and a GPS unit to navigate to the monitoring reach.

B. Mark the point with a pin flag or flagging tape. This point is the center of the reach. In perennial streams, you can mark either side of the channel.

Determining reach length

A. Use a range finder or transect tape to measure the width of the active riparian zone at the centroid, rounding to the nearest 1 m.

- The active riparian zone boundary is defined as the intersection of surfaces dominated by riparian vegetation with surfaces dominated by upland vegetation.
- Good indicator species of the active riparian zone include *Salix exigua* and *Baccharis* species.
- Legacy riparian species, especially mature cottonwood trees, may be present beyond the active riparian zone, but they will not dominate the surface or have active regeneration (i.e., seedlings or saplings) on the surface.
- In some instances, this boundary may be between a riparian surface and a bedrock valley wall or colluvial deposit.

B. Re-measure the width of the riparian zone at four additional locations, two upstream and two downstream from the centroid.

- Separate each additional width measurement using spacing equal to the width of the riparian zone at the centroid.
- Measure the spacing between additional width measurements along the thalweg or lowest point along the stream bed.

C. Average the five measurements and multiply by 6. This number is the length of the monitoring reach. If the reach length falls outside of the desired range of 180 – 360 m, default to the minimum or maximum reach length.

- Minimum reach length is 180 m.
- Maximum reach length is 360 m.

Evaluating the sampling reach

Walk the entire length of the reach to determine if the reach meets the acceptance criteria described below. An acceptable monitoring reach contains riparian vegetation and remains relatively homogenous throughout its entire length.

A. No more than 25% of the reach:

- Is confined by bedrock or colluvium (CARE and ZION only; Figure 1).
- Has a bedrock channel (ARCH and NABR only)
- Lies within a different stream type (perennial, intermittent, ephemeral).
- Is influenced by side canyon springs.

B. No major tributary junctions occur within the reach.

Major tributaries are indicated by either of the following:

- Perennial flow.
- Deposition areas that visibly affect the main channel, such as cobble bars or boulder deposits, even if flow is ephemeral.

C. No significant archeological sites exist within the reach.

If a reach is rejected for any of the above reasons, be sure to collect the centroid pin flag and move on to the next consecutively numbered reach for evaluation.

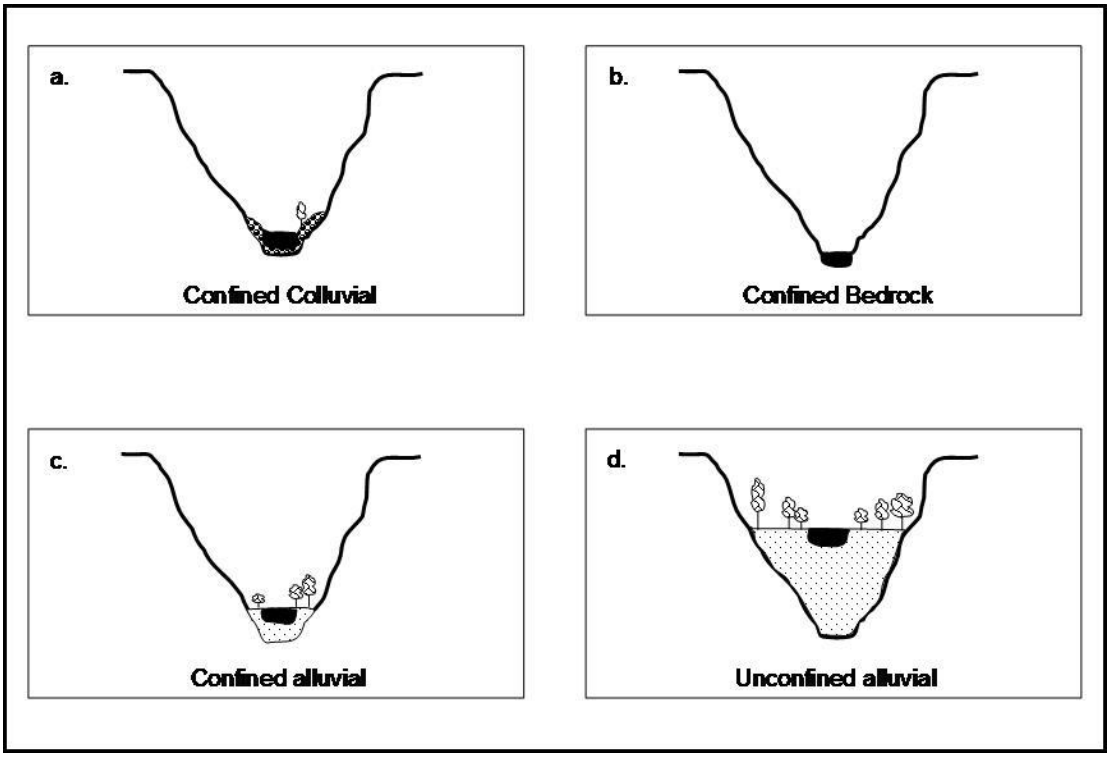


Figure 1. Idealized stream channel valley settings, including (a) colluvial, (b) bedrock, (c) confined alluvial, and (d) alluvial or unconfined alluvial. Colluvial material is typically found at the foot of a slope and is deposited as a result of gravitational action. Alluvium is material deposited by running water. The active channel is represented as solid black. Confined here refers to a channel where the valley width is less than two active channel widths. Adapted from Montgomery and Buffington (1993).

1.2 Site Establishment

Record directions to the reach

Write directions to the reach and include sufficient detail for someone who has never been there to relocate it. Begin with road travel from a designated location (such as the park's visitor center), where to park, and the route used. Describe (and photograph) landmarks used to navigate to the reach centroid. Note obstacles or hazards to be avoided at and en route to this particular site. Use specific language such as "southwest" and "downstream" rather than ambiguous terms such as "left" or "below." You may also GPS the route (see SOP #3).

Establishing a monitoring reach

A monitoring reach consists of 7 transects where the majority of sampling is conducted (Figure 2). Transects are numbered 1 through 7, in order, from upstream to downstream and have a maximum length of 100 m. Transects are spaced equally throughout the reach at a distance of the reach length divided by 6.

A. Mark the centroid flag as Transect 4.

B. From the centroid flag, walk downstream along the thalweg, or lowest part, of the channel. Use a rangefinder or transect tape to walk the distance determined above (total reach length divided by 6).

C. Mark the middle of the stream or the stream bank with a pin flag or flagging tape labeled "5."

D. Proceed downstream in the same manner, marking the location of Transects 6 and 7 along the stream.

E. Return to the centroid and walk upstream along the thalweg. Mark the locations of Transects 1-3 along the stream.

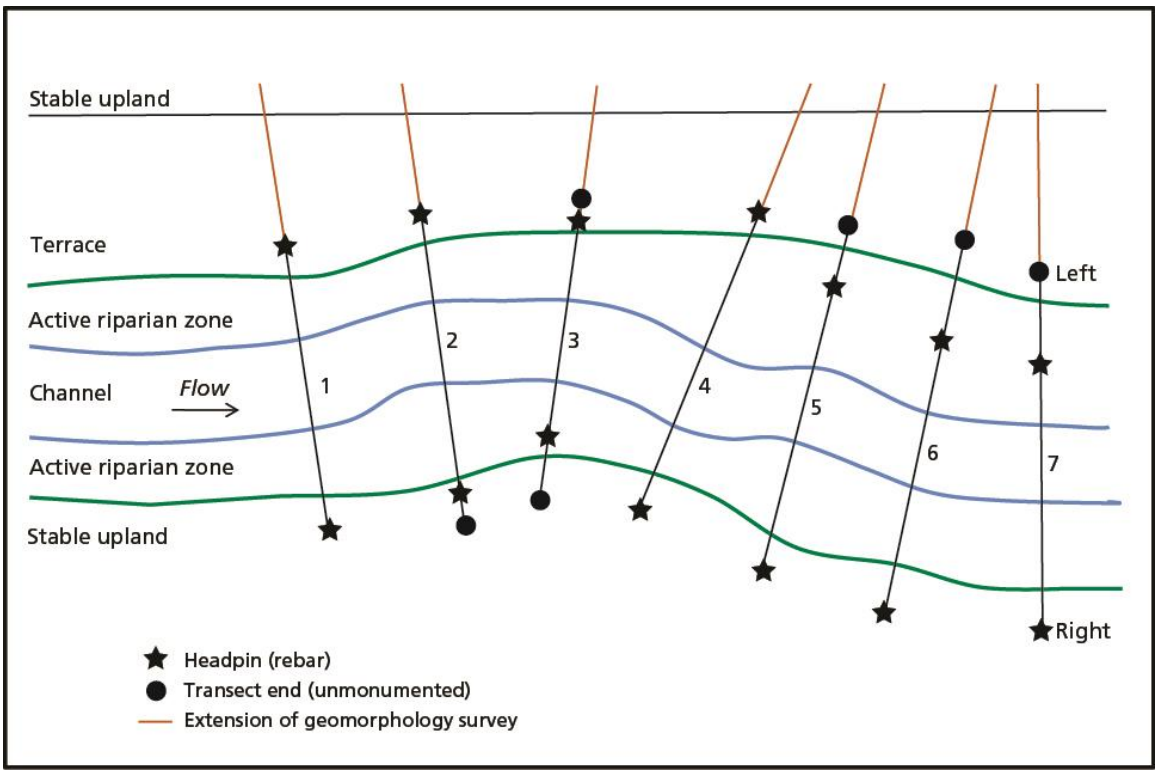


Figure 2. Features of an established sampling reach. "4" is the centroid, star symbols indicate locations of headpins, black circles indicate the locations of transect end points without monuments, and the green line represents the upland-riparian zone boundary. Geomorphology transects extend to a stable upland surface when necessary.

Establishing transects

When all transect locations have been determined, flagged mid-stream, and labeled with the appropriate transect number, you are ready to install permanent headpins.

A. Starting at the center of the transect, have two crew members walk in opposite directions perpendicular to the channel (Figure 2). In braided channels, set up transects perpendicular to the entire channel area. It is helpful to have additional crew members remain at the centroid or position themselves along the desired line to assist in lining up the transect.

B. Walk until you arrive at a stable surface, upslope of surfaces that are flooded frequently.
   - The most stable surface is dominated by upland plant species and does not show active erosion such as landslides, slumps, rockfalls, gullying, etc.
   - If stable surfaces are >100 m apart, headpins may be located on relatively stable surfaces such as terraces, indicated by legacy riparian species that show no recruitment (i.e., no seedlings or saplings are present, only mature trees).
   - If the active riparian zone is >100 m wide, place one of the headpins in a stable area and the other in the floodplain. Document the headpin in the floodplain using witness trees (see below).

C. Mark the location with an appropriately numbered pin flag. If on bedrock, make a 2-rock cairn or stand in place.

D. Stand over the pin flag, and confirm with the other crew members that the transect line is still perpendicular to the channel.

E. Once the line has been confirmed, pound in the rebar used to mark the locations of the headpins.
   - Whenever possible, headpins are located the ends of a transect.
   - In places where a transect end is on an unstable surface or bedrock, the headpin is installed at a different location along the transect. Select the most stable ground along the transect in the general vicinity of the transect end. The two headpins on a transect should be a minimum of 10 m apart.
   - Hammer the rebar to within 15 cm of the ground surface.

F. Inscribe the reach number, transect number, and river right or left (e.g., 1-4L for Reach 1, Transect 4 river left) on a metal tag or rebar cap. Right and left are determined while facing downstream. Tags or caps can be prepared beforehand in the office or in camp.

G. Attach the metal tag to the rebar using galvanized wire or gently hammer the cap onto the rebar, protecting the top of the cap with a leather strip.

H. Record the locations of the headpins and transect ends using a mapping grade GPS unit (see SOP #3). Be sure to take a waypoint for each headpin and each transect

end even if the headpin is located at the transect end. Also record UTMs of each headpin and transect end on the paper data sheet.

- If there is no satellite coverage at the point, move to a location with coverage and offset the point.
- If offsetting is not possible, mark the location of the headpin or transect end on an aerial photo or topographic map.

I. Record the location of the headpins along the transect and the total transect length to the nearest 0.1 m. This is especially important when headpins are not located at the ends of the transect. If an unmonumented transect end is on bedrock or an unstable surface, end the transect in a location that gives you approximately a level tagline.

J. Record the bearing of the transect (from right headpin to left headpin) in degrees. Use true north (i.e., compass declination should be set and recorded on the data sheet).

K. Take reference photos to document locations of all headpins and any unmonumented transect ends. Include the cliff line, surrounding perennial vegetation and/or other recognizable landmarks in the background to help the returning field crew relocate these points.
   - Label a chalkboard with the park code, reach code, transect number, river right or left, and direction facing (upstream [US], downstream [DS], right to left [R -> L], or left to right [L->R], etc.) (e.g., ZION, P-01, T3R, US).
   - Place the chalkboard in a location near the headpin or transect end where it will be easy to read in the photo.
   - Clearly mark the location of the headpin or unmonumented transect end in relation to recognizable landmarks. This location should be marked by bright-colored pin flags, placed either in the soil at the point or held above the point where they will be visible in the photo. Unlike repeat photos, you may include anything in reference photos that may assist with re-locating the point (i.e., crew members, bright-colored flagging, etc.).
   - Take a photo and check the quality. If the photo is blurry or otherwise not acceptable, delete it and take another one.
   - Record the digital file name and photographer on page 2 of the photo data sheet (see SOP #5).

L. If the headpin is located in dense vegetation or on an unstable surface, establish three witness trees.
   - Select three healthy trees within 20 m of the headpin. If possible, use different species of trees.
   - Record the diameter at breast height (DBH) and species of each tree. See SOP #6 for methods to measure DBH.
   - Align the nail so that it enters the tree at breast height (1.37 m) facing the headpin. Drive the nail into the tree at an angle, so that the tag hangs down and away

from the tree. Leave several centimeters of nail exposed so the tree has ample space for growth.
- Record the tag number, bearing in degrees from the tree to the headpin, and distance in meters from the tree to the headpin.

M. Continue throughout the reach, establishing headpins in the same manner for the remaining six transects.
   - If channel sinuosity is such that adjacent transects cross, establish the transects as described above. Sampling proceeds as usual with the exception of collecting 5-m belt data (SOP #6). Be sure to note which transects cross in the comments section of the data sheet.

Transect troubleshooting
Under certain scenarios, some transects may need to be repositioned as you are establishing the reach. The distance a transect is repositioned depends on the scale of the reach and the situation which requires it to be moved. Always slide transects away from the centroid in 10-m increments until a suitable location is reached. After repositioning or sliding a transect, each subsequent transect should be located using the original spacing. Situations in which a transect may need to be repositioned include:

- If a transect location falls immediately upstream from a sharp, 90˚ bend in the channel and valley axis, causing the transect to run parallel to the channel and valley.
- If a transect location intersects a tributary, and as a result the transect extends up a side canyon instead of intersecting an upland terrace or colluvial surface of the main stream.
- If crew safety is endangered by a permanent, fast-flowing deep section of river or other safety concern.

Setting up long transects and/or transects through thick brush
On many occasions, it may not be possible to align the headpins and transect center from a vantage point in the channel. One crew member may be able to direct the others by going to a higher vantage point (e.g., on top of a bedrock rim). In cases where it is impossible to see the entire transect by any means, use a compass to proceed at the proper bearing, leap-frogging with crew members in visible positions until you reach the headpin. It is helpful in these situations to tie flagging tape to properly aligned vegetation as you go.

2. Setting up transects

Relocating the transects

A. Use the site description, topographic maps, GPSed coordinates and routes, and photos to navigate to the reach.

B. Use UTMs, witness trees, azimuths, and reference photos to locate the transect headpins.

- If the headpin is missing, use the information provided by the sources above to relocate the headpin as accurately as possible.
- If the headpin location is no longer available or has become unstable (e.g., active erosion zone, tree fall, etc.), establish a new headpin location along the same azimuth as the previous headpin. Use the guidelines in Section 1.2 above to select a headpin location.
- If a headpin is moved, remove and relocate witness tree markers as needed.
- Document the new headpin using the guidelines in Section 1.2 above.

C. Place a pin flag or flagging at the headpins and mid-stream of each transect.

Setting up a transect

A. Check the data sheet to see where the headpins are located relative to the transect ends.

B. Have one person stand at each headpin location. On transects with thick vegetation, additional people may be needed to stand in line with the headpins to provide an accurate line of sight.

C. Drive a piece of rebar into the ground at each transect end point.
- If the headpin is located at the transect end point, place the temporary rebar behind the headpin.
- Leave adequate space above ground on the temporary rebar for attaching the tagline and/or transect tape.
- Use the recorded azimuth to make sure the temporary rebar is in line with the permanent transect.

D. Attach the Kevlar tagline and/or the transect tape to the temporary rebar on river right. Remember that river right and left are determined while facing downstream.
- Attach the tagline so that one of the marked meters falls over the permanent headpin.
- Use a chaining pin to align the transect tape such that the 0 m mark falls over the permanent headpin.
- Do not attach the tagline or transect tape to the permanent headpins, as this may cause the headpins to move.

E. Run the tagline and/or transect tape from river right to river left.
- To avoid trampling vegetation sampling areas, walk on the downstream side of the transect whenever possible.
- Keep the tagline and/or transect tape as straight as possible, both vertically and horizontally. Thread through vegetation as necessary.
- Check the length of the transect at establishment to make sure you are within 0.25 m of the original length during a re-visit.

F. Tighten the tagline and/or transect tape.

G. Adjust the tagline and/or transect tape as needed.
   - Whenever possible, the line should not rest against any tree trunks or other obstacles such as boulders or debris (Figure 3).
   - Obstructing branches can be moved or tied back with flagging.

H. Attach the tagline and/or transect tape to the temporary rebar on river left.

I. If using both a tagline and a transect tape, run the tagline first, make any necessary adjustments, and then run the transect tape. Take up any slack in the tape by tying it to the tagline with flagging at regular intervals. This step is especially important in windy conditions.

J. Begin sampling.

Transect end point located on bedrock
If a transect end point is located on bedrock, you will not be able to place the temporary rebar at the transect end. Place the temporary rebar as close to the transect end as possible, and secure the tagline and/or transect tape to this point following the instructions above. To sample the transect beyond the temporary rebar, you will need to extend the transect tape using other methods. If possible, use a rock cairn to hold the transect tape in place. If this is not possible, have a crew member hold the transect tape in place while you are sampling.

References

Montgomery, D.R. and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Report prepared for the SHAMW committee of the Washington State Timer/ Fish/ Wildlife Agreement. Report TFW-SH10-93-002.

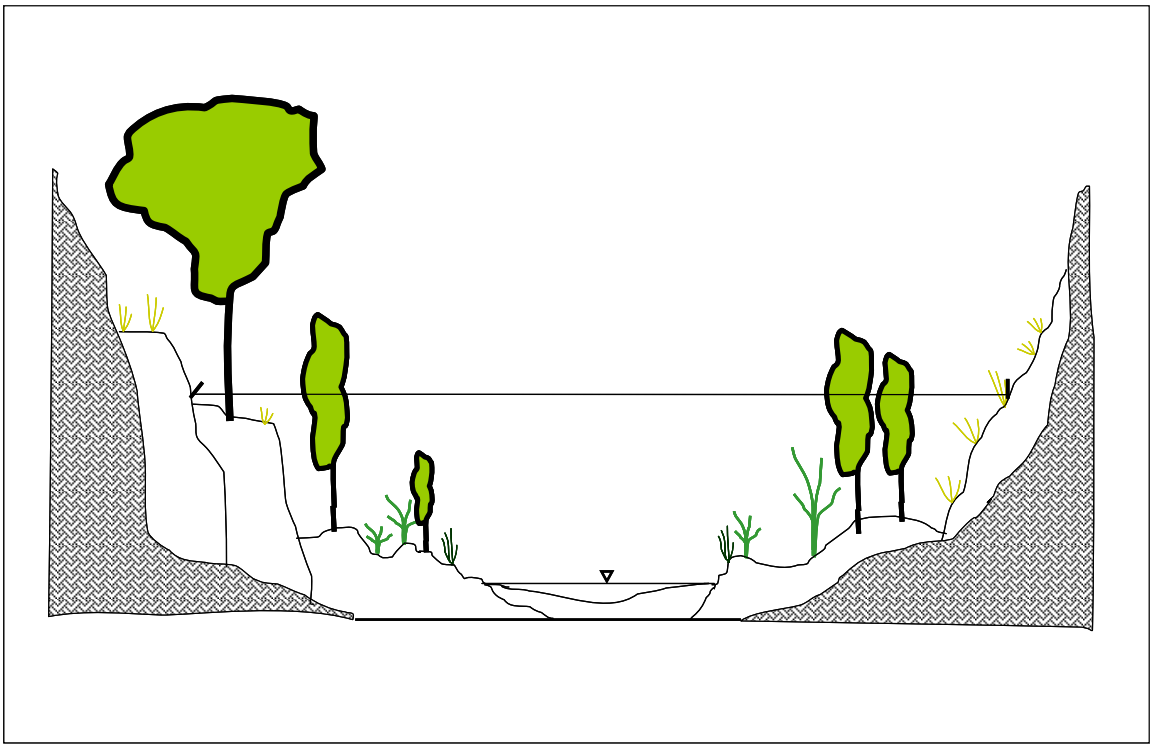


Figure 3. Diagram of Kevlar tagline established between two rebar headpins. Always establish taglines as taut as possible. If the line runs through vegetation, make sure that branches do not cause the line to bend. Vertical elevations are exaggerated in this diagram.

Reach Establishment

Data entered by: Data verified by: p.1

NCPN Riparian Monitoring

Park Code: _____ Stream Name: _____ Reach ID: _____ Accept Reject

Observers: _____ Date: _____

Rejection criteria (circle appropriate):
>25% confined
>25% different stream types
>25% spring-influenced
major tributary present
archeological site present
other (describe):

Centroid UTMs: Datum: _____ Zone _____ _____ N _____ E

Active Riparian Zone Width (m): _____ _____ _____ _____ _____

Average Reach Width (m): _____ x 6 = Reach Length: _____ Min. 180m Max. 360m

% Valley Setting: Confined colluvial _____% Confined bedrock _____% Confined alluvial _____% Unconfined alluvial _____%

% Stream Type: Perennial _____% Intermittent _____% Ephemeral _____%

Directions to Reach:

Comments:

Reach Establishment

Data entered by: Data verified by: p.2

NCPN Riparian Monitoring

Headpin Coordinates

Compass declination _____

Headpin	Right			Left			Transect Length (m)	Bearing (R to L)
	Easting	Northing	Location (m)	Easting	Northing	Location (m)		
T1 (upstream)								
T2								
T3								
T4								
T5								
T6								
T7 (downstream)								

Transect End Point Coordinates

Transect	Right		Left	
	Easting	Northing	Easting	Northing
1				
2				
3				
4				
5				
6				
7				

Establish transects from upstream (1) to downstream (7) and from right (R) to left (L) when facing downstream.

Witness Trees

Monu-ment*	Tag #	Species	DBH (cm)	Bearing (°)	Distance to rebar (m)

*Include the transect number, river right or left, and a letter to identify witness trees (e.g., T1-Ra, T1-Rb, T1-Rc, T1-La, etc.)

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 5

Repeat Photos

Version 1.01 (November 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	11/2011	D. Witwicki & K. Lund	Clarify wording; improve data sheet	Confusion between headpins and transect end points	1.01

This SOP provides instructions for taking photos at each reach during vegetation sampling. Repeat photos are taken at each transect end point and facing upstream and downstream at mid-channel. Reference photos taken to document locations of headpins and unmonumented transect ends during reach establishment (SOP #4) are recorded on the photo data sheet.

Photo Points

Photos are taken using a digital camera. If a film camera must be used, procedures are the same, but the film-roll information is also recorded in the photo # column on the data sheet.

Fill out the top of the data sheet:

Park Code – The four letter park code
Reach ID – The reach ID number
Date – Use the format mm/dd/yyyy

1. Repeat Transect Photos

Take transect photos from the origin and end of each transect while the meter tape or tagline is stretched out along the transect.

A. Label the chalkboard with the information below and place it near the origin or end of a transect so that it will be visible in the photo.

Site – Park code and Reach ID number (e.g., ZION-P1)
Date – mm/dd/yyyy, e.g., 08/22/2010
Transect # and side - i.e., T1-L and R = river right, L = river left when facing downstream

If you are having difficulty propping up the chalkboard, use additional objects behind it rather than including field crew members or their body parts in the photos. You can also

hang the chalkboard on vegetation.

B. Stand at the transect origin or end, set the camera body on top of a fully extended laser monopod (1.5 m in height) and point the camera down the transect.

C. Orient the camera so that it is rotated 90˚ and takes a vertical format (portrait) photo.

D. Check to ensure that the chalkboard is visible at the bottom of the field of view and the tape or tagline is visible in the middle of the photo.

E. Take a photo. Check the quality of the photo by setting the camera to "play" mode to view the photo. If the photo is blurry or otherwise not acceptable, delete it and take another one.

F. Record the digital file name, photographer, and location along the transect where the photo was taken. The location of the photo point is recorded as 0 m on river right and as the location on the transect to the nearest 0.1 m on river left.

Recording the Digital File Name

a. While the camera is in "play" mode, you will be able to view the number assigned to the photo. *Do not record this number*. This number changes when the photos are downloaded from the camera. Instead, use the following instructions to record the digital file name on the data sheet.
b. The last 4 digits of the number displayed on the camera (those following the dash) represent a unique photo number.
c. The template for the number you will record is P*mdd9999*, where P=photos, *m* = month (Jan – Sept are coded 1-9, Oct = A, Nov = B, Dec = C); *dd* = day (01-31); and *9999* = the unique number of the photo. For example, photo 0300 taken on October 1 would be recorded as PA010300.

2. Repeat Mid-Channel Photos

Because the chalkboard cannot be placed in these photos, always take the photo facing upstream first, followed by the photo facing downstream.

A. Stand 3 m downstream from the tagline at mid-channel, set the camera body on top of a folding engineer ruler or monopod extended to 1.5 m high, and point the camera upstream. Midchannel photos should be taken in the direction of the current channel and do not need to be taken perpendicular to the tape.

B. Orient the camera so that it takes a horizontal format (landscape) photo.

C. Take a photo and record the photo information on the data sheet. Record the approximate location of the photo point along the transect tape, rounding to the nearest 0.5 m.

D. Stand 3 m upstream of the tagline and take a photo facing downstream using the same methods.

3. Other Photos

Crew members are encouraged to take other photos to document specific aspects of a reach or to provide scenic or fieldwork photos for publications.

A. Fill in the type of photo: archeology, disturbance, fauna, fieldwork, flora, scenic, or other.

B. Record the photo number and a description of the photo.

4. Reference Photos

Reference photos are taken during reach establishment to document the locations of headpins and unmonumented transects ends (see SOP #4 for detailed instructions). Use page 2 of the data sheet to record this information.

Photos

Data entered by: p.1

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Repeat Photos - Transect Ends and Mid-Channel

Transect	Direction	Digital file name	Photographer	Location (m)
1	Right End			
	Facing Upstream			
	Facing Downstream			
	Left End			
2	Right End			
	Facing Upstream			
	Facing Downstream			
	Left End			
3	Right End			
	Facing Upstream			
	Facing Downstream			
	Left End			
4	Right End			
	Facing Upstream			
	Facing Downstream			
	Left End			
5	Right End			
	Facing Upstream			
	Facing Downstream			
	Left End			
6	Right End			
	Facing Upstream			
	Facing Downstream			
	Left End			
7	Right End			
	Facing Upstream			
	Facing Downstream			
	Left End			

Other photos

Type	Photo #	Photographer	Description

Type = archeology, disturbance, fauna, fieldwork, flora, scenic, other

Reference Photos - Headpins and Unmonumented Transect Ends p.2

Transect end	Location	Digital file name				Photographer
		Upstream	Downstream	R→L	L→R	
1R	Headpin					
	Transect end					
1L	Headpin					
	Transect end					
2R	Headpin					
	Transect end					
2L	Headpin					
	Transect end					
3R	Headpin					
	Transect end					
3L	Headpin					
	Transect end					
4R	Headpin					
	Transect end					
4L	Headpin					
	Transect end					
5R	Headpin					
	Transect end					
5L	Headpin					
	Transect end					
6R	Headpin					
	Transect end					
6L	Headpin					
	Transect end					
7R	Headpin					
	Transect end					
7L	Headpin					
	Transect end					

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) #6

Measuring Vegetation

Version 1.04 (January 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	11/2008	R. Weissinger	Remove 1-m belt and take density measures in 5-m belt; do not sample trees beyond the headpins; do not record geomorphic surface	Simplify sampling; not connected to active riparian zone; measure not repeatable between observers	1.01
1.01	4/2010	R. Weissinger	Added crown health class 6 and instructions; discontinue shrub line intercept sampling	Standardize with upland methods; redundant with point-intercept	1.02
1.02	1/2011	R. Weissinger	Added densitometer for measuring tall canopy; added species richness; deleted exotic density and added exotic frequency	Tall shrub layer not captured by laser; detect more rare species; increase repeatability and detect annuals	1.03
1.03	1/2012	K. Lund, D. Witwicki	Clarify when to record full species name; improve instructions for greenline sampling; remove species richness	Only needed once per reach; difficult to determine location of greenline; no longer used	1.04

This SOP describes methods used to conduct vegetation sampling in a reach. NCPN vegetation sampling includes *cover* of dominant species along cross-section and greenline transects, *frequency* of exotic plant species in 1-m^2 quadrats, canopy closure, *density* of tree species by diameter in a 5-m belt, and a census of all large diameter trees (≥25 cm at breast height) in the reach. A list of necessary equipment for these procedures can be found in SOP #1.

A two-person team comprised of a data recorder and an observer skilled in plant identification can efficiently complete the tasks described below. Generally, it will be easiest to record point-intercept data first, then record exotic frequency and canopy closure as you walk back along the transect. It is important to record understory measures first as they are susceptible to trampling impacts. In dense vegetation, tree density measures in the 5-m belt may require two passes along the transect.

For all vegetation sampling, record the full Latin name of each species the first time it is encountered at a reach. Any additional times the species is encountered, use the six-letter code composed of the first three letters of the genus and specific epithet.

1. Point-Intercept Cover

Point-intercept sampling is used to sample vegetation on seven cross-section transects of varying length and on fourteen 10-m greenline transects. Cross-section transects are sampled at a 0.5 m interval, and greenline transects are sampled at a 0.25 m interval.

1.1 Cross-section transects

Fill out the top of the data sheet including:

Park Code: Use the standard 4-letter code to indicate the park unit.
Reach ID: A pre-assigned, unique code provided for each stream reach.
Transect #: 1-7, upstream to downstream.
Observer: Record the initials of the person calling out the intercept data.
Recorder: Record the initials of the person recording the data.
Date: mm/dd/yyyy

Record point-intercept data for understory species and tall shrubs.

A. Stand on the downstream side of the transect and work from river right to river left.

B. Start at 0.5 m on the tape and move forward 0.5 m for each consecutive point. The final point sampled is the last half meter interval before the transect end point.

C. If there is a shrub canopy layer taller than 1.5 m from the ground surface, use a densitometer to record the top canopy layer at the correct point on the tape. Position the densitometer on the monopod just above the laser, and level both before collecting the point.

D. Position a fully extended monopod (1.5 m tall) at the correct point on the tape with the laser extending out perpendicular to the tape on the upstream side.

E. Use the bubble on the monopod to level the laser. With the laser leveled, push the button to take a point.

F. Once you have recorded a hit, move the uppermost vegetation away so that you can take subsequent hits for lower canopy and surface layers. If it is difficult to keep the monopod level and record hits, have one person hold the monopod level while a second person reads and records hits. On a windy day, it is important to turn the laser on for just a second to record a hit.

G. With the laser leveled, record every plant species it intercepts. Record each canopy species no more than twice, a maximum of one live hit and one dead hit, even if it is intercepted several times. Record the following information for each point:

A. **Top Canopy** - Record the species of the top plant intercepted in the "Top canopy" column (Table 1 & Figure 1). The top canopy may be a species intercepted by the densitometer or the laser. If a plant cannot be identified to species, follow the instructions below to name and collect a specimen. If a plant is not intercepted, leave this column blank. After the species code, write "-D" if the part of the plant intercepted by the laser is dead.

B. **Lower canopy layers**- From the top canopy species, move down the laser and record species intercepted in the order that they occur. Use the "Lower canopy" columns (Table 1 & Figure 1) to record all additional species intercepted by the laser. Record the plant as dead following the guidelines above. You may also intercept litter and woody debris, but it must be elevated above the soil surface to be considered a lower canopy layer (Table 2). If you hit more than two lower canopy layers, be sure to record them on the back of the data sheet under "Additional canopy layers". If you do not encounter lower canopy layers leave these columns blank.

Table 1. Sample data sheet for examples illustrated in Figure 1. Points 1 and 2 show the first two points on a transect. In Point 1, the laser is touching saltgrass (*Distichlis spicata*), dead bentgrass (*Agrostis stolonifera*), clover (*Melilotus officinalis*), live bentgrass, and coarse gravel. Record bentgrass twice for one dead and one live intercept. Notice that additional canopy hits can be recorded in the "Additional canopy layers" section at the bottom of the datasheet. In Point 2, the laser touches dead bentgrass, then touches litter, and finally the bentgrass plant base. The table below shows how to record these two points on the data sheet. Notice that all plants are recorded using six-character abbreviations.

Point	Top canopy	Lower canopy		Soil surface	Disturb.
		1	2		
1	Dis spi	Agr sto - D	Mel off	GC	
2	Agr sto - D	L		Agr sto	
3	Bac vim - D	Poa pra	L	F	ant
etc.					

Additional canopy layers

Point	Lower Canopy		
	3	4	5
1	Agr sto		

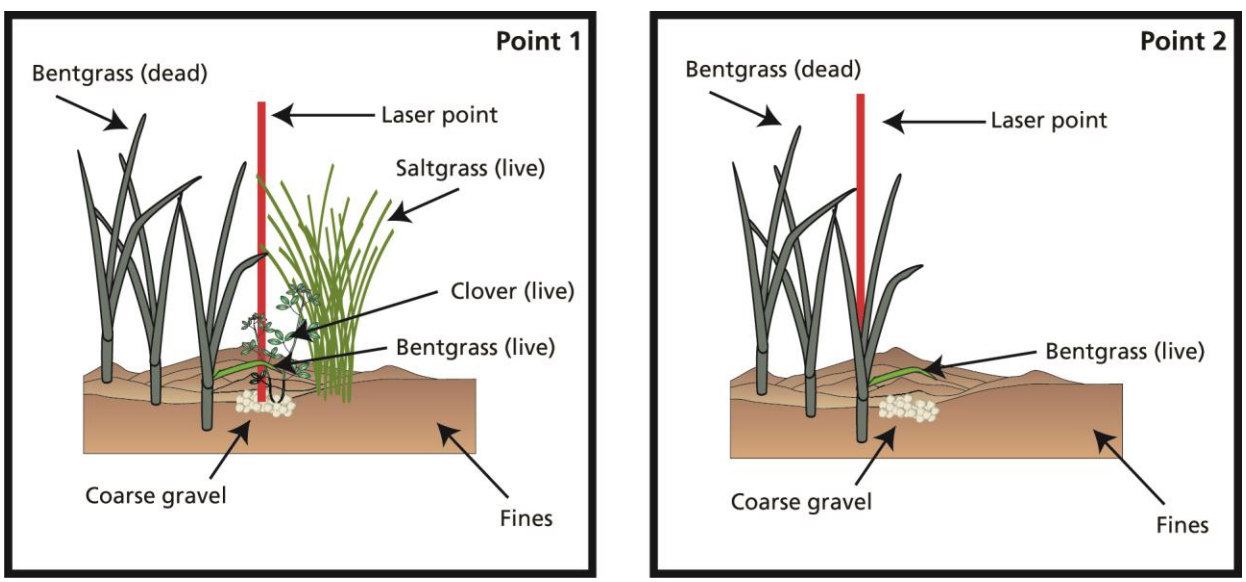


Figure 1. Points along a transect associated with the example in Table 1 (adapted from Herrick et al. 2005).

Table 2. Abbreviations and definitions of litter and woody debris as lower canopy layer classes for point-intercept sampling.

Code	Lower canopy cover type	Definition
L	Litter	Detached dead plant material less than 2.5 cm in diameter that is elevated above the soil surface
WD	Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter that is elevated above the soil surface

C. **Surface Features** - In the "Surface" column record whether the laser intercepts a plant base (Figure 2) or a surface feature. Use the abbreviations of surface features defined in Table 3 to record all other surface features.

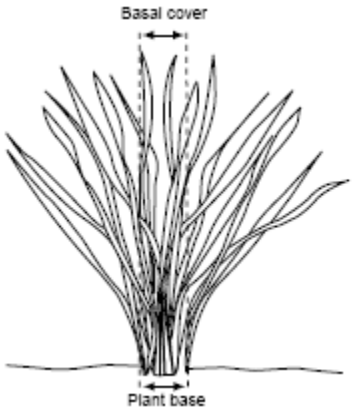


Figure 2. Area defined as plant base and included as basal cover (from Herrick et al. 2005).

Table 3. Abbreviations and definitions of surface feature classes for point-intercept sampling.

Code	Surface Feature	Definition
F	Fines	Loose mineral particles 0-2 mm in diameter
GF	Gravel, Fine	Particles 2-16 mm in size; ant to beetle-sized
GC	Gravel, Coarse	Particles 16-64 mm in size; beetle to baseball-sized
CB	Cobble	Particles 64-256 mm in size; baseball to basketball-sized
BL	Boulder	>256 mm in size; larger than a basketball
BR	Bedrock	Exposed bedrock
WA	Water	Flowing or pooled water
BSC	Biological soil crust	Cyanobacterial crust, sometimes in community with mosses and lichens
L	Litter	Detached dead plant material that is less than 2.5 cm in diameter
WD	Woody debris	Detached woody plant material that is greater than 2.5 cm in diameter and in direct contact with soil
SL	Scat, livestock	Any type of livestock scat
SW	Scat, wildlife	Any type of wildlife scat

D. Disturbance - Record whether the laser intercepts a disturbance on the soil surface in the "Disturb." column (Table 1 & Figure 1). Use abbreviations from Table 4 to label the type of disturbance. Leave this column blank if there is no disturbance.

Table 4. Abbreviations and definitions of soil-surface disturbance classes for point-intercept sampling.

Code	Disturbance type	Definition
Ant	Ant mound	Holes and mounds created by ants
Bike	Bicycle	Disturbances caused by non-motorized bicycles
Trail	Trail	Defined tracks or trails from wildlife, livestock, or humans
Camp	Campsite	Bare ground associated with camping
Auto	Motor vehicle	Disturbances caused by any motorized vehicle, including two tracks and roads
Flood	Recent flooding	Recent flooding indicated by flattened vegetation, mud, and debris lines
Graze	Grazing	Grazing or browsing by wildlife or livestock
Other	Other	Any other disturbance

1.1.3 Unknown Plants

Sometimes it may be difficult or impossible to determine the specific identity of individual plants encountered during sampling. Crews may be unfamiliar with a plant or unable to distinguish one species from other similar species at the time of sampling. Before sampling, review previously collected unknown species from the stream and use existing unknown names whenever possible.

When an unknown plant is encountered

A. Search the immediate area surrounding the point or transect, looking for specimens of the unknown plant that are more readily identifiable (i.e., due to the presence of flowers or fruits from current or previous seasons).

B. If an identifiable specimen cannot be found, create a unique name using the following code: unk + 4 letter park code + reach number + your initials + collection number for the reach (e.g., unkZION-P1-ST1). Record this code in the appropriate column on your vegetation sampling datasheet instead of the species name.

C. Take a photograph of the unknown plant.

D. As you proceed through the reach, continue to attempt to find identifiable specimens of unknowns.

E. It is permissible to identify a plant only to the genus level if no identifiable parts are present for keying, or if hybridization makes species delineation difficult. Record the full Latin name of the genus followed by "sp." (e.g., *Opuntia* sp., *Tamarix* sp., etc.).

Collecting unknown plants

Once it has become apparent that no identifiable plants can be found or that a plant with identifiable features cannot be keyed out in the field, a collection of the plant should be made.

A. Collect specimens from outside of the monitoring transects whenever possible.

B. Attempt to collect as many identifiable parts as possible, including flowers, fruits, leaves, and roots. It is especially important to collect roots of forbs and grasses. You may need to collect from more than one plant to achieve this goal.

C. If you must collect from inside a monitoring reach, remove only a minimal amount of plant material. Do not remove roots of perennial species that are collected within the transect.

D. Wrap a piece of masking tape around the plant and use a fine-point permanent marker to label it with the unknown species code.

E. Carefully place the specimen inside a resealable plastic bag labeled with the reach number, unknown species code, date, and collector.

F. Place the sample in your backpack and in a shady spot until you get back to camp. Attempt to identify the plants when you return to camp.

G. If the specimen cannot be identified right away, preserve the bag in a cooler as soon as possible. Make sure the specimen does not get wet. If a cooler is not available, press the plant between two sheets of newspaper.

H. Fill out an unknown species datasheet for each specimen. It is especially important to fill out datasheets for specimens that do not have identifiable characteristics in this sampling year, but may be identified in future years.

Datasheets

When filling out the datasheet, give a detailed description of each characteristic. This allows greater potential for future identification when crews return to the site. Fill in the top of the data sheet and record the following information:

- **Unknown Code:** unk + 4 letter park code + reach number + your initials + collection number for the reach (e.g. unkZION-P1-ST1).
- **Plant type and General Description:** Circle the appropriate categories and provide a succinct description of the overall appearance (e.g., tiny *Eleocharis*).
- **Most Salient Feature:** A unique characteristic that identifies the plant from others.
- **Leaf Characteristics (optional):** Describe the leaf type, leaf margin, leaf surface, petiole, etc.
- **Stem Characteristics (optional):** Describe the shape, pubescence, markings, and color of the stem, as well as the bud characteristics.
- **Flower Characteristics (optional):** Describe the floral formula, location (axillary or terminal), habit (indeterminate or determinate), pubescence, and color.
- **Microhabitat Characteristics:** Describe the microhabitat in which it was found if unique in the reach (e.g., wash bottom, limestone outcrop, etc.).
- **Collected:** Circle yes or no, whether a specimen was collected.
- **Best Guess:** Preliminary guess about species in field.

Annotating datasheets

When updating data sheets with identified plants, draw a line through the unknown code and write in the correct species code in the nearest available space. Initial and date the change on the data sheet.

1.2 Greenline transects

Greenline transects are recorded at perennial streams only (CARE and ZION). The greenline is the first rooted line of perennial vegetation adjacent to the channel that is the dynamic interface of stream and terrestrial ecosystems. The greenline targets phreatophyte diversity and cover and is also an indicator of stream bank stability.

A. Fill out the top of the data sheet and record whether you are sampling the greenline on river right or left. Right and left are determined while facing downstream.

B. Where the cross-section transect intercepts the greenline, run a transect tape along the greenline for 10 m upstream (Figure 3). Use chaining pins to secure the tape.

C. Use the directions in section 1.1 to sample vegetation at 0.25-m intervals along the transect, starting at 0.25 m and ending at 10 m. Record each species encountered along the greenline. If a species is encountered at a point, record the surface hit as NA. If no vegetation is encountered, record a surface hit using the codes in Table 3.

D. Place the monopod on the stream side of the tape with the laser extending out perpendicular to the tape on the upslope side (away from the channel), and shoot the laser.

E. Sample greenline transects on river right and river left for each cross-section transect (Figure 3).

Identifying the Greenline

The greenline is the rooted line of perennial vegetation closest to the stream, according to the following criteria:

- At least 25% cover of live, rooted perennial riparian species. Indicators that a plant is perennial: woody tissue, leaves/stems present from previous year, or roots stained brown rather than white.
- Typical greenline genera in a riparian setting include *Scirpus*, *Juncus*, *Carex*, *Salix*, and *Baccharis*. Emergent aquatic species (e.g., *Typha*, *Carex*, *Eleocharis*, etc.) are used to define the greenline, but floating aquatic species (e.g., *Lemna*, *Rorippa*, etc.) are not.
- The greenline is located at the rooted point of vegetation, not necessarily at the canopy of the vegetation (Figure 4).
- The greenline may occur at different locations depending on water levels and stream bank dynamics including:
    i. Very close to the edge of the water (Figure 5)
    ii. Several feet above or away from the stream's edge during lower flows (Figure 6)
    iii. Underwater at high flows and when bank building is occurring. Sampling may occur when the greenline is emergent but should be suspended if the greenline is entirely submerged.
    iv. If the channel is incised or is bordered by a cutbank, the greenline may be formed by upland species on top of the cutbank (Figure 7).
- The greenline may be discontinuous.
    i. Move sampling perpendicular to greenline tape in order to capture >25% riparian cover (Figure 8).
    ii. If no qualifying greenline exists near the water's edge, sample at the first flat floodplain-like or depositional feature (e.g., the top of a cutbank; see Figure 7). In this case, the greenline tape follows the edge of the cutbank, and sampling is not moved upslope into upland vegetation to achieve 25% cover. However, sampling is moved downslope (towards the stream) if riparian vegetation has >25% cover at any point along the greenline transect (Figure 8).

iii. If no flat depositional surface exists either, probably due to the presence of bedrock or a colluvial slope, sample the lowest edge of this feature.
iv. Include patches of vegetation on depositional bars or slump blocks on the channel margins, as long as the bars and slumps are not separated from the bank by part of the channel.

- Islands in the channel are not part of the greenline.
- Do not slide the greenline because of a tributary, bedrock or trail entering the stream. Record that there is no vegetation in these areas.

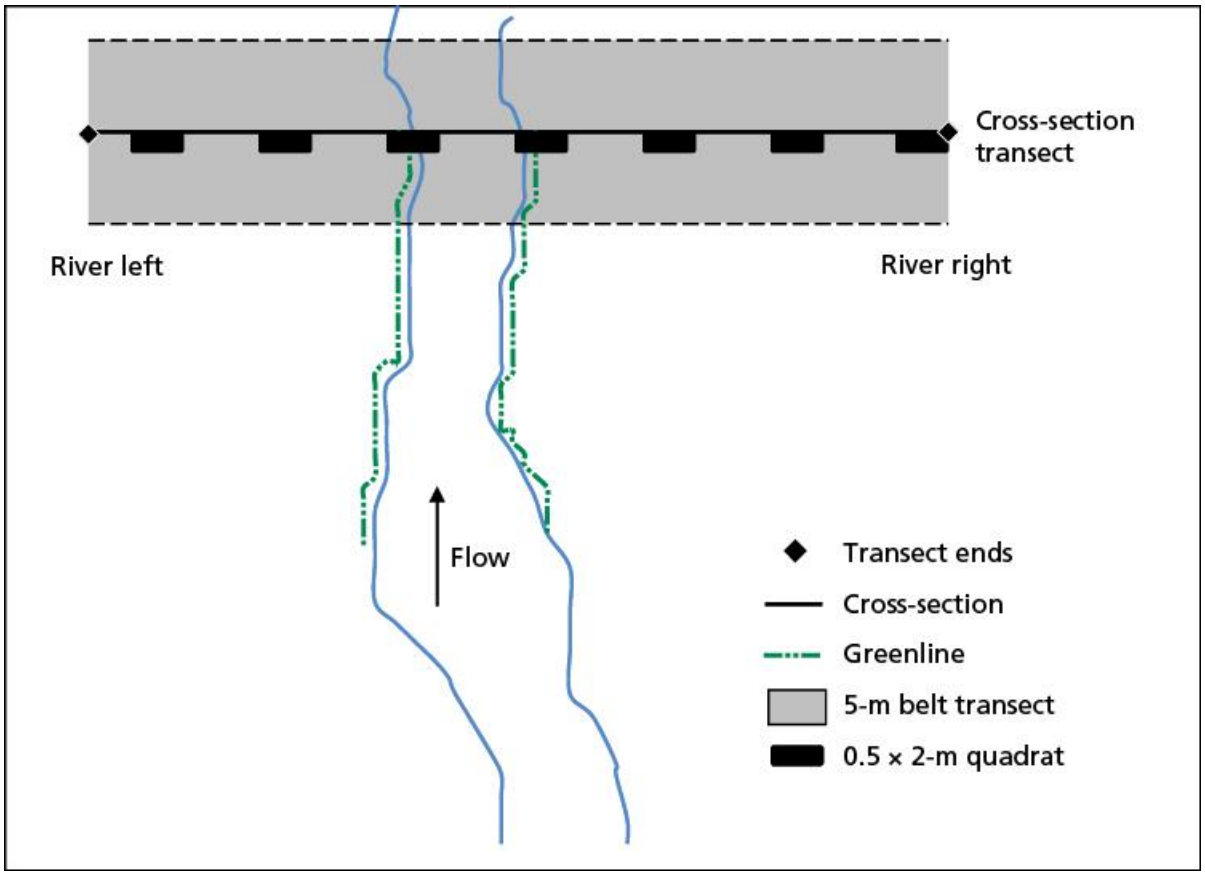


Figure 3. Locations of vegetation sampling along each cross-section transect.

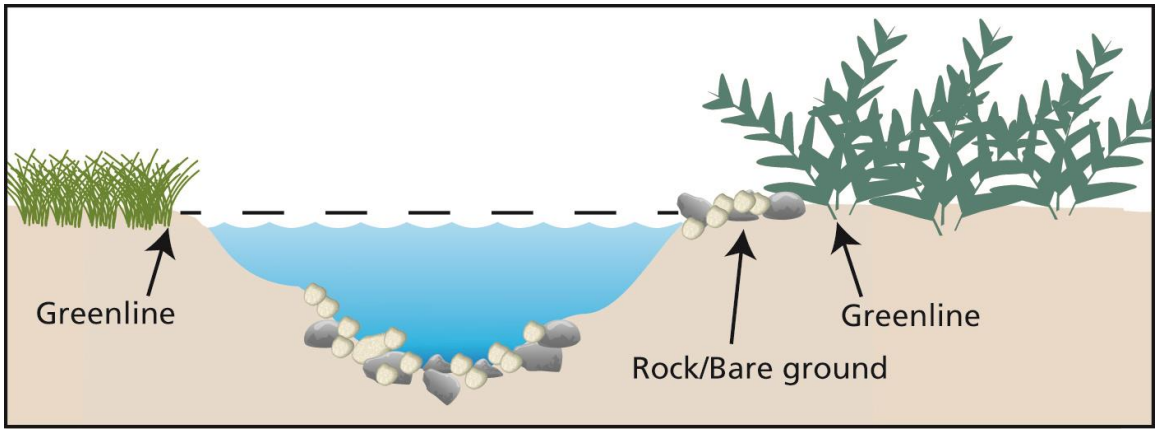


Figure 4. Location of greenline data collection for herbaceous vegetation (left) and shrubs (right). Note that the rooted point is where the transect is placed, not necessarily at the canopy of the woody vegetation. Figure adapted from Leary and Ebertowski (2010).

Figure 5. Greenline (white dashed line) along Fremont River in Capitol Reef National Park located very close to the water's edge.

Figure 6. During lower flows, the greenline (white dashed line) may be located beyond a gravel or sandbar, as in this example on the East Fork Virgin River in Zion National Park.

Figure 7. In this example on the East Fork of the Virgin River in Zion National Park, no qualifying greenline exists. The greenline (white dashed line) is then located on top of the eroded cutbank (i.e., the first flat floodplain-like feature) and is comprised of mostly upland species.

Figure 8. Example of how to sample a discontinuous greenline (dashed white line). Sampling begins downstream (right side of photo) on the first flat floodplain-like feature. Where perennial riparian vegetation cover is >25%, sampling is shifted towards the stream (dotted white line).

2. Exotic Frequency

Record the presence of all exotic plant species rooted in 0.5-m x 2-m quadrats placed every 5 meters along each cross-section transect.

A. The quadrat is oriented so that the long end lies on the transect tape and the upstream side of the transect is sampled beginning at 0 m (Figure 3). Use engineering rulers to delineate the quadrat starting at the 0-m mark on the transect tape and ending on the 2-m mark.

B. Record each exotic species rooted in the quadrat. All live annual and perennial exotic species, or species that were alive earlier in the growing season, are recorded. For any plant rooted underneath the sampling frame, count ones that are rooted at least 50% within the quadrat.

C. Sample exotic frequency in quadrats beginning at 0 m, 5 m, 10 m, 15 m, and every 5 m thereafter for the entire length of the transect. Do not sample quadrats that start on the transect and extend beyond the transect end point.

3. Canopy Closure

Canopy closure is recorded every 10 m along the transect starting at the 5-m mark (i.e., 5, 15, 25 m, etc.) using a modified concave spherical densiometer.

A. Hold the densiometer 12” in front of you at elbow height with your elbows steadied against your torso. Level the densiometer using the bubble level. Position your body so that your forehead is visible at the top of the mirror as you make the reading (Figure 5).

B. Count the number of point intersections covered by live or dead vegetation above the V (maximum is 17). Do not count canyon walls or cutbanks.

C. Four measurements are made: (1) facing downstream, (2) facing the right bank, (3) facing upstream and, (4) facing the left bank. Keep the densiometer in the same place as you rotate it and yourself for each reading. It does not matter what order you take the readings.

Occasionally, you may not be able to take the measurement at one of the standard locations because a tree trunk is blocking that location. If this occurs, move down the transect 0.5 m (i.e., move to 5.5 m) until you can hold the densiometer in the correct location. Do not move the location of the densiometer along the transect for branch obstructions. You should be able to move the densiometer up or down a centimeter or so in order to take the measurement.

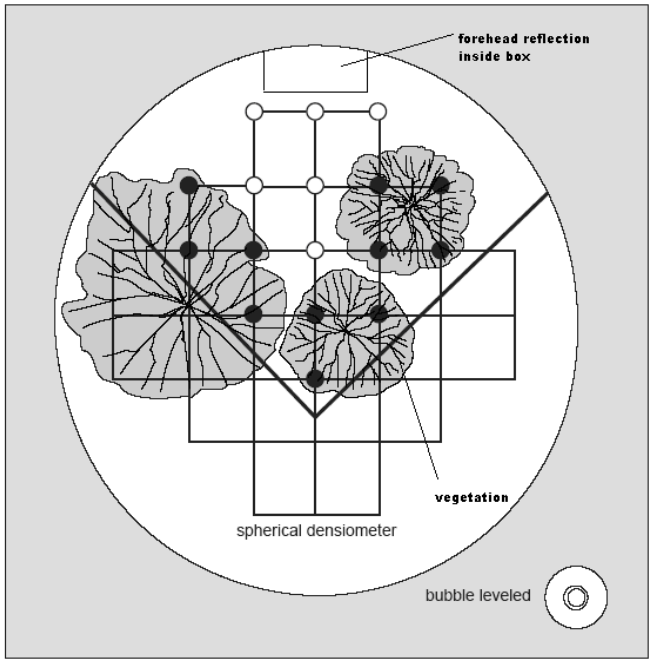


Figure 5. A modified concave spherical densiometer. Note the bubble level, line marking right angle (above which points are counted), and 17 points of intersection. Closed circles represent line intersections where vegetation is present and consequently counted in measurement of canopy closure (example shows 11 out of 17 points) (from Fitzpatrick at el. 1998).

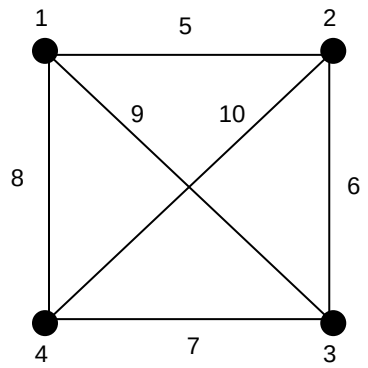
4. 5-m Belt

Tree density by size class is recorded in a 5-m belt that is centered on each cross-section transect (2.5-m upstream and 2.5-m downstream). Seedlings, saplings, and overstory trees are sampled simultaneously.

4.1 Seedling density

A. Use a 2.5 meter pole to determine the boundaries of the 5-m belt on each side of the cross-section transect.

B. Use a dot tally to record the density of all live exotic and native tree seedlings ≤1.37 m in height or ≤2.5 cm DBH. A dot tally is created by forming the following figure as you count stems:



C. *Tamarix* species and *Salix exigua* are not considered trees during this tally.

D. The goal of seedling density is to count discrete young individuals. Multiple "suckers" that originate from the same location and stump sprouts are considered one seedling. If any of the suckers or stump sprouts are >2.5cm DBH, measure each one as a sapling and do not count any as seedlings. Do not count attached branches, partially or completely covered by soil at the base, as seedlings.

E. At sites with high densities, estimate density using the following categories: 100-250, 251-500, 501-1000, and >1000 individuals.

F. After completing a belt, add up the dot tally marks for each species and write in the numeric total in the "Total" row.

Sampling adjustment if two transects cross

If two transects cross, do not sample the lower numbered transect's belt area where it overlaps with the higher numbered transect. Note on the datasheet where tallying stops, and at what point it restarts if necessary. Use this rule for seedlings, saplings, and overstory trees in the 5-m belt.

4.2 Sapling and overstory tree density

Record DBH of live and dead tree saplings and mature trees >2.5 cm DBH in a 5-m belt.

A. Measure all individuals rooted more than 50% within the 5-m belt. If a tree is rooted near the belt transect boundary, use a tape or pole to measure the perpendicular distance between the tree and the transect line.

B. Record the tree species. Use "-D" to denote dead individuals. Record unknown species using the guidelines in Section 1 of this SOP.

C. Measure the diameter at breast height (DBH) of the stem or trunk using the guidelines below. Trees greater than 25 cm DBH are also recorded in the reach census.

- If using the 15-cm plastic calipers, record to the nearest 0.5 cm.
- If using the DBH tape, record to the nearest 0.1 cm.
- Do not measure stems that lean more than 45 degrees (these are considered branches).

Measuring DBH:

- Use the DBH tape to measure the diameter of the tree at 1.37 m above the ground surface (breast height).
- If the tree is on a slope, stand on the uphill side of the tree to measure DBH (Figure 6).

Using the DBH tape

1. Hook the end of the tape into the bark and run the tape around the trunk, ensuring that the tape is straight and pulled perpendicular to the axis of the trunk. Bowed tapes will give an overestimate of trunk diameter.

2. Wrap the tape tightly around the tree and read the number where the tape crosses the zero mark at the beginning (hook end) of the tape (see Figure 7).

3. Make sure that you are reading the correct side of the DBH tape. Often one side has standard centimeters and the other side has units calibrated to give the diameter in centimeters when wrapped around the circumference of the tree. Read the calibrated side of the tape.

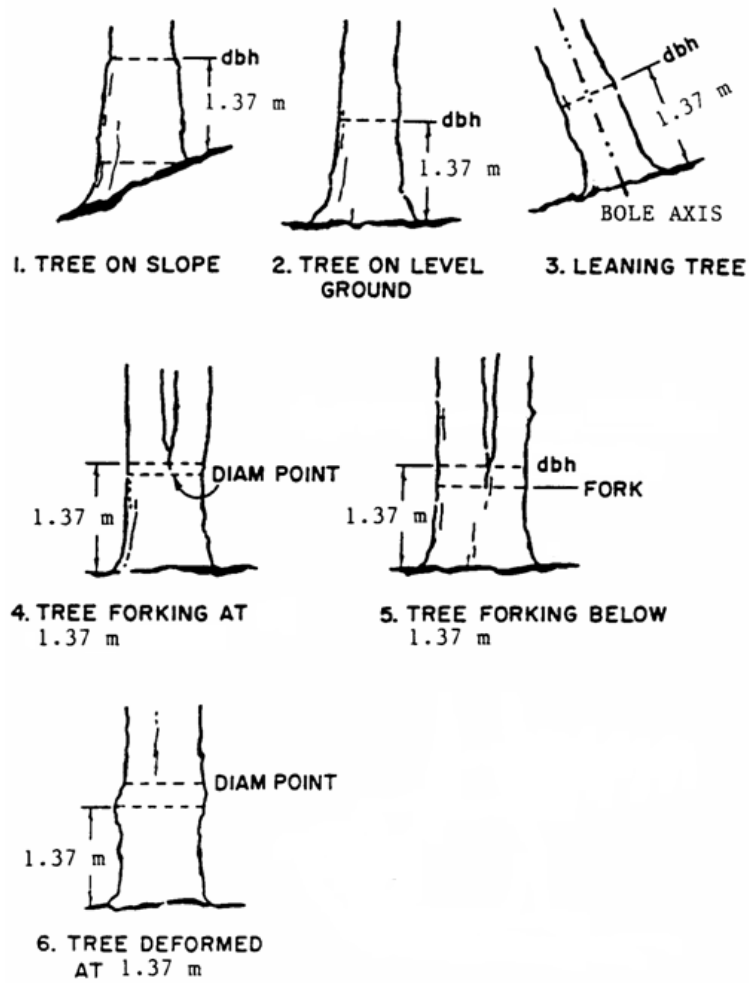


Figure 6. Locations of diameter at breast height (DBH) measurements for a variety of bole forms. DBH measurements will always be taken perpendicular to the bole axis as illustrated (modified from USDA Forest Service 2005).

Common stem irregularities (see Figure 6)

- *Trees with swellings, bumps, depressions, and branches at breast height* - Measure diameter immediately above the irregularity at the place it ceases to affect normal stem form.
- *Trees missing bark or wood at breast height* - Record diameter of the wood and bark that is still attached to the tree.
- *Curved, leaning, or flood-trained trunks* - Find the point equivalent to breast-height (1.37 m) by measuring along the curvature of the bole on the upper surface of the tree.
- *Trees that fork at breast height* - If forking influences DBH, the diameter should be measured below the fork.
- *Trees that fork below breast height* – Measure the DBH of each side of the fork.

Figure 6. The proper method for securing a DBH tape.

5. Reach Census

All individuals of woody species within the reach with a DBH greater than or equal to 25 cm are tagged and measured. This includes large individuals of species that are considered shrubs in other parts of the protocol (e.g., *Tamarix* spp., *Salix exigua*, etc.).

A. Start at one end of the reach and work your way to the other end. It is often easiest to sample all of the woody species between two adjacent transects before taking down the tagline and setting up a new transect. The area sampled includes:

- the area between Transect 1 and Transect 7
- the active riparian zone and any surfaces between the headpins.

B. Locate a woody species, hereafter referred to as tree, with a diameter at breast height of ≥25 cm.

C. If the tree is not tagged, affix a pre-numbered tag to the tree using a nail.

- When establishing a reach, tag trees in numeric order.
- When revisiting a reach, use tree tags from a different numeric series to add individuals to the census. For example, if tags 1-80 were used during establishment, use tags 100-199 during the subsequent visit for new trees.
- Align the nail so that it enters the tree at breast height (1.37 m). If the tree forks below breast height, both forks should be tagged.

- Drive the nail into the tree at an angle, so that the tag hangs down and away from the tree. Leave several centimeters of nail exposed so the tree has ample space for growth.

D. Record the tag number and species of the tree. If a tree is dead, write (-"D") after the species name. If the species is unknown, write UNKT -D.

E. For reaches with a high density if trees, you may also want to record the location of the tree in the GPS (see SOP #3 for further instructions) to help returning crews relocate them.

F. Measure DBH using the notes in Section 4.2 of this SOP.

- Measure just above the nail.
- Measure to the nearest 0.1 cm, making sure to read the correct side of the DBH tape.
- Sometimes flooding will alter the ground surface so that the nail is no longer at breast height during a revisit. Leave the nail in its current location and measure diameter just above the nail.

G. Record Crown Health

Evaluate the density of each tree's crown in relation to crowns of the same species located in a similar position within the canopy, and from a similar habitat. Crown health codes are defined in Table 5 and listed at the bottom of the data sheet. Classes 1 through 4 refer to the estimated amount of the foliage that is intact, expressed as a percent. Class 5 is used to designate standing dead trees with an overall height greater than 1.37 meters that are still rooted to the ground.

Class 6 should only be used to record trees that were previously tagged and standing but have fallen down since the last reach visit. This class is used in order to not confuse fallen trees with missing data. After a tree has been recorded once as class 6, it does not need to be recorded on the data sheet in subsequent reach visits.

Standing dead trees whose diameters fall below 25 cm since the last reach visit (usually due to decay) should be recorded as class 5. A comment should also be included in the Notes/Conditions field explaining why a tree < 25 cm dbh was recorded on the data sheet. After a tree has been recorded once as class 5 and < 25 cm dbh, it does not need to be recorded on the data sheet in subsequent reach visits.

Table 5. Crown health classes for forest species

Crown Health Class	Description
1	90-100% live foliage
2	50-89% live foliage
3	16-49% live foliage
4	0.1 – 15% live foliage
5	standing dead
6	dead and down

H. Record Conditions/Notes.

Any significant damage to a living tree should be recorded. Scan each tree carefully for signs of damage, including but not limited to beaver browsing, recent fire scars, lighting strike scars, mistletoe infestation, bark beetles, cankers, stem decays, wood-boring insects, tent caterpillars, or broken or dead top.

References

Fitzpatrick, F.A., I.R. Waite, P.J. D'Arconte, M.R. Meador, M.A. Maupin, and M.E. Gurtz. 1998. Revised methods for characterizing stream habitat in the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 98-4052, 67 p.

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2005. *Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick start*. USDA-ARS Jornada Experimental Range, Las Cruces, NM. 36 pp. [available on-line at http://usda-ars.nmsu.edu/jer/monit_assess/monitoring.htm]

Leary, R.J. and P. Ebertowski. 2010. Effectiveness monitoring for streams and riparian areas: sampling protocol for vegetation parameters. Unpublished paper on file at: http://www.fs.fed.us/biology/fishecology/emp.

USDA Forest Service. 2005. Forest Inventory and Analysis National Core Field Guide, Vol. 1: Field Data Collection Procedures for Phase 2 Plots, Version 3.0. Available online at: http://fia.fs.fed.us/library/field-guides-methods-proc/docs/2006/core_ver_3-0_10_2005.pdf

Point Intercept

Data entered by: Data verified by: p.1

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:** **Page _____ of _____**

Observer: **Recorder:** **Transect:** 1 2 3 4 5 6 7

Point (m)	Top Canopy	Lower canopy 1	Lower canopy 2	Soil surface	Disturb.	Point (m)	Top Canopy	Lower canopy 1	Lower canopy 2	Soil surface	Disturb.
0.5						13					
1						13.5					
1.5						14					
2						14.5					
2.5						15					
3						15.5					
3.5						16					
4						16.5					
4.5						17					
5						17.5					
5.5						18					
6						18.5					
6.5						19					
7						19.5					
7.5						20					
8						20.5					
8.5						21					
9						21.5					
9.5						22					
10						22.5					
10.5						23					
11						23.5					
11.5						24					
12						24.5					
12.5						25					

Additional canopy layers can be added on other side

Top canopy
Species code*
Lower canopy layers
Species code*, litter (L), woody debris (WD)
Plant Status
*If part of plant touching laser is dead, write "-D" after species code.

Surface Feature
F = Fines
GF = Gravel, fine (ant to beetle)
GC = Gravel, coarse (beetle to baseball)
CB = Cobble (baseball to basketball)
BL = Boulder
BR = Bedrock

Surface Feature
WA = Water
BSC = Biological soil crust
L = Litter
WD = Woody debris
SL = Scat, livestock
SW = Scat, wildlife

Disturbance
Ant = Ant mound
Bike = Bicycle
Trail = Trail
Camp = Campsite
Auto = Motor vehicle
Flood = Recent flooding
Graze = Recent grazing
Oth = Other

Point Intercept p.2

Point (m)	Top Canopy	Lower canopy		Soil surface	Disturb.
		1	2		
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
31.5					
32					
32.5					
33					
33.5					
34					
34.5					
35					
35.5					
36					
36.5					
37					
37.5					

Point (m)	Top Canopy	Lower canopy		Soil surface	Disturb.
		1	2		
38					
38.5					
39					
39.5					
40					
40.5					
41					
41.5					
42					
42.5					
43					
43.5					
44					
44.5					
45					
45.5					
46					
46.5					
47					
47.5					
48					
48.5					
49					
49.5					
50					

Additional canopy layers

Point (m)	Lower Canopy		
	3	4	5

Point (m)	Lower Canopy		
	3	4	5

Greenline

Data entered by: Data verified by: p. 1

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Observer: **Recorder:** **Transect:** 1 2 3 4 5 6 7 River Left River Right

Point (m)	Top Canopy	Lower canopy						Surface*
		1	2	3	4	5	6	
0.25								
0.5								
0.75								
1								
1.25								
1.5								
1.75								
2								
2.25								
2.5								
2.75								
3								
3.25								
3.5								
3.75								
4								
4.25								
4.5								
4.75								
5								

*Record soil surface for all points without vegetation; otherwise record NA

Additional canopy layers

Point (m)	Lower Canopy			
	7	8	9	10

Point (m)	Lower Canopy			
	7	8	9	10

Greenline p. 2

Point (m)	Top Canopy	Lower canopy						Surface
		1	2	3	4	5	6	
5.25								
5.5								
5.75								
6								
6.25								
6.5								
6.75								
7								
7.25								
7.5								
7.75								
8								
8.25								
8.5								
8.75								
9								
9.25								
9.5								
9.75								
10								

Additional canopy layers

Point (m)	Lower Canopy			
	7	8	9	10

Point (m)	Lower Canopy			
	7	8	9	10

Canopy Closure and Exotic Frequency

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Observer: **Recorder:** **Transect:** 1 2 3 4 5 6 7

Spherical Densiometer

5-m	_____	_____	_____	_____	35-m	_____	_____	_____	_____	65-m	_____	_____	_____	_____
15-m	_____	_____	_____	_____	45-m	_____	_____	_____	_____	75-m	_____	_____	_____	_____
25-m	_____	_____	_____	_____	55-m	_____	_____	_____	_____	85-m	_____	_____	_____	_____
										95-m	_____	_____	_____	_____

Exotic Frequency – Quadrats

	Meter																			
Species	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95

5-m Belt Transect

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Observer: **Recorder:** **Transect:** 1 2 3 4 5 6 7

Tree Seedlings (<1.37 m tall or ≤2.5 cm DBH)

Species	Tally	Total

Density Classes: 100-250, 251-500, 501-1000, >1000

Trees (>2.5 cm DBH)

Species	DBH

Trees (>2.5 cm DBH)

Species	DBH

Reach Census

Data entered by: Data verified by: Pg _____ of _____

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:** **Observer:** **Recorder:**

Tag #	Species	DBH	Crown Health	Location	Notes

Crown Health

1 = 90-100% live
2 = 50-89% live
3 = 16-49% live
4 = 0.1 - 15% live
5 = standing dead
6 = dead and down

Notes
Examples include: beaver browsing, fire scar, lightning strike, canker, tent caterpillar infestation, etc.

Unknown Plant Species

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:** **Collected by:**

Transect: 1 2 3 4 5 6 7 **Position on transect (m) / method:** **Photo #s:**

Unknown species code: _____

Plant Type & General Description: *tree* *shrub* *grass* *forb* *other*_____

Forbs and grasses: *annual* *perennial*

Perennial Grasses: *bunchgrass* *rhizomatous*

General Description:

Most salient feature:

Leaf Characteristics (optional):

Leaf Type: (compound/simple, arrangement, etc.)

Margin:

Other: (pubescence, sap, stipules, etc)

Stem Characteristics (optional): (shape, pubescence, bud)

Flower Characteristics (optional): (color, location, floral formula)

Microhabitat Characteristics:

Collected: *Yes* *No*

Best Guess:

Confirmed to be:

Identified by: Date:

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) #7

Assessing Channel Substrate Particle-size Distribution using a Pebble Count

Version 1.00 (June 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP provides instructions for conducting a pebble count along cross-section transects at each reach.

Fill out the datasheet:
Park Code – The four letter park code
Reach ID – The reach ID number
Date – Use the format mm/dd/yyyy
Observer: Record the initials of the person measuring the pebbles.
Recorder: Record the initials of the person recording the data.

Pebbles are sampled in the channel along each cross-section transect. Begin at Transect 7 (the downstream end of the reach) to reduce disturbances upstream before you sample.

A. Lay the transect across the channel perpendicular to flow.

   Perennial streams - Sample the wetted width of the stream and any adjacent scoured channel.
   Dry Channel - Sample the scoured channel bottom.
   Braided channels - Lay the transect tape across the entire channel, but only sample pebbles from scoured areas (i.e., not from islands).

B. Measure the wetted width or channel width in meters.

C. Divide the width by 60 to determine the sampling interval. The minimum sampling interval is 0.1 m.

D. Begin sampling on one side of the channel. Without looking at the channel bottom, plunge your index finger into the water towards the first sampling point.

E. Pick up the first pebble that you touch. If there is silt or sand on top of a rock or bedrock, record "F" for fines.

F. If there is not silt or sand on the pebble, measure the intermediate axis (not the shortest or longest) using a ruler (Figure 1). Record the length to the nearest 0.1 cm on the data sheet. The intermediate axis corresponds to the axis that determines the sieve size through which a particle can fall.

- If a pebble is <0.2 cm, record "F" on the data sheet. Enter as 0.1 in the database.
- If you touch bedrock, record "BR" on the data sheet. Enter as 1000 in the database.

G. Continue across the channel, sampling at the pre-determined interval.

H. After recording 60 pebbles, move upstream to the next transect.

Fig. 1. Measuring the intermediate axis. Note its position relative to the longest axis (the vertical axis in this image) and the shortest axis (pebble depth in this image).

Rules for Pebble Counts

- If the minimum sampling interval of 0.1 m does not allow 60 pebbles to be sampled in one pass, move upstream 0.5 m and do a second pass parallel to the cross-section. Sample equally across the channel (i.e., if only 20 pebbles are needed, sample them at equidistant intervals such that the entire channel is sampled)
- Do not count a pebble twice. If a large rock is intercepted multiple times, record the rock once and move on to the next location that intercepts a new pebble.
- If a rock is too large to pick up, measure the smaller of the two available axes.
- If water is too deep at the cross-section location (i.e., it would flow over your shoulder when picking up pebbles), move the pebble count location upstream at 0.5-m intervals until the water is shallow enough for sampling.

Pebble Count

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Minimum sampling interval is 0.1 m. Measure to nearest 0.1 cm.

Width T7(m): **Width/60:** **Observer:** **Recorder:**

1	7	13	19	25	31	37	43	49	55
2	8	14	20	26	32	38	44	50	56
3	9	15	21	27	33	39	45	51	57
4	10	16	22	28	34	40	46	52	58
5	11	17	23	29	35	41	47	53	59
6	12	18	24	30	36	42	48	54	60

Width T6(m): **Width/60:** **Observer:** **Recorder:**

1	7	13	19	25	31	37	43	49	55
2	8	14	20	26	32	38	44	50	56
3	9	15	21	27	33	39	45	51	57
4	10	16	22	28	34	40	46	52	58
5	11	17	23	29	35	41	47	53	59
6	12	18	24	30	36	42	48	54	60

Width T5(m): **Width/60:** **Observer:** **Recorder:**

1	7	13	19	25	31	37	43	49	55
2	8	14	20	26	32	38	44	50	56
3	9	15	21	27	33	39	45	51	57
4	10	16	22	28	34	40	46	52	58
5	11	17	23	29	35	41	47	53	59
6	12	18	24	30	36	42	48	54	60

Width T4(m): **Width/60:** **Observer:** **Recorder:**

1	7	13	19	25	31	37	43	49	55
2	8	14	20	26	32	38	44	50	56
3	9	15	21	27	33	39	45	51	57
4	10	16	22	28	34	40	46	52	58
5	11	17	23	29	35	41	47	53	59
6	12	18	24	30	36	42	48	54	60

Pebble Count p.2

Minimum sampling interval is 0.1 m. Measure to nearest 0.1 cm.

Width T3(m): **Width/60:** **Observer:** **Recorder:**

1	7	13	19	25	31	37	43	49	55
2	8	14	20	26	32	38	44	50	56
3	9	15	21	27	33	39	45	51	57
4	10	16	22	28	34	40	46	52	58
5	11	17	23	29	35	41	47	53	59
6	12	18	24	30	36	42	48	54	60

Width T2(m): **Width/60:** **Observer:** **Recorder:**

1	7	13	19	25	31	37	43	49	55
2	8	14	20	26	32	38	44	50	56
3	9	15	21	27	33	39	45	51	57
4	10	16	22	28	34	40	46	52	58
5	11	17	23	29	35	41	47	53	59
6	12	18	24	30	36	42	48	54	60

Width T1(m): **Width/60:** **Observer:** **Recorder:**

1	7	13	19	25	31	37	43	49	55
2	8	14	20	26	32	38	44	50	56
3	9	15	21	27	33	39	45	51	57
4	10	16	22	28	34	40	46	52	58
5	11	17	23	29	35	41	47	53	59
6	12	18	24	30	36	42	48	54	60

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) #8

Site Impact Assessment

Version 1.01 (December 2010)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	11/2009	R. Weissinger	Added timed walk for presence of exotic species	More information for resource managers	1.01

This SOP provides instructions for detecting and describing disturbances and exotic plant species at a reach. This assessment is conducted every time vegetation is sampled.

Fill out the datasheet

Park Code: Use the standard 4-letter code to indicate the park unit.
Reach ID: A pre-assigned, unique code provided for each stream reach.
Recorder – Record the initials of the person(s) recording data.
Date – mm/dd/yyyy.

1. In-stream disturbances

Record the presence of all in-stream disturbances listed on the data sheet (see Table 1). If a significant disturbance is present but not listed on the data sheet, be sure to record it. If there is no disturbance to report, enter "none". Write a detailed description of any disturbances that you find.

Table 1. Common in-stream disturbances on the Colorado Plateau.

Disturbance Type	Description
Channel modification	Anthropogenic modification such as a dam, structure, or diversion
Road crossing	
Beaver dam	
Recent flooding	Indicated by flattened vegetation, turbidity, and debris lines. Only record flooding that appears to have occurred in the previous several days.
Crayfish	All crayfish species in this region are exotic. They look like little lobsters.

2. Terrestrial disturbances

Follow the instructions in section 1 to record terrestrial disturbances. Common terrestrial disturbances are listed in Table 2.

Table 2. Common riparian disturbances on the Colorado Plateau.

Disturbance Type	Description
Road	Paved, dirt, or two-track. Note whether it is currently open or closed.
Trail	Livestock or human trail. Note whether it is maintained or social.
Campsite	Denoted by compacted areas devoid of vegetation, fire rings, etc.
Beaver browsing	Chewed and/or felled trees.
Livestock trampling/grazing	Indicated by the presence of livestock or livestock scat.
Wildlife trampling/grazing	Significant impacts due to native ungulates.
Insect infestation	
Fire	Indicated by fire scars on trees, charred vegetation, etc. Note if fire is recent or not.
Exotic plant removal	Indicated by cut stumps, debris piles, etc.
Tamarisk beetle	Indicated by presence of eggs, larvae, adults, or extensive tamarisk defoliation.

3. Exotic plant species

Perform a timed 30-minute walk through the reach and record all annual and perennial exotic plant species present. Make sure to record any species that were not detected during vegetation sampling. Describe the number of plants detected, the size of the invasion, and the approximate location within the reach.

It is the park's responsibility to remove invasive exotics, but the crew may decide to pull exotics if only a few plants are present and if the time needed to hike to the reach is great. Record if plants were pulled by the crew and their general location.

4. Other notes

Record any other notes that may assist in interpreting data for the reach. Describe interesting features of the reach, such as amphibians or fish species seen, management activities noted, etc.

Site Assessment

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Recorder:** **Date:**

In-Stream Disturbance

Channel Modification	Yes	No
Road Crossing	Yes	No
Beaver Dam	Yes	No
Recent Flooding	Yes	No
Crayfish Present	Yes	No
Other	Yes	No

Describe all:

Terrestrial Disturbance

Road	Yes	No
Trail	Yes	No
Campsite	Yes	No
Beaver Browsing	Yes	No
Livestock Grazing	Yes	No
Wildlife Trampling/Grazing	Yes	No
Insect Infestation	Yes	No
Fire	Yes	No
Exotic Plant Removal	Yes	No
Other	Yes	No
Tamarisk Beetle	Yes	No

Describe all:

Site Assessment

Data entered by: Data verified by: p. 2

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Recorder:** **Date:**

Exotic Plant Species Present: (number of plants/size of the invasion, location, note if pulled)

Other Notes:

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) #9

Stream Channel Surveying

Version 1.01 (May 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	5/2011	K. Lund		Update protocol based on field testing	1.01

This SOP gives detailed instructions for surveying the stream channel using a total station and post-processing survey data after returning from the field. A list of necessary equipment for these procedures can be found in SOP #1.

A three-person team comprised of a survey lead and two rod persons can efficiently complete the tasks described below. The survey lead should be skilled in total station operation at remote field sites and have experience with rod duties (i.e., running rod) and post-processing survey data.

1. Surveying

1.1 Establishing the survey layout

A. Locate headpins for all transects at the reach, and mark with pin flags and flagging.

B. Identify potential instrument setup locations, including occupied points and backsight positions. The survey lead should determine these locations with the help of one of the other crew members to check lines-of-sight. Make sure to describe these locations in the field notes.

Survey notes in field notebook (see Figure 1 for an example)

- Record the date, park unit, ReachID, field crew members and their duties (i.e., total station operator or rod crew), scale factor, and general notes (foliage present, weather conditions, etc.).
- Record all rod heights before the survey begins.
- Make a list of surveyed control points including detailed descriptions of all occupied points, backsights, and reference marks shot during the survey.

- Document instrument and backsight heights for each occupied position.
- Record photos taken at each control point and reference mark.
- Record all transect and stream profile points. The datalogger requires a number and description for each point, and this number should be recorded in your notes for all points. These may be grouped in your notes since details of every point are stored in the datalogger.
- List all errors made during the survey so they can be corrected later (e.g., mis-naming of points and any rod heights that were entered incorrectly in the data logger). **It is very important to keep track of the rod height at all times and record any errors.**
- Define all codes that are not established in Table 1 of this SOP.
- Sketch the reach including relative locations of transects, reference marks, instrument setups, and the riparian corridor.

Table 1. Definitions and abbreviations for survey terminology. In codes, # is replaced with the number of the transect that is being surveyed; * indicates L for river left and R for river right.

Survey terminology	Code	Definition
Occupied point	OP or OPTEMP	Monumented or unmonumented points occupied by the total station during a survey
Backsight	BS	A measurement taken back towards a point of known elevation (or arbitrary elevation entered in the total station), or a point previously occupied by the total station used to maintain survey control
Control point	CP	Monumented occupied point or backsight location
Reference marks	RM	Other points used as controls that are not monumented or used as instrument setups (e.g., bedrock, boulder, benchmark, etc.)
Instrument height	HI	Height of the total station from the top of the rebar to the horizontal axis indicator mark on instrument (to the nearest millimeter)
Backsight height	HB	Height of the backsight prism above the top of the rebar marking a backsight position (to the nearest millimeter)
Rod height	HR	Height of prism rod from the bottom of the rod to the center of the prism (to the nearest millimeter)
Top of headpin	T#L or T#R *	Shot taken with the rod on top of the headpin
Headpin ground surface	T#LGS or T#RGS *	Shot taken with the rod on the ground surface
Bankfull elevation	BFL or BFR *	Shot taken with the rod at bankfull elevation
Edge of water	LEW or REW *	Shot taken with the rod at the edge of flowing water
Cross-section transect points	T#	All other points shot along each transect, including shots taken at 1-m intervals and at surface breaks
Thalweg length	P#	Shots of the thalweg
Top of well cap	T#WELL	Shot taken on the top of a well cap
Well at ground surface	T#WELLGS	Shot taken ground surface next to well

Date: Park: ReachID: Crew: Scale factor: Conditions:

Point no.	OP	BS	Notes	# of rods	HRs (m)
1	CP 1		rebar with aluminum cap "CP1", HI = 1.452 m	1	1.853
2		CP2	high point on boulder ~210 m DS of CP1; valley left; 4 m up on bench	2	3.054
			(photos- P8090402, P8090403, P8090404) --shot with rod	3	etc.
3			RM 1 is the obvious knob on a grayish 10-ft boulder on valley right ~60 m US of CP1 (photos- P8090405, P8090406, P8090407)		
1000			T1L		
1001			T1LGS		
1002-1150			T1, moving river L to river R		
8000-8073			PROFILE1, DS T1 through T2. Flagged where we stopped at T2.		
1151			T1R		
1152			T1RGS		
TURN TO CP3					
4	CP3		high point on reddish, flat 12 ft x 5 ft x 8 ft boulder, valley left, at base of bluff (photos- P8090408, P8090409, P8090410, P8090411), HI = 1.530 m		
2		CP2	setup tripod BS; HR= 1.278 m		
5			re-shot RM 1		
6			RM 2 is the high point on oblong reddish boulder, valley right, ~120 m DS of CP3. Boulder is ~4 ft x 4 ft x 6 ft, near bases of 3 much larger, whiter boulders (photos- P8090412, P8090413, P8090414). HI = 1.530 m		
2000			T2L		
2001			T2LGS		
2002-2059			T2, moving right L to river R		
2060			2 HR not 4		
2061-2146			T2, moving river L to river R; incomplete; flagged for completion from CP4.		
TURN TO CP4…					

Codes
DS = downstream
US = upstream

Figure 1. Example of survey field notes. Codes are defined in Table 1.

C. Monument the initial occupied point and backsight position. Flag the area around the instrument setup for easy visibility while surveying. The initial backsight will ideally be the second occupied point.

Monuments
All permanent monuments must be cleared ahead of time with the park unit. Check to see what is permitted before you leave for the field. Permanent monuments are typically established with 0.5-m lengths of 3/8" rebar. Place an aluminum cap on top of the rebar stamped with NCPN, the ReachID, and the appropriate code for the control point.

D. Locate at least two reference marks. These are best located on bedrock or very stable boulders. Reference marks provide a control on survey precision and are used to triangulate positions if monuments marking instrument setups are lost. Any benchmarks located near the reach should be used as reference marks. Make sure to describe these in the field notes.

E. Take photos of each control point and reference mark. The photos should include 1) a few shots with enough background topography for anyone returning to the reach to find the approximate location, and 2) at least one close-up of the precise position of the point. Try to include either the total station or rod person in each photo.

F. Record the location of each control point and reference mark using the highest grade GPS unit available. These will be used to translate and rotate the survey data into real-world coordinates.

The next section describes steps to set up the total station (also referred to as the instrument), datalogger, and backsight. Most of these steps are performed by the survey lead while the rod crew members run the tagline (see SOP#4 for instructions) for two adjacent transects, install monuments, take photos, and hold the rod for any control shots.

G. Set up the total station at the initial occupied point, using standard leveling procedures. Measure the height of the instrument (HI), to the nearest millimeter, from the top of the permanent rebar to the horizontal axis indicator mark on the side of the instrument. Document how the measurement was obtained in the field notes.

H. Measure the height of each rod, to the nearest millimeter, from bottom of rod to center of prism. Make sure that prisms are set so that the heights of both rods are identical. Always raise the rod from the top section (the smallest rod), followed by the next-to-top section, etc. Document rod heights in the field notes (e.g., 1HR = 1.768 m, 2HR = 2.987 m, 3HR = 4.151 m…6HR = 7.680 m). If rod heights are changed during survey, the rod person will immediately notify the survey lead.

I. Set up the backsight in the initial position. If the backsight will be established with a tripod/tribrach/prism, set up the tripod and tribrach using standard leveling methods. Measure the height, to the nearest millimeter, from top of the permanent rebar to the center of the prism. If the backsight will be established using a rod and prism, make sure it can be shot at a single rod since higher rods are less precise.

J. Turn on the datalogger and open Survey Pro. Turn off all unnecessary features in the datalogger and make sure is set to automatically shut off. You may run the Spectra Precision Ranger datalogger until it runs out of power since it automatically saves and backs up the data. Losing power will not impact saved data or configurations other than the real time clock.

K. Set the initial parameters for the survey. In File, select Open to open a file from a previous survey or New to begin a new survey. Enter the following information:

- Default units
  - Azimuth Type: North Azimuth
  - Units for Distances: Meters
  - Units for Angles: Degrees
  - Do not check Adjust for Earth Curvature / Refraction
  - Do not check Use Scale Factor.
  - Make sure prism constant matches prism (our's is -30mm; printed on the actual prism) in datalogger. Do not set prism constant in gun.
  - Click Next.
- Enter First Point
  - Point Name: 1
  - Northing: 5000.0 m (Y coordinate)
  - Easting: 5000.0 m (X)
  - Elevation: 1000.0 m (Z). *Note: the initial survey at each reach establishes an arbitrary coordinate system that is translated and rotated into UTM coordinates during post-processing in the office.*
  - Description: Enter code/description of point you're shooting (i.e., CP1).

L. Go to Job to adjust additional settings. Under Settings, choose between Bluetooth (wireless option) or using the manual cord to connect to the total station. If you need to look at a point later in the survey, you can also do this under Jobs, Edit Points.

M. Enter the instrument location set up information. Go to Survey, then Station Setup, and enter the following:

- Setup Type
  - Known Point: Setup at a point with known or assumed coordinates.
  - Unknown Point/Resection: Setup at an unknown location by observing 2 or more known points.
- Occupy Point: Enter the code for this point.
- Do not check the 2D survey box.
- Enter HI (Instrument Height)
- Do not click Remote Elevation.

The Information Box displays previously entered assumed coordinates. Click Next after you finish entering the information.

N. Enter the backsight settings in the datalogger.

- Select one of the following:
  - New Point: Observe and store a new reference point for orientation
  - BS Point: Use an existing point for a reference. This is generally used after starting the survey and backsighting to a known location that was already shot.
  - BS Azimuth: Orient along an assumed reference azimuth. This is generally used when shooting the first backsight at the beginning of the survey. A compass is used to get the general bearing (i.e., 0, 90, 180, etc. degrees).
- Choose one of the following:
  - Fixed Target: Use a dedicated target for the backsight, usually on a tripod.
  - Roving Target: Use a single target for both the backsight and the foresight, usually a rod and prism.
- Enter the rod height (HR).

O. Perform the backsight circle. **The total station needs to be on the record screen (not the bubble screen) to take readings. Use the yellow REC/ENT button on the instrument to go to the correct screen.** Sight the backsight prism precisely on the center. If a rod is used to shoot in the backsight, use the total station crosshair to ensure that the prism is on a precise vertical line above the backsight point and a rod level to ensure front-to-back leveling. Make sure that the crosshairs visible through the total station sight are sharp and dark to reduce parallax.

- In the datalogger, click Read Circle. An acceptance sound indicates that this is complete.
- Click Send Circle. Wait for the acceptance sound.
- Click Next.
- Station Check: Use this to check errors before continuing with survey.
  - Choose from three options: By Distance, By Angle, or By Point to check for errors and double-check the station set-up. Do not continue if errors are outside the acceptable range. Stop and remedy the problem.

Acceptable errors

Horizontal (includes the northing and easting): 0.000 - 0.030 (3 cm).
Ideally, it is best to have < 0.020 (2 cm) error.

Vertical (includes elevation): 0.000-0.010 (1 cm).
Ideally, it is best to have <0.005 (0.5 cm) error.

This is the process for setting the total station angle to zero (i.e., zeroing the instrument). **Make no changes along the horizontal axis once the total station has been zeroed**.

P. Now the actual location of the backsight can be established. Go to the "Traverse/Sideshot" menu. The foresight number should automatically be set to "3." Make sure that the height shown on the screen is the same as the tripod or rod height at the backsight. Enter a description (e.g., BS1 = CP2), and shoot the point as a sideshot. Return to the backsight setup screen. Change the backsight point to "3." Rerun the two backsight checks described above. Both the horizontal and vertical distance errors should now be 0.000.

Q. If one or more reference marks have been established, shoot those points next. All control shots (occupied points, backsights, and reference marks) should be given point numbers from 1 to 100. Use point numbers > 100 for transect and stream profile shots. Organize shots by transect using a hundred or thousand series starting with the number of each transect (i.e., 100 or 1000 series for transect 1, 200 or 2000 series for transect 2, etc.). The thousand series should be used when there could be more than 100 shots per transect. Each occupied point, control point, or reference mark is assigned an integer; duplicate shots on the point are incremented using tenths beginning at 0.2 (e.g., OP1, OP1.2, OP 1.3). Make sure that all control shots are documented in detail in the field notes.

1.2 Surveying transects

Shots along each transect are taken at 1) one-meter intervals marked on the tagline, 2) slope break points that provide an accurate depiction of topography (see Figure 2), 3) the top of each headpin and the surface next to the rebar, 4) the left and right edge of the water, and 5) bankfull elevations on both banks.

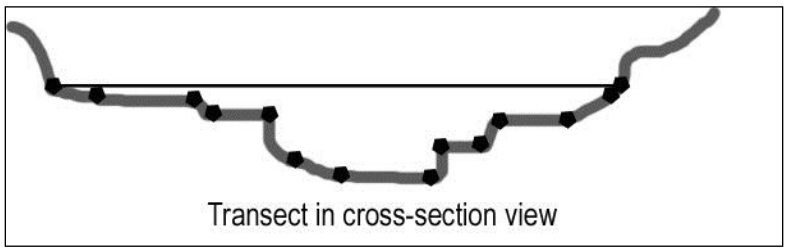


Figure 2. Example of slope breaks points surveyed in addition to 1-m intervals.

A. Begin at any location along the tagline. Shoot as much of the transect as possible from the initial instrument setup. Use codes in Table 1 to name shots in the datalogger and field notes (see Figure 1). Code names for each point should include the transect number, but there is no need to distinguish between 1-m interval shots and slope break shots along the transect.

Rod technique

Raising the rod – Shots are generally taken at the lowest rod height unless there is an obstruction. If the total station does not have a clear line of sight to the prism, try raising the rod until the shot is successful. Always raise the rod from the top section (the smallest rod), followed by the next-to-top section and so forth.

Rod positioning - Each shot should be taken with the rod flush against the downstream side of the tagline. Use the rod level to make sure that you are holding the rod precisely vertical. When two crew members are running rod, they should "leapfrog" across the tagline or down the profile for the greatest efficiency.

Communication - Use radios to communicate. The survey lead uses an ear piece and microphone attached to the radio to free their hands for operating the total station and datalogger. The rod person should always let the total station operator know how many

rods are up before the shot is taken. The total station operator will let the rod person know when the shot has been successfully completed. When two rods are being using to survey a transect, only the prism of the current shot should be facing the total station operator. Crew members running rod need to make sure their prisms are facing away from the total station while setting up for their next shot. Any shot errors (e.g., rod not raised to full height, incorrect rod height relayed to survey lead) should be relayed to the survey lead immediately, documented, and corrected by re-taking the shot, if necessary.

Shooting through dense vegetation

If vegetation is blocking part of the prism but some of the glass is still visible, aim the total station at the crosshairs in the center of the prism and not at the portion of visible glass. If you are unable to get a shot at any of the standard rod heights, the following alternatives may be attempted.

- Move the rod slightly upstream or downstream while keeping the bottom of the rod on the same geomorphic surface. The rod person will need to estimate the distance upstream or downstream of the tagline and relay this to the total station operator to document in the field notes. Make sure to level the rod in the new location.
- Use an alternative rod height. The total station operator finds a section of the rod that is visible and sets the crosshairs to the elevation shown on the rod face (e.g., 1.5 m). The rod person then adjusts the rod so that the prism is at this height. The total station operator instructs the rod person to raise or lower the prism until it is centered in the pre-set crosshairs, takes the shot, and enters the appropriate rod height. It is also possible to place the prism directly on the ground (i.e., by laying the rod on its side) if that is the only way to get shot. Measure rod height from the ground to center of prism.
- Take a shot using the horizontal or vertical offset functions in Survey Pro (see instructions for the software).

B. Rod crew members should alert the total station operator when they reach a headpin. If it has a permanent monument, set the rod on top of the rebar, notifying the total station operator that the shot is “Top of Pin.” The next shot should be on the ground surface next to the rebar. If endpoints are not monumented, shoot the ground surface at the pin flag.

C. After surveying transects along the tagline, use the data in the total station to extend the transects beyond the headpins onto the upland terrace. Use a feature in Survey Pro called the Stakeout to Line, where you designate which points are used to make the line and the total station tells you how close each shot is to the line (see software manual for details). You may also extend the tag line along the correct azimuth to help line up the shots. Beyond headpins, points should be surveyed at 2-5 m intervals and all surface breaks until you reach a very stable upland surface.

Woody debris and other obstacles along the survey transect

Where large woody or other debris precludes placing the base of the rod on the ground surface, the rod person should place it on the object for the shot, and relay to the total

station operator the height of the debris above the ground surface. This can be measured using the increments marked on the face of the rod. The total station operator should document this information in the field notes in order to make later adjustments to the survey data.

D. Determine when to move the total station. Follow the instructions in the next section to establish a new occupied point and continue surveying.

- If you can shoot additional transects from the existing instrument setup, perform the following checks before beginning the next transect.
  - Check the backsight and correct any errors reported by the datalogger.
  - Re-shoot any reference marks.
- If the total station must be moved to accommodate the next transect, shoot as much of the stream profile as possible before moving the instrument.
- If a transect needs to be shot from two different instrument setups, mark the location where you stopped surveying with flagging so that you can begin surveying at the correct location from the new instrument setup.

1.3 Establishing a new instrument setup

Make as many shots as possible from each instrument setup, including transects, stream profile, and hydrologic instrumentation. Follow the instructions below to establish a new instrument setup.

A. Move the total station to the backsight location, and use the previous occupied point as the new backsight. Adjust the appropriate settings in the datalogger, and shoot the backsight and reference marks from the new location. Shoot as many transect and stream profile points from this location as possible.

B. Shoot in a new instrument setup location (CP3). Use one of the existing controls (CP1 or CP2), an existing reference mark, or any headpin that has already been surveyed as the new backsight. Monument, flag, and photograph the new instrument setup as described in section 1 above, and shoot in the new point before moving the total station. Make sure to document any additional instrument locations and backsights used in the field notes.

Shoot in additional instrument setup locations as necessary to complete the survey.

1.4 Surveying the stream profile

The stream's thalweg profile is surveyed throughout the reach. This includes the entire length between the transects and far enough upstream and downstream to capture important features near the ends of the reach (approximately 10 m upstream and downstream of the reach). Shots should accurately represent major slope breaks and channel features such as pools, runs, riffles, and meander bends.

- The total station operator shoots as much of the stream profile as possible from each instrument setup.

- To ensure continuity of the survey, rod persons mark the start and end of each section of profile shot with flagging. Label this flagging to differentiate it from flagging used to identify transect locations.
- Rod persons should leap-frog 1-m intervals, moving continuously upstream or downstream for each section.

Number each segment shot of the thalweg profile separately for clarity in deciphering the final map layout. Use PROFILE# for the descriptions, with PROFILE0 being the most upstream 10m, PROFILE1 from T1 to T2, PROFILE2 from T2 to T3. Use a numbering system that does not correspond with any transects (recommend using 800 or 8000 series for the profile shots).

1.5 Surveying wells and other hydrologic monitoring equipment

Survey all hydrologic monitoring equipment in and around the reach. If instrumentation occurs outside of the reach, make sure to survey the section of stream profile near the instrumentation.

Piezometers/instream wells – Survey the top of the capped well and the ground surface downstream of the well. If you have pipe wrenches available to open the well cap, also shoot the top edge of the opened well.

Crest stage gages - Survey the top of the gage and the post or bolt that supports the stick inside the crest stage gage. Also survey at least one reference mark near the gage in case the gage is damaged or removed by flooding.

Staff gages – Select a height on the staff gage to take a shot (e.g., 1.00 m, as read from the face of the staff gage), and record this in the field notes. If the staff gage contains more than one section (e.g., one for ≤ 1.0 m and one for 1.0-2.0 m), collect readings for both.

1.7 Locating positions and lines from previous surveys

Follow instructions in the Survey Pro documentation to locate positions and lines from previous surveys.

2. After the field visit

2.1 Downloading total station survey data

Survey data should be downloaded as soon you return from the field.

A. Make a copy of the original data and paste it into the corrected data folder. Rename the file so that it begins with “corr” and ends with the extension .txt (see Figure 3). Make sure to keep a copy of the original data for the archives.

B. Open the copied coordinate file (corrFremont01crd.txt in Figure 3) in Excel. The file should have five columns: point number, x, y, and z coordinates, and point description. Save the file as an .xls file using the naming convention in Figure 3.

C. Make corrections from field notes in the Excel file. For example, where an incorrect rod height is documented in the field notes, locate the appropriate point number in the Excel file, and make the needed correction to the elevation recorded for the shot. Notes describing each correction can be made to the coordinate and raw data files in the corrected data folder. When all corrections are complete, save the worksheet as a comma-delimited file (.csv) in the corrected folder.

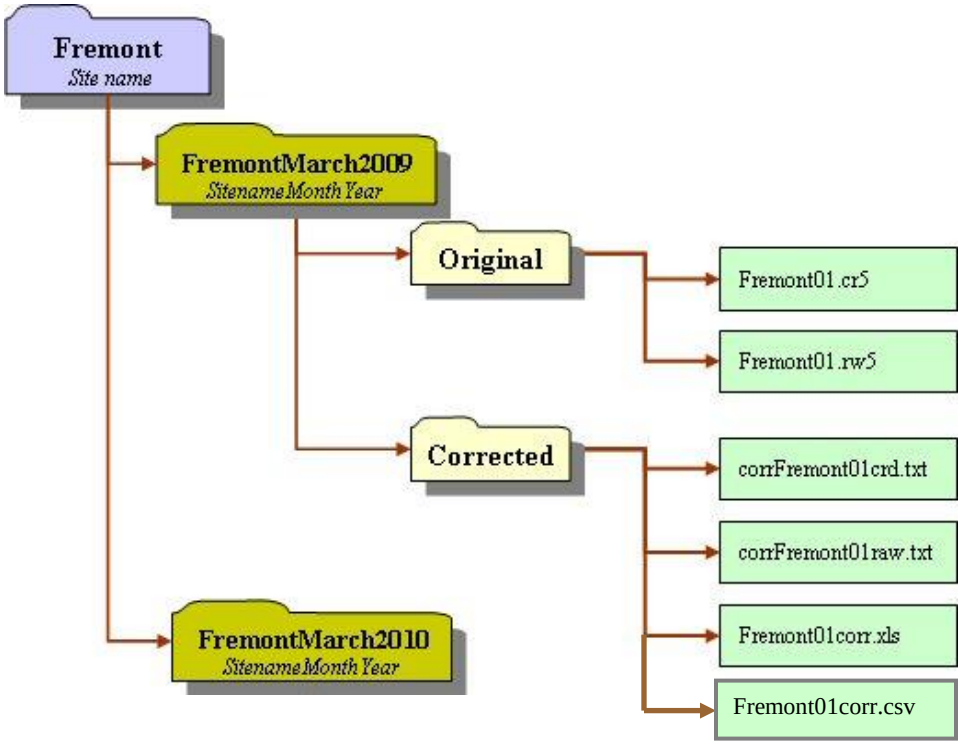


Figure 3. Folder and file naming conventions for survey data.

2.2 Downloading waypoints

Each GPS waypoint should be downloaded and differentially corrected as soon as you return from the field.

2.3 Post-processing survey data

Using Terramodel software, survey data are converted to UTM coordinates, and profiles are created for each transect and the thalweg.

A. Convert total station survey data to UTM coordinates.

   a) Import the corrected .csv file into Terramodel.

b) Obtain differentially-corrected data for all instrument setup and reference mark points. Examine the GPS report to identify points with the lowest PDOP values and reported errors. Select the most accurate point, and move all surveyed points so that coordinates of the selected point match the GPS data.

c) Modify the elevations of all points so that this point's elevation is the same as that reported by GPS. This change is to modify the surveyed elevations to within ~1 m of real world elevations. It is the only change to surveyed elevations that should be made, as the relative elevations recorded by the total station will be more accurate than elevations collected by GPS.

d) Reproject all survey data to UTM coordinates. Use NAD83 for the datum and the zone appropriate for the reach.

e) Select the second-most accurate GPS point. Rotate all survey data around the initial point so that the coordinates of this second point are as close as possible to those reported by GPS. Check the northing and easting coordinates for the remaining setup locations and reference marks to make sure that they are within a few centimeters to those reported by GPS. If the error is greater than this, check all transformations and rotations to identify any errors and correct them.

f) Separate all control shots from transect and profile shots using Relayer in Terramodel. Surveyed transects will appear as rows of points crossing the long line of points that represents the thalweg profile. Export all control point coordinates into the "final control" worksheet in your Excel file. Repeat for all transect and profile shots and label this one "final topography." These coordinate values will be used to overlay the transect and profile points on aerial photos.

B. Obtain detailed cross-sections by using the xline function for each transect and exporting the coordinate values for all points along each transect into the Excel file. Use a separate worksheet for each transect and label each by its transect number. The Pythagorean theorem equation can be used to translate x,y coordinates into stationing values. The left endpoint should be considered the "100" station. Generate cross-section drawings in the Excel file, using uniform scales for the x and y axes.

C. Export the thalweg profile shots into a separate Excel worksheet. Transform into stationing values, from downstream-most to upstream-most point. The downstream point should be labeled as station "0." Generate a profile drawing in Excel using an appropriate vertical exaggeration.

D. In the Terramodel file, appropriately label control shots (distinguish between occupied points and reference marks), transects, and the points shot along the thalweg profile. Label the drawing with survey dates and other appropriate information for the archive.

2.4 Archiving

Create shape files and the accompanying metadata for the finalized survey data. The following should be archived:

1) Terramodel file.
2) Shape files of all spatial data.
3) Metadata file.
4) Excel file consisting of 11 worksheets: 7 transect worksheets with finalized survey coordinates, transformed stationing/elevation values, and drawing; 1 profile worksheet with finalized survey coordinates, transformed stationing/elevation values, and drawing; 1 control point and 1 topography worksheet with coordinate values and descriptions, and the original coordinate correction worksheet.
5) Field notes with sketch of reach.
6) Photographs of all control points and reference marks.
7) Original coordinate and raw data files.

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 10

Well Installation and Hydrologic Monitoring

Version 1.01 (January 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	1.9.2012	D. Witwicki	Updated Fig. 1	Consistency with other SOPs	1.01

This SOP describes installation techniques, instrument set up, and monitoring measurements for surface and groundwater wells.

A three-person team comprised of one installation specialist and two assistants is required to effectively complete the tasks described below. All crew members should have good physical endurance and be capable of heavy lifting.

1. Installation Procedure

1.1 Preparing well point assemblies

Two distinct types of wells are installed at each transect: riparian piezometers and instream wells. It is critically important to understand the different equipment used to construct each type of well. Installing the wrong equipment would be an extremely costly mistake, necessitating removal of the entire well assembly and reinstalling an entire new well assembly. The equipment used to construct each type of well is detailed below:

Riparian piezometer – This type of well is used to measure groundwater elevation in the riparian zone. It typically consists of one screened well point on the bottom attached to *one or more sections of solid galvanized pipe* reaching to the surface.

Instream well – This type of well is used to measure surface water elevation in the stream channel. It typically consists of one screened well point on the bottom attached to *a screened galvanized riser*. The screened riser section must be fabricated prior to the field visit using one of the following methods:

- Cut off the point of a screened well point and install threads on the remaining screened section. A rock saw will easily cut off the tip, and this equipment is often available at maintenance yards in park units. The thread will need to be installed at a local hardware store.

- Alternatively, a screened riser section can be fabricated by drilling a series of 1/8" holes into the entire section of galvanized pipe. A drill press or a standard power drill can be used to make these holes. If this method is used, make sure there are enough holes drilled in the portion of the pipe exposed above the stream bed to ensure connectivity with surface water (7-10 holes).

When referring to both types of wells, the general terms "well" and "well point assembly" are used.

1.2 Determining well locations

Wells are typically installed in either transect 1 or 7 (Figure 1). Wells may be located in another transect if the well locations in transects 1 and 7 are particularly vulnerable to large flood events. Proximity to small side canyons or culverts may also necessitate locating wells in other transects. Wells should be co-located with other hydrologic monitoring devices such as gaging stations or existing wells if they exist anywhere in the reach.

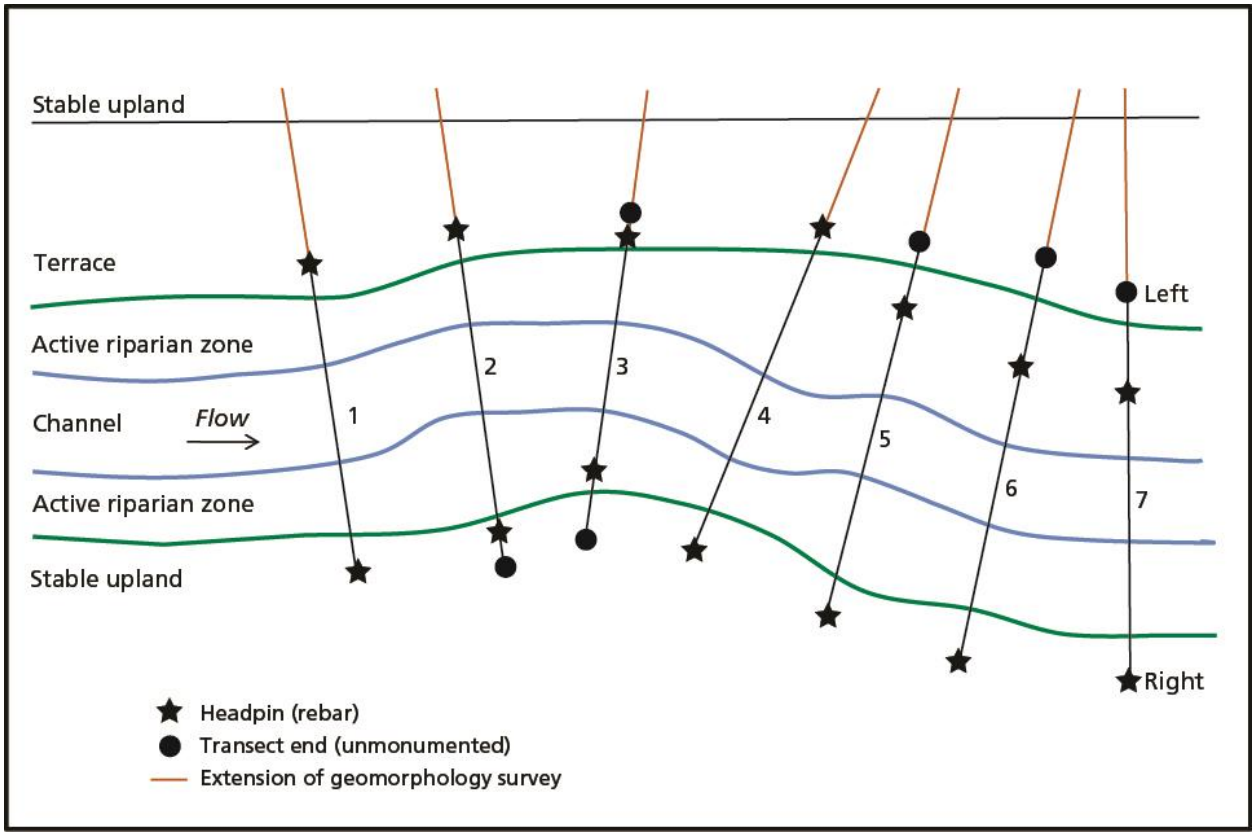


Figure 1. Example of a riparian monitoring reach with seven equidistant cross-section transects.

Two riparian piezometers are installed along the transect on floodplain terraces. They are located three-quarters of the distance from the thalweg to each head-pin (Figure 2). Some constricted reaches may not permit installation of two riparian piezometers due to the presence of bedrock. In this case, only one riparian piezometer should be installed on the non-constricted side of the riparian corridor.

The instream well should be installed in the stream channel near the edge of the stream. If a depositional bank is present, install the well on this side of the stream. If no obvious depositional bank is present, locate the well on the side of the stream that would minimize damage during flood events. For perennial streams, the instream well should be installed at a location that ensures the pressure transducer is submerged during low-flow periods.

A. Locate both head-pins within the selected transect. Follow instructions in SOP#4 to run the tagline and 100-m tape between the head-pins.

B. Determine the location of the thalweg within the stream.

C. Determine the distance between each respective head-pin and the thalweg, and calculate location of riparian piezometers (3/4 distance from thalweg to head-pin; see Figure 2). Mark riparian piezometer locations using pin flags.

1.3 Preparing the riparian surface

After the riparian locations are marked, dig the deepest hole reasonably possible with a shovel, making sure that the diameter of the hole is not greater than 3 feet. In many cases, it should be possible to dig a hole as deep as the entire shovel and no more than 2 feet in diameter. This preparation will significantly reduce total resistance between the well point assembly and the surrounding sediments during installation.

1.4 Assembling the well

The initial height of the well point assembly depends on the depth of the hole in the riparian surface and the height of the crew members relative to the top of the well point assembly.

A. Connect a screened well point to the appropriate galvanized riser piper (Figure 3). Be absolutely sure that you have connected the appropriate type of riser pipe (screened for instream wells or solid for piezometers- see section 1.1 for more details). Add enough sections of pipe so that the top of the well point assembly will be approximately shoulder height prior to pounding. Be sure to coat all of the threads with Teflon tape, and use drive couplings at each pipe junction.

B. Attach a sacrifice pipe to the top of the well point assembly, and attach a drive cap to the top of the sacrifice pipe. Make sure to use Teflon tape and drive couplings here as well.

C. Use two large pipe wrenches to tighten all of the threaded junctions as much as possible.

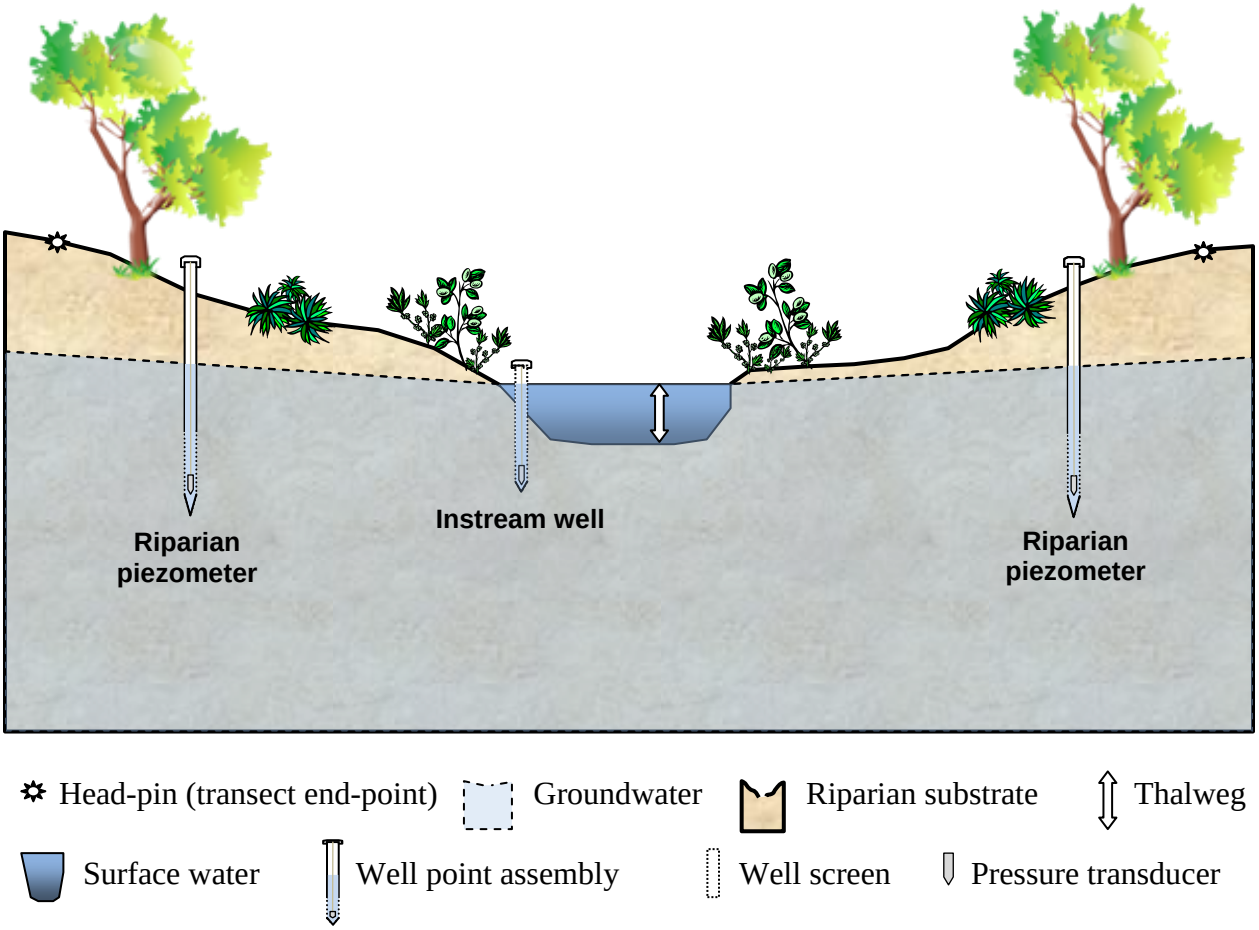


Figure 2. Cross-section of a riparian transect. Notice the riparian piezometers are spaced three-quarters of the distance from the thalweg to each head-pin, and the instream well is placed on the depositional edge of the channel (the gradual sloped edge). The instream well is fully screened (surface and sub-surface), while the riparian piezometers are only screened at depth.

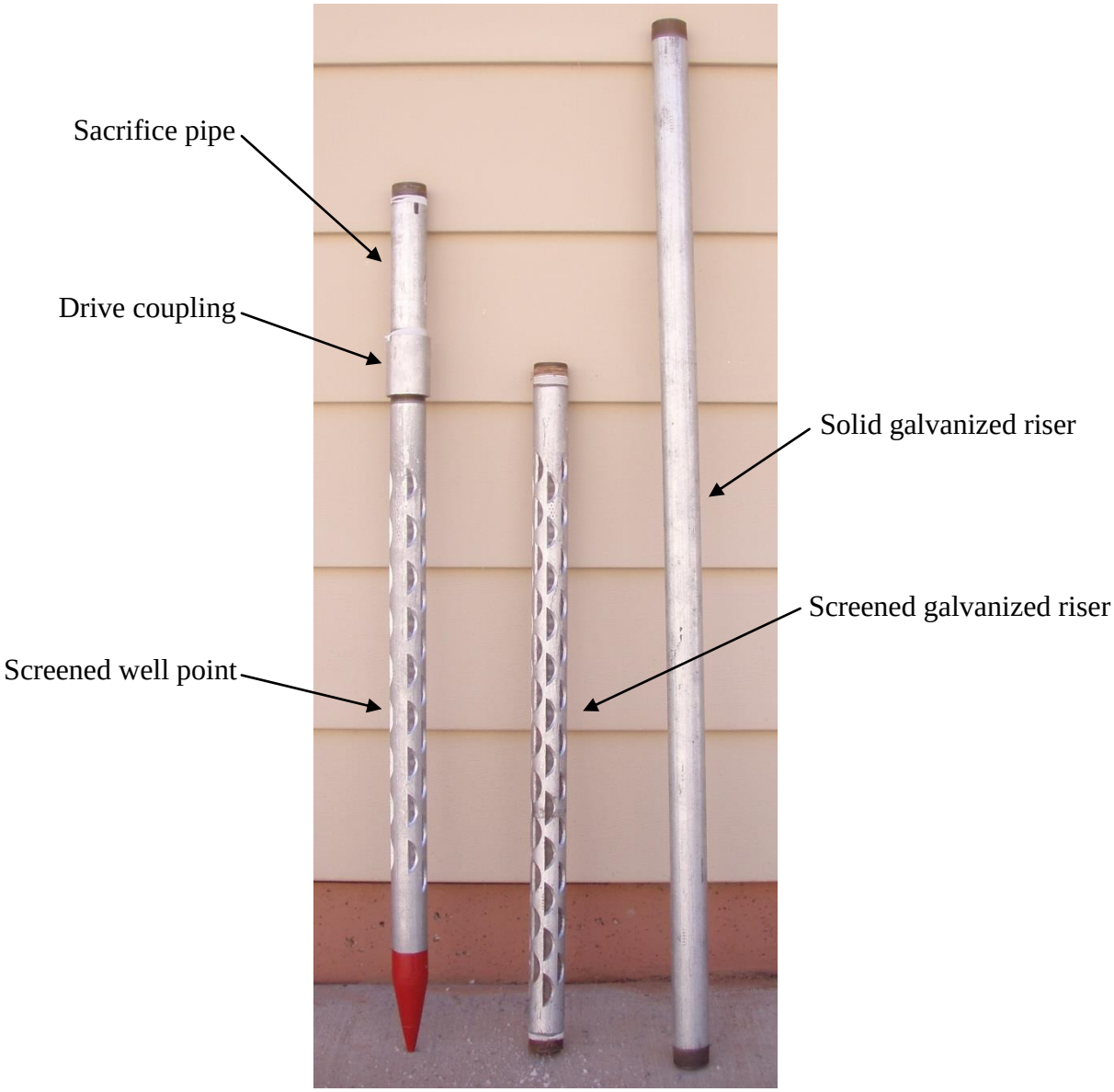


Figure 3. Components of the monitoring well assembly, including screened well point, drive coupling, sacrifice pipe, screened galvanized riser, and solid galvanized riser.

1.5 Driving in the well point assembly

Use a large diameter and heavy-weight fence post driver to pound the wells into place (Figure 4). Handlebar grip tape (used on road bikes) attached to the handles of the fence post driver will significantly reduce the vibration on your hands. Use thick padded gloves (or two sets of gloves) to additionally reduce vibration forces. High decibel ear protection must be worn by all crew members at the installation location. Ear muff-type protection is recommended (versus ear-plugs) due to ease of taking them on and off.

Figure 4. Installing a riparian piezometer at the East Fork of the Virgin River, Zion National Park.

A. Place the well point assembly at the pre-determined instream location or in the hole on the riparian surface. One person should stabilize the well point assembly, while another person levels it with the bubble level. Once level, place the fence post driver on well point assembly and two crew members can begin pounding. Determine the number of repetitions (reps) before you begin to pound (typically 7 reps).

Make sure you don't over-drive the well. It needs to be checked and adjusted periodically during installation to ensure it is level upon completion.

Leveling the well point assembly

-Check the alignment of the well at two perpendicular locations along the riser section. Use a bubble level to perform this task between each set of reps of pounding.

-At first it should be easy to level the well point assembly. The well point can be shifted to the level position with little effort in between reps.

-Once the well point assembly attains a sufficient depth, it will no longer be easy to level. Try moving the assembly in a circular motion to loosen the adjacent sediments, and then re-level. Be careful not to torque the assembly while leveling. Too much torque can make it bend which may necessitate removal and reassembly. It is preferential to have the well not perfectly vertical than to bend the assembly.

-After 3-5 feet of the well point assembly is beneath sediments, it will become extremely difficult to adjust the alignment of the well. If necessary, one crew member can use a rope to apply pressure to the well point assembly while the other two crew members initiate pounding. Loop the rope around the well point assembly near the soil surface and apply a constant pulling force.

B. After one set of reps, remove the fence post driver. Level the well and use the pipe wrenches to tighten all threaded junctions again. Tightening should be performed every time the fence post driver is removed (between 1 and 3 sets of approximately 7 reps). If threaded junctions are not regularly tightened, the threads may suffer significant and irreparable damage. Thread damage to the well point assembly (not the sacrifice pipe), may necessitate removal and re-assembly.

If the well point assembly is bent or threads are damaged during installation
- The well point assembly should be removed and a new one should be installed. It may be necessary to dig deeper to remove the well point assembly. Removal may be difficult or impossible depending on the depth achieved before damaged occurred.

-If the well point assembly has been damaged enough that it will not function properly, and it cannot be removed, the last resort is to detach remaining riser sections and bury the stuck section. ***This should be avoided at all costs.***

C. Once the well point assembly is level and all pipe junctions are tight, begin pounding again. Do not pound too much before re-tightening and re-leveling. The number of sets (e.g., one set equals 7 reps) gradually increases to three or four sets of 7 reps once the ability to re-level the well point assembly has diminished.

Determining total well depth
Instream wells should be installed to a depth of approximately 5 feet below the streambed. Typically, 1-2 feet of pipe are left exposed above the streambed.

Riparian piezometers should be installed to a depth of 2-3 feet below the lowest anticipated water level. Installations that take place during the fall (September-November) should be installed 4-5 feet below the water level in the well. In most locations, the total length of the well point assembly will be between 11 and 15 feet.

D. For riparian piezometers, you will need to determine the depth to groundwater in order to install the well to the correct depth. Once 11 feet of the well point assembly are below the surface, attempt to measure the water level in the well using the water level meter (see instructions in section 1.8). It will typically be necessary to agitate the sediments surrounding the well screen with an inertial lift pump to ensure sufficient hydraulic connectivity (see instructions in section 1.6). After agitating the sediments, allow time for the water level to equilibrate prior to measuring the water level.

E. If the depth of the riparian piezometer is not sufficient, continue pounding until the appropriate depth is reached. Depending on the groundwater level, you may choose to use a smaller length of riser pipe for the last section. Six to18 inches of pipe should be exposed above the surface of the completed piezometer. You may choose to keep the exposed section shorter for aesthetic reasons (e.g. proximity to a trail or likelihood of visitor interaction) or longer to prevent burial during large flood events.

1.6 Developing the well

The sediments surrounding the well screen may become smeared during installation, reducing hydraulic conductivity of the sub-surface material. Pump the well with an inertial lift pump to eliminate smearing and to create a sedimentary filter pack surrounding the well screen that maintains proper hydraulic connectivity in the sub-surface environment and responds quickly to changes in water level. The amount of time it takes for water levels to respond to natural variation in the well is a function of the hydraulic conductivity of the sub-surface material and the connectivity between this material and the well screen. The plunging motion of the pump will effectively push the finest sediments (fine sand, silt and clay) further away from the well screen or suck them into the well, allowing coarser materials (coarse sand, gravel, and cobble) to remain closer to the screen. This procedure reduces or eliminates fine sediment buildup in the well over time.

Both riparian piezometers and instream wells require plunging and pumping for development. This procedure is most effective when performed by two crew members, although the task can be completed by one person if necessary.

A. Insert the foot valve end of the inertial lift pump into the well until it reaches the bottom (Figure 5). With one person holding the opposite end of the tubing away from the well, the other person should initiate a plunging motion within the well.

B. The check valve in the pump allows water in the well to enter the tubing during the downward motion, and prevents water from escaping during the upward motion (see Figure 5). Water will continue to fill the tubing with each plunge and eventually will be expelled from the opposite end. The water will slowly clear as this procedure continues, typically in 5-10 minutes of pumping.

C. Once the water expelled from the well is no longer opaque and begins to clear, remove the inertial lift pump and insert the tubing attached to the Geopump 2 peristaltic pump (Figure 6). The flexible tubing should reach the bottom of the well. Turn on the peristaltic pump and allow it to continue pumping until the water being removed from the well is visibly clear.

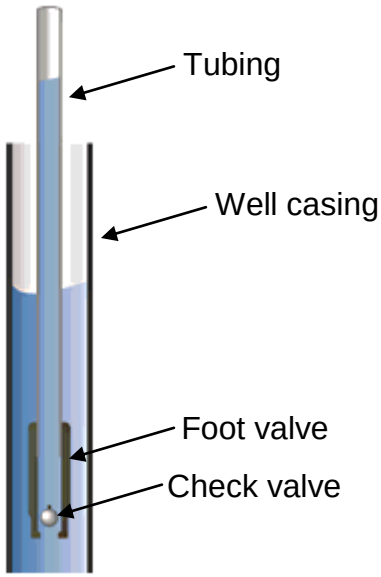


Figure 5. Diagram of inertial lift pump (image from www.waterra.com). On the actual pump, the tubing extends several meter beyond the top of the well casing so that you can direct the expelled water away from the well.

Figure 6. Pumping a well with a peristaltic pump at the East Fork of the Virgin River, Zion National Park.

1.7 Completing the well

Once the well is installed to a sufficient depth and pumped, a few remaining tasks are necessary to complete the installation.

Riparian piezometers

A. For riparian piezometers, it will be necessary to back-fill the sediments removed during the installation. Fill in sediments until approximately 2 feet of the hole remains below the riparian surface. Stamp the sediments down with your foot.

B. Place enough dry bentonite pellets in the bottom of the 2-foot deep hole surrounding the piezometer to cover the surface (a few shovels worth). Arrange the pellets so that there is thicker coat around the exposed piezometer riser section.

C. Using a small bucket or water bottle, slowly pour water on top of the bentonite pellets. Use your hand to ensure that all of the bentonite pellets become saturated and form a smooth impermeable surface. Pay careful attention to the area around the exposed piezometer. Once hydrated, the bentonite pellet layer will effectively seal the annular space surrounding the piezometer and prevent preferential flow paths from forming adjacent to the piezometer.

D. Back-fill the rest of the hole, and scatter leaves and branches to camouflage the site (Figure 7).

Figure 7. Completed riparian piezometer in Courthouse Wash, Arches National Park.

Instream wells

If the screened riser section was fabricated from a well point, the following tasks are not necessary. If the riser section is a pre-drilled piece of galvanized pipe, follow the steps below to complete the well installation.

A. Cut a section of filter fabric (synthetic landscaping fabric found at a hardware store) approximately two feet long. The width should be slightly shorter than the exposed section of the instream well.

B. Tightly wrap the filter fabric around the exposed section of the instream well. Align the bottom of the filter fabric with the streambed. Slide approximately four evenly spaced hex-head hose clamps over the riser section and filter fabric. Tighten the hose clamps on top of the filter fabric, ensuring the filter-fabric is completely taught in between each clamp.

C. Pour water into the instream well to ensure proper connectivity with the surface water. If proper connectivity was achieved, the level in the well should quickly equilibrate with the surface water elevation.

1.8 Measuring water level in the well

The water surface level is depth of the water surface beneath the top of the well casing. Use a Solinst water level meter and the appropriate data sheet (Well Installation or Well Revisit) to record your measurements.

A. Water levels in riparian piezometers are measured from the downstream side of the exposed riser pipe. Water levels in instream wells are measured from the nearest bank. These locations should be marked before using the water level meter to ensure water level measurements are recorded from the same position at every visit (Figure 8). If it has not been marked yet, use a round metal file and a thick permanent marker to mark this location on the inside and outside of the well.

B. Align the tape guide with the marked location on the well (Figure 8), place the meter tape in the tape guide, and allow the water level sensor to hang from the tape guide. Lower the water level sensor into the well, then attach the tape guide in the correct location.

C. Turn on the water level meter and adjust to maximum sensitivity.

D. Release the brake, and slowly lower the water level meter into the well.

E. When the sensor encounters water, you will hear a loud constant tone. Raise the water level meter up until the tone stops. Slowly lower the water level meter back into the well, and determine the depth of the water surface (DWS) using the notch on the tape guide once the sensor begins making the tone again. It may be necessary to raise and lower several times before getting an accurate measurement.

F. On the data sheet, record the time the measurement was taken and the number read from the notch in the "Measured" column. DWS is the measured distance between the top of the well casing (TOC) and the water surface within the well. The number read from the notch is 6 cm above the top of the well casing (TOC). The corrected value will be filled in the "Calculated" column automatically in the database.

G. Turn off the sensor.

H. Lower water level meter until it reaches the bottom of the piezometer or instream well. The tape will go slack when you reach the bottom. It may be necessary to raise and lower the water level meter to obtain an accurate measurement.

I. Record the depth between the TOC and the bottom of the well (BW) in the "Measured" column on the data sheet. Read this value from the notch on the tape guide. If the well point assembly has just been installed, this measurement will also used to estimate the length of Kevlar rope that will suspend the pressure transducer in the well.

J. Remove the water level meter from the well.

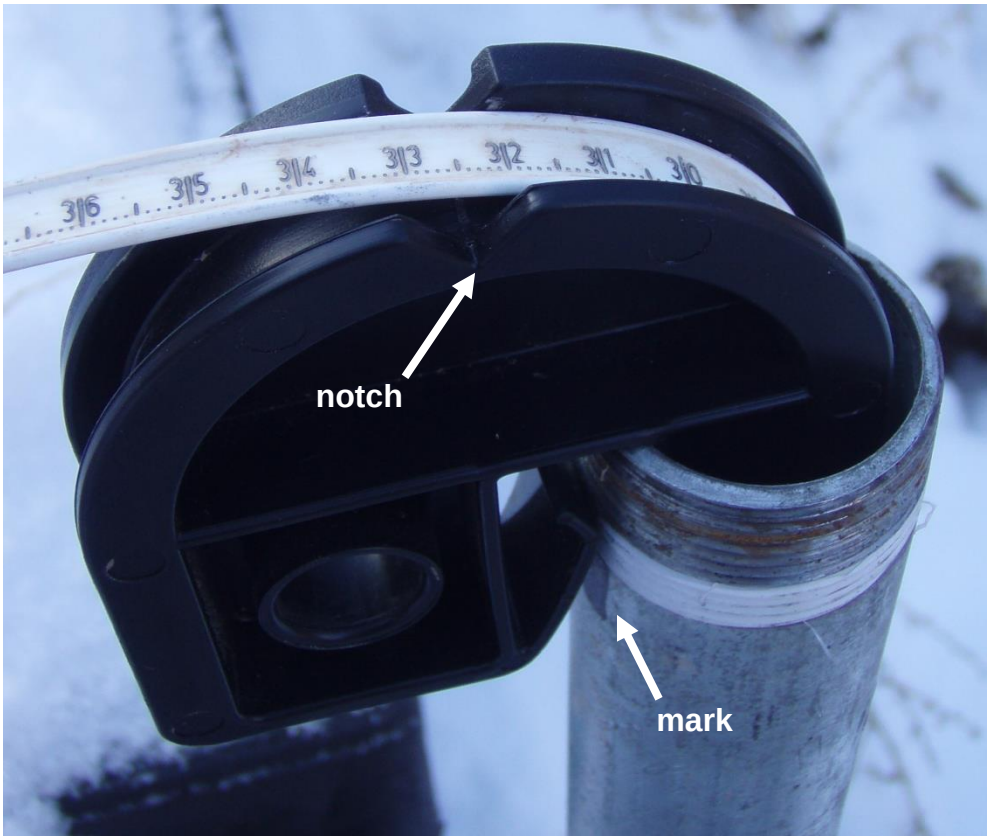


Figure 8. Aligning and reading the water level meter. Align the tape guide on the top of the well with the file/permanent marker mark. Read the water level meter at the notch and enter the value in the "Measured" column on the data sheet.

1.9 Installing the pressure transducer

The settings on the pressure transducer need to be adjusted before it can be installed in the well. These procedures are specific to the manufacturer and the type of logger used. For detailed instructions on settings, refer to the instrument's user manual (i.e. Solinst Levellogger User Manual). Depending on accessibility of the reach, you may perform these steps in the office ahead of time or in the field using a laptop loaded with Solinst Levellogger 3.4.0 software.

A. Electronically label each pressure transducer with the stream and reach location, and any well-specific identification information.

B. Set the logging interval to 15 minutes in systems that contain a long-term gaging station (i.e. an active USGS gaging station with several years of historic data) nearby, and 30 minutes in systems that do not contain long-term gaging stations.

C. Change the units to centimeters, and adjust the site elevation. Elevations acquired from online mapping applications such as Google Maps are sufficient for this setting.

A. Synchronize the instrument time with the system time on your computer (MST), and set a future launch date and time. It is best to set the start time in the field just prior to installation so you can collect a representative water level elevation and flow measurement at the same time. If this step is completed prior to field work, make sure to provide an appropriate buffer between the anticipated time of well completion and the logger start date and time.

To install the pressure transducer in the well:

D. Lay the Kevlar rope and transect tape on the ground and measure the appropriate length of rope. Align the sensor opening on the bottom of the pressure transducer (PTS) with the meter tape (Figure 9). With one person holding the pressure transducer and meter tape, extend the Kevlar rope and meter tape until you reach the distance measured between the BW and the TOC.

E. Make sure the Kevlar rope and meter tape are taught, and mark the distance on the Kevlar rope with a permanent marker that corresponds with the BW-TOC measurement.

F. Cut the Kevlar rope above the mark you just created, leaving approximately 20 cm of extra rope.

G. Tie the end of the Kevlar rope that was not marked with the permanent marker to the hanger on the pressure transducer using several square knots or a figure 8.

H. Align the mark on the other end of the Kevlar rope with the tip of the 3/16" x 2" eye-bolt, and tie the Kevlar rope to the eye-bolt using several square knots or a figure 8. The knot(s) will reduce the distance you measured by several centimeters.

I. Re-measure the distance between the pressure transducer sensor (PTS) and the tip of the eye bolt (Figure 10) with the meter tape. Record this number on the Well Installation

data sheet as the TOC-PTS measurement. The location of the TOC is equivalent to the location of tip of the eye-bolt when the well is completely assembled.

J. Use a small hex-head cable clamp (1/16”) to secure the end of the rope, to help ensure it does not unravel over time.

K. Attach the eye-bolt to the well cap through the vent opening (Figure 10). Insert the threads through the vent from inside to outside so that the eye portion of the bolt is facing inward, and tighten the nut on top of the well cap.

L. One hole will need to be drilled in the exposed section of the riparian piezometers near the well cap to make sure internal pressure equilibrates with the atmosphere. Since it is difficult to predict which section of pipe will be exposed at the surface, drilling must be performed in the field. Instream wells are connected to the surface water through a screened opening, and therefore do not need any more holes drilled after installation.

M. Lower the pressure transducer into the well, and tighten the well cap with pipe wrenches.

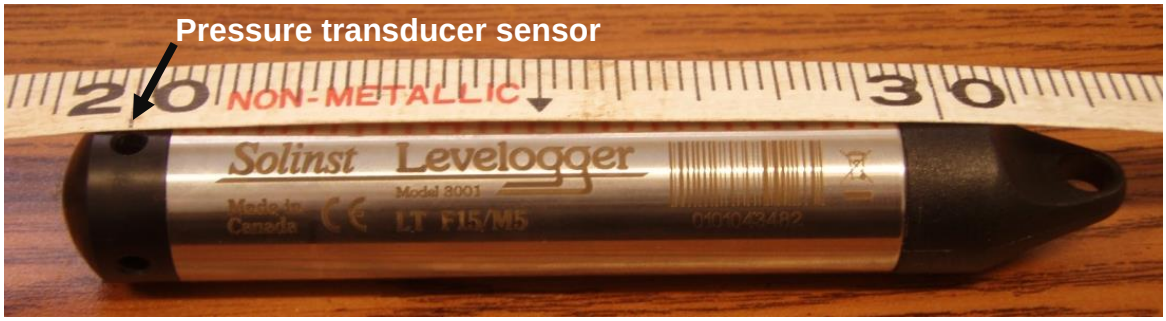


Figure 9. Pressure transducer alignment along meter tape. The sensor is located in the bottom of the pressure transducer underneath a protective plastic covering with four holes in it. To determine the depth of the pressure transducer sensor, align the meter mark on the tape with the mid-point of one of the four openings with the pressure transducer sensor and measure the length of the rope to the tip of the eye-bolt.

Figure 10. Well cap and eye-bolt. Insert threaded end of eye-bolt through the vented opening in the well cap from inside to outside. Thread the nut on the eye-bolt, and fasten securely. Once assembled, the “eye” portion of the bolt should be on the inside of the well cap.

1.10 Installing the barometric logger

Barometric pressure is used to correct the effect of atmospheric pressure on water surface elevations. The settings on the barometric logger need to be adjusted before it can be installed in the field. These procedures are specific to the manufacturer and the type of logger used. For detailed instructions on settings, refer to the instrument's user manual (i.e. Solinst Barologger User Manual). Depending on accessibility of the reach, you may perform these steps in the office ahead of time or in the field using a laptop loaded with Solinst Levellogger 3.4.0 software.

B. Electronically label the barometric logger with the stream and reach location.

C. Set the logging interval to match that of the pressure transducers (i.e. 15 or 30 minutes).

D. Synchronize the logger time with the system time on your computer (MST), and set a future launch date and time. It is best to set the start time in the field just prior to installation. If this step is completed prior to field work, make sure to provide an appropriate buffer between the anticipated time of well completion and the logger start date and time.

To install the barometric logger in the field:

E. Attach the programmed barometric logger to a large tree in a discrete location near the transect. Use parachute cord (p-cord) tied around the base of the trunk or a large limb to attach the logger.

1.11 Recording location and photos

Record a waypoint for each piezometer and instream well using a mapping grade GPS unit (see SOP#3 for the details of operating a GPS). Make sure the coordinate system of the GPS unit is set to NAD 1983. Also record the northing, easting, and elevation of each well on the Well Installation data sheet.

Photos should be taken throughout the well installation process to document conditions that may help interpret results, including photos of each completed well. To help re-locate wells during future site visits, take landscape photos of the wells that contain unique features, such as rock outcrops or large trees that serve as reference points. On the Well Installation data sheet, record the photo number, the Well ID, the photographer, and a brief description of each photo.

Well locations are also recorded during the total station survey (SOP#9.)

1.12 Measuring flow

Collection of flow measurements over time will enable calculation of a stage-discharge relationship. Once this relationship is developed, the instream well will begin to function as a gaging station and every additional flow and stage measurement will further optimize the rating curve.

A. Take a flow measurement on the transect with the wells. Water Quality SOP#8 contains detailed instructions for measuring stream flow.

B. Record measurements and qualitative stream condition information on the Flow Measurement data sheet. Do not manually calculate flow, average velocity, or any of the unit conversions on the data sheet. These will be calculated automatically after the data is entered into the database.

C. If flow is recorded using a Rickly Pygmy Meter, the electronic data file should be copied and pasted into the electronic version of the data sheet.

2. Return Site Visits

Each set of monitoring wells is visited four times per year, and visits should occur in each of the four seasons. Visits timed to capture the greatest variation in stage and streamflow will enable computation of a robust stage-discharge relationship over time.

On each visit to the wells the following procedures should be performed. Record measurements on the Well Revisit and Flow Measurement data sheets.

A. Measure the water level in each well following the instructions in section 1.8.

B. Measure the distance between the top of casing (TOC) and bottom of the well (BW) following the instructions in section 1.8. If the TOC-BW measurement is smaller than what was recorded during the original installation (due to sediment buildup), then well re-development is necessary. Follow the well development procedures in section 1.6 to remove the sediment. If there is more than 6 cm of sediment buildup, you should re-develop the well during this visit. Otherwise, you can plan on developing the well during the next site visit. Always keep well development equipment in your vehicle in case you need it.

C. Download data from pressure transducers and barometric loggers. Detailed instructions for downloading data are provided in the manufacture's user manual for each instrument. Save these data in Excel files.

   A field laptop loaded with Solinst Software can be used to download data from wells that are close to the vehicle. Make sure to bring the optical interface USB cable that is compatible with the pressure transducers and barometric logger. A field laptop may also be used to re-program instruments when necessary.

   For routine visits to wells in remote locations, a smaller Solinst Levelloader PDA is recommended. Make sure to bring the correct interface cable (which is different than the cable used with a field laptop). The Levelloader does not have the ability to re-program the instruments so you will need to bring a laptop if this is necessary.

D. Collect a flow measurement (see Water Quality SOP#8).

Well Installation

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Observers: **Transect:** 1 2 3 4 5 6 7 **Start Time:**

Measurements for Levellogger deployment

WELL ID	Measurement description	Abbrev.	Measured	Units
Right*	Distance between top of casing (TOC) and bottom of well (BW)	**TOC- BW**	_____	(cm)
	Distance from TOC to pressure transducer sensor (PTS)	**TOC-PTS**	_____	(cm)
Left*	Distance between top of casing (TOC) and bottom of well (BW)	**TOC- BW**	_____	(cm)
	Distance from TOC to pressure transducer sensor (PTS)	**TOC-PTS**	_____	(cm)
Instream	Distance between top of casing (TOC) and bottom of well (BW)	**TOC- BW**	_____	(cm)
	Distance from TOC to pressure transducer sensor (PTS)	**TOC-PTS**	_____	(cm)

*Riparian piezometer on right and left side when facing downstream

Water Surface Elevation Measurements

DWS = depth to surface water, Time = time of measurement (24:00)

WELL ID	Measurement description	Abbrev.	Time	Measured	Calculated	Units
Right	Distance between TOC and DWS	**DWS**	_____	_____	_____	(cm)
Left	Distance between TOC and DWS	**DWS**	_____	_____	_____	(cm)
Instream	Distance between TOC and DWS	**DWS**	_____	_____	_____	(cm)

GPS Coordinates

UTM NAD 1983

Log at least 30 points on GPS

WELL ID	Northing	Easting	Elevation	Units
Right	_____	_____	_____	(m)
Left	_____	_____	_____	(m)
Instream	_____	_____	_____	(m)

Photo Log

Photos taken? yes no

Reference images taken of well and general comments

Photo #	***Photo Type***	*Well ID*	*Photographer*	*Description*
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____

Field Notes

Add descriptive notes and general comments below

Well Revisit

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Observers: **Transect:** 1 2 3 4 5 6 7 **Start Time:**

Water Surface Elevation Measurements

TOC=Top of casing, DWS = depth to surface water, Time = time of measurement (24:00)

WELL ID	Measurement description	Abbrev.	Time	Measured	Calculated	Units
Right*	Distance between TOC and DWS	**DWS**	_____	_____	_____	(cm)
Left*	Distance between TOC and DWS	**DWS**	_____	_____	_____	(cm)
Instream	Distance between TOC and DWS	**DWS**	_____	_____	_____	(cm)

*Riparian piezometer on right and left side when facing downstream

Maintenance Reference Measurements

For comparison of TOC-BW measurements with previous measurements

WELL ID	Measurement description	Abbrev.	Measured	Units
Right	Distance between top of casing (TOC and bottom of well (BW)	**TOC- BW**	_____	(cm)
Left	Distance between TOC and BW	**TOC- BW**	_____	(cm)
Instream	Distance between TOC and BW	**TOC- BW**	_____	(cm)

Photo Log

Photos taken? yes no

Reference images taken of well and general comments

Photo #	***Photo Type***	*Well ID*	*Photographer*	*Description*
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____
_____	digital	_____	_____	_____

Field Notes

Add descriptive notes and general comments below

Flow Measurement (See Water Quality SOP #8 for detailed instructions)

Data entered by: Data verified by:

NCPN Riparian Monitoring

Park Code: **Reach ID:** **Date:**

Observers: **Transect:** 1 2 3 4 5 6 7 **Time of Measurement:**

measurable discharge yes no **Water color**_____ **Visual est. of mixing** _____

Discharge Method	Measurement Device	Flow Value	Units (C,G,M,blank)	Measurement type (M,E,blank)	Avg velocity (ft/s, blank)	Vtype (M,E,blank)
_____	_____		_____	_____		_____

C=cfs, G = gpm, M = mL/s M=measured, E=estimated

Gage height (ft):

Q inst. (cfs): **Hydrograph stage:** _____ **Flow severity:** _____

AquaCalc file name:

Current meter discharge (cfs): **estimated discharge (cfs):** _____ **estimate type:** _____

Volumetric

measurement	*vol.(mL)*	*time (s)*	*(mL/s)*	*(gpm)*	*(cfs)*	estimated % loss	adjusted flow *(cfs)*
1	_____	_____				_____	
2	_____	_____				_____	
3	_____	_____				_____	
4	_____	_____				_____	
5	_____	_____				_____	
		stable flow?	yes no			***average***	

Weir

measurement	*stage (ft)*	*calculated (gpm)*	*(cfs)*	estimated % loss	adjusted flow *(cfs)*
1	_____			_____	
2	_____			_____	
3	_____			_____	
4	_____			_____	
5	_____			_____	
		stable flow? yes no		***average***	

Flume

measurement	*stage (ft)*	*Look up (gpm)*	*(cfs)*	estimated % *loss*	adjusted flow *(cfs)*
1	_____			_____	
2	_____			_____	
3	_____			_____	
4	_____			_____	
5	_____			_____	
		stable flow? yes no		***average***	

Discharge comments

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 11

After each Field Visit

Version 1.01 (June 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	6/9/11	R. Weissinger	Added more detailed decontamination instructions	Clarification	1.01

This SOP details procedures performed at the end of each field trip, including equipment maintenance, data management, and trip reports.

Procedures

1. Follow check-out procedures with Glen Canyon dispatch detailed in the NCPN Backcountry Safety Plan.

2. Report all broken or missing equipment to the field crew coordinator. Repair equipment if possible or indicate if new equipment needs to be purchased before the next field hitch.

3. Check-in cameras, lasers, satellite phones, and GPS units. Also check-in lasers, total station, data logger, water level meter, and/or PDA if used.

4. Remove plant collections from the press or cooler, and store them in a secure location where they will not be damaged.

5. Complete data entry and verification. Resolve any questions with the crew members who collected the data.

6. Organize and file datasheets.

7. Download photos and organize by park code and reach name.

8. Download data from total station surveys (see SOP #9) or hydrologic monitoring (see SOP #10) and perform any post-processing.

9. The crew leader should complete a trip report detailing the dates of field work, crew members participating, work completed, travel and housing availability, safety concerns and how they were accommodated, weather conditions, any equipment problems or needs, and any other pertinent information. Also note any interesting or unusual findings, observations of disturbance, human or animal activity, deviations from the SOP, or access issues.

10. Organize monitoring boxes for the next hitch.

11. Charge camera and satellite phone batteries. Also charge batteries for the total station, data logger, PDA, and field laptop if these electronics were used.

12. Return GPS units to the GIS technician for downloading and charging.

13. Clean the insides of vehicles. Especially dirty or muddy vehicles may be washed as often as monthly when needed. Report vehicle repair needs to the field crew coordinator.

14. Decontaminate all equipment, personal items, and clothing that have come into contact with water or mud. The following procedures are to be used to prevent the spread of exotic invasive organisms.
    - Remove all mud and debris using a scrub brush.
    - Spray with 5% Quat solution (instructions below) and allow to rest 10 minutes.
    - Rinse with water.
    - When feasible, allow to dry completely before entering another body of water.

15. Tidy the conference room before leaving for multiple days off.

Decontamination Procedure

- Set up a portable disinfection tank using a 5% cleaning solution of quaternary ammonium compound – common cleaning agents used in homes, swimming pools, and hospitals that are safe for gear and equipment when used at the recommended concentration. Two brands are readily available from GSA or local suppliers: *Quat128*® (by Waxie) or *Sparquat 256*® (by Spartan). Costs and effectiveness are comparable; use either.

  Recipe for 5% cleaning solution using either *Quat128*® ***or*** *Sparquat 256*®

Volume of tap water	**Volume of *Quat128*®**	**Volume of *Sparquat 256*®**
100 mL water	4.63 mL	3.00 mL
1 gallon water	6.35 liquid oz.	4.12 liquid oz.
1 gallon water	12.7 tbsp	8.2 tbsp
1 gallon water	0.79 cups	0.51 cups
100 gallons water	4.96 gallons	3.22 gallons
1000 gallons water	49.6 gallons	32.2 gallons

- Put the 5% cleaning solution in backpack spray pumps to clean portable equipment. The solution must be in contact with the surface being sanitized for at least 10 minutes and then rinsed with water.

- Test cleaning solution before each use according to the directions below. The cleaning solution can be used repeatedly for up to a week unless heavily muddied or diluted. If the concentration is too weak, dispose of the used solution properly and make a new solution.

Safety

- Use protective, unlined rubber gloves and splash goggles or face shield when handling the cleaning solution and take extra precautions when handling undiluted chemicals. Have eye wash and clean water available on-site to treat accidental exposure.
- Consult the product label and Material Safety Data Sheet for additional information.

Testing Solution

- To determine if the solution is below the 5% strength use "Quat Chek 1000" Test Papers (purchase these from the supplier of the cleaning compound). The used cleaning solution needs to be diluted to about 600 ppm of ammonium compounds before it can be tested with these papers.
  - Take **one** cup of 5% *Sparquat 256*® cleaning solution, pour into a bucket. Add **5** cups of water. Mix. OR
  - Take **one** cup of 5% *Quat128*® cleaning solution, pour into a bucket. Add **4** cups of water. Mix.
- Test the diluted solution with "Quat Chek" Test Paper. Match up the color of the paper with the ppm's on the color chart. For optimal disinfection, the diluted solution should have a concentration between 600 and 800 ppm. If it is too dilute, dispose of properly and make a new cleaning solution.

Disposal

- Do not dump cleaning solution into any stream or lake, or on areas where it can migrate into any stormdrain, waterbody, or sensitive habitat.

Storage

Sparquat 256® and *Quat128*® can be stored up to two years in an unopened container without losing its effectiveness. Both should be stored in a cool, dry place, out of direct sunlight. Temperatures can range from 32° to 110° F.

Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 12

After the Field Season

Version 1.00 (December 2010)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP details procedures performed at the end of the field season, including equipment maintenance and data management.

Procedures

1. Equipment maintenance. Inspect all equipment for damage and note any missing equipment. Clean and repair all equipment prior to returning it to the project leader.

2. Equipment inventory. Ensure that adequate supplies are on hand for the next field season and create a list of supplies that need to be ordered.

3. Complete identification of unknown plants. The field crew leader is responsible for ensuring complete resolution of all unknown plants. Plants are identified to species, family, or at least life form. Annotate the data sheets with the correct identifications and ensure that species are entered correctly in the database.

4. New species follow-up. The field crew leader is responsible for ensuring that plant species not on current park lists are submitted for NPSpecies updates. The field crew leader is also responsible for mounting, labeling, and preparing voucher specimens for any new species collected in a park unit. Update park plant species lists and the species list in the database.

5. Field herbaria. The field crew leader mounts and labels appropriate specimens for the field herbarium.

6. Data management. The field crew leader is responsible for ensuring that all data sheets are completed properly.

7. Data entry. The field crew leader is responsible for ensuring that all data are entered and verified according to procedures outlined in SOP #12. Also download all photographs to the X:\ drive and make sure they are correctly labeled.

8. Field season review procedures. Prior to the departure of the field crew, the project manager will query the field crew for issues with existing monitoring protocols and field logistics and will seek recommendations for improvements.

9. Logistics. The field crew leader updates access documents with new and updated access and logistical information, such as road closures, park personnel turnover, etc.

Riparian Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 13

Data Management

Version 1.01 (January 2012)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	11/2011	H. Thomas	Modified instructions for correcting field sheets	To clarify procedures	1.00
1.00	1/2012	H. Thomas	Updates due to protocol changes in 2011	To document database and data management procedure changes related to protocol changes made in 2011	1.01

This Standard Operating Procedure (SOP) describes data management procedures for all data derived from riparian monitoring in Northern Colorado Plateau Network (NCPN) park units. The procedures for data management given in this SOP follow guidelines and standards that are described in the NCPN Data Management Plan (Beer et al 2005).

1 Definitions and Acronyms

NPS	National Park Service
NCPN	Northern Colorado Plateau Network
I&M	Inventory & Monitoring Program of the National Park Service
IRMA	Integrated Resource Management Applications
SOP	Standard Operating Procedure
GIS	Geographic Information Systems
GPS	Global Positioning System
PDF	Portable Document Format
TIFF	Tagged Image File Format
JPG	Joint Photographic Experts Group File Format
DLL	Dynamic Link Library
FGDC	Federal Geographic Data Committee. The interagency committee that promotes the coordinated development, use, sharing, and dissemination of geographic data.
Tabular dataset	A dataset organized in a table or group of tables where each column and row has a specific interpretation; often produced by Microsoft (MS) Excel, MS Access, database, or statistical

	software, and managed as text, spreadsheet, or relational databases.
Spatial dataset	A dataset that is natively read by mapping software; often produced by mapping software, such as ESRI ArcMap and ArcInfo; also includes georeferenced imagery, geodatabases, as well as hardcopy aerial photographs, satellite imagery and maps.
Primary dataset	The dataset that is the most comprehensive and representative of the data associated with a project. This dataset can normally be used independently of other project datasets and is often distributed to external users. The primary dataset can be tabular or spatial. For most NCPN monitoring projects, the primary dataset will be either an MS Access database or a geodatabase.
Raw data	Data that have not been subjected to either quality control or documentation procedures; includes data recorded by hand on hard-copy forms, digital files from handheld devices, GPS receivers, telemetry data loggers, etc.
Certified data	Finalized project data, i.e., data that have undergone thorough quality assurance and screening as well as complete documentation.
Working database	A project-specific database for entering and processing data for the current season (or other logical period of time). This might be the only database for short-term projects where there is no need to distinguish working data for the current season from the full set of validated project data.
Master database	Project-specific database for storing the full project data set, used for viewing, summarizing, and analysis. Only used to store certified data.
Data products	Information that is derived from certified project data.
Project level metadata	A metadata record associated with the primary project dataset that contains cross references to all project data products and is uploaded to the IRMA Data Store.
Quality assurance (QA) procedures	Procedures used to maintain a defined level of quality throughout all stages of data development.
Quality control (QC) procedures	Procedures used to monitor or evaluate the quality of data products.

2 Database Design

The primary dataset associated with the NCPN riparian monitoring project is a tabular dataset stored in a Microsoft (MS) Access database, referred to subsequently as the riparian database. The version of the database described in this SOP (version 1.12) was used during the 2011 field season and accommodates only the vegetation methods used in riparian monitoring. The riparian database is written in Access 2003, and has a frontend/backend file structure:

- *Riparian.mdb*: This frontend file contains all queries, forms, reports, and associated Visual Basic (VB) application code.

- *Riparian_be.mdb*: This backend file contains the database tables.

The frontend/backend file structure allows multiple users to enter data in a network environment, and allows for easy backup and transfer of the data tables. Users typically launch the frontend file, and a utility will prompt them to establish a link to the backend file.

The riparian database was developed following the NPS Natural Resource Database Template (NRDT), which is based on a location record, one or more related event records, and observation data elements linked to each event. Figure 1 shows the relationships between the primary riparian database tables (all tables are not shown).

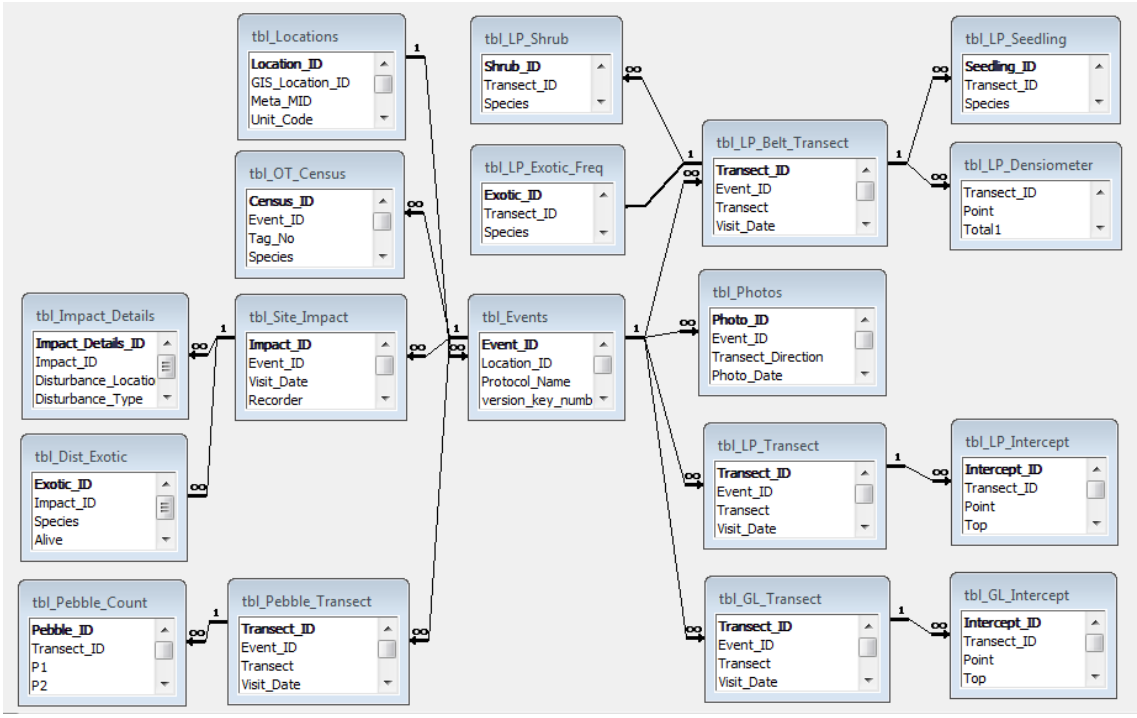


Figure 1 Data Model for Riparian Database

Each riparian monitoring site or reach has a record in *tbl_Locations*, which stores basic location information as well as other site characteristics that are recorded during reach establishment. Each reach can have many site visits, which are recorded in *tbl_Events*. During each site visit, several different types of observations are recorded. The main types of observations recorded are described briefly below:

- Understory species, surface features, and disturbance are recorded using point-intercept sampling for each of seven cross-section transects and stored in *tbl_LP_Transect* and *tbl_LP_Intercept*.
- Understory is recorded using greenline sampling for each of fourteen greenline transects and stored in *tbl_GL_Transect* and *tbl_GL_Intercept*.

- Density of trees and tree seedlings is measured in a 5-m belt transect for each of seven cross-section transects and recorded in tables. *tbl_LP_Belt_Transect*, *tbl_LP_Shrub*, and *tbl_LP_Seedling*.
- Estimates of canopy closure are recorded for each of seven cross-section transects in *tbl_LP_Densiometer*.
- Exotic species frequency is sampled in quadrats placed at regular intervals along each of seven cross-section transects and is recorded in table tbl_LP_Exotic_Freq (starting in 2011).
- A pebble count is conducted at each of seven cross-section transects and recorded in *tbl_Pebble_Transect* and *tbl_Pebble_Count*.
- Transect and transect establishment photos are taken for each of seven cross-section transects and recorded in *tbl_Photos*.
- A reach census is conducted and the resulting tree measurements are recorded in *tbl_OT_Census*.
- Qualitative descriptions of reach disturbances are recorded in *tbl_Site_Impact* and *tbl_Impact_Details*. Exotic plant species observed during a timed plant walk are recorded in tables tbl_Site_Impact and tbl_Dist_Exotic

Each site visit is linked to tables *tbl_master_version* and *tbl_SOP_version* (not shown in the figure), which together define the narrative and suite of SOP versions in effect at the time of the site visit. Documentation of all tables and fields in the riparian database is provided in Appendix A.

3 Populating the Riparian Database

Prior to each field season, the working database for the riparian monitoring protocol is prepared for the upcoming field season's data entry. The working database is initially an "empty" database, i.e., it contains no observation data, just populated lookup tables and certain "static" site information (e.g., location information). The working database is used for data entry, verification, and validation for a given field season. After the dataset in the working database is certified, it is merged into the master riparian database.

For the remainder of this document, the term "riparian database" refers to the working database. The riparian database will be populated via a combination of data import and data entry.

3.1 Data Import

Records for riparian monitoring sites can be established in the database either manually or by importing site location data collected via GPS units. It is expected that most site records will be created manually during data entry. In such cases, the site record will subsequently be updated with the corrected GPS data. Table 1 lists the fields either imported or derived from GPS data (see Appendix A for field descriptions). Elevation will not be imported directly from the GPS data, but rather will be derived from digital elevation models. Note that the fields "T1_RLocation, T1_LLocation, …, T7_RLocation, T7_LLocation" represent the rebar locations (right and left) for the seven transects, and

the fields "T1_RN, T1_RE, T1_LN, T1_LE, …, T7_RN, T7_RE, T7_LN, T7_LE" represent the UTM coordinates (right and left) for the seven transects.

Table 1. Fields Imported/Derived from GPS Data into tbl_Locations

Elevation	Max_PDOP	T1_RN
E_Coord N_Coord	Max_HDOP	T1_RE
Coord_Units	T1_RLocation	T1_LN
Coord_System	T1_LLocation…	T1_LE…
Datum	T7_RLocation	T7_RN
UTM_Zone	T7_LLocation	T7_RE
Rcvr_Type		T7_LN
		T7_LE

Site location data are expected to be relatively static over time. Thus, GPS data will normally only be imported when a reach is initially established. If the location information for a given site changes for some reason (e.g., a rebar gets lost and it's not possible to establish the new rebar at the same location), it will need to be re-imported from the GPS files. When imported, reach location data will be imported from corrected GPS files into *tbl_Locations*.

3.2 Data Entry

The majority of data in the riparian database will be populated via data entry. Data entry should occur as soon as possible after data collection is completed, before the next observation occurs, and by the person who collected the data or someone who is familiar with the project and data. The primary goal of data entry is *to record data in digital form with 100% accuracy.*

Detailed data entry instructions are provided in the Integrated Riparian Database User's Guide – Draft (NCPN-NPS 2010a). The user's guide is also available as a standalone document in the same folder location as the working copy of the riparian database:

X:\Active_Monitoring_Projects\Riparian\Data\Database\Current

The project manager makes certain that persons performing data entry are familiar with the user's guide and understand how to enter data and follow the protocols. Data entry technicians are responsible for becoming familiar with the field data forms, database software, database structure, and any standard codes for data entry. The data manager, in conjunction with the project manager, will ensure that the user's guide is kept current as new features are implemented in the database and/or as data entry procedures change.

QA/QC measures for data entry will be built into the database forms to automatically validate data where possible. Data entry forms will maximize the use of auto-filled fields, range limits, pick lists, and spelling checks. Error messages will alert the operator to correct mistakes. Any errors or omissions that become apparent during data entry should be resolved as soon as possible. In such cases, the data entry technician should contact the person who collected the data for clarification. The appropriate modifications

should then be made to the field sheets or documented in a log according to the instructions provided in Section 4.

4 Data Verification and Validation

To ensure that riparian monitoring data are of the highest possible quality, verification and validation of riparian monitoring data will be performed according to the procedures described in the NCPN Quality Assurance and Quality Control Guidance Document (NCPN-NPS 2008a). *Data verification* checks that data entered into a secondary (i.e., electronic) format match the source data, while *data validation* checks that the data make sense.

4.1 Data Verification

Data verification immediately follows data entry and involves checking the accuracy and completeness of the computerized records against the hard copy field records and identifying and correcting any errors. The following verification methods will be used to verify riparian data:

1. **Visual review at data entry**. The person doing data entry verifies each and every record after input and immediately corrects any errors.
2. **Visual review after data entry**. All records are compared to the original data source. Each data field on the corresponding electronic data entry form is compared with the original values from the hard copy, preferably by a second person who did not perform the data entry. Any errors that are discovered are corrected in the database as soon after data entry as possible.
3. **Summary queries and tallies**. Queries are run that detect broad errors such as duplicate or omitted records. Examples of such queries for riparian data are given below:
    a. Listing and count of the monitoring reaches established by park by year.
    b. Listing and count of the monitoring reaches visited by park by year.
    c. For each year/park/reach combination, a count of the number of photo points recorded.
4. **Visual review of spatial data**. Using GIS, riparian monitoring reach data are visually inspected for accuracy. This review will take place at the end of the field season.

Detailed verification procedures are provided in Integrated Riparian Database Quality Assurance (QA)/Quality Control (QC) Procedures – Draft (NCPN-NPS 2010b).

4.2 Data Validation

While many errors are prevented by including validation routines that function during data entry, additional review of the data by the project manager is needed to detect generic and specific errors that fall outside the scope of automated validation.

Invalid data commonly consist of slightly misspelled names, the wrong date, or out-of-range errors in parameters with well-defined limits (e.g., elevation). Other errors consist of unreasonable metrics or associations. For example, suppose a species was dominant on a reach during the current year's visit, but there was no observation recorded during the previous year's visit. Such data seem questionable and might indicate a species identification error. These types of logic errors (or potential errors) can be challenging to resolve, and in some cases it may not be possible to resolve them during the current year. Such questionable data will be flagged for future resolution.

Validation queries will be of two types: one type will present tabular data in ways that allows records to be reviewed for content and context; the other type will perform specific calculations or routines to detect logic or range errors. Corrections to errors detected during validation require notations in the *original paper field records* about how and why the data were changed. Modifications to the field records, whether made during data collection or subsequently, should be clear and concise while preserving the original data entries or notes. The original data entries should be crossed out with a single line and initialed - they should ***not*** be erased. Validation efforts should also include a check for the completeness of a data set since field sheets or other sources of data could easily be overlooked.

Detailed validation procedures are provided in Integrated Riparian Database Quality Assurance (QA)/Quality Control (QC) Procedures – Draft (NCPN-NPS 2010b).

4.3 Data Quality Review and Communication

The project manager and any personnel involved in data collection or entry will meet several times during the field season to discuss data quality problems and issues. Procedures may need revision if verification and validation processes reveal an unacceptable level of data quality. Quality checks may also reveal the need to modify field or computer forms if data transcription or entry errors are frequent.

Once validation has been completed, metadata will be created for the riparian dataset (refer to Section 7 for details on metadata). An important part of this metadata is data quality documentation, which consists of the verification and validation results. This data quality documentation, along with the project data certification form, will be used to notify end users and other project personnel of project data quality. For example, any questionable data that have been flagged will be identified. The project data certification form will be completed by the project manager to indicate that the data are complete, they have passed quality assurance checks, and they are documented and ready for archiving, posting, and distribution. The data certification form can be found in the NCPN Project Data Life Cycle Guidance Document (NCPN-NPS 2007a). The data quality documentation and data certification form will be stored in the riparian project archive folder.

5 Version Control

Version control is the process of managing copies of changing files over the course of a project. Change includes any alteration to the structure or content of the files, which should not be made without the ability to fully recover a dataset as it existed before changes were made. NCPN uses several techniques to help ensure proper version control: data archiving (refer to Section 6 for data archiving details), directory structure conventions, backup procedures (refer to the user's guide (NCPN-NPS 2010a)), and database versioning.

5.1 Directory Structure Conventions

NCPN has adopted directory structure conventions for I&M project folders (NCPN-NPS 2007b). Based on these conventions, each project has an active folder for storing all current or working project files and an archive folder for storing archived project files. In general, the active project folder stores only the most recent project files (e.g., data and reports from current year, current protocol version). All active project folders are stored on the NCPN shared drive (X:). The active riparian project folder is in the following location:

X:\Active_Monitoring_Projects\Riparian

The structure of the active project folder is as follows (all folders are not shown):

- **Data**:
  - **Database**:
    - **Backups**: Contains one or more backup copies of database files made during data entry (not retained permanently).
    - **Current**: Contains the working database (current year data) and user's guide.
    - **Master**: Contains a copy of the master database (complete data record) to be used for analysis and reporting (the master database is stored in the riparian archive folder).
  - **Field_Forms**: Contains scanned field forms for current year.
  - **GPS_Downloads**: Contains corrected data downloaded from GPS units.
  - **Spatial**: Contains GIS files related to site selection.
- **Field_Crews**: Contains files used by field crews, such as plant lists and trip reports.
- **NCPN_Working_Files**: Contains miscellaneous files used internally, such as database requirements documentation.
- **Project_Life_Cycle**: Contains files related to project data life cycle tracking for current year, e.g., data certification form, data quality documentation (refer to Section 7 for more details on the project data life cycle).
- **Protocol**:
  - **PDF**: Contains PDF of current version of protocol.
  - **Native_Format**: Contains source files for current version of protocol.
- **Protocol_Review**: Contains current documents associated with operational protocol reviews.
- **Reports**:

  - **PDF**: Contains PDF version of current annual project reports and any other reports produced during current year.
  - **Native_Format**: Contains source files used to create current year reports.
- **Sampling_Design**: Contains files related to sampling design.

For additional details on NCPN directory structure conventions, refer to the NCPN Directory Structure Guidance Document (NCPN-NPS 2007b).

5.2 Database Versioning

Database versioning refers to the process of tracking modifications to the database structure or application code, which can occur independently of modifications to the data. NCPN uses a version numbering scheme to track database modifications, in which modifications are grouped into software releases. Major releases are those involving significant changes to the database and are designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). For releases with only minor database changes (e.g., bug fixes), version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02, etc). Database version information is maintained within the database, and can be viewed by choosing the **About** tab on the riparian main menu page, and then choosing **View release history**. Whenever a database version change occurs, copies of the database files are placed in the appropriate archive location (refer to Section 6).

6 Data Archiving

Archiving is a critical step in ensuring the long-term preservation of data. Riparian data will be archived on an annual basis, after the current year data have been certified and annual report completed. Archiving of certain data may occur more frequently, e.g., if a protocol version change occurs. Archiving will be done for both digital and hard copy data.

6.1 Digital Data Archiving

All digital riparian data will be archived on the NCPN read-only shared drive (R:) in the riparian archive folder (R:\Archive\Monitoring_Archive\Riparian\). Table 2 lists the riparian monitoring digital data files that require archiving, along with their respective archive folder locations. The digital files listed in Table 2 will also be burned onto an archival-standard CD or DVD and sent to the Western Archeological and Conservation Center (WACC) according to the procedures outlined in the NCPN Archiving Guidance Document (NCPN-NPS 2010c).

Table 2. Riparian Digital Data Archiving Summary

Data Product(s)/ File(s)	Archive Location[1]	Comments
Database	Data\<*year*[2]>\Database\	• Contains certified database files for a given year, master database files, and

[1] Archive location is relative to R:\Archive\Monitoring_Archive\Riparian\ unless stated otherwise.
[2] <*year*> indicates year in yyyy format.

Data Product(s)/ File(s)	Archive Location[1]	Comments
		metadata
Field forms	Data\<*year*>\Field_Forms\	• Contains digital field forms (PDF) for a given year
GPS data	Data\<*year*>\GIS_Data\ GPS_Data\	• Contains both uncorrected and corrected GPS data files for a given year
Field crew files	Field_Crews\<*year*>\	• Contains archived field crew files (e.g., trip reports) for a given year
Project data life cycle files	Project_Life_Cycle\<*year*>\	• Contains archived files related to project data life cycle tracking for a given year
Protocol	Protocol\<*version*[3]>\	• Contains archived protocol files (PDF and source files) for a given version
Protocol review	Protocol_Review\<*year*>\	• Contains archived protocol review documents for a given year
Reports	Reports\<*year*>\	• Contains archived report files (PDF and source files) for a given year
Sampling design files	Sampling_Design\<*year*>\	• Contains archived files related to sampling design for a given year
Photos	R:\Archive\ NCPN_Photos_Archive\ NCPN Photos\ Riparian	• Archive location is an absolute path • Renamed photo files archived as part of NCPN photo database processing - refer to NCPN Photo Management Guidance Document (NCPN-NPS 2008b) for details
Original photos	R:\Archive\ NCPN_Photos_Archive\ Raw_Photo_Data_Archive\ Monitoring\Riparian\<*year*>	• Archive location is an absolute path • Contains original, unedited (e.g., not rotated) photo files • Archived as part of photo database processing

6.2 Hard Copy Data Archiving

All hard copy riparian data will be archived at WACC according to the procedures outlined in the NCPN Archiving Guidance Document (NCPN-NPS 2010c). Table 3 lists the riparian monitoring hard copy data files that require archiving, along with a summary of archiving procedures. Digital copies of applicable items in Table 3 are also provided to parks for their working files.

Table 3. Riparian Hard Copy Data Archiving Summary

Data Product(s)/File(s)	Comments
Field forms	• Original field forms stored in NCPN archives at WACC. • Digital copies retained in NCPN office and provided to parks as working copies.
Reports	• Archival copies stored in NCPN archives at WACC. • Hard copies retained in NCPN office and provided to parks

[3] <*version*> indicates protocol version key number, e.g., Version_Key_1

Data Product(s)/File(s)	Comments
	included in riparian monitoring project.
Protocol	• Archival copies stored in NCPN archives at WACC. • Hard copies retained in NCPN office. • Digital copies provided to parks included in riparian monitoring project.
Protocol review	• Archival copies stored in NCPN archives at WACC. • Hard copies retained in NCPN office.
Photos	• Slides or selected prints stored in NCPN archives at WACC. • Digital copies retained in NCPN office and provided to parks included in riparian monitoring project.
Data/metadata Printouts	• Archival copies of project-level metadata stored in NCPN archives at WACC. • Hard copies retained in NCPN office. • Digital copies provided to parks included in riparian monitoring project. • Above applies to any other data/metadata printouts deemed critical to long-term riparian monitoring
Project data life cycle files	• Archival copies stored in NCPN archives at WACC. • Hard copies retained in NCPN office. • Digital copies provided to parks included in riparian monitoring project.

7 Metadata

Metadata, which is defined as structured information about the content, quality, condition, and other characteristics of data, is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. Metadata can take many different forms, including formal FGDC-compliant metadata, IRMA Data Store records, and protocol version information.

To comply with NPS metadata requirements, metadata for riparian datasets will be created following NCPN metadata procedures (NCPN-NPS 2007c):

- An IRMA Data Store metadata record will be created for the riparian database (since it is considered the *primary dataset* for the riparian monitoring project). The Data Store metadata record, also referred to as the project level metadata, will be updated annually.
- All other riparian datasets and data products (see **Dataset/Data Product** column in Table 4) will be documented as cross-reference citations in the project level metadata record.

Another type of metadata specific to NCPN is the Project Data Life Cycle (PDLC) checklist, which helps to ensure that all data management activities (e.g., data verification/validation, metadata, archiving) are completed each year for monitoring projects. In accordance with this requirement, a PDLC checklist will be completed each year for riparian monitoring data. For further details related to the PDLC checklist, refer to the NCPN Project Data Life Cycle Guidance Document (NCPN-NPS 2007a).

Table 4 summarizes the metadata tasks required for riparian monitoring datasets and data products, and Table 5 describes the tasks and provides references where more detailed procedures are described.

Table 4 Summary of Metadata Tasks for Riparian Monitoring Data

Dataset/ Data Product	IRMA Data Store	X-Ref Citation	PDLC Check-list	MVT	Photo DB	DB Doc
Database	X		X			X
GIS Data		X	X			
Report(s)	X	X	X			
Protocol	X	X	X	X		
Photos		X	X		X	
Field Forms		X	X			

Table 5 Metadata Task Descriptions

Metadata Task	Metadata Task Description	Reference(s)
IRMA Data Store	An IRMA Data Store record is created for the project metadata and then updated annually. Data Store records are also created for each report. A Data Store record is also created for the protocol and updated as needed.	Metadata Guidance Document (NCPN-NPS 2007c), IRMA Data Store Documentation and Help Manual (NRSS-NPS 2011)
X-Ref Citation	A cross reference citation is added to the project level metadata record.	Metadata Guidance Document (NCPN-NPS 2007c)
PDLC Checklist	The PDLC checklist is completed, which includes adding product records to the NCPN Project Tracking Database.	Project Data Life Cycle Guidance Document (NCPN-NPS 2007a), Project Tracking Guidance Document (NCPN-NPS 2008c, in development)
MVT	The Master Version Table is updated as needed.	Protocol Versioning Guidance Document (NCPN-NPS 2009)
Photo DB	Photo records are added to the NCPN Photo Database.	Photo Management Guidance Document (NCPN-NPS 2008b)
DB Doc	Database table and field documentation is updated as needed.	Appendix A

A metadata questionnaire has been developed to assist in gathering the information needed for metadata creation (see the NCPN Metadata Guidance Document (NCPN-NPS 2007c)).

The complete protocol for this project (Protocol Narrative and all SOPs) is an integral component of the project metadata. All narrative and SOP version changes are noted in a Master Version Table (MVT), which is maintained in SOP #15. Any time the narrative or an SOP version change occurs, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The Version Key number is essential for project information to be properly interpreted and analyzed. *The protocol narrative, SOPs, and data should not be*

distributed independently of this table. Refer to the NCPN Protocol Versioning Guidance Document (NCPN-NPS 2009) for detailed protocol versioning procedures.

8 References

- Beer, M., E. Nance, A. Wight, M. Powell, and R. DenBleyker. 2005. Northern Colorado Plateau Network, data management plan. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT. 86 pp plus appendices.
- NCPN-NPS 2007a. Project Data Life Cycle Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2007b. Directory Structure Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2007c. Metadata Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2008a. Quality Assurance and Quality Control Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2008b. Photo Management Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2008c. Project Tracking Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2009. Protocol Versioning Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2010a. Integrated Riparian Database User's Guide - Draft. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2010b. Integrated Riparian Database Quality Assurance (QA)/Quality Control (QC) Procedures - Draft. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.
- NCPN-NPS 2010c. Archiving Guidance Document, Version 2.00. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.

Appendix A Documentation of Database Tables

The table and field definitions in this appendix correspond to version 1.12 of the riparian database (the version used during the 2011 field season). The database consists of three types of tables: data tables, lookup tables, and metadata tables. Tables appear in alphabetical order within each of these three categories.

Data Tables

Table Name: tbl_Dist_Exotic
Description: Table of exotic plant species observed on reach during site assessment.

Field Name	Field Description	Field Type	Field Width
Exotic_ID	Unique record identifier - primary key	dbText	50
Impact_ID	Foreign key to tbl_Site_Impact	dbText	50
Species	Exotic species code	dbText	15
Alive	Is species alive?	dbBoolean	1
Notes	Notes on species	dbMemo	0

Table Name: tbl_Events
Description: Table of sampling events.

Field Name	Field Description	Field Type	Field Width
Event_ID	Event identifier (Event_ID)	dbText	50
Location_ID	Link to tbl_Locations (Loc_ID)	dbText	50
Protocol_Name	The name or code of the protocol governing the event (Protcl_Nam)	dbText	100
version_key_number	Master protocol version key	dbLong	4
Start_Date	Starting date for the event or site visit (Start_Date)	dbDate	8
Comments	Reach revisit comments	dbMemo	0
Observer	Reach revisit observer	dbText	50
Census_Observer	Reach census observer	dbText	50
Census_Recorder	Reach census recorder	dbText	50
Census_Date	Date of census observation	dbDate	8

Table Name: tbl_GL_Intercept
Description: Table of greenline point intercept measurements.

Field Name	Field Description	Field Type	Field Width
Intercept_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_GL_Transect	dbText	50
Point	Intercept point - increments of 0.25m up to 10m	dbDecimal	16
Top	Top canopy species code	dbText	15
Alive	Is top canopy species alive?	dbBoolean	1
Surface	[not used]	dbText	15
Surface_Alive	[not used]	dbBoolean	1
LCS1	Lower canopy species 1 - Database flattened to accommodate field data entry and work around Access limitations.	dbText	15
LCA1	Lower canopy alive 1	dbBoolean	1
LCS2	Lower canopy species 2	dbText	15
LCA2	Lower canopy alive 2	dbBoolean	1
LCS3	Lower canopy species 3	dbText	15
LCA3	Lower canopy alive 3	dbBoolean	1
LCS4	Lower canopy species 4	dbText	15

Field Name	Field Description	Field Type	Field Width
LCA4	Lower canopy alive 4	dbBoolean	1
LCS5	Lower canopy species 5	dbText	15
LCA5	Lower canopy alive 5	dbBoolean	1
LCS6	Lower canopy species 6	dbText	15
LCA6	Lower canopy alive 6	dbBoolean	1
LCS7	Lower canopy species 7	dbText	15
LCA7	Lower canopy alive7	dbBoolean	1
LCS8	Lower canopy species 8	dbText	15
LCA8	Lower canopy alive 8	dbBoolean	1
LCS9	Lower canopy species 9	dbText	15
LCA9	Lower canopy alive 9	dbBoolean	1
LCS10	Lower canopy species 10	dbText	15
LCA10	Lower canopy alive 10	dbBoolean	1
D1	[not used]	dbText	15
D2	[not used]	dbText	15
D3	[not used]	dbText	15
D4	[not used]	dbText	15
D5	[not used]	dbText	15

Table Name: tbl_GL_Transect
Description: Table of transect information for greenline point intercept measurements.

Field Name	Field Description	Field Type	Field Width
Transect_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect	Transect number: 1 to 7.5 (right transects numbered as .5)	dbDecimal	16
Visit_Date	Date of visit	dbDate	8
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50

Table Name: tbl_Impact_Details
Description: Table of site impact assessment details

Field Name	Field Description	Field Type	Field Width
Impact_Details_ID	Unique record identifier - primary key	dbText	50
Impact_ID	Foreign key to tbl_Site_Impact	dbText	50
Disturbance_Location	Observation-location type: in-stream or terrestrial.	dbText	15
Disturbance_Type	Disturbance type (tlu_Disturbance).	dbText	50
Disturbance_Description	Description of disturbance including potential effects on fire or erosion processes.	dbMemo	0

Table Name: tbl_Location_History
Description: Site and reach definition history table

Field Name	Field Description	Field Type	Field Width
Location_History_ID	Location identifier (Loc_ID)	dbText	50
Location_ID	foreign key to tbl_Location	dbText	50
Unit_Code	Park Code.	dbText	4
Plot_ID	Reach identifier	dbInteger	2
Modify_Date	Date of update	dbDate	8
Stream_Name	Name of stream	dbText	100
Recorder	Person recording data	dbText	50
E_Coord	UTM East of Centroid (X_Coord)	dbDouble	8

Field Name	Field Description	Field Type	Field Width
N_Coord	UTM North of Centroid (Y_Coord)	dbDouble	8
T1_RN	Transect 1 Right Northing UTM	dbDouble	8
T1_RE	Transect 1 Right Easting UTM	dbDouble	8
T1_RLocation	Transect 1 Right location in meters	dbDecimal	16
T1_LN	Transect 1 Left Northing UTM	dbDouble	8
T1_LE	Transect 1 Left Easting UTM	dbDouble	8
T1_LLocation	Transect 1 Left location in meters	dbDecimal	16
T1_Length	Transect 1 Length in meters - 1 decimal	dbDecimal	16
T1_Bearing	Transect 1 Bearing in degrees R to L	dbInteger	2
T2_RN	Transect 2 Right Northing UTM	dbDouble	8
T2_RE	Transect 2 Right Easting UTM	dbDouble	8
T2_RLocation	Transect 2 Right location in meters	dbDecimal	16
T2_LN	Transect 2 Left Northing UTM	dbDouble	8
T2_LE	Transect 2 Left Easting UTM	dbDouble	8
T2_LLocation	Transect 2 Left location in meters	dbDecimal	16
T2_Length	Transect 2 Length in meters - 1 decimal	dbDecimal	16
T2_Bearing	Transect 2 Bearing in degrees R to L	dbInteger	2
T3_RN	Transect 3 Right Northing UTM	dbDouble	8
T3_RE	Transect 3 Right Easting UTM	dbDouble	8
T3_RLocation	Transect 3 Right location in meters	dbDecimal	16
T3_LN	Transect 3 Left Northing UTM	dbDouble	8
T3_LE	Transect 3 Left Easting UTM	dbDouble	8
T3_LLocation	Transect 3 Left location in meters	dbDecimal	16
T3_Length	Transect 3 Length in meters - 1 decimal	dbDecimal	16
T3_Bearing	Transect 3 Bearing in degrees R to L	dbInteger	2
T4_RN	Transect 4 Right Northing UTM	dbDouble	8
T4_RE	Transect 4 Right Easting UTM	dbDouble	8
T4_RLocation	Transect 4 Right location in meters	dbDecimal	16
T4_LN	Transect 4 Left Northing UTM	dbDouble	8
T4_LE	Transect 4 Left Easting UTM	dbDouble	8
T4_LLocation	Transect 4 Left location in meters	dbDecimal	16
T4_Length	Transect 4 Length in meters - 1 decimal	dbDecimal	16
T4_Bearing	Transect 4 Bearing in degrees R to L	dbInteger	2
T5_RN	Transect 5 Right Northing UTM	dbDouble	8
T5_RE	Transect 5 Right Easting UTM	dbDouble	8
T5_RLocation	Transect 5 Right location in meters	dbDecimal	16
T5_LN	Transect 5 Left Northing UTM	dbDouble	8
T5_LE	Transect 5 Left Easting UTM	dbDouble	8
T5_LLocation	Transect 5 Left location in meters	dbDecimal	16
T5_Length	Transect 5 Length in meters - 1 decimal	dbDecimal	16
T5_Bearing	Transect 5 Bearing in degrees R to L	dbInteger	2
T6_RN	Transect 6 Right Northing UTM	dbDouble	8
T6_RE	Transect 6 Right Easting UTM	dbDouble	8
T6_RLocation	Transect 6 Right location in meters	dbDecimal	16
T6_LN	Transect 6 Left Northing UTM	dbDouble	8
T6_LE	Transect 6 Left Easting UTM	dbDouble	8
T6_LLocation	Transect 6 Left location in meters	dbDecimal	16
T6_Length	Transect 6 Length in meters - 1 decimal	dbDecimal	16
T6_Bearing	Transect 6 Bearing in degrees R to L	dbInteger	2
T7_RN	Transect 7 Right Northing UTM	dbDouble	8
T7_RE	Transect 7 Right Easting UTM	dbDouble	8

Field Name	Field Description	Field Type	Field Width
T7_RLocation	Transect 7 Right location in meters	dbDecimal	16
T7_LN	Transect 7 Left Northing UTM	dbDouble	8
T7_LE	Transect 7 Left Easting UTM	dbDouble	8
T7_LLocation	Transect 7 Left location in meters	dbDecimal	16
T7_Length	Transect 7 Length in meters - 1 decimal	dbDecimal	16
T7_Bearing	Transect 7 Bearing in degrees R to L	dbInteger	2
Plot_Directions	Directions to plot	dbMemo	0

Table Name: tbl_Locations
Description: Site and reach definition table

Field Name	Field Description	Field Type	Field Width
Location_ID	Location identifier (Loc_ID)	dbText	50
GIS_Location_ID	Link to GIS feature, equivalent to NPS_Location_ID (GIS_Loc_ID)	dbText	50
Meta_MID	Link to NR-GIS Metadata Database (Meta_MID)	dbText	50
Unit_Code	Park Code.	dbText	4
Plot_ID	Reach identifier	dbInteger	2
Stream_Name	Name of stream	dbText	100
Av_Reach_Width	Average width of reach in meters	dbInteger	2
Reach_Length	Length of reach in meters.	dbInteger	2
SiteDate	Date reach established	dbDate	8
Observer	Person observing data	dbText	50
Recorder	Person recording data	dbText	50
Soil_Survey_Area	[not used]	dbMemo	0
Soil_Map_Unit	[not used]	dbText	10
GPS_File_Name	GPS file name for centroid coordinates	dbText	50
Rcvr_Type	GPS unit type	dbText	50
Elevation	Elevation of site origin in meters	dbInteger	2
E_Coord	UTM East of Centroid (X_Coord)	dbDouble	8
N_Coord	UTM North of Centroid (Y_Coord)	dbDouble	8
Coord_Units	Coordinate distance units (Coord_Unit)	dbText	50
Coord_System	Coordinate system (Coord_Syst)	dbText	50
UTM_Zone	UTM Zone (UTM_Zone)	dbInteger	2
Datum	Datum of mapping ellipsoid (Datum)	dbText	5
Max_PDOP	Horizontal accuracy	dbDouble	8
Max_HDOP	Positional accuracy	dbDouble	8
Updated_Date	Date of entry or last change (Upd_Date)	dbText	50
ARZW1	Active riparian zone width 1 in meters	dbInteger	2
ARZW2	Active riparian zone width 2 in meters	dbInteger	2
ARZW3	Active riparian zone width 3 in meters	dbInteger	2
ARZW4	Active riparian zone width 4 in meters	dbInteger	2
ARZW5	Active riparian zone width 5 in meters	dbInteger	2
Confined_Colluvial	Percentage of the reach that is confined colluvial.	dbDecimal	16
Confined_Bedrock	Percentage of the reach that is confined bedrock.	dbDecimal	16
Confined_Alluvial	Percentage of the reach that is confined alluvial.	dbDecimal	16
Unconfined_Alluvial	Percentage of the reach that is unconfined alluvial.	dbDecimal	16
Perennial_Pct	Percent perennial stream type	dbDecimal	16
Intermittent_Pct	Percent intermittent stream type	dbDecimal	16
Ephemeral_Pct	Percent ephemeral stream type	dbDecimal	16
Site_Selection	Site accepted or rejected	dbBoolean	1
Site_Selection_Comments	Additional site selection comments	dbMemo	0

Field Name	Field Description	Field Type	Field Width
Rejection_Criteria	Reason for rejection	dbText	50
T1_RN	Rebar location reach 1 Right Northing UTM	dbDouble	8
T1_RE	Rebar location reach 1 Right Easting UTM	dbDouble	8
T1_RLocation	Rebar location reach 1 Right location in meters	dbDouble	8
T1_LN	Rebar location reach 1 Left Northing UTM	dbDouble	8
T1_LE	Rebar location reach 1 Left Easting UTM	dbDouble	8
T1_LLocation	Rebar location reach 1 Left location in meters	dbDouble	8
T1_Length	Rebar location reach 1 Length in meters - 1 decimal	dbDecimal	16
T1_Bearing	Rebar location reach 1 Bearing in degrees R to L	dbInteger	2
T2_RN	Rebar location reach 2 Right Northing UTM	dbDouble	8
T2_RE	Rebar location reach 2 Right Easting UTM	dbDouble	8
T2_RLocation	Rebar location reach 2 Right location in meters	dbDouble	8
T2_LN	Rebar location reach 2 Left Northing UTM	dbDouble	8
T2_LE	Rebar location reach 2 Left Easting UTM	dbDouble	8
T2_LLocation	Rebar location reach 2 Left location in meters	dbDouble	8
T2_Length	Rebar location reach 2 Length in meters - 1 decimal	dbDecimal	16
T2_Bearing	Rebar location reach 2 Bearing in degrees R to L	dbInteger	2
T3_RN	Rebar location reach 3 Right Northing UTM	dbDouble	8
T3_RE	Rebar location reach 3 Right Easting UTM	dbDouble	8
T3_RLocation	Rebar location reach 3 Right location in meters	dbDouble	8
T3_LN	Rebar location reach 3 Left Northing UTM	dbDouble	8
T3_LE	Rebar location reach 3 Left Easting UTM	dbDouble	8
T3_LLocation	Rebar location reach 3 Left location in meters	dbDouble	8
T3_Length	Rebar location reach 3 Length in meters - 1 decimal	dbDecimal	16
T3_Bearing	Rebar location reach 3 Bearing in degrees R to L	dbInteger	2
T4_RN	Rebar location reach 4 Right Northing UTM	dbDouble	8
T4_RE	Rebar location reach 4 Right Easting UTM	dbDouble	8
T4_RLocation	Rebar location reach 4 Right location in meters	dbDouble	8
T4_LN	Rebar location reach 4 Left Northing UTM	dbDouble	8
T4_LE	Rebar location reach 4 Left Easting UTM	dbDouble	8
T4_LLocation	Rebar location reach 4 Left location in meters	dbDouble	8
T4_Length	Rebar location reach 4 Length in meters - 1 decimal	dbDecimal	16
T4_Bearing	Rebar location reach 4 Bearing in degrees R to L	dbInteger	2
T5_RN	Rebar location reach 5 Right Northing UTM	dbDouble	8
T5_RE	Rebar location reach 5 Right Easting UTM	dbDouble	8
T5_RLocation	Rebar location reach 5 Right location in meters	dbDouble	8
T5_LN	Rebar location reach 5 Left Northing UTM	dbDouble	8
T5_LE	Rebar location reach 5 Left Easting UTM	dbDouble	8
T5_LLocation	Rebar location reach 5 Left location in meters	dbDouble	8
T5_Length	Rebar location reach 5 Length in meters - 1 decimal	dbDecimal	16
T5_Bearing	Rebar location reach 5 Bearing in degrees R to L	dbInteger	2
T6_RN	Rebar location reach 6 Right Northing UTM	dbDouble	8
T6_RE	Rebar location reach 6 Right Easting UTM	dbDouble	8
T6_RLocation	Rebar location reach 6 Right location in meters	dbDouble	8
T6_LN	Rebar location reach 6 Left Northing UTM	dbDouble	8
T6_LE	Rebar location reach 6 Left Easting UTM	dbDouble	8

Field Name	Field Description	Field Type	Field Width
T6_LLocation	Rebar location reach 6 Left location in meters	dbDouble	8
T6_Length	Rebar location reach 6 Length in meters - 1 decimal	dbDecimal	16
T6_Bearing	Rebar location reach 6 Bearing in degrees R to L	dbInteger	2
T7_RN	Rebar location reach 7 Right Northing UTM	dbDouble	8
T7_RE	Rebar location reach 7 Right Easting UTM	dbDouble	8
T7_RLocation	Rebar location reach 7 Right location in meters	dbDouble	8
T7_LN	Rebar location reach 7 Left Northing UTM	dbDouble	8
T7_LE	Rebar location reach 7 Left Easting UTM	dbDouble	8
T7_LLocation	Rebar location reach 7 Left location in meters	dbDouble	8
T7_Length	Rebar location reach 7 Length in meters - 1 decimal	dbDecimal	16
T7_Bearing	Rebar location reach 7 Bearing in degrees R to L	dbInteger	2
Plot_Directions	Directions to plot	dbMemo	0
Greenline_PI_Applies	Does greenline point intercept method apply to this reach	dbText	3

Table Name: tbl_LP_Belt_Transect
Description: Table of transect information for 5 meter belt transect measurements.

Field Name	Field Description	Field Type	Field Width
Transect_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect	Transect number: 1 to 7	dbByte	1
Visit_Date	Date of visit	dbDate	8
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50

Table Name: tbl_LP_Densiometer
Description: Table of Spherical Densiometer point intersection counts in 5 meter belt transect.

Field Name	Field Description	Field Type	Field Width
SD_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Point	Point on transect	dbText	4
Total1	Total count, measurement 1	dbInteger	2
Total2	Total count, measurement 2	dbInteger	2
Total3	Total count, measurement 3	dbInteger	2
Total4	Total count, measurement 4	dbInteger	2

Table Name: tbl_LP_Exotic
Description: Table of exotic perennial species in 5 meter belt transect [Discontinued use in 2011]

Field Name	Field Description	Field Type	Field Width
Exotic_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Exotic species code	dbText	15
Alive	Is species alive?	dbBoolean	1
Total	Total count	dbInteger	2

Table Name: tbl_LP_Exotic_Freq
Description: Table of exotic frequency by quadrat [Added in 2011]

Field Name	Field Description	Field Type	Field Width
Exotic_ID	Unique record identifier - primary key	dbText	50

Field Name	Field Description	Field Type	Field Width
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Exotic species observed	dbText	15
M0	Zero point quadrat species detected checkbox	dbBoolean	1
M5	5 meter quadrat species detected checkbox	dbBoolean	1
M10	10 meter quadrat species detected checkbox	dbBoolean	1
M15	15 meter quadrat species detected checkbox	dbBoolean	1
M20	20 meter quadrat species detected checkbox	dbBoolean	1
M25	25 meter quadrat species detected checkbox	dbBoolean	1
M30	30 meter quadrat species detected checkbox	dbBoolean	1
M35	35 meter quadrat species detected checkbox	dbBoolean	1
M40	40 meter quadrat species detected checkbox	dbBoolean	1
M45	45 meter quadrat species detected checkbox	dbBoolean	1
M50	50 meter quadrat species detected checkbox	dbBoolean	1
M55	55 meter quadrat species detected checkbox	dbBoolean	1
M60	60 meter quadrat species detected checkbox	dbBoolean	1
M65	65 meter quadrat species detected checkbox	dbBoolean	1
M70	70 meter quadrat species detected checkbox	dbBoolean	1
M75	75 meter quadrat species detected checkbox	dbBoolean	1
M80	80 meter quadrat species detected checkbox	dbBoolean	1
M85	85 meter quadrat species detected checkbox	dbBoolean	1
M90	90 meter quadrat species detected checkbox	dbBoolean	1
M95	95 meter quadrat species detected checkbox	dbBoolean	1

Table Name: tbl_LP_Intercept
Description: Table of cross-section point intercept measurements.

Field Name	Field Description	Field Type	Field Width
Intercept_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Transect	dbText	50
Point	Intercept point - increments of 0.5m up to length of transect	dbDecimal	16
Top	Top canopy species code	dbText	15
Alive	Is top canopy species alive?	dbBoolean	1
Surface	Soil surface code	dbText	15
Surface_Alive	If soil surface is a species, is it alive?	dbBoolean	1
LCS1	Lower canopy species 1 - Database flattened to accommodate field data entry and work around Access limitations.	dbText	15
LCA1	Lower canopy alive 1	dbBoolean	1
LCS2	Lower canopy species 2	dbText	15
LCA2	Lower canopy alive 2	dbBoolean	1
LCS3	Lower canopy species 3	dbText	15
LCA3	Lower canopy alive 3	dbBoolean	1
LCS4	Lower canopy species 4	dbText	15
LCA4	Lower canopy alive 4	dbBoolean	1
LCS5	Lower canopy species 5	dbText	15
LCA5	Lower canopy alive 5	dbBoolean	1
LCS6	Lower canopy species 6	dbText	15
LCA6	Lower canopy alive 6	dbBoolean	1
LCS7	Lower canopy species 7	dbText	15
LCA7	Lower canopy alive7	dbBoolean	1
LCS8	Lower canopy species 8	dbText	15

Field Name	Field Description	Field Type	Field Width
LCA8	Lower canopy alive 8	dbBoolean	1
LCS9	Lower canopy species 9	dbText	15
LCA9	Lower canopy alive 9	dbBoolean	1
LCS10	Lower canopy species 10	dbText	15
LCA10	Lower canopy alive 10	dbBoolean	1
D1	Disturbance code 1	dbText	15
D2	Disturbance code 2	dbText	15
D3	Disturbance code 3	dbText	15
D4	Disturbance code 4	dbText	15
D5	Disturbance code 5	dbText	15
Geomorphic_Surface	Master stratification for summaries and analysis	dbText	50

Table Name: tbl_LP_Seedling
Description: Table of tree seedlings in 5 meter belt transect.

Field Name	Field Description	Field Type	Field Width
Seedling_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Seedling species code	dbText	15
Total	Total count	dbInteger	2

Table Name: tbl_LP_Transect
Description: Table of transect information for cross-section point intercept measurements.

Field Name	Field Description	Field Type	Field Width
Transect_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect	Transect number: 1 to 7	dbByte	1
Visit_Date	Date of visit.	dbDate	8
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50

Table Name: tbl_LP_Tree
Description: Table of mature trees in 5 meter belt transect.

Field Name	Field Description	Field Type	Field Width
Shrub_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_LP_Belt_Transect	dbText	50
Species	Tree species code	dbText	15
Alive	Is tree species alive?	dbBoolean	1
DBH	Diameter at breast height in centimeters	dbSingle	4

Table Name: tbl_Monument
Description: Table of monument tree information.

Field Name	Field Description	Field Type	Field Width
Monument_ID	Unique record identifier - primary key	dbText	50
Location_ID	Foreign key to tbl_Locations	dbText	50
Monument_Code	Corner code (tlu_Monument_Code)	dbText	5
Tag_No	Tag number of monument tree	dbInteger	2
Species	Species code of monument tree	dbText	15
DBH	Diameter at breast height in centimeters	dbSingle	4
Bearing	Bearing from monument tree to rebar in degrees	dbInteger	2
Rebar_Distance	Distance from center point of monument tree to rebar in	dbSingle	4

Field Name	Field Description	Field Type	Field Width
	meters		

Table Name: tbl_OT_Census
Description: Table of reach tree census information.

Field Name	Field Description	Field Type	Field Width
Census_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Tag_No	Tag number	dbInteger	2
Species	Tree species code	dbText	15
DBH	Diameter at breast height in centimeters	dbSingle	4
Crown_Health	Crown health class (tlu_Crown_Health_Class)	dbInteger	2
Notes	Notes about any significant damage to a living tree	dbText	255

Table Name: tbl_Pebble_Count
Description: Table of pebble counts.

Field Name	Field Description	Field Type	Field Width
Pebble_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_Pebble_Transect	dbText	50
P1	b-axis measurement to nearest 0.1 cm, pebble 1	dbSingle	4
P2	b-axis measurement to nearest 0.1 cm, pebble 2	dbSingle	4
P3	b-axis measurement to nearest 0.1 cm, pebble 3	dbSingle	4
P4	b-axis measurement to nearest 0.1 cm, pebble 4	dbSingle	4
P5	b-axis measurement to nearest 0.1 cm, pebble 5	dbSingle	4
P6	b-axis measurement to nearest 0.1 cm, pebble 6	dbSingle	4
P7	b-axis measurement to nearest 0.1 cm, pebble 7	dbSingle	4
P8	b-axis measurement to nearest 0.1 cm, pebble 8	dbSingle	4
P9	b-axis measurement to nearest 0.1 cm, pebble 9	dbSingle	4
P10	b-axis measurement to nearest 0.1 cm, pebble 10	dbSingle	4
P11	b-axis measurement to nearest 0.1 cm, pebble 11	dbSingle	4
P12	b-axis measurement to nearest 0.1 cm, pebble 12	dbSingle	4
P13	b-axis measurement to nearest 0.1 cm, pebble 13	dbSingle	4
P14	b-axis measurement to nearest 0.1 cm, pebble 14	dbSingle	4
P15	b-axis measurement to nearest 0.1 cm, pebble 15	dbSingle	4
P16	b-axis measurement to nearest 0.1 cm, pebble 16	dbSingle	4
P17	b-axis measurement to nearest 0.1 cm, pebble 17	dbSingle	4
P18	b-axis measurement to nearest 0.1 cm, pebble 18	dbSingle	4
P19	b-axis measurement to nearest 0.1 cm, pebble 19	dbSingle	4
P20	b-axis measurement to nearest 0.1 cm, pebble 20	dbSingle	4
P21	b-axis measurement to nearest 0.1 cm, pebble 21	dbSingle	4
P22	b-axis measurement to nearest 0.1 cm, pebble 22	dbSingle	4
P23	b-axis measurement to nearest 0.1 cm, pebble 23	dbSingle	4
P24	b-axis measurement to nearest 0.1 cm, pebble 24	dbSingle	4
P25	b-axis measurement to nearest 0.1 cm, pebble 25	dbSingle	4
P26	b-axis measurement to nearest 0.1 cm, pebble 26	dbSingle	4
P27	b-axis measurement to nearest 0.1 cm, pebble 27	dbSingle	4
P28	b-axis measurement to nearest 0.1 cm, pebble 28	dbSingle	4
P29	b-axis measurement to nearest 0.1 cm, pebble 29	dbSingle	4
P30	b-axis measurement to nearest 0.1 cm, pebble 30	dbSingle	4
P31	b-axis measurement to nearest 0.1 cm, pebble 31	dbSingle	4
P32	b-axis measurement to nearest 0.1 cm, pebble 32	dbSingle	4
P33	b-axis measurement to nearest 0.1 cm, pebble 33	dbSingle	4

Field Name	Field Description	Field Type	Field Width
P34	b-axis measurement to nearest 0.1 cm, pebble 34	dbSingle	4
P35	b-axis measurement to nearest 0.1 cm, pebble 35	dbSingle	4
P36	b-axis measurement to nearest 0.1 cm, pebble 36	dbSingle	4
P37	b-axis measurement to nearest 0.1 cm, pebble 37	dbSingle	4
P38	b-axis measurement to nearest 0.1 cm, pebble 38	dbSingle	4
P39	b-axis measurement to nearest 0.1 cm, pebble 39	dbSingle	4
P40	b-axis measurement to nearest 0.1 cm, pebble 40	dbSingle	4
P41	b-axis measurement to nearest 0.1 cm, pebble 41	dbSingle	4
P42	b-axis measurement to nearest 0.1 cm, pebble 42	dbSingle	4
P43	b-axis measurement to nearest 0.1 cm, pebble 43	dbSingle	4
P44	b-axis measurement to nearest 0.1 cm, pebble 44	dbSingle	4
P45	b-axis measurement to nearest 0.1 cm, pebble 45	dbSingle	4
P46	b-axis measurement to nearest 0.1 cm, pebble 46	dbSingle	4
P47	b-axis measurement to nearest 0.1 cm, pebble 47	dbSingle	4
P48	b-axis measurement to nearest 0.1 cm, pebble 48	dbSingle	4
P49	b-axis measurement to nearest 0.1 cm, pebble 49	dbSingle	4
P50	b-axis measurement to nearest 0.1 cm, pebble 50	dbSingle	4
P51	b-axis measurement to nearest 0.1 cm, pebble 51	dbSingle	4
P52	b-axis measurement to nearest 0.1 cm, pebble 52	dbSingle	4
P53	b-axis measurement to nearest 0.1 cm, pebble 53	dbSingle	4
P54	b-axis measurement to nearest 0.1 cm, pebble 54	dbSingle	4
P55	b-axis measurement to nearest 0.1 cm, pebble 55	dbSingle	4
P56	b-axis measurement to nearest 0.1 cm, pebble 56	dbSingle	4
P57	b-axis measurement to nearest 0.1 cm, pebble 57	dbSingle	4
P58	b-axis measurement to nearest 0.1 cm, pebble 58	dbSingle	4
P59	b-axis measurement to nearest 0.1 cm, pebble 59	dbSingle	4
P60	b-axis measurement to nearest 0.1 cm, pebble 60	dbSingle	4

Table Name: tbl_Pebble_Transect
Description: Table of transect information for pebble counts.

Field Name	Field Description	Field Type	Field Width
Transect_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect	Transect number: 1 to 7	dbByte	1
Visit_Date	Date of visit	dbDate	8
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50
Wet_Width	Wetted width in meters	dbSingle	4
Sampling_Interval	Sampling interval in meters	dbSingle	4

Table Name: tbl_Photos
Description: Table of reach visit photos

Field Name	Field Description	Field Type	Field Width
Photo_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect_Direction	Transect number and direction (tlu_Photo_Location)	dbText	25
Photo_Date	Date photograph taken.	dbDate	8
Photo_Type	[not used]	dbText	50
Roll	Roll for film photos	dbText	10
Frame	Frame for film photos; sequential number for digital photos	dbInteger	2

Field Name	Field Description	Field Type	Field Width
Digital_File	Digital file name	dbText	50
Photographer	Photographer	dbText	50
Location	Location of photo point along transect in meters	dbDecimal	16
Other_Type	[not used]	dbText	12
Other_Identifier	[not used]	dbText	50
Comments	Photo comments or description	dbMemo	0
NCPN_Image_ID	Digital file name in NCPN Photo Database	dbText	50

Table Name: tbl_Site_Impact
Description: Table of site impact assessment information

Field Name	Field Description	Field Type	Field Width
Impact_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Visit_Date	Date of visit	dbDate	8
Recorder	Person recording site impact information	dbText	50
Site_Sketch	[not used]	dbLongBinary	0
Other_Notes	Other disturbance notes	dbMemo	0

Table Name: tbl_SL_Transect
Description: Table of transect information for shrub line-intercept gaps [Discontinued in 2010]

Field Name	Field Description	Field Type	Field Width
Transect_ID	Unique record identifier - primary key	dbText	50
Event_ID	Foreign key to tbl_Events	dbText	50
Transect	Transect number: 1 to 7	dbByte	1
Visit_Date	Date of visit	dbDate	8
Observer	Name of person observing	dbText	50
Recorder	Name of person recording	dbText	50

Table Name: tbl_SLI_Gaps
Description: Table of shrub line-intercept gaps [Discontinued in 2010]

Field Name	Field Description	Field Type	Field Width
SLI_ID	Unique record identifier - primary key	dbText	50
Transect_ID	Foreign key to tbl_SL_Transect	dbText	50
Species	Species code	dbText	50
Shrub_Start	Start of shrub cover to nearest centimeter	dbLong	4
Shrub_End	End of shrub cover to nearest centimeter	dbInteger	2

Table Name: tbl_Unknown_Species
Description: Table of unknown plant species

Field Name	Field Description	Field Type	Field Width
Unknown_ID	Unique record identifier - primary key	dbText	50
Species_ID	[not used]	dbText	50
Unknown_Code	Temporary code for unknown species	dbText	15
Collected_by	Person collecting specimen	dbText	50
Plant_Type	Plant type: herb, shrub, tree, grass, sedge, other	dbText	50
Plant_Description	General description	dbMemo	0
Salient_Feature	Most salient feature	dbText	255
Leaf_Type	Leaf type: compound/simple, arrangement	dbText	50
Margin	Leaf margin	dbText	50
Other_Characteristics	Other leaf characteristics: pubescence, sap,	dbText	255

Field Name	Field Description	Field Type	Field Width
	stipules		
Stem_Characteristics	Stem characteristics: shape, pubescence, bud	dbText	255
Flower_Characteristics	Flower characteristics: color location floral formula	dbText	255
General_Characteristics	General and microhabitat characteristics	dbText	255
Collected	Was plant collected	dbBoolean	1
Best_Guess	Best guess species name	dbText	50
Confirmed_Code	Confirmed species code	dbText	50
Have_Photos	Are there photos?	dbBoolean	1
Forb_Grass_Type	Annual or Perennial	dbText	10
Perennial_Grasses	Perennial grass type: Bunchgrass or Rhizomatous	dbText	15
Identified_by	Person making final identification	dbText	50
Identified_Date	Date of identification	dbDate	8
Position	Position on Transect (m)	dbInteger	2

Lookup Tables

Table Name: tlu_Contacts
Description: Contact data for project-related personnel.

Field Name	Field Description	Field Type	Field Width
Contact_ID	Contact identifier (Contact_ID)	dbText	50
Last_Name	Last name (Cnt_Last)	dbText	50
First_Name	First name (Cnt_First)	dbText	50
Middle_Init	Middle initial (Cnt_MI)	dbText	4
Organization	Organization or employer (cntorg)	dbText	50
Position_Title	Title or position description (cntpos)	dbText	50
Address_Type	Address (mailing, physical, both) type (addrtype)	dbText	50
Address	Street address (cntaddr)	dbText	50
Address2	Address line 2, suite, apartment number (Cnt_Addr2)	dbText	50
City	City or town (city)	dbText	50
State_Code	State or province (state)	dbText	8
Zip_Code	Zip code (postal)	dbText	50
Country	Country (country)	dbText	50
Email_Address	E-mail address (cntemail)	dbText	50
Work_Phone	Phone number (cntvoice)	dbText	50
Work_Extension	Phone extension (Work_Ext)	dbText	50
Contact_Notes	Contact notes (Cnt_Notes)	dbMemo	0

Table Name: tlu_Cover_Class
Description: Lookup table of veg cover classes for soil stability.

Field Name	Field Description	Field Type	Field Width
Cover_Class	Veg Cover Class	dbText	2
Cover_Description	Cover class description	dbText	25

Table Name: tlu_Crown_Health_Class
Description: Lookup table of crown health classes

Field Name	Field Description	Field Type	Field Width
Crown_Health_Class	Crown health class	dbInteger	2
Class_Description	Health class description	dbText	50

Table Name: tlu_Densiometer_Point

Description: Lookup table of valid densiometer points

Field Name	Field Description	Field Type	Field Width
Point	Densiometer measurement point	dbText	4
Sort_Seq	Sort sequence	dbInteger	2

Table Name: tlu_Disturbance
Description: Lookup table of site impact disturbances

Field Name	Field Description	Field Type	Field Width
Dist_Code	Disturbance code	dbText	50
Dist_Type	Disturbance type - 1=In-stream, 2=Terrestrial	dbByte	1
Disturbance	Disturbance description	dbText	255

Table Name: tlu_LP_Disturbance
Description: Lookup table of point intercept disturbances

Field Name	Field Description	Field Type	Field Width
Dist_Code	Disturbance code	dbText	5
Disturbance	Disturbance description	dbText	50

Table Name: tlu_LP_Soil_Surface
Description: Lookup table for point intercept soil surface codes

Field Name	Field Description	Field Type	Field Width
Surface_Code	Soil surface code	dbText	5
Surface_Description	Soil surface description	dbText	50
LC_Code	Lower canopy code - 1=applies also to lower canopy	dbByte	1

Table Name: tlu_Monument_Code
Description: Lookup table of monument tree corner codes

Field Name	Field Description	Field Type	Field Width
Monument_Code	5 character monument corner code.	dbText	5

Table Name: tlu_NCPN_Plants
Description: Contains all NCPN master plant species

Field Name	Field Description	Field Type	Field Width
Master_Family	Master_Family	dbText	50
Master_PLANT_Code	Master Species PLANTS Code	dbText	20
Master_Species	Master Species (ITIS)	dbText	50
UT_Family	Utah Family	dbText	50
CO_Family	Colorado Family	dbText	50
WY_Family	Wyoming Family	dbText	50
Utah_PLANT_Code	Utah Species PLANTS Code	dbText	20
Utah_Species	Utah Species (Welsh et al 2003)	dbText	50
Co_PLANT_Code	Colorado Species PLANTS Code	dbText	20
Co_Species	Colorado Species (Weber & Wittmann 2001)	dbText	50
Wy_PLANT_code	Wyoming species PLANTS code	dbText	20
Wy_Species	Wyoming Species (Dorn 2001)	dbText	50
Add_Synonyms	Additional Synonyms	dbMemo	0
Taxonomic_Notes	Taxonomic Notes	dbMemo	0
Master_Common_Name	Master Common Name	dbText	50
ARCH	Park presence descriptor for ARCH	dbText	15
BLCA	Park presence descriptor for BLCA	dbText	15
BRCA	Park presence descriptor for BRCA	dbText	15
CANY	Park presence descriptor for CANY	dbText	15

Field Name	Field Description	Field Type	Field Width
CARE	Park presence descriptor for CARE	dbText	15
CEBR	Park presence descriptor for CEBR	dbText	15
COLM	Park presence descriptor for COLM	dbText	15
CURE	Park presence descriptor for CURE	dbText	15
DINO (UT)	Park presence descriptor for DINO - Utah	dbText	15
DINO (CO)	Park presence descriptor for DINO - Colorado	dbText	15
FOBU	Park presence descriptor for FOBU	dbText	15
GOSP	Park presence descriptor for GOSP	dbText	15
HOVE (UT)	Park presence descriptor for HOVE - Utah	dbText	15
HOVE (CO)	Park presence descriptor for HOVE - Colorado	dbText	15
NABR	Park presence descriptor for NABR	dbText	15
PISP	Park presence descriptor for PISP	dbText	15
TICA	Park presence descriptor for TICA	dbText	15
ZION	Park presence descriptor for ZION	dbText	15
Lifeform	Lifeform derived from USDA Plants	dbText	255
Duration	Duration derived from USDA Plants	dbText	255
Nativity	Nativity derived from USDA Plants	dbText	255
Trinomial	True if species code represents a trinomial name	dbBoolean	1
Unique_Species	True if species code represents a genus and species designation	dbBoolean	1
New_Record	Is it a new record?	dbBoolean	1
LU_Code	Shorthand (a.k.a. 6-Letter) Lookup Code	dbText	25
Wetland_Code	Code identifying wetland designation (see http://plants.usda.gov/wetinfo.html#categories)	dbText	20
Wetland_Code_Info_Source	Information source used to determine wetland classification	dbText	50

Table Name: tlu_Parks
Description: Look-up table of parks in the Northern Colorado Plateau Network

Field Name	Field Description	Field Type	Field Width
ParkCode	Four-letter abbreviation for park code	dbText	5
ParkName	Full name of park where data were collected	dbText	50
ParkState	State code.	dbText	2

Table Name: tlu_Photo_Location
Description: Lookup table of transect/direction for photos

Field Name	Field Description	Field Type	Field Width
Sort_Sequence	Sort order	dbInteger	2
Location	Transect - Direction identifier	dbText	25

Table Name: tlu_Photo_Type
Description: Lookup table of other photo types

Field Name	Field Description	Field Type	Field Width
Other_Type	Non-transect photo type	dbText	12

Table Name: tlu_Profile_Depth
Description: Lookup table of soil profile depths

Field Name	Field Description	Field Type	Field Width
Depth	Soil profile depth	dbText	9

Table Name: tlu_Rejection_Criteria

Description: Lookup table of reach rejection criteria

Field Name	Field Description	Field Type	Field Width
Rejection_Criteria	Site rejection criteria	dbText	50
Sort_Sequence	Sort sequencing	dbInteger	2

Table Name: tlu_Sand_Modifier
Description: Lookup table of sand modifiers

Field Name	Field Description	Field Type	Field Width
Modifier	Sand modifier	dbText	25

Table Name: tlu_Stream_Name
Description: Lookup table of stream names

Field Name	Field Description	Field Type	Field Width
Stream_Name	Stream Name	dbText	100
Unit_Code	Park Code	dbText	4

Table Name: tlu_Wetland_Code
Description: Lookup table of wetland indicator categories

Field Name	Field Description	Field Type	Field Width
Monument_Code	Wetland indicator code	dbText	5
Wetland_Type	Wetland type	dbText	20

Table Name: xref_Event_Contacts
Description: Cross-reference table between events and contacts.

Field Name	Field Description	Field Type	Field Width
Event_ID	Link to tbl_Events (Event_ID)	dbText	50
Contact_ID	Link to tlu_Contacts (Contact_ID)	dbText	50
Contact_Role	The contact's role in the protocol (Cnt_Role)	dbText	50

Metadata Tables

Table Name: tbl_master_version
Description: Table of protocol version information

Field Name	Field Description	Field Type	Field Width
project_ID	Project ID number to ensure uniqueness across all projects	dbLong	4
version_key_number	Protocol version key number	dbLong	4
version_key_date	Date of protocol version key number	dbDate	8
narrative_version	Version of protocol narrative	dbDecimal	16
version_comments	Comments regarding version, if any	dbMemo	0

Table Name: tbl_SOP_version
Description: Table of SOP version information

Field Name	Field Description	Field Type	Field Width
version_key_number	Protocol version key	dbLong	4
SOP_number	SOP number	dbLong	4
SOP_version_number	SOP version number	dbDecimal	16
active_flag	Yes indicates SOP is active	dbBoolean	1

Table Name: tlu_projects
Description: Table of NCPN project information

Field Name	Field Description	Field Type	Field Width
project_ID	Project ID number to ensure uniqueness across all projects	dbLong	4
project_name	Project name	dbText	50
project_linkfile	Path and file name of project database	dbText	255
project_include_flag	True indicates project is to be included in query results	dbBoolean	1
project_comments	Comments regarding project, if any	dbMemo	0

Table Name: tsys_App_Releases
Description: Application table - Application release history

Field Name	Field Description	Field Type	Field Width
Release_ID	Unique identifier for the release	dbText	50
Release_date	Date of the release	dbDate	8
Database_title	Title of the database	dbText	100
Version_number	Version control number	dbText	20
File_name	Filename, used to identify older versions of the database	dbText	50
Release_by	Person who made the release	dbText	50
Release_notes	Release notes, which may include a summary of revisions	dbMemo	0
Author_phone	Phone number of application author	dbText	50
Author_email	Email address of application author	dbText	50
Author_org	Organization (NPS Unit code) for the author's place of work	dbText	10
Author_org_name	Name of organization for author's place of work	dbText	100

Riparian Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 14

Data Analysis and Reporting

Version 1.01 (January 2012)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	1/2012	D. Witwicki	Correction to basal area calculation; update summary for species richness	Incorrect; no longer measured in 1-m belt	1.01

This SOP provides an overview of analysis and reporting procedures. After raw data from the field season are quality checked and certified, they are then summarized to the reach level. Additional QAQC is performed comparing these data to previously collected data to catch misidentified species and values that represent unlikely amounts of change between years. Once data quality issues are resolved, analyses can be conducted. Two general types of analyses are performed: 1) annual reporting of the most recent monitoring observations (annual reports and briefs), and 2) comprehensive assessments of the long term data set (variance estimation of the overall sampling design, evaluation of status and trends, and correlations with other vital signs).

1.0 Data Summary

The sampling unit for all riparian analyses is the reach, and sub-samples recorded on transects must be scaled to this level (see Figure 1). Vegetation and geomorphology data may be integrated at the transect level, but ultimately need to be summarized to the reach level. Hydrology data need to be summarized from data taken throughout the water year. Summary queries should be created in Access to expedite this process.

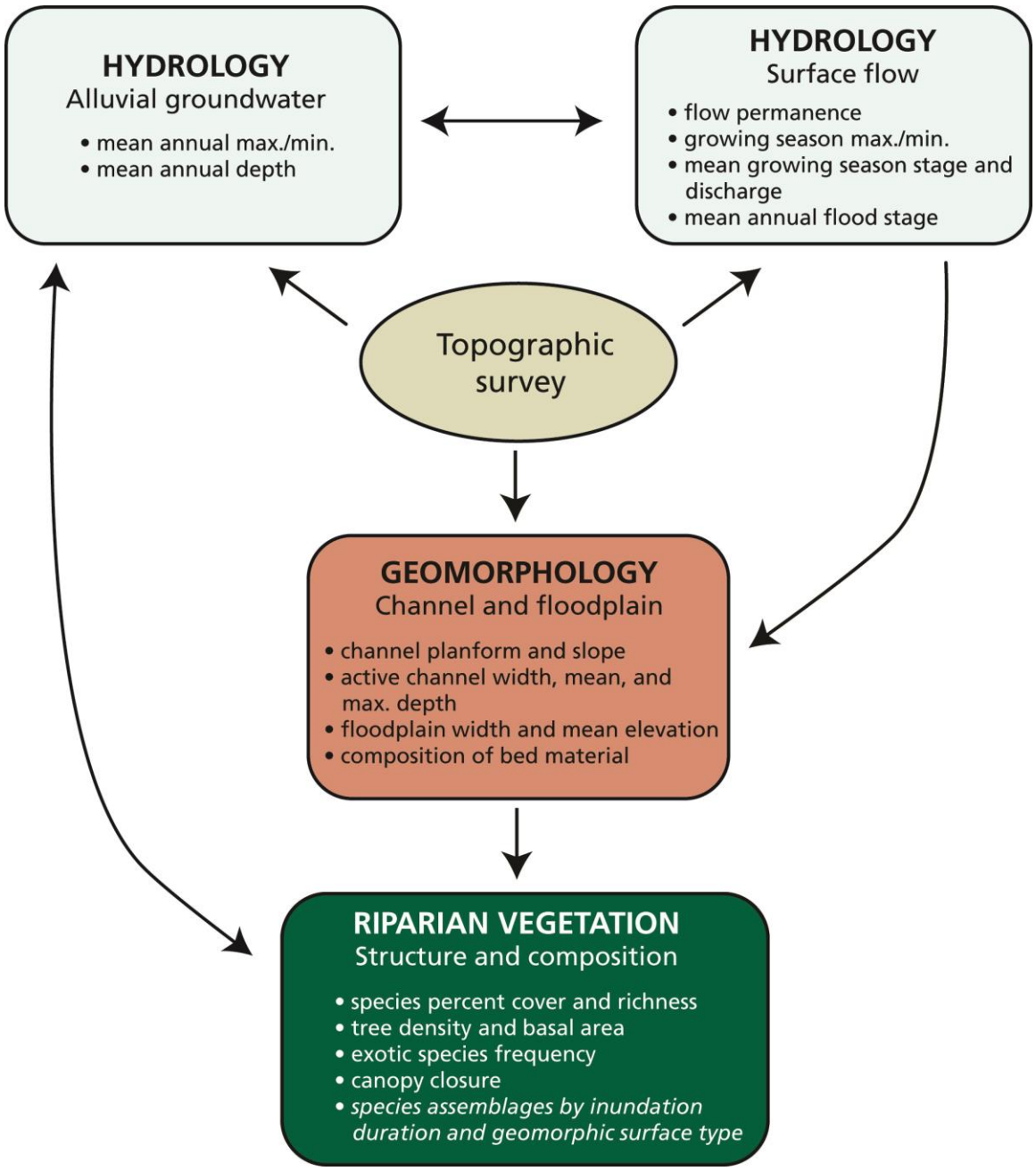


Figure 1. Conceptual model illustrating relationships among measurements for integrated riparian vital signs and their metrics. Geomorphic metrics of channel planform and slope and the vegetation metric for large trees are established at the reach scale. These are integrated with the remaining metrics, which are collected at the transect scale.

Vegetation Summaries

Richness

Species richness is the number of unique species encountered. For each reach, calculate richness of all species, native species, species by life form (e.g., tree, shrub, etc.), and species by wetland status group. Richness of dominant species can be compiled from point-intercept data. It is important that species richness is derived using the same methods and area sampled for all years and reaches in an analysis. Otherwise, rarefaction methods will need to be used if the number of sub-samples changes within or among monitoring plots (e.g., Krebs 1989, Ludwig and Reynolds 1988). In addition, a species list for the reach is assembled using all vegetation measures.

Percent Cover

Percent cover is calculated for each species, life form, wetland status group, ground cover attribute, and disturbance using point-intercept data from transects. It is derived by summing the number of points where each species, etc. is hit, and dividing by the total number of point-intercept readings across all transects, times 100 (eq. 1, Table 1). Percent cover of species along the greenline is calculated the same way using data from the 14 greenline transects on perennial stream reaches. Canopy closure is the average of all densiometer readings across a reach expressed as a percent (eq. 1, Table 1).

Exotic frequency

Exotic frequency is derived from the number of detections of each exotic species in the 1-m^2 quadrats, and reported as the percent of detections.

Density

Density is derived from trees in the 5-m belt. It is the number of trees counted divided by the total area of the belt transects, scaled to stems per ha (eq. 2, Table 1). This measure is calculated for each species by size class.

Basal Area

Basal area is the cross-sectional area of trees divided by the total area of the 5-m belt transects, scaled to m^2 per ha. Basal area and density are correlated and should always be considered together when reviewing data summaries of each (eq. 3, Table 1).

Census of legacy trees

The tree census summary should include the total number of trees and the distribution of DBH and crown health classes.

Geomorphology Summaries

After total station survey post processing, relevant geomorphic surfaces are delineated by elevation or abrupt surface breaks on each transect. The data can then be integrated with other measurements or summarized to the reach-level.

Channel morphology

The mean active channel width and depth in meters (eq. 4, Table 1) and the channel gradient in percent slope are calculated for the reach using data from the geomorphology survey transects. The distribution of particle sizes in the channel bed is derived from the pebble count.

Flood plain morphology

The mean flood plain width and elevation in meters is calculated for the reach using data from the geomorphology survey transects. The delineation of the flood plain will be estimated until enough hydrologic data are collected to determine this.

Hydrology Summaries

Surface Flow

Data from instream monitoring wells and gauges are used to calculate mean and range of annual and growing season stream stage in meters, annual and growing season stream discharge in m^3 per second, annual flood stage in meters, and flow permanence expressed as a percent of the growing season.

Alluvial Ground Water

Data from riparian piezometers are used to calculate mean annual and growing season depth to water and the range of intra-annual fluctuations.

Integrated Summaries

Vegetation data are integrated with the geomorphology survey transects to derive mesic to xeric plant cover by surface elevation and species richness and percent cover by geomorphic surface elevation. Vegetation data are integrated with the hydrology data to derive species assemblages by inundation duration and frequency.

Inundation duration of the floodplain (% of growing season) will be determined using geomorphology surveys and hydrologic data, and will be more meaningful as additional floods are recorded. Inundation frequency of the floodplain (return frequency in years) requires multiple years of hydrologic data in addition to a survey of the flood plain.

Table 1. Formula for deriving reach-level measures.

Percent Cover

$$PC = (h / n)*100 \quad (1)$$

where PC = percent cover
h = the number of points where each species, ground cover attribute, life form, or overstory is hit
n = the total number of points per reach

Tree Density

$$D = 10{,}000 * t / (\sum_{i=1}^{q} z_i) * w \quad (2)$$

where D = density of trees in stems/ha
t = the number of trees in the 5-m belt
z_i = length of riparian transect i
q = total number of riparian transects
w = width of belt transect in m

Basal area

$$BA = (\sum_{i=1}^{y} [(DBH_i /[2*100])^2 * \pi]) / [(\sum_{i=1}^{q} z_i) * w / 10000] \quad (3)$$

where BA = basal area in m^2/ha
DBH_i = diameter at breast height in cm for tree i in the 5-m belt
y = the total number of trees with DBH measures
π = 3.142
z_i = length of riparian transect i in m
q = total number of riparian transects
w = width of belt transect in m

Mean (channel width, etc.*)

$$M = (\sum_{i=1}^{v} c_i) / v \quad (4)$$

where M = mean channel width in m
c_i = channel width in m for transect i in a reach
v = the total number of transects in the reach

* channel width shown in this example, but this formula is also used for channel depth, flood plain width and elevation, annual and growing season stream stage, annual and growing season stream discharge, annual flood stage, and depth to ground water.

2.0 Data Quality Assessment

Before data analysis and reporting, reach-level data should be additionally evaluated for reasonable levels of change based on historical conditions at each reach. For instance, a measure may appear to be valid based on the database domain, but represent an unreasonable (and unlikely) change in reach conditions since the last field visit. Summarized attributes should be compared between years, and all suspect values (large increases or decreases) should be flagged and resolved before the data are analyzed. In addition, data should be evaluated for the omission of historically dominant species or the appearance of dominant species not detected in previous years. New occurrences of a species should be compared with the park-level species list and species-range limits.

Suspect measures or species should be evaluated by field crew members and by field verification if possible. Any corrections made to the database should be recorded in the QAQC log. Suspect data that are not resolved should also be flagged in the QAQC log so that it can excluded from analyses, if appropriate. Suspect data that cannot be resolved in the office should be brought to the attention of the field crew at the next monitoring visit so that they may eventually be resolved.

3.0 Annual Reporting

Annual Reports
The primary objectives of the annual report are to 1) document monitoring activities for the year, 2) summarize annual data and describe the current condition of resources, and 3) provide information to park managers in a timely manner that increases data utility and communication. A separate annual report is completed for each NCPN park unit with riparian monitoring. Existing NCPN annual reports should be consulted for formatting.

Annual Briefs
Each year, information from annual reports and other analyses is further summarized in 1-2 page briefs that provide resource managers with a concise summary of issues of concern. NCPN produces two types of briefs: vital signs briefs and park briefs. The riparian vital signs brief summarizes findings from riparian monitoring in all NCPN parks. Park briefs are produced for each NCPN park unit and contain a section on riparian monitoring. Existing vital signs briefs and park briefs should be consulted for formatting.

4.0 Comprehensive Assessments

Comprehensive analyses and reports are completed periodically on the long term data set. Comprehensive reports should be structured like typical scientific manuscripts (introduction, methods, results, discussion, and literature cited sections) and may include any of the analyses described in this section.

Sampling-Design Variance Assessment

The sampling design for riparian monitoring at each stream is documented in a separate report that outlines specific sampling objectives. Periodic checking of the assumptions of the sampling design affords timely opportunities to invoke enhancements to meet the original monitoring and sampling objectives. Sampling designs are evaluated by calculating variance and power for trend, and assessments are recommended every 5-7 years.

Variance estimates are derived from all years of monitoring data, not just observations from the current field season. Where necessary, alternative survey designs are evaluated to determine appropriate enhancements, such as an increase in sample size or more frequent visits to established reaches, to achieve the original sampling objective. Power-for-trend is evaluated with alternative numbers of panels, sample sizes, and re-visit schemes. A trend may be reported as a yearly rate or a rate over a set number of years. This conversion is outlined for increasing (eq. 5, Table 2) and decreasing (eq. 6, Table 2) rates of trend. Results are then used to determine which survey designs best meet the original sampling objectives.

Table 2. Formula for converting a yearly rate of trend to a rate of trend over a set number of years.

Conversion for rate of trend

$$I = e^{rt} \quad (5)$$

$$D = 1 - e^{rt} \quad (6)$$

where;

I = % increase over t years
D =% decrease over t years
r = the yearly rate of increase or decrease
t = the total time period of increase or decrease

Status and Trend Assessments

The underlying motivation for using survey designs to monitor wadeable streams is the ability to make inferences to a finite, target population. Alternatively, model-based designs and assessments rely on modeled relationships, and thus tend to have inherent assumptions, and in some cases, limitations in terms of the scope of inference. However, model-based assessments may be useful to help explain reasons for trends observed in survey-design efforts, and information from other vital signs monitoring (e.g., climate, air quality, land use, land condition) or other sources may prove critical to interpreting

observed riparian trends. Bayesian methods may detect trends earlier than frequentist methods and should be developed over time.

Status and trend analyses are performed after at least 5 years of monitoring data are collected. When significant trends are detected, reasons for these trends should be evaluated by literature reviews, comparison with similar data sets, and additional assessments using ancillary information. When unidirectional trends are not detected, correlations may help us understand system drivers.

Frequentist Methods

Frequentist trend assessments of complex survey designs are performed using a mixed-effects model (Larsen et al. 1995). Reach-scale measures are used in the model and evaluated on the basis of time. The output from this model is a measure of the intercept and slope, the significance of the slope and intercept being different from zero, and measures of the variance and covariance of the regression parameters. A significant slope indicates a significant trend at the alpha level used to assess significance or below.

Status is the condition of the attribute and is derived in two ways. If the trend slope is not significantly different from zero, mean and variance of status is simply the mean and variance of all measures of the attribute up to the current time period. If the slope is significant, then status is the solution of the regression model for the latest time period of the data used to generate the trend line (eq. 7 in Table 3). Variance measures of mean status are derived from the covariance matrix of the regression coefficients (eq. 8 in Table 3).

Table 3. Formula for deriving status and trend estimates.

Mean Status From a Trend Line

$$ST_t = b_0 + b_1 * t \qquad (7)$$

where;

ST_t = estimate of mean status at time = t
b_0 = the estimated intercept parameter
b_1 = the estimated slope parameter
t = the most recent time period of the data (in the same units used to generate b_0 and b_1)

Standard Error of Status

$$SeSTt = \sqrt{(\sigma^2_{b0} + 2t\,\sigma_{b0b1} + \sigma^2_{b1}t^2)} \qquad (8)$$

where;

$SeST_t$ = the standard error of the mean-status estimate at time = t

σ^2_{b0} = the variance of the intercept parameter
σ_{b0b1} = the covariance of the regression parameters
σ^2_{b1} = the variance of the slope parameter
t = the most recent time period of the data

Model-Based Methods
Model-selection procedures consider a range of potential factors influencing directional change in resource conditions. Even if a significant trend occurs as a function of time, the relationship between other explanatory variables and riparian measures should be evaluated to determine potential 'causal' factors of trends. These other explanatory variables can include biophysical features of the reaches as well as measures from other vital signs monitoring (e.g., climatic conditions).

Model selection methods (Burnham and Anderson 1998) evaluate the explanatory power of different models of trends in riparian measures. Multiple models are considered, each with different combinations of independent variables and interaction terms. All models should be based on hypothesized, ecologically meaningful relationships. Adjusted AIC (Akaike's Information Criterion) values generated with a mixed-effects model are used to determine the best predictive model as well as the importance of independent variables.

The primary model in this model-selection procedure is the response of interest vs. time (see frequentist methods above). Alternative models can be based on measures of climate, air quality, land use, and land condition, as well as other measures that may be considered important. When evaluating other variables, they are either included in an interaction with time or time is replaced with the variable.

The result of the model-selection procedure is the selection of the model (i.e., set of independent variables) which best predicts the trend of the response variable. This, in turn, aids in explaining reasons for the observed trend. For instance, if alternative models with one or more driver attributes (e.g., drought days) accounted for more variance than just using time, trends may be attributed to these attributes in a correlational relationship, but not necessarily a causal relationship. If alternatives to time account for less variance, other avenues of investigation should be considered to explain reasons for observed trends.

Bayesian Methods
Bayesian methods for trend assessment identify the probability of different slope-parameter values (Gelman et al. 2000, Wade 2000) given the observed data. This differs from frequentist methods which calculate the probability of observing data given a specific value for a parameter, such as the null hypothesis. Assessing the probability of

different slope values is potentially important for various reasons. First, sampling designs are largely based on a few key features. The minimum detectable trend at a reasonable power level for many of the other responses will likely be much higher. Estimating the probability of slope values may be the best way to provide insight into trends for these attributes. Second, even for the key features around which sampling designs were based, Bayesian methods may reveal the potential of declining trends before rejecting the null hypothesis that the regression slope equals 0 with conventional statistics.

Bayesian methods use a likelihood distribution generated from the sample data that provides the probability of observing the data for every possible parameter value. Combining this with a prior distribution produces a posterior distribution which is used to make inference about parameters. The prior distribution reflects previous knowledge about the distribution of parameters. In the absence of such knowledge, a non-informative distribution can be used, which essentially is a uniform distribution across the range of the likelihood distribution. In subsequent analyses, the posterior distribution of previous assessments is used as the prior distribution. The posterior distribution allows assessments of the probability of user-selected parameter values. The probability of various increasing and decreasing slopes should be evaluated based on the posterior distribution and the consequences of not alerting management of a potential trend. The result of this assessment is the derivation of the probability of different levels of decline/increase. Even though conventional statistics may not reveal a significant trend, relatively high probabilities (e.g., $\geq$0.70) of trends with a Bayesian method may warrant special attention.

Correlations

There will be instances where a monitored attribute fails to exhibit a trend (i.e., a direction change), but instead may have periods of decline followed by recovery. In other words, natural variation may be more evident than a precipitous decline or increase, and it may mirror the variation in a key driver attribute. Discerning this variation and reasons for it can involve many complex procedures. As a first step, however, correlational methods can provide useful insight and are relatively simple.

For attributes that fluctuate between declines and increases, correlations with climate, air quality, land cover/use, land condition, and other potential drivers should be considered. Strong correlations between a response and driver may be sufficient to understand reasons for the observed variation over time (e.g., strong correlation between shrub cover and annual precipitation).

Another type of correlation assessment is path analysis (Lindquist 2000). This method accounts for the inter-correlated structure among factors by decomposing correlations to direct and indirect effects. For instance, changes in grass cover in a shrub-steppe system may be influenced by shrub cover alone or by climate alone or by the influence of climate on shrub cover. A path analysis would decompose the effects of climate and of shrubs on grass cover, while considering the combined influence of climate and shrubs. The result

of a path analysis is the indication of the strength of direct and indirect factors on a response, thus providing insight into reasons for the observed changes in a response. Path analysis is based on correlation values and the simultaneous solution of structural equations. Simple examples of the construction and use of path analysis are provided in Lindquist (2000) and Van Bruggen and Arneson (1986); details of path analysis are provided in Pugesek et al. (2003).

5.0 References

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Riparian Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 15

Revising the Protocol Narrative and SOPs

Version 1.03 (January 2012)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	4-1-2009	H. Thomas	Updated master version table (MVT)	To reflect protocol changes based on field work.	1.01
1.01	4-1-2010	H. Thomas	Updated MVT	To reflect protocol changes based on field work.	1.02
1.02	1-12-2012	H. Thomas	Updated MVT	To reflect protocol changes based on field work.	1.03

This SOP explains how to make and track changes to the protocol narrative and related SOPs. Following these guidelines ensures that data collection and processing procedures are documented and retained for use and interpretation of historical data sets. Project staff should refer to this SOP when any changes to an approved protocol document are necessary. The procedures in this SOP are based on the NCPN Protocol Versioning Guidance Document (NCPN-NPS 2009).

Procedures

1. Modifications must be reviewed for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by NCPN Inventory and Monitoring staff. An outside review is required for substantive changes in methods. Regional and national staff of the National Park Service and experts outside of the Park Service with familiarity in vegetation monitoring, hydrology, geomorphology, and data analysis will be used to review major changes.

2. Record all changes to a protocol document (protocol narrative or SOP) in the document's revision history log, even minor edits like fixing typos or formatting changes. It is not necessary to record the specific edits made, rather just the fact that typos were fixed or formatting changes were made. For minor edits, record the same document version number in the revision history log. For actual protocol changes (e.g., changes in methods, equipment), assign a new version number in the revision history log. Depending on the significance of the changes, it may be okay to combine multiple changes in the same entry in the revision history log. Version numbers

increase incrementally by hundredths (e.g. version 1.01, version 1.02, etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). Record the previous version number, date of revision, author of the revision, and the reason for the changes along with the new version number (if applicable).

3. Narrative and SOP updates may occur independently. That is, a change in one SOP will not necessarily invoke changes in other SOPs; a narrative update may not require SOP modifications. The NCPN tracks the narrative and SOP version numbers in a Master Version Table (MVT), which is maintained in this document (SOP #15). Any time a narrative or an SOP version change occurs, a new record is added to the MVT.

4. New versions of the protocol narrative and SOPs must be posted on the NCPN web page. Older versions of the Protocol Narrative and SOPs must be archived in the NCPN Riparian Protocol Library: (R:\Monitoring_Archive\Riparian\Protocol).

Master Version Table

A reorganization of the protocol occurred after the 2010 field season. As a result, some SOPs were renumbered. To simplify version tracking, two master version tables are maintained, one for the initial SOPs (2008 to 2010), and one for the current SOPs (2011).

A dash ("-") in a cell indicates that the narrative or SOP is not applicable during the corresponding time period. An "x" indicates that an SOP has been discontinued.

Riparian Monitoring of Wadeable Streams, Master Version Table, 2008-2010

Effective Date	Narrative	1-Preparations for the Field Season	2-Hiring & Training Field Technicians	3-Using GPS Units	4-Reach Establishment	5-Transect Setup	6-Point Intercept Transect	7-Line Intercept Transect	8-Belt Transect	9-Measuring Trees	10-Unknown Plants	11-Repeat Photos	12-Site Impact Assessment	13-Pebble Count	14-After the Field Season	15-Revising the Protocol
1/1/2008	-	1.00	-	-	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	1.00	-	-	1.00
1/1/2009	-	1.00	-	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.00	1.00	1.00	1.00	-	1.01
1/1/2010	-	1.00	1.00	1.00	1.00	1.00	1.00	x	1.01	1.02	1.00	1.00	1.01	1.00	1.00	1.02

Riparian Monitoring of Wadeable Streams, Master Version Table, 2011

Effective Date	Narrative	1-Preparations for the Field Season	2-Hiring & Training Field Technicians	3-Using GPS Units	4-Reach Establishment	5-Repeat Photos	6-Measuring Vegetation	7-Pebble Count	8-Site Impact Assessment	9-Stream Channel Surveying	10-Hydrologic Monitoring	11-After each Field Visit	12-After the Field Season	13-Data Management	14-Data Analysis & Reporting	15-Revising the Protocol
1/1/2011	1.01	1.01	1.00	1.03	1.01	1.01	1.04	1.00	1.01	1.01	1.01	1.01	1.00	1.01	1.01	1.03

References

NCPN-NPS 2009. Protocol Versioning Guidance Document, Version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.