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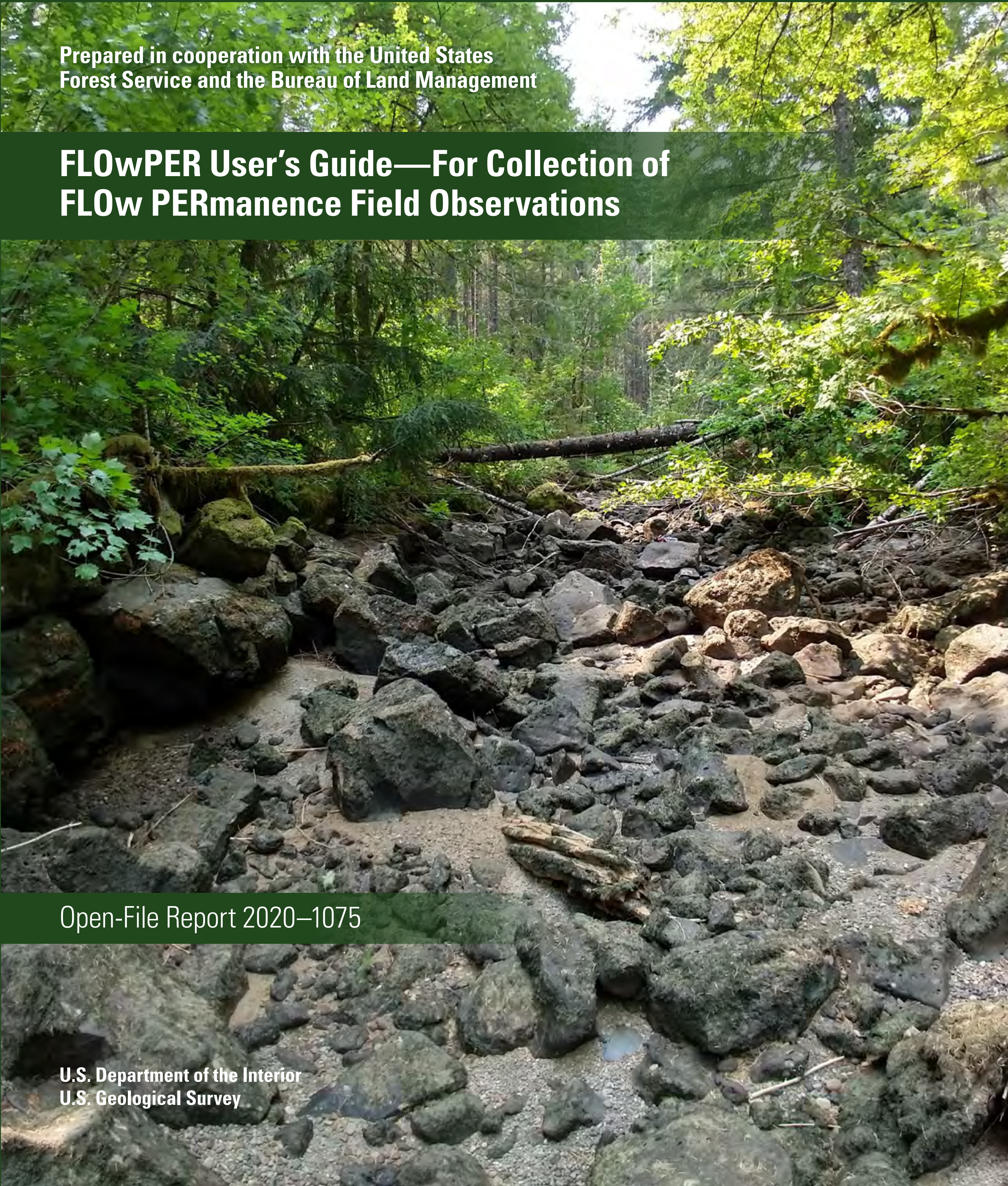
FLOwPER User’s Guide—For Collection of FLOw PERmanence Field Observations



Open-File Report 2020–1075

U.S. Department of the Interior
U.S. Geological Survey

Covers:
Front: Photograph of stream showing a FLOwPER streamflow status of *dry*, Lost Creek, tributary to Little White Salmon, Washington.
Back: Photograph of stream showing a FLOwPER streamflow status of *continuous flow*, tributary to McRae Creek, HJ Andrews Experimental Forest, Oregon.
Photographs by Emily D. Heaston, U.S. Geological Survey.

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DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

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Suggested citation:
Jaeger, K.L., Burnett, J., Heaston, E.D., Wondzell, S.M., Chelgren, N., Dunham, J.B., Johnson, S., and Brown, M., 2020, FLOwPER user guide—For collection of FLOw PERmanence field observations: U.S. Geological Survey Open-File Report 2020–1075, 40 p., https://doi.org/10.3133/ofr20201075.

ISSN 2331-1258 (online)

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)

Datum

Observations collected in the FLOwPER application and uploaded to the FLOwPER database, as well as vertical and horizontal coordinate information, are referenced to the World Geodetic System 1984 (WGS 84).

Abbreviations

App	mobile application
AGOL	Esri ArcGIS Online
ArcGIS	Arc geographic information system
BLM	Bureau of Land Management
Esri	Environmental Systems Research Institute
FLOwPER	FLOw PERmanence
GIS	geographical information systems
GNIS	Geographic Names Information System
GPS	Global Positioning System
NHD	National Hydrography Dataset
USFS	United States Forest Service
USGS	United States Geological Survey

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FLOwPER User's Guide—For Collection of FLOW PERmanence Field Observations

By Kristin L. Jaeger[1], Jonathan Burnett[2], Emily D. Heaston[3], Steve M. Wondzell[2], Nathan Chelgren[3], Jason B. Dunham[3], Sherri Johnson[2], and Mike Brown[4]

Abstract

The accurate mapping of streams and their streamflow conditions in terms of presence or absence of surface water is important to both understanding physical, chemical, and biological processes in streams and to managing land, water, and ecological resources. This document describes a field form, FLOwPER (FLOw PERmanence), available within a mobile application (app), for standardized data collection of the presence or absence of surface flow in streams. The FLOwPER Database is a publicly available geodataset that can be used for research and management applications. This document provides instructions on how to (1) access and download the FLOwPER field form within the mobile app service, (2) use and complete a FLOwPER field form, and (3) view and download data from the FLOwPER Database.

Introduction

"Flow permanence" refers to patterns of wetting and drying of stream channels across landscapes over time often expressed as the probability of drying, as well as the timing, duration, frequency, and extent of drying (Jaeger and others, 2014, 2019). The U.S. Geological Survey (USGS) identifies three stream types based on patterns of flow permanence (perennial, intermittent, and ephemeral [**table 1**]) and maps them in the National Hydrography Dataset [NHD; U.S. Geological Survey, 2020). These streamflow classifications are based on a combination of historical field observations, updated observations, and modeling efforts. Large-scale spatial databases face several limitations, including the ability to accurately map the distribution of perennial, intermittent, and ephemeral streams, particularly headwater streams, over large spatial extents (Fritz and others, 2013), and to compile these field observations into a common format in a shared database. Updating these spatial datasets can also be labor-intensive and difficult to implement (Bhamjee and Lindsay, 2011; Neadeau and others, 2015). In this document we describe the FLOwPER (FLOW PERmanence) field form, available in a mobile application (app) for standardized data collection. The FLOwPER field form, hereafter referred to as FLOwPER, can be easily and quickly used to map the presence of flow in streams and upload the input data to an ArcGIS database. These data can be used for multiple purposes, such

[1] United States Geological Survey Washington Water Science Center
[2] United States Forest Service Pacific Northwest Research Station
[3] United States Geological Survey Forest and Rangeland Ecosystem Science Center
[4] Bureau of Land Management

as archiving where flowing water is present in forest planning units, informing modeling efforts of streamflow permanence, and providing information needed to update stream classifications across any spatial extent.

Table 1. Definition of three stream types recognized by the U.S. Geological Survey (https://water.usgs.gov/water-basics_glossary.html#E), based on patterns of flow permanence.

Stream type	Definition
Perennial	A stream that normally has water in its channel at all times.
Intermittent	A stream that flows only when it receives water from rainfall runoff or springs, or from some surface source such as melting snow.
Ephemeral	A stream or part of a stream that flows only in direct response to precipitation; it receives little or no water from springs, melting snow, or other sources; its channel is at all times above the water table.

FLOwPER is intended to facilitate the rapid collection of streamflow-permanence observations (for example, flowing or dry) with versions programmed into mobile apps designed to conduct surveys through customized field forms that collect data via mobile devices and securely upload the input data to the ArcGIS online (AGOL) environment. FLOwPER is programmed into the mobile app, Survey123™ (ArcGIS online, Environmental Systems Research Institute (Esri), ArcGIS, 2020), which operates on a variety of mobile devices, including those from agencies and personal mobile devices, that allow crowdsourcing[5] of observations; FLOwPER is also editable in the S1 Mobile Mapper[6] app (Bureau of Land Management, 2020), which is a custom mapping and field data collection application used by the Bureau of Land Management (BLM) and Region 6 U.S. Forest Service (USFS) in the Pacific Northwest. FLOwPER is designed for seamless communication with ArcGIS online for easy uploading of collected observations into a publicly available master database (FLOwPER Database) that can include any geographic region.

FLOwPER focuses on the rapid collection of a set of simple visual observations that can be recorded from a road over a stream or while standing on the bank of a stream. Use of FLOwPER requires only a mobile device with the mobile app and FLOwPER field form and an accurate Global Positioning System (GPS) antenna (for example, rated accuracy of 1 meter or less). While it is possible to collect FLOwPER data using the GPS on a mobile device such as a smartphone, tablet, or a recreational grade GPS, the positional accuracy can be very poor, thus limiting the usefulness of the data.

With crowdsourced observations collected by many users of FLOwPER, it is possible to collect a large number of observations from a wide geographical range from all parts of the stream network at any time of the year. Although seasonal drying of streams is often of interest, FLOwPER can be used to evaluate patterns of flow permanence at any time of year, including times when stream networks are greatly expanded during wet cycles (Ward and others, 2018;

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[5] Crowdsourcing as used here is defined as “a process in which individuals or organizations submit an open call for voluntary contributions from a large group of unknown individuals (“the crowd”) or, in some cases, a bounded group of trusted individuals or experts” (U.S. Government, 2020).

[6] The FLOwPER AGOL feature layer is editable in S1 and you can utilize the FLOwPER feature layer to collect data in S1. Refer to the S1 mobile mapping application, download and edit the feature class in S1. Follow the S1 documentation and User Manual to do this.

Prancevic and Kirchner 2019). Additionally, observations of headwater hollows that lack a distinct channel are just as important as observations of streams with or without surface flow present. This allows delineation of both the hydrographic (or stream) network and the geomorphic channel network, which includes channels that can be dry for part of, or even most of, the year. The stream network and the geomorphic channel network are critical components of many water resource and ecological applications. In summary, data collected using FLOwPER and housed in the FLOwPER Database can be used to determine flow permanence and hydrography of streams.

What is a FLOwPER Observation

A FLOwPER observation occurs within a discrete stream reach of 10 meters (m) (approximately 30 feet [ft]) in length. For observations made from roads at stream crossings, the portions of the channel obviously disturbed by the presence of the road should not be included in the 10-m observation reach–for example, wedges of sediment accumulated above a culvert or the plunge-pool below the culvert (Cenderelli and others, 2011). The critical piece of data to record is whether the 10-m observation reach has continuous flow of water, discontinuous flow, or is dry. Other variables should be quickly estimated to provide a rough description of the channel. Section on "Collecting FLOwPER Data in Survey123" has more information on this topic.

Disclaimers

No warranty, expressed or implied, is made by the USGS, USFS, or the U.S. Government, in general, as to the functionality of the application and related material nor shall the fact of release constitute any such warranty. The FLOwPER field survey form is provided on the condition that neither the USGS, USFS, nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the FLOwPER field survey form.

The contributions to the FLOwPER Database by non-USGS or non-USFS users of the FLOwPER field form are published as they were submitted. Contributions provided entirely by non-USGS or non-USFS users do not represent the views or position of the USGS, the USFS, or the U.S. Government and are published solely as part of the larger FLOwPER Database

Unless otherwise stated, all data, metadata, and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. No warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Terms of Use

In connection with submitting to the USGS FLOwPER Database and using the FLOwPER ArcGIS application, this work–which includes, but is not limited to biological, spatial, physical, and chemical data–and text, image(s), audios, videos, and/or audio-videos, I, the provider state that they were either created in my capacity as a Federal Government employee and are therefore in the U.S. public domain or they were created by me alone in my private capacity and automatically qualify for a U.S. copyright. If a U.S. copyright presently applies to any of the items submitted by me through the FLOwPER ArcGIS application, I agree to irrevocably dedicate that or those copyrights to the public domain.

I am the sole copyright owner of the work. I understand that I must either be the sole copyright owner of this work or I must obtain written permission from all co-owners of the work. I hereby warrant and represent that I have the full right, power, and authority to irrevocably dedicate the copyright to the public domain and that use of the work will not violate any rights of any kind or nature whatsoever of any third party.

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Dependencies

This user's guide was developed for the following equipment and software versions. The accuracy of this guide for use on other equipment and (or) other software versions is not guaranteed.

- Tablet: Samsung Galaxy Tab Active 2
- Android ver. 9
- Survey123 for ArcGIS Application ver. 3.9
- GAIA EOS Arrow 100 GPS firmware ver. 5.9.Aa05
- Organizational Esri ArcGIS Online Account

Joining FLOwPER as Data Contributor

To access FLOwPER and the AGOL geodatabase that stores the FLOwPER Database, users must have an organizational AGOL account and request to be added to the FLOwPER AGOL group.

The FLOwPER AGOL group is housed within the USGS ArcGIS Online Enterprise and contains both the FLOwPER field form and the FLOwPER Database, an AGOL geodatabase that serves as the direct repository for all collected FLOwPER data.

To request access to FLOwPER:

1. Send an email request to gs-flowper@usgs.gov to join the FLOwPER AGOL group.
2. An administrator will send an email invitation to join the group.
3. To accept the invitation, log into user's AGOL account in a web browser and select the notification bell in the top right corner of the screen (fig. 1). Accept the invite.
4. The FLOwPER AGOL group will now be accessible under the GROUPS page and FLOwPER will be accessible in the Survey123 app while logged into the added account.

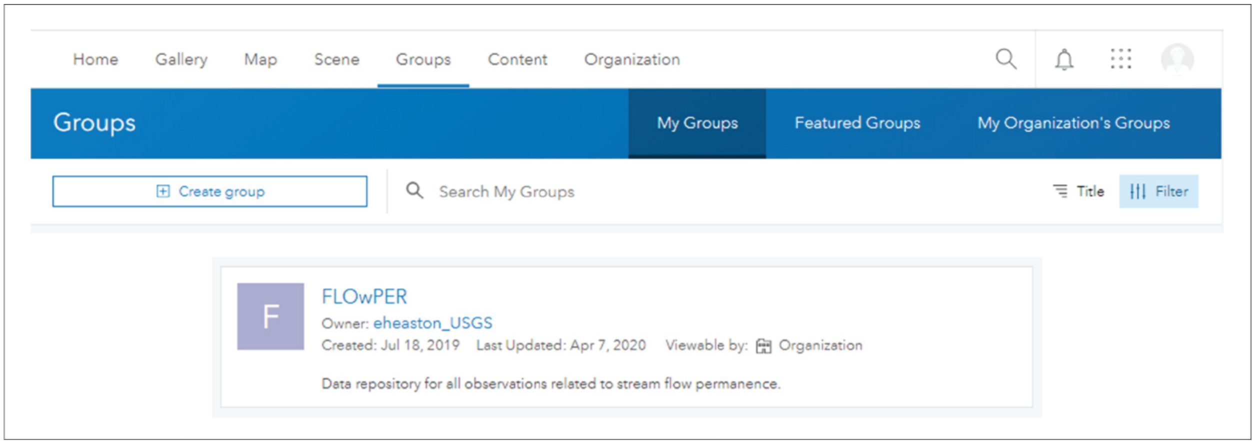

Figure 1. Screen capture showing use of organizational AGOL account to access FLOwPER.

Establish Global Positioning Satellite Connection

Establish a connection between the mobile device and the high accuracy GPS prior to data collection. Make sure the GPS unit and mobile device are properly connected and working to ensure all the needed GPS data are collected. To establish the initial GPS connection, it is helpful and often necessary to be outside with a good view of the sky.

User will need:

- Mobile device: Tablet or smartphone
- High accuracy Bluetooth® GPS unit with rated accuracy of 1 meter or less. The FLOwPER field form can be completed using the built-in GPS on mobile devices, however, the recreational grade GPS units or the built-in GPS antennas on mobile devices will typically not provide the location accuracy necessary to snap the collected point to a high-resolution map of the stream network in locations with relatively high stream density.
- Only Bluetooth GPS connectivity is supported at this time.
- Internet connectivity

In the following section are steps necessary to pair a mobile device with the EOS Arrow 100 GPS antenna via Bluetooth. Follow the instructions from the manufacturer and (or) software designer or contact user’s Tech Support department for troubleshooting or when using a different GPS unit.

Global Positioning System Unit Setup

1. Power on the Bluetooth enabled GPS unit. Refer to the GPS device manual for detailed Bluetooth pairing instructions.

   For the EOS Arrow 100 GPS:

   a) Connect the antenna to the GPS unit using the orange quick connect cables.
   b) Make sure cable fittings are secure.
   c) Turn on the GPS unit.
   d) The blue light on the GPS unit should be flashing, indicating the GPS unit is now ready to be paired with the mobile device.

2. Pair the GPS unit to the mobile device (fig. 2).

   a) Power on mobile device
   b) Select Settings => Connections => Bluetooth

      i. Make sure Bluetooth is turned on
      ii. Let the mobile device scan for 30–60 seconds.
      iii. When the GPS unit is found, click on it and select “Pair”

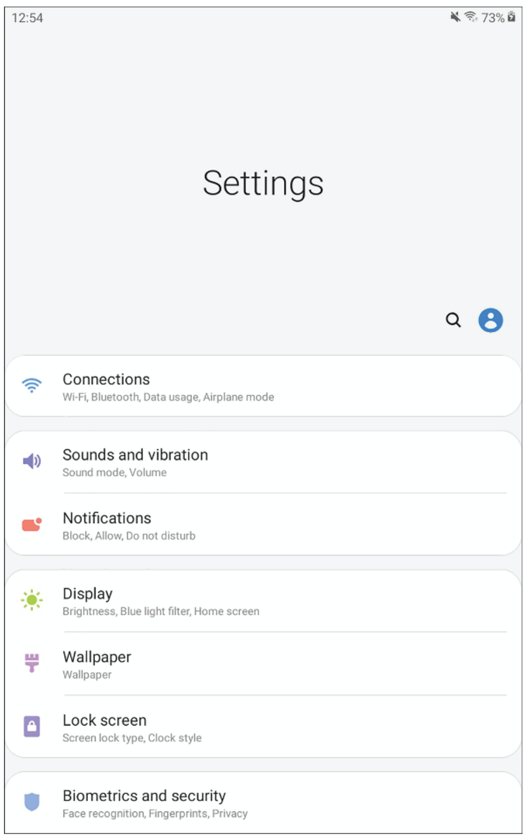

Figure 2. Screen capture showing the “Settings” menu for the Android mobile device. [Settings menus may vary among Android versions and software updates.]

Troubleshooting Issues with Pairing

1. Make sure all other Bluetooth sources within 6 m (approximately 20 ft) are turned off.
2. Reset the GPS unit and mobile device and retry.
3. Contact users' agency or manufacturer's tech support.

FLOwPER in Survey123

It is recommended that the "Survey123 Setup" and "Collecting FLOwPER Data in Survey123" are completed before field data collection to ensure that the GPS connection is recognized and that FLOwPER is available for use.

Survey123 Setup

FLOwPER in Survey123 works primarily as a series of multiple-choice questions along with a few items that require text entry. Below are instructions on how to download the Survey123 app and access FLOwPER within the app.

Once the GPS unit is paired to the mobile device, configure the Survey123 app to use the GPS unit and download FLOwPER housed in Survey123.

1. Download the Survey123 app from the mobile device's app store (fig. 3).

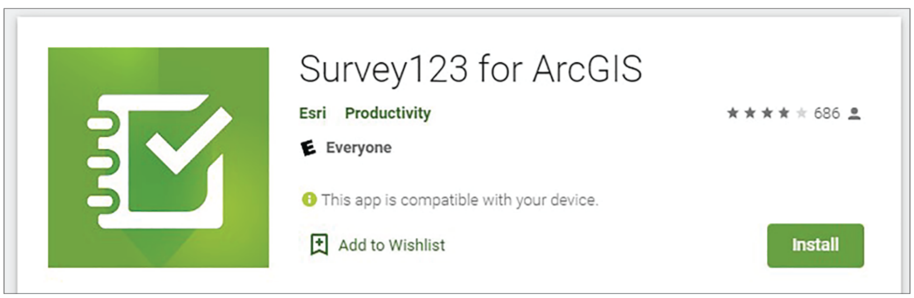

Figure 3. Screen capture showing Survey123 application for download.

2. Open the Survey123 app on the mobile device.

3. Sign into users' AGOL account using users' organizational account credentials (fig. 4). The app may provide a "Sign In" prompt automatically; if not, select the options menu in the top right corner of the screen and then select "Sign In".

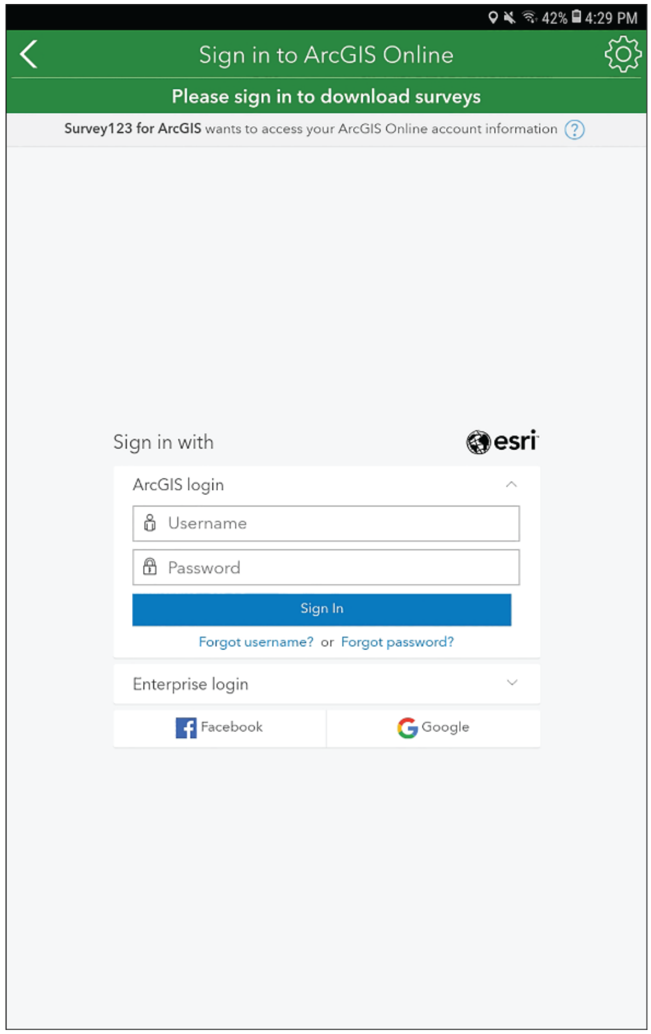

Figure 4. Screen capture showing the login screen for the users' Organizational ArcGIS Online account credentials within the Survey123 application.

4. Configure the GPS unit in Survey123.
   a) Select the options menu in the top right corner of the screen and select "**Settings"** (fig. 5). If logged in to users' AGOL account, the options menu will be a circle icon containing users' initials and, if not logged into an AGOL account, the icon will be a hamburger (three horizonal lines).

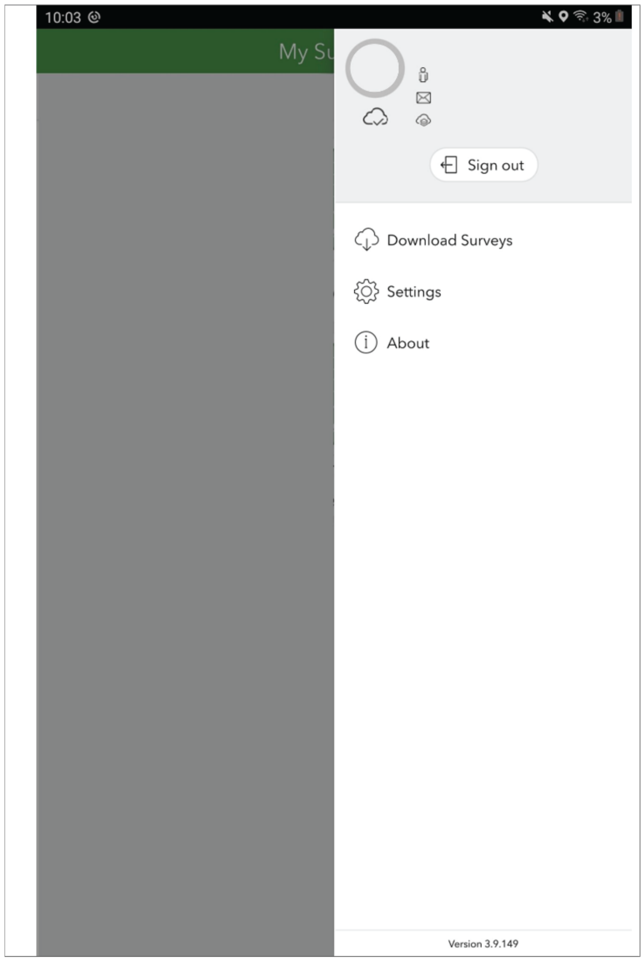

Figure 5. Screen capture showing the options menu in the Survey123 application.

b) Select “**Location**” (fig. 6).

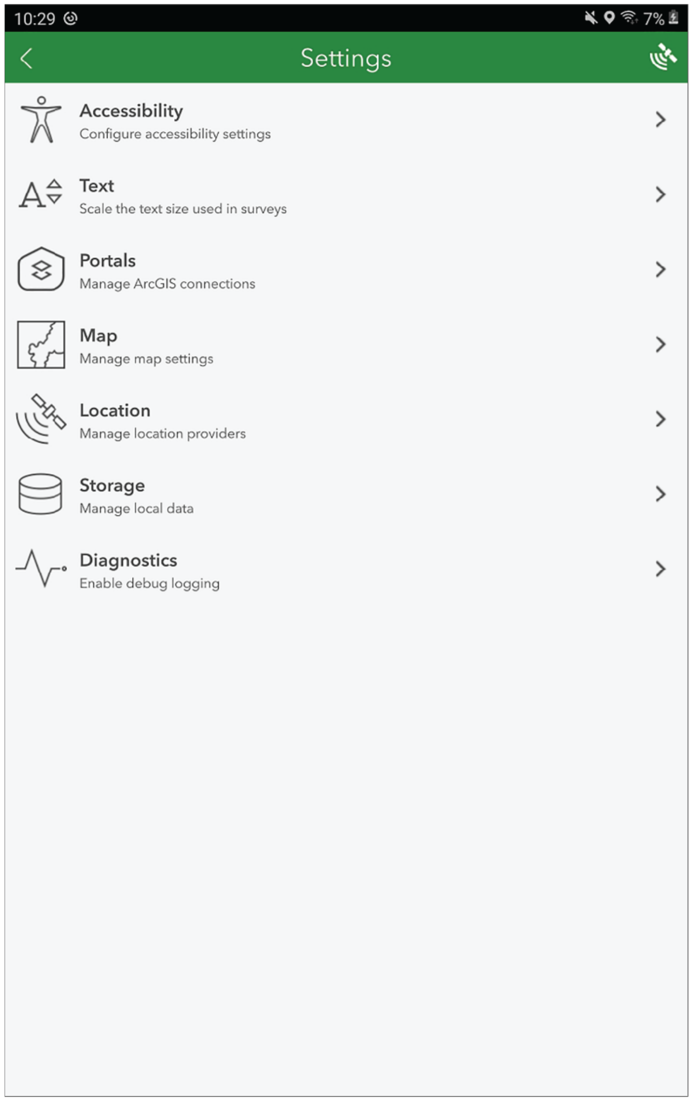

Figure 6. Screen capture showing the settings menu in the Survey123 application.

c) Select “**Add Provider”** (fig. 7).

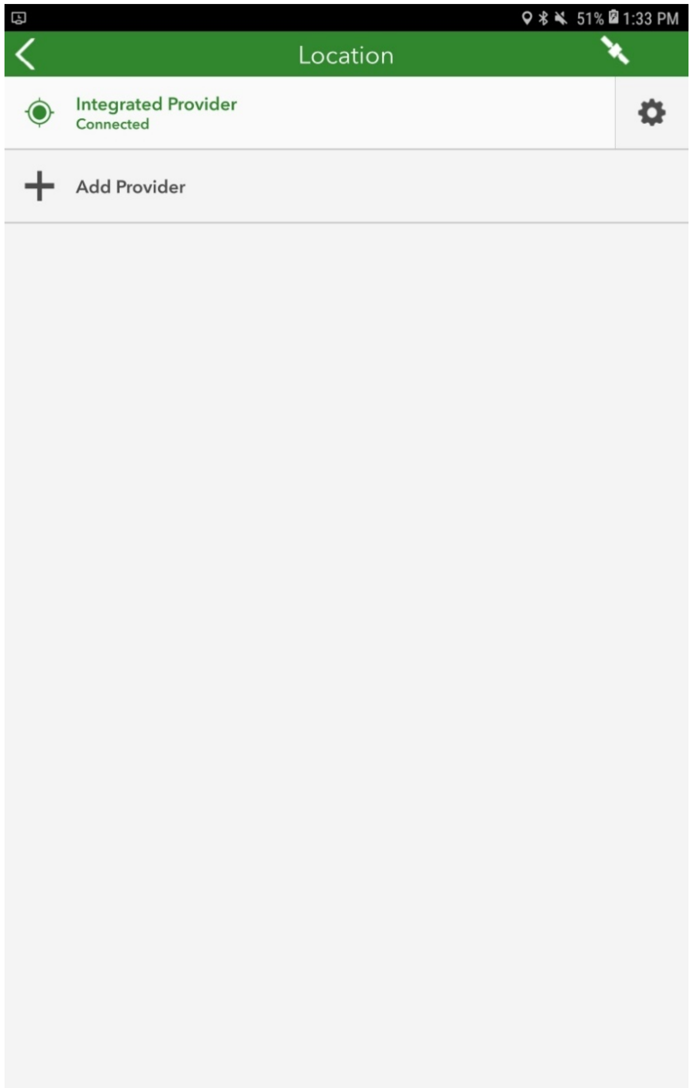

Figure 7. Screen capture showing the options for adding an external GPS unit as a location provider in the Survey123 application.

d) Select the appropriate GPS unit (for example, “Arrow,” “**Bad ELF GPS**,”) (fig. 8).

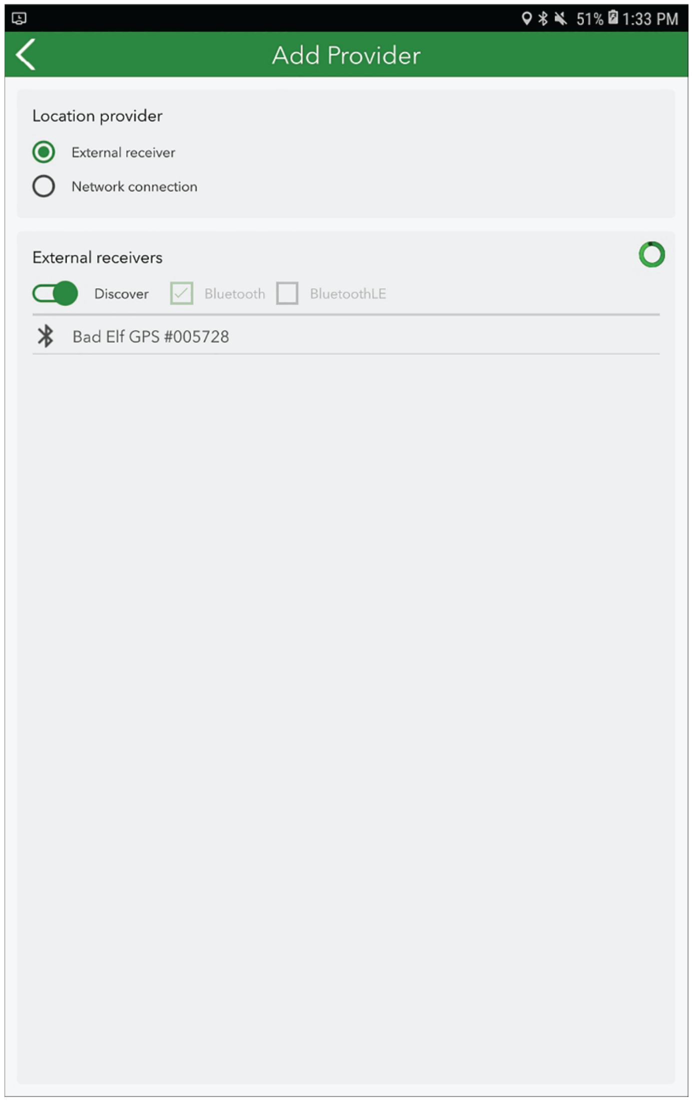

Figure 8. Screen capture showing selection of appropriate GPS unit as a Bluetooth device.

e) Click the ‘Gear’ icon (fig. 9).

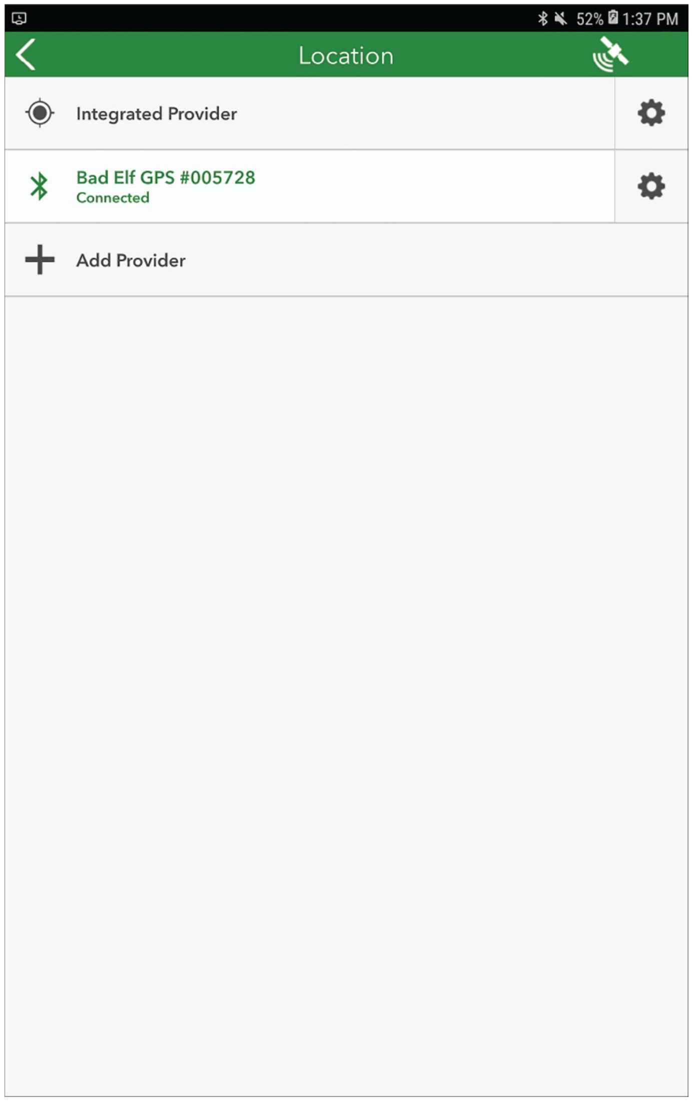

Figure 9. Screen capture showing the ‘Gear’ icon to the right of the selected Bluetooth GPS unit (**Bad Elf GPS**).

f) Select "**Alerts**" (fig. 10) -> turn off "**Audio**" and "**Vibrate**" and turn on **"Visual"** (fig. 11). This step is optional and does not affect the technical use of Survey123 or FLOwPER.

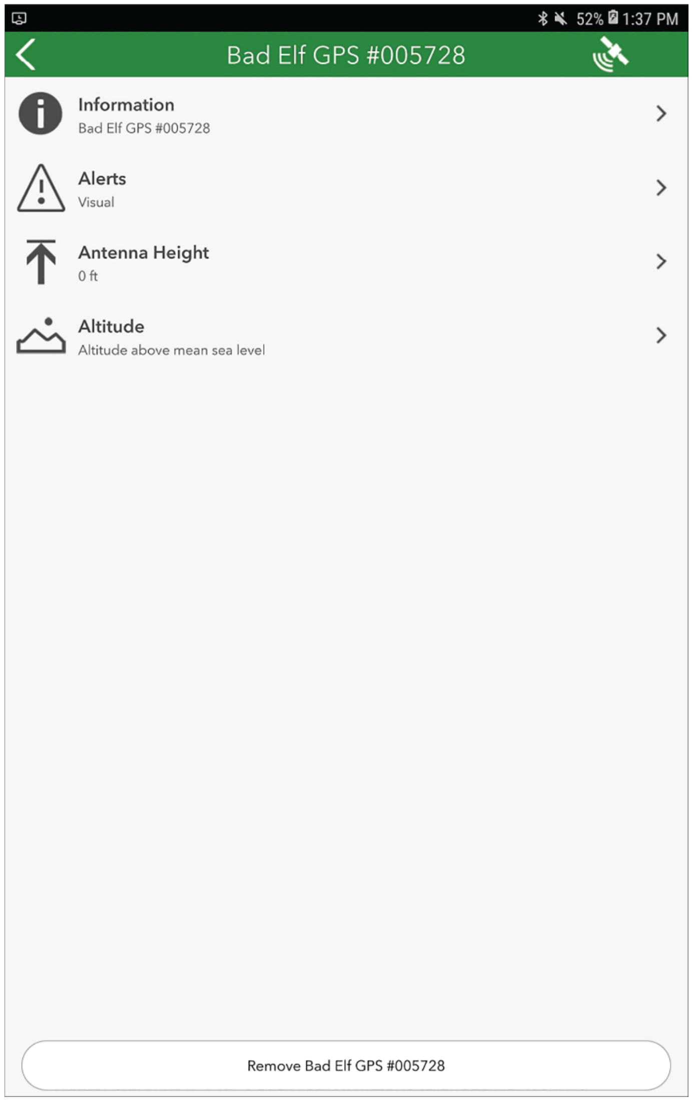

Figure 10. Screen capture showing the external GPS unit options menu.

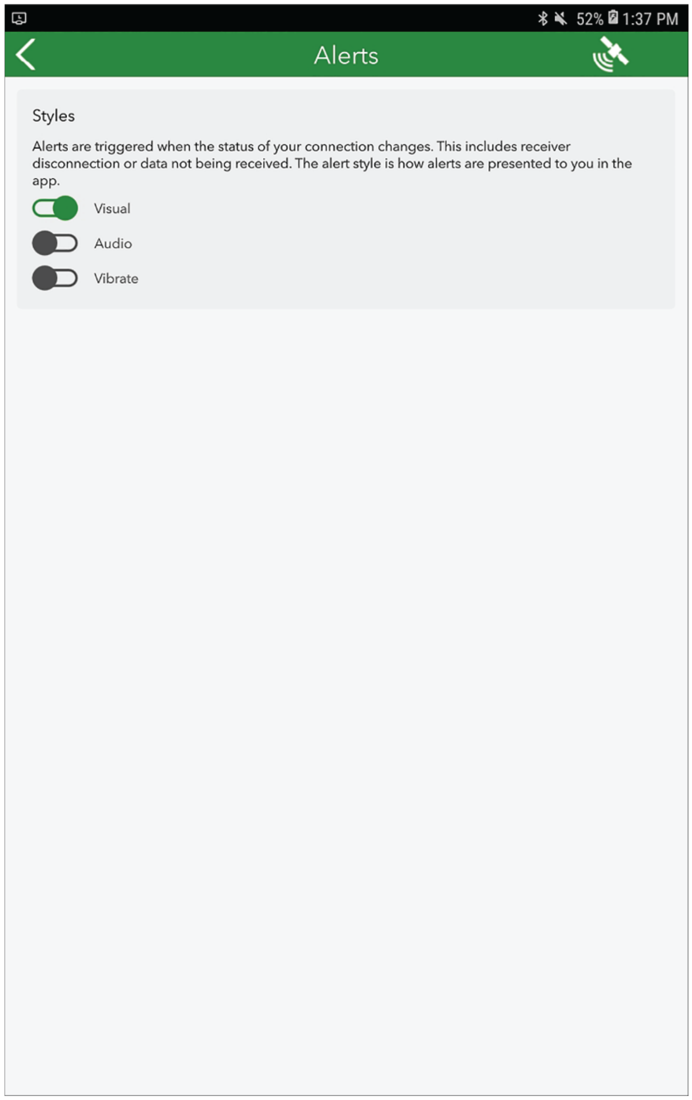

Figure 11. Screen capture showing the preferred GPS unit alert settings with only Visual Alerts turned on. The Survey123 application will notify the user when the external GPS unit is disconnected.

5. Download FLOwPER in Survey123
   a) Select “Get Surveys” or select the options menu in the upper right corner of the screen and then “Download Surveys” (fig. 12).

Figure 12. Download Surveys option when first opening the Survey123 application.

6. Select the FLOwPER field form labeled "**FLOwPER v2.0 Field Form**" and tap the download (cloud) icon. (fig. 13).
    a) User may have to scroll down and find it or wait until the list of available forms populates, then use the search bar at the top of the screen.

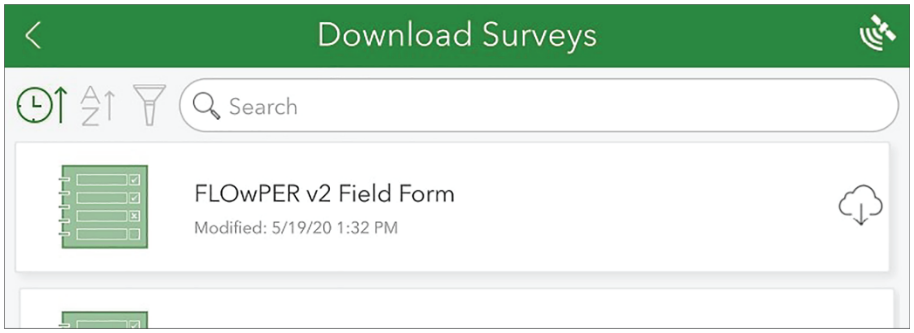

Figure 13. Screen capture showing the Download Surveys search menu in Survey123 application.

Collecting FLOwPER Data in Survey123

Complete procedures outlined in sections "Establish GPS Connection" and "Survey123 Setup" prior to collecting data with FLOwPER in Survey123.

1. Ensure the external GPS unit is powered on and paired with the mobile device. Open the Survey123 app from the mobile device.
2. Select the "FLOwPER v2.0 Field Form" and click "Collect" at the bottom of the screen (fig. 14)

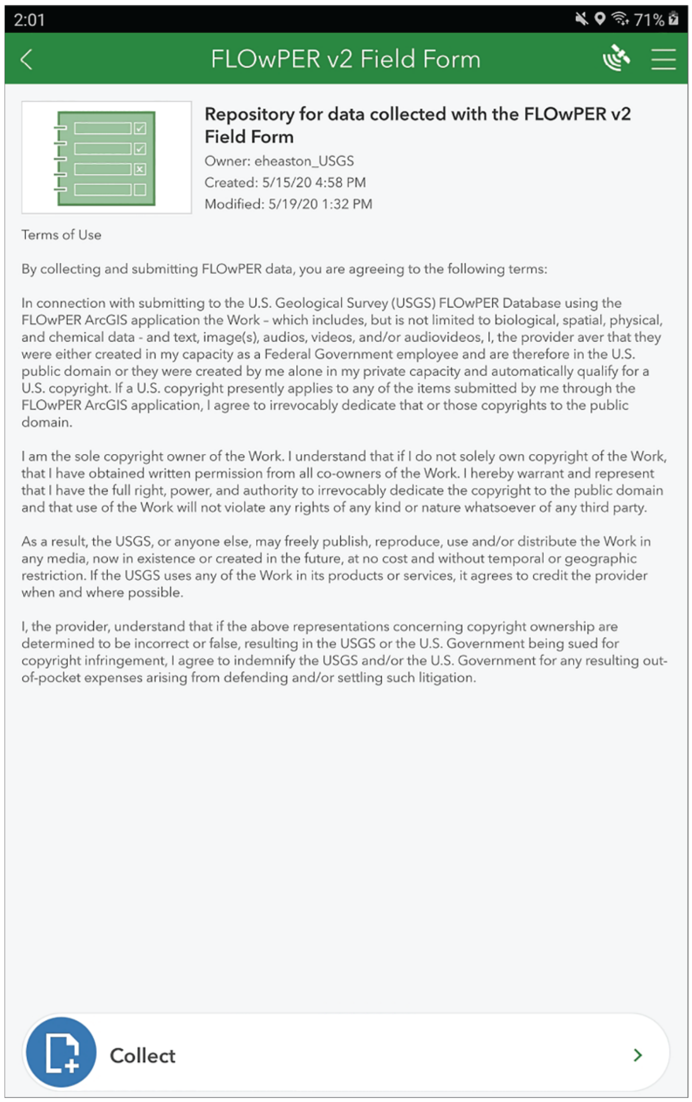

Figure 14. Screen capture showing the FLOwPER v2.0 Field Form page in the Survey123 application.

3. Open FLOwPER:
   a) To double check that the application is receiving data from the Bluetooth GPS unit, select the satellite icon at the top right corner of the screen (fig. 15). This will open the "Location Status" page (fig. 16). Hit the back button to return to the field form.
   b) The "FLOwPER Quick Guide" (appendix 1) provides concise instructions to complete FLOwPER. The FLOwPER Quick Guide can be referenced and opened in FLOwPER by selecting the drop-down bar at the top of the form titled "FLOwPER Quick Guide Reference" (fig. 15).

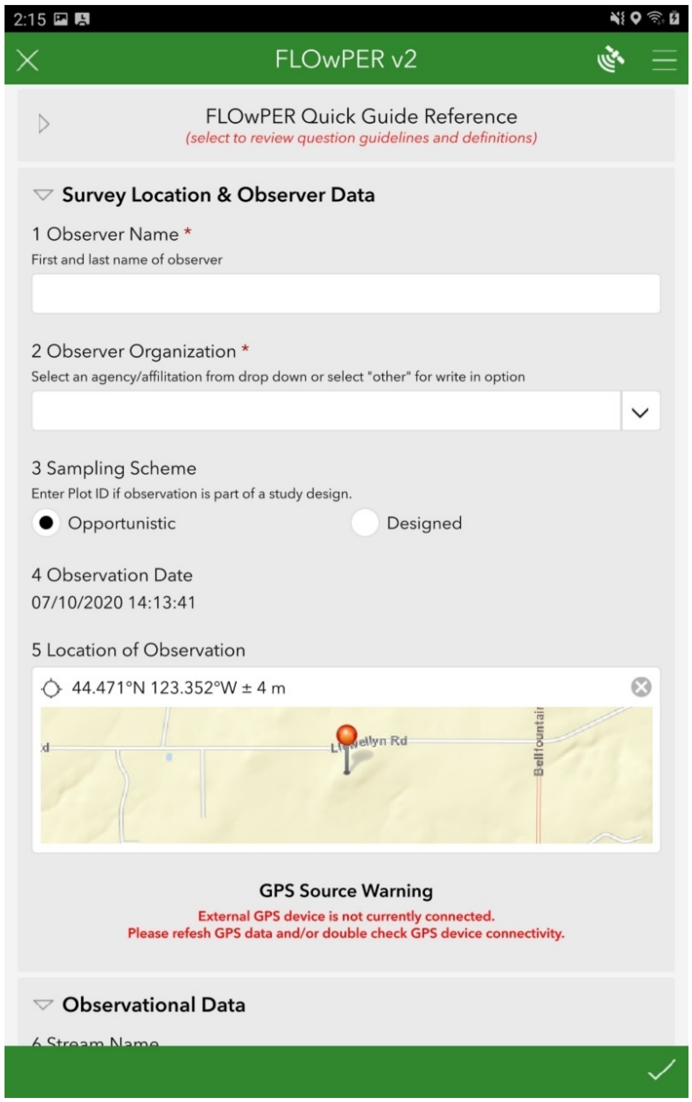

Figure 15. Screen capture showing the FLOwPER v2 Field Form in the Survey123 app including Quick Guide Reference. The target icon is located to the left of the GPS coordinates in the geopoint box under the question 5 heading.

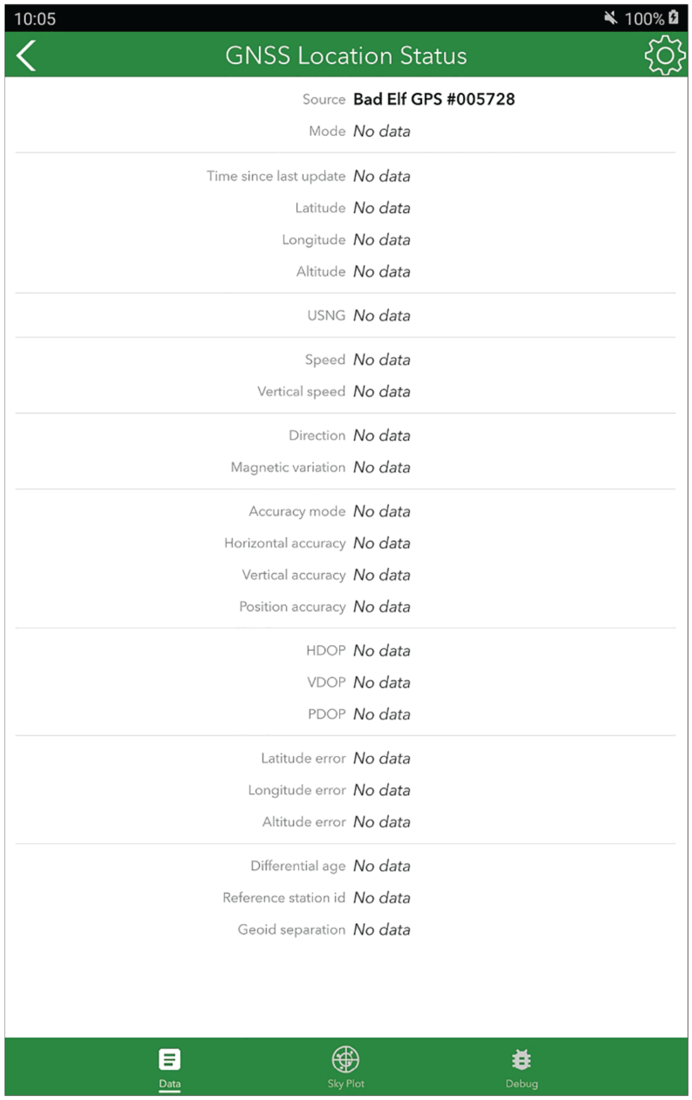

Figure 16. Screen capture showing Location Status page in Survey123.

FLOwPER Field Survey Form

The following steps describe data collection information required for the FLOwPER v2 Field Form (fig. 15). Note that format of the numbered steps was changed to maintain consistency with format in Survey123.

Required Data Collection

1. **Observer Name**: Enter the first and last name of the observer, here defined as the person taking a FLOwPER observation.
2. **Observer Organization**: Select one option from the drop-down menu.
3. **Sampling Scheme**: In some cases, FLOwPER observations will be part of a larger study design that includes a predetermined observation location as part of the study design's sampling scheme. FLOwPER observations that are not part of a predetermined sampling scheme are considered "opportunistic."
   - 3.1. Opportunistic (default): the collected point is not predetermined through a defined sampling strategy.
   - 3.2. Designed: If the data point being collected is based on a predetermined sampling scheme, select this option and the user will be prompted to enter PLOT ID.
     - 3.2.1. Plot ID: Enter the Plot ID or sample-point identifier.
4. **Date of Observation** automatically collected. Date of observation cannot be changed.
5. **Location of Observation:** Automatically collected from the external GPS. Location of observation cannot be changed.
   - 5.1. If the external Bluetooth GPS unit is not connected, red warning text will appear on the screen. If this occurs, check to make sure that the app is accessing the external GPS unit by selecting the small satellite icon at the top right of the screen (fig. 15).
   - 5.2. Clicking the location target icon will manually refresh the recorded GPS data (fig. 15).
   - 5.3. To ensure the best GPS accuracy, multiple positions can be averaged by pressing and holding the location target icon for 3 seconds. This will turn on averaging. To stop averaging click the location target icon again.
   - 5.4. The location coordinates and accuracy will display in the survey form. Red warning text will appear if the GPS accuracy is below 15 m. Wait until this warning goes away to submit the collected data. Always check GPS accuracy before submitting the survey.
6. **Stream Name**
   - 6.1. Select "Yes" if the official USGS Geographic Names Information system (GNIS) name is known. After selecting "Yes," a text box will appear for user to enter the GNIS stream name.
   - 6.2. Otherwise select "No." This option is default.

7. **Flow Status**
   - 7.1. Continuous Flow describes a channel that has visible surface water over the full length of the 10-m (30-ft) observation reach. If there are multiple channels, only a single channel need have continuous flow for the entire reach to be categorized "Continuous Flow."
   - 7.2. Discontinuous Flow describes a channel where a portion of the length of the 10-m (30-ft) observation reach is dry across the full width of the bankfull channel. If there are multiple channels, then all channels must be dry, at some point along their length.
   - 7.3. Dry describes a channel that has no flowing or standing water anywhere over the length of the 10-m (30-ft) observation reach.
   - 7.4. No data is the null entry.

   Note: If only a part of the 10-m (30-ft) observation reach is visible, oftentimes when an observer cannot safely exit the vehicle and (or) physically walk the observation reach, the observer should make the best judgement on determining the flow status on the part of the observation reach that is visible.

8. **Stream Type**
   - 8.1. Natural Channel indicates a stream channel without obvious human modifications.
   - 8.2. Leveed or channelized indicates a natural stream that has been modified to channelize flow through human construction of a dike, ridge, or embankment on one or both sides.
   - 8.3. Ditch or canal indicates (1) a manmade channel typically used for conveyance of runoff and (or) diverted flow from a stream, or (2) a stream channel altered for the conveyance of water.
   - 8.4. Other (Select if none of the options apply including if there is more than one stream type within the observation reach. A text box will appear for observer entry.)

   If the observation point is at a location where there is no defined channel, select "Other" and in the step below, select "No obvious channel" for **Step 9. Channel Bed: Dominant Substrate Type**. This might happen where the NHD or the LiDAR interpretation of the channel network extends a channel into a headwater hollow that is too small to support a channel, or in locations along intermittent sections of tiny headwater streams where the channel is persistently dry. Culverts may be found in these locations because they route water from the roadbed, under the road, to minimize flow accumulation in the borrow-ditch and associated erosion.

9. **Channel Bed: Dominant Substrate Type**
   - 9.1. No obvious channel
   - 9.2. Fine sediment: Streambed dominated by silt, clay, or organic rich mucks
   - 9.3. Coarse sediment: Streambed dominated by sand, gravel, cobbles, or boulders
   - 9.4. Bedrock: Large, continuous areas of solid rock on most of the channel bed
   - 9.5. Artificial: Streambed dominated by concrete, riprap, or other human-placed substrate
   - 9.6. No Data

   A Note on the channel bed dominant substrate type: These variables only require visual estimates. They can be used in models to predict whether a channel will be perennial, intermittent, or ephemeral. The focus of the variables is to provide an estimate of the capacity of the valley-floor sediment to conduct subsurface flow of water. If sediment is deep and coarse, and the valley is both steep and relatively wide, then substantial down-valley flow can occur in the subsurface and, for a given drainage area, these streams are more likely to be dry. Conversely, if the valley floor is scoured to bedrock, any flow will be visible on the surface so that bedrock channels will be more likely to be perennial. The estimates of the bed sediment texture, the wetted channel width, and the width of the active valley floor are expected to be rather crude estimates; they do not require direct measurement.

10. **Road or Trail Crossing? (y/n)** (fig. 17)
    - 10.1. Yes – continue below
    - 10.2. No – skip to #11

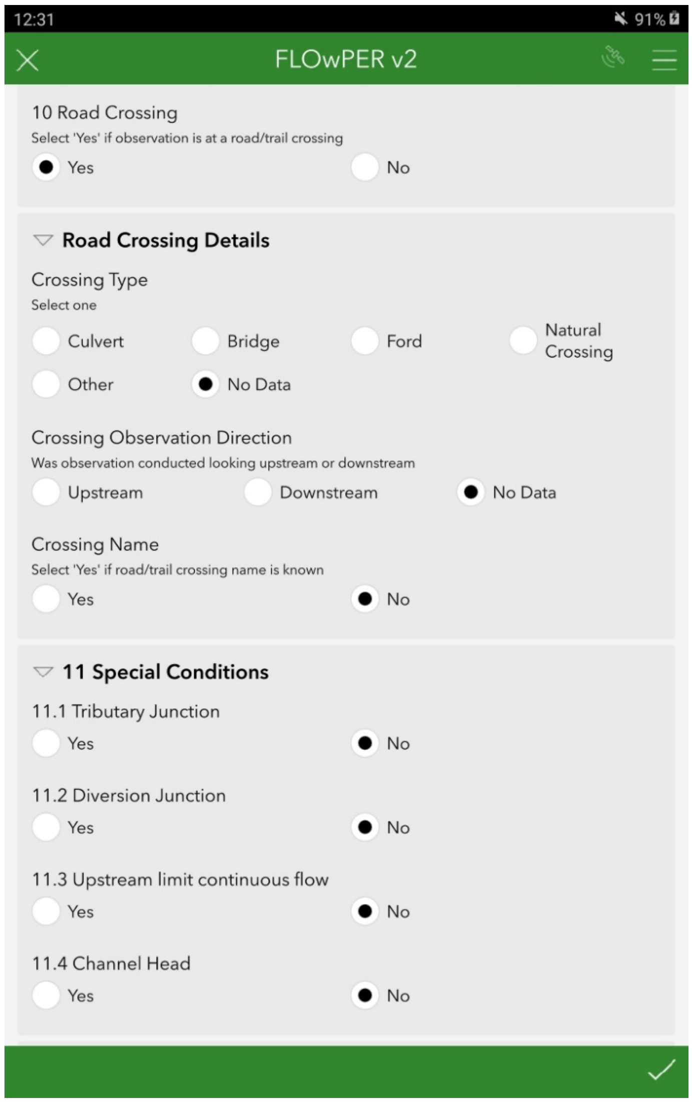

Figure 17. Screen capture showing the Road or Trail Crossing input fields in FLOwPER.

Crossing Type (select one)

10.2.1. Culvert
10.2.2. Bridge
10.2.3. Ford (road-tracked or constructed crossing through the streambed)
10.2.4. Natural crossing (not constructed)
10.2.5. Other
10.2.6. No Data

Observation Direction (select one)

10.2.7. Upstream of crossing
10.2.8. Downstream of crossing
10.2.9. No Data

Crossing Name

10.2.10. Select "Yes" if the official USGS GNIS name is known. After selecting "Yes," a text box will appear for observer to enter the GNIS stream name.
10.2.11. Otherwise select "No."

11. **Special Conditions:** Answer any of the following if they apply (fig. 17).

11.1. Tributary Junctions (fig. 18): Are locations that pose special challenges in that three potentially different stream channels (fig. 18) all connect at a single point. FLOwPER data can be collected from any (or all) of the three channels, but they must be labeled as shown because GPS accuracy may not correctly associate the point with the correct channel. Note that where two unnamed tributaries join to form the mainstem, the larger one should always be denoted as the "upstream mainstem." If they are of exactly equal size, the left-most tributary (looking upstream) should be denoted as the "upstream mainstem."

11.1.1. On mainstem: downstream of tributary junction
11.1.2. On mainstem: upstream of tributary junction
11.1.3. On tributary

11.2. Diversion Junction: Treated similarly to tributary junctions requiring identification of the specific channel segment on which the observation is made.

11.2.1. On stream: downstream of diversion junction
11.2.2. On stream: upstream of diversion junction
11.2.3. On diversion

11.3. Upstream limit of spatially continuous flow (fig. 19): On the date of observation. Accurate determination of these points will require walking a substantial portion of the channel. This is the highest point in the stream network below which flowing water is spatially continuous with the remainder of the stream network; above this point the stream is spatially intermittent.

11.4. Channel Head (fig. 19)

11.4.1. Continuous – The continuous channel head is the highest point in the geomorphic channel network, below which a continuous and distinct channel (signs of scour or deposition, vegetation free, and distinct banks; may not have flowing water) connects to the remainder of the channel network.

11.4.2. Discontinuous – A discontinuous channel head marks the upper most extent of any geomorphic channel that is not continuous with the channel network downstream – that is, it lies above an area that lacks evidence of a distinct channel so that its connection to the channel network is interrupted.

11.4.3. No data

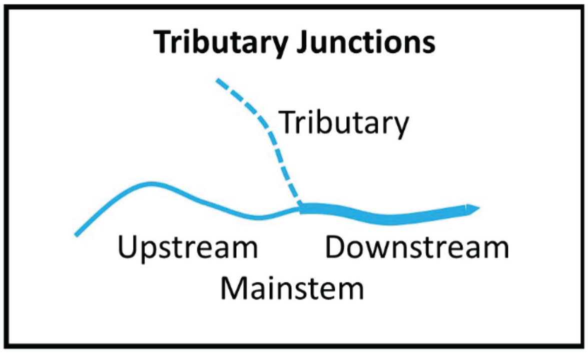

Figure 18. Schematic illustrating tributary junctions.

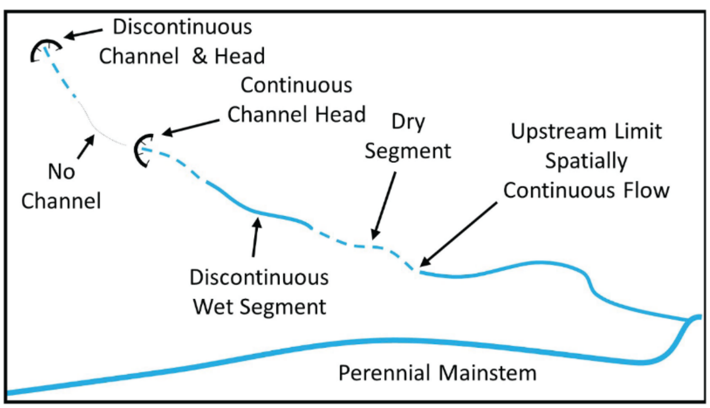

Figure 19. Schematic illustrating upstream limit of spatially continuous flow and channel heads.

12. **Non-Observational Data: Judgement Calls (**fig. 20**)—**In some stream survey protocols, observers use indicators such as the presence of specific plants or macroinvertebrate species to estimate the condition expected during the late-summer low-flow period. Locations where late summer conditions are estimated should be identified here so that they can also be identified in the FLOwPER database to avoid mixing "judgement calls" with the actual observed conditions recorded in the field at the time of the survey. If an observer's survey protocol calls for the determination of low-flow stream extents based on indicators, then **(1)** be sure to have entered the current observed condition, especially #7 and #11 above, and then **(2)** select one option below to record the expected late-summer low-flow condition.

    12.1. <u>Likely to be perennial</u>
    12.2. <u>Likely to be intermittent</u>
    12.3. <u>Likely to be ephemeral</u>
    12.4. <u>Likely upstream limit of continuous perennial flow</u>
    12.5. <u>No data</u>

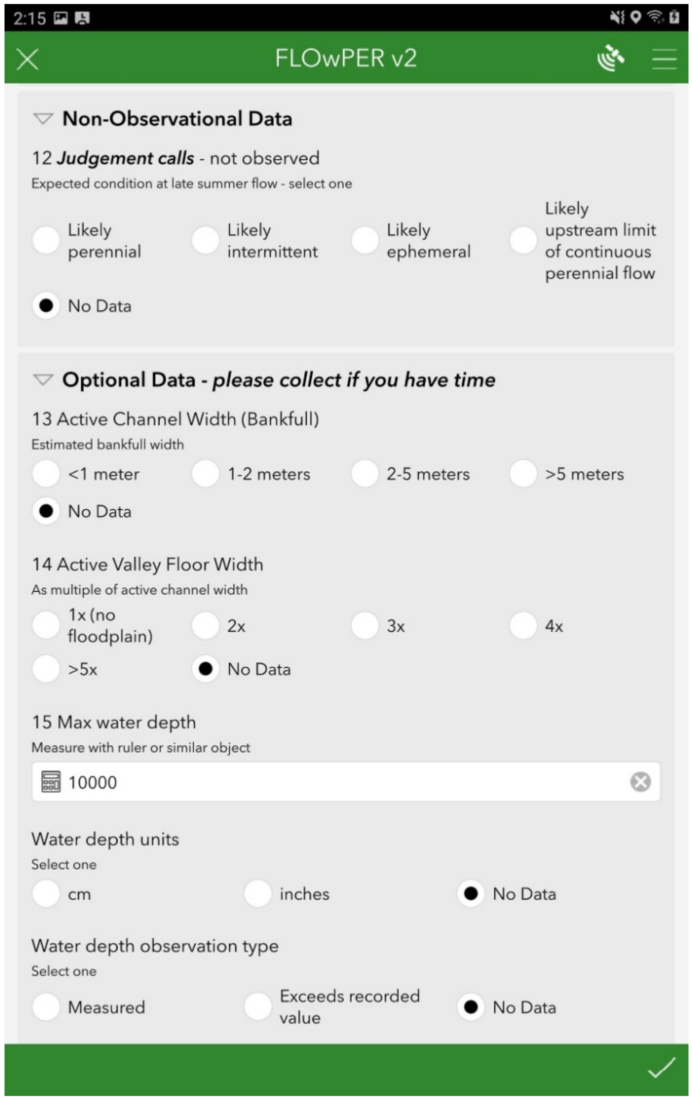

Figure 20. Screen capture showing non-observational data judgement calls and optional data in FLOwPER.

Optional Data Collection

Optional data specified by FLOwPER provides additional information on stream channel characteristics that can be used to develop stronger models of streamflow permanence and allow for inference in streams where there are no observations (fig. 20). Note that the water depth field is an actual measured value, and would thus require parking, hiking down to the stream with a ruler or tape measure, and making a measurement.

Channel widths can be estimated visually and not directly measured. The focus of the variables is to provide an "index" of the capacity of the valley-floor sediment to conduct subsurface flows (fig. 21). Deep and coarse sediment in a steep and wide valley allows substantial subsurface flow and, for a given drainage area, these streams are more likely to be dry. Conversely, if the valley floor is scoured to bedrock, any flow will be visible on the surface so that bedrock channels will be more likely to be perennial.

Bankfull (or Active) Channel: The stream channel at bankfull stage typically showing signs of recent scour and typically free of perennial vegetation (may be colonized each year by annuals). If recent, large floods or debris flows may dramatically increase the width of the scoured zone and do not represent the true width of the active channel.

Wetted Channel: That portion of the active channel that is currently wet due to the presence of standing or flowing water. Varies with time as streamflow changes–record the observed wetted channel width at the time/date of observation.

Bankfull Stage: Typical indicators of the bankfull stage include: (1) the height of depositional features, especially the top of pointbars such as gravel bars on the inside of a meander bend, which define the lowest possible water level for bankfull stage; (2) a change in vegetation, especially the lower limit of perennial species; (3) a slope break from the flat floodplain to the steeper bank; (4) a change in the particle size of bank material, such as the boundary between coarse cobble or gravel of the streambed with fine-grained sand or silt of the floodplain; (5) undercuts in the bank, which usually reach an interior elevation slightly below bankfull stage; and (6) stain lines or the lower extent of lichens on boulders (modified from Harrelson and others, 1994).

Active Floodplain: The portion of the valley floor that can be inundated during floods, often resulting in scour or deposition of sediment creating a relatively flat surface adjacent to many stream channels. Active floodplains may be discontinuous, present on only one side of the channel, or completely absent (modified from Harrelson and others, 1994). Floodplains are typically most prominent along low-gradient, meandering reaches, although they can occur along any stream reach. They can be difficult to identify in steep mountain streams, and in some locations, the active channel may encompass the entire width of the valley so that no floodplain is present.

Active Valley Floor: This includes both the bankfull (or active) channel as well as the active floodplain.

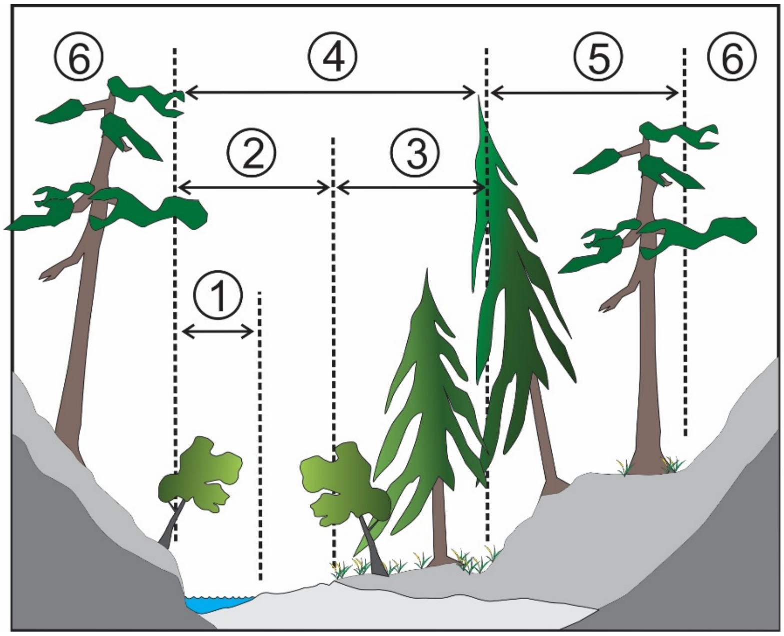

Figure 21. Example of a headwater valley showing: (1) wetted channel; (2) bankfull channel; (3) active floodplain; (4) active valley floor; (5) terrace; and (6) uplands / hillslopes. This example, typical of a small western Oregon stream, shows an unvegetated gravel bar within the bankfull channel and slight differences in vegetation among the other surfaces. Note that the bankfull channel width is included in the width of the active valley floor as shown in this figure, and in this case, the active valley floor is approximately two-times the width of the bankfull channel.

13. **Bankfull (or Active) Channel Width**: Select the appropriate width range (*choose one*).

  13.1. <1 meter (3 ft)
  13.2. 1–2 meters (3-6 ft)
  13.3. 2–5 meters (6-15 ft)
  13.4. >5 meters (greater than 15 ft)
  13.5. No data

14. **Active Valley Floor Width**: Select the appropriate width as a multiple of active channel width (*choose one*).
    14.1. 1x: The channel fills the entire width of the valley floor; there is no floodplain.
    14.2. 2x: The valley floor is twice as wide as the active channel width.
    14.3. 3x: The valley floor is three times as wide as the active channel width.
    14.4. 4x: The valley floor is four times as wide as the active channel width.
    14.5. 5+x or greater: The valley floor is 5 or more times wider than the active channel width.
    14.6. No data is the null entry.
15. **Max Water Depth** (enter number)

    *10,000 is the null entry (no data)

    Max Water Depth Units

    15.1. Centimeters (cm)
    15.2. Inches (in)

    Note: The maximum water depth within the observation reach needs to be measured with a ruler–this will be the deepest single point of the thalweg (thalweg is the deepest and fastest flowing part of the stream). If it is not safe to wade in the stream, or if the water is too deep, then measure the deepest point you are able to measure safely and enter "Max depth exceeds recorded value" for the "Type of depth observation."
    Road-based observers will not be able to collect maximum depth observations. Leave the null-value of 10,000 and enter "none" for the "Type of depth observation."

    Type of water depth observation

    15.3. None: Water depth not measured
    15.4. Measured: Maximum thalweg depth measured with a ruler in the field
    15.5. Exceeds recorded value: Deepest location was not safe to wade/measure.
16. **Comments and Photos: Pertinent Notes**—Add comments about the survey point and describe any extenuating circumstances that might influence how the point is interpreted.
    16.1. Photos: Take a photo of the stream at location of observation. Additional photos can be added if needed.

Saving the FLOwPER Field Survey

1. Select the check mark at the bottom right corner of the screen

   When collecting data offline:

   a) The survey completed notification will appear (fig. 22); select "Save this survey in the Outbox."
   b) Collect as many FLOwPER points as needed and continue to save in the Outbox. Once offline fieldwork is completed and an internet connection is established, follow the "**Uploading Observations in Survey123**" instructions in the next section of this guide.

When collecting data online:

a) The “Survey Completed” notification box will appear (fig. 22) and provide the options to send the survey now or save it in the outbox to send later.
b) If “Send now” is selected, no further action is required to upload FLOwPER data to the database. The data just submitted will be uploaded directly to the AGOL FLOwPER database.
c) If “Save this survey in the Outbox” is selected, follow the “**Uploading Observations in Survey123**” instructions in the next section of this guide to upload data to the AGOL FLOwPER database.

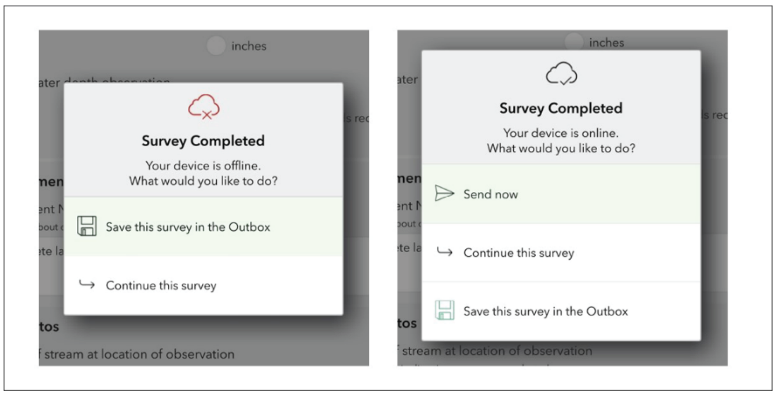

Figure 22. Screen capture showing successful completion of a FLOwPER field form while offline (left box) and online (right box).

Uploading Observations in Survey123

1. Open the Survey123 app on the mobile device.
   a) Sign in using the appropriate credentials (if not already signed in).
      i. See “Survey123 Setup” for more information on credentials.

2. Select the “**FLOwPER v2.0**” survey then select “**Outbox”** (fig. 23).
   a) The number in the upper left corner of the outbox icon displays the number of observations that need to be uploaded.
3. Click the “Send” icon in the bottom right corner of the screen to upload all records in the outbox.
4. Close Survey123.

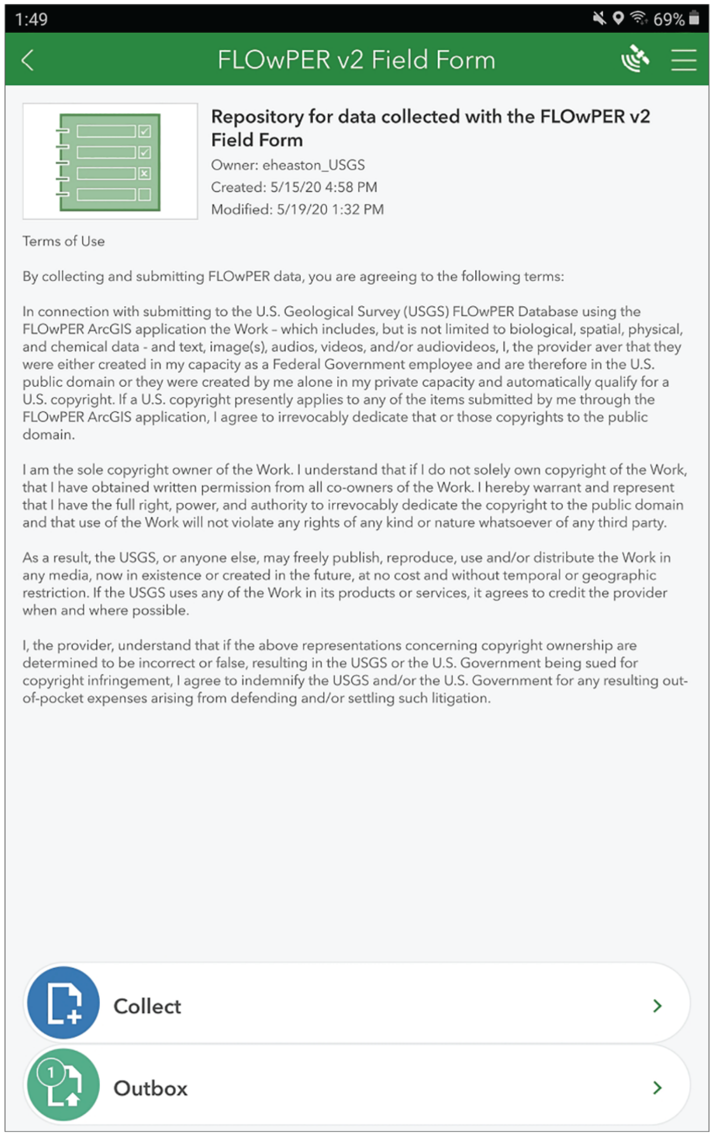

Figure 23. Screen capture showing the outbox at the bottom of the screen where data collected in the field is held in the Survey123 application prior to uploading to the AGOL FLOwPER database.

Updating the FLOwPER Field Form in the Survey123 Application

Periodic updates may be available to FLOwPER in Survey123. A notice in “My Surveys” in Survey123 app will appear if updates are available for download.

Accessing Data in the FLOwPER Database

As a contributor to the FLOwPER database, the database is available in AGOL to view and download the data. These data have not been reviewed for accuracy. Please see the section “DISCLAIMER” for more information. Please contact observers’ in-house GIS support for help in accessing the FLOwPER database in the FLOwPER group.

Periodically, FLOwPER observations will be archived in a publicly available FLOwPER database accessed at https://www.sciencebase.gov/catalog/item/5edea67582ce7e579c6e5845.

Maps

Maps can provide orientation and context for taking observations. FLOwPER in Survey123 provides limited internal mapping. Additional maps that include some combination of topography, land cover, the most up-to-date and highest resolution stream network layer, and roads can be generated as a georeferenced map and uploaded into Survey123 or a separate mobile application (for example, Avenza®) to be used while completing FLOwPER. Contact user agency’s GIS support for more details.

Troubleshooting

EOS Arrow 100 Global Positioning Satellite Unit Is Not Working

1. Make sure GPS unit is powered on (red indicator light is illuminated and not flashing).
   a) If not powered on, hold power button for 5 seconds until a red light appears.
2. If GPS unit is not powering on, try re-seating the battery.
3. If GPS unit is still not powering on, the battery may be dead. Charge the GPS unit with the correct power adaptor.
4. Make sure Bluetooth on the GPS unit is paired with the mobile device (blue indicator light is illuminated and not flashing).
5. Make sure the GPS unit is functioning (green GPS indicator light is illuminated and not flashing) (fig. 24).
6. Run diagnostic check in EOS Tools Pro (see “Diagnostic Check in EOS Tools Pro” below)

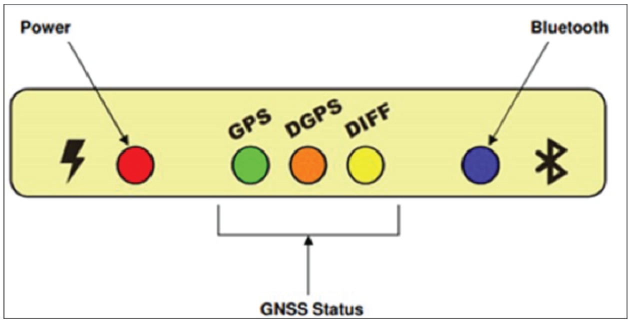

Figure 24. Screen capture showing EOS Arrow 100 GPS unit display on side of unit that indicates power, Bluetooth status, and Geographic Names Information system status.

EOS Arrow GPS Unit is Reporting Poor Quality Positions

1. Make sure GPS unit is working properly (see section on “EOS Arrow 100 GPS Unit Not Working”).
2. Make sure high precision modes are functioning.
3. Check if GPS unit is in DGPS mode (orange indicator light is illuminated and not flashing).
4. Check if GPS unit is in DIFF mode (yellow indicator light is illuminated and not flashing).
5. Follow instructions in “Diagnostic Check in EOS Tools Pro.

Diagnostic Check in EOS Tools Pro

1. Download the EOS Tools Pro application from the mobile device’s app store.
2. Open EOS Tools Pro application on the mobile device.
    a) Make sure the GPS unit is connected to the mobile device as indicated by a BLUE colored Bluetooth icon in the top right of the screen.

b) If not connected, click the kebab menu (three vertical dots icon) and select “**Start GPS**” (fig. 25).

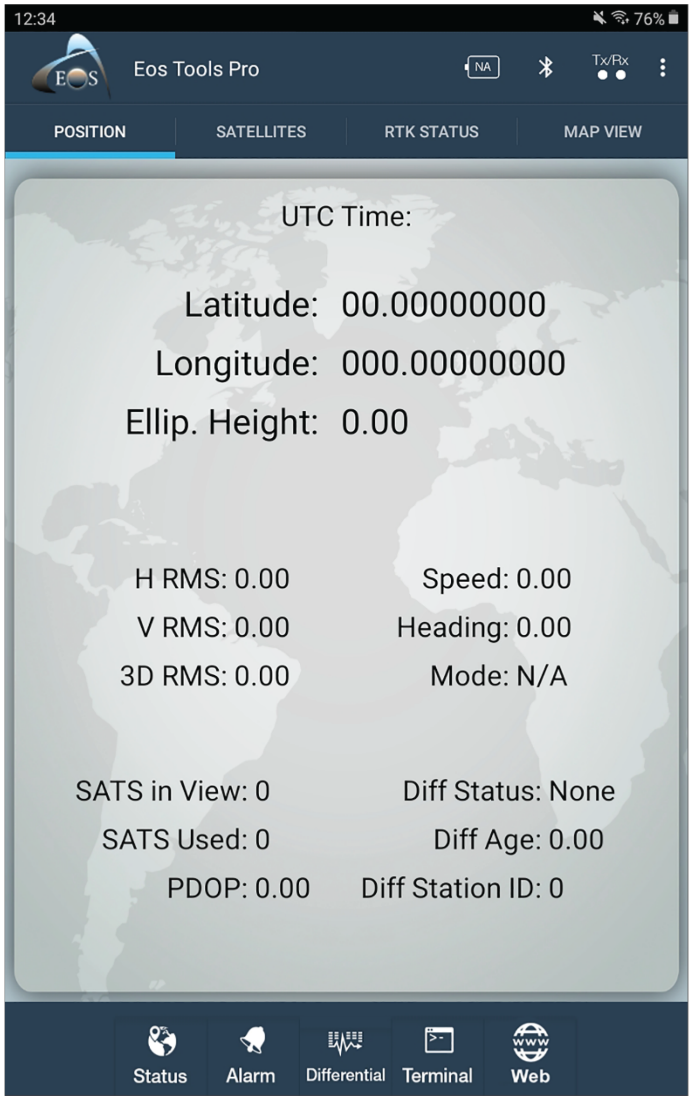

Figure 25. Screen capture showing EOS Tools Pro application on an Android tablet. [Bluetooth indicator and kebab menu (three vertical dots icon) are in the upper right corner of the screen.]

3. If the GPS unit still does not connect, reboot the mobile device and the GPS unit.
4. Check **Latitude/Longitude** stability. If the third and fourth digits are not stable, there is a poor GPS position.
5. To ascertain GPS position quality check:

   a) **H RMS:** If this is more than 2 meters, it’s a poor position.

b) **SATS Used:** If this is less than 5, expect to have a poor position.
   i. In a clear open sky, 9+ satellites should be in view and being used. In a highly constrained valley, it would be normal to only have three to five usable satellites. If this constraint does not apply to observers' position, reboot the GPS unit-and wait **NO MORE THAN 10 minutes** to get **H RMS** down to less than or equal to 2 meters. If it never drops below 2, just take a position anyway.

c) **PDOP**: Should be less than two but no more than four. In a highly constrained valley that has no southern or northern visibility this might be more than four.

d) **Diff Status**: Should read DGPS; if reads anything else, try elevating the antenna or moving to a slightly different position in the stream channel for a clear view of the sky. Wait no more than 10 minutes to get a Diff Status change.

6. **Bottom line**: Wait no more than 10 minutes to obtain **H RMS** below 2 meters. Under dense canopy in a valley, **H RMS** may not reach below 2 meters. If position is worse than 10 meters **H RMS**, reboot mobile device and GPS unit and wait 2 more minutes. If position never improves, take the position and make a note in the comments section regarding poor GPS quality.

How to Recover Survey 123 Data that is Not Uploading

Contact agency's FLOwPER coordinator for help or agency's GIS support staff.

How to Download FLOwPER Data from AGOL FLOwPER User Group

1. Go to the FLOwPER v2 feature layer.
2. Select "Export Data".
3. Select preferred export format.
4. Provide a tag (can be any user specified language) and the "Export" button will darken and can then be selected.

Acknowledgments

We thank B. Staab, K. Hafen, R. Sando, and R. McShane for discussions leading to development of the FLOwPER database and app. We also thank C. Cheng and J. Ebersole for their constructive reviews.

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Appendix 1. FLOwPER Quick Guide 2.0

See User's Guide for more complete information. FLOwPER Quick Guide is available as a separate downloadable file at https://pubs.er.usgs.gov/publication/ofr20201075.

1. **Observer Name** (enter text)
2. **Organization** (choose one)
   - 1.1. USFS
   - 1.2. USGS
   - 1.3. BLM
   - ….many choices not shown…
   - 1.12. Other
3. **Sampling Scheme**
   - 3.1. Opportunistic (default)
   - 3.2. Designed
     - 3.1.1. Plot ID
4. **Date of Observation** (automated)
5. **Location of Observation** (automated)
6. **Stream Name**
   - 6.1. Yes (if USGS name known)
     - 6.1.1. Name: (enter text)
   - 6.2. No
7. **Flow Status** *(*current flow condition observed in 10-m observation reach*)*
   - 7.1. Continuous Flow
   - 7.2. Discontinuous flow
   - 7.3. Dry
   - 7.4. No data
8. **Stream Type** *(*choose one or enter text*)*
   - 8.1. Natural channel
   - 8.2. Leveed or channelized
   - 8.3. Ditch or canal
   - 8.4. Other (enter text)
9. **Channel Bed** (choose one)
   - 9.1. No obvious channel
   - 9.2. Fine sediment (clay, silt, mucky)
   - 9.3. Coarse sediment (sand, gravel cobble)
   - 9.4. Bedrock
   - 9.5. Artificial (concrete, riprap)
   - 9.6. No data (default)
10. **Road or Trail Crossing** (Y/N)
    - 10.1. Yes: Continue below
    - 10.2. No: Skip to #11

Crossing Type *(select one)*
- 10.2.1. Culvert
- 10.2.2. Bridge
- 10.2.3. Ford (constructed)
- 10.2.4. Natural crossing
- 10.2.5. Other
- 10.2.6. No data (default)

Observation Direction *(select one)*
- 10.2.7. Upstream of crossing
- 10.2.8. Downstream of crossing
- 10.2.9. No data

Crossing Name *(enter text)*
- 10.2.10. Yes (if road/trail name known)
- 10.2.11. Name: (enter text)
- 10.2.12. No

11. **Special Conditions** (select all that apply)
    - 11.1. Tributary Junction (trib. jct.)
      - 11.1.1. Mainstem: downstream of trib jct.
      - 11.1.2. Mainstem: upstream of trib. jct.
      - 11.1.3. On tributary
    - 11.2. Diversion Junction
      - 11.2.1. Stream: **downstream** of diversion
      - 11.2.2. Stream: **upstream** of diversion
      - 11.2.3. On diversion
    - 11.3. Upstream limit of continuous flow
    - 11.4. Channel Head
      - 11.4.1. Continuous
      - 11.4.2. Discontinuous
12. **Judgement calls - not observed**

(If observer is estimating the expected condition at late summer low flow – then select one):
- 12.1. Likely to be perennial
- 12.2. Likely to be intermittent
- 12.3. Likely to be ephemeral
- 12.4. Likely upstream limit of continuous perennial flow
- 12.5. No data

OPTIONAL DATA - Please do if you have time

13. Bankfull (or active) channel width
    - 13.1. <1 meter
    - 13.2. 1–2 meters
    - 13.3. 2–5 meters
    - 13.4. >5 meters
    - 13.5. No data
14. Active valley floor width (as a multiple of active channel width)
    - 14.1. 1x (no floodplain)
    - 14.2. 2x
    - 14.3. 3x
    - 14.4. 4x
    - 14.5. 5+x or greater
    - 14.6. No data
15. **Max water depth** (enter number)
    - 15.1. *10,000 is null entry (no data)
    - 15.2. Units
    - 15.3. cm
    - 15.4. inches

    Type of water depth observation *(choose one)*

    - 15.5. None
    - 15.6. Measured
    - 15.7. Exceeds recorded value
16. **Pertinent Notes (enter text) & Photos**

FLOwPER Quick Guide 2.0

FLOwPER 2.0 Quick Guide (See User's Guide for more complete information)

Use an ACCURATE External GPS Antenna

The 10-m OBSERVATION REACH:

- Observation is based on estimates averaged over a 10 m (30 ft) reach of stream.
- Ignore portions of the reach obviously disturbed by artificial structures (for example, roads) and (or) associated components (for example, wedges of sediment accumulated above a culvert, plunge-pool below the culvert, etc.).
- ***CRITICAL*** - Record whether reach has continuous flow, discontinuous flow, or is dry
- Observations upstream of the road are preferred.

7. **Flow Status: Observed**

Option 7.1 Continuous Flow denotes visible surface water over the full length of the 10 m observation reach. If there are multiple channels, only a single channel need have continuous flow for the entire reach to be categorized "Continuous Flow."

Option 7.2 Discontinuous Flow is assigned where some portion of the length of the observation reach is dry across the full width of the active channel. If there are multiple channels, then all channels must be dry, at some point along their length.

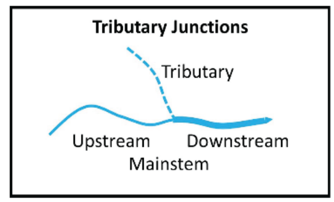
Option 7.3 Dry denotes a channel that has no flowing or standing water anywhere over the length of the 10 m observation reach.

Note: If only a part of the 10-m (30-ft) observation reach is visible, oftentimes when an observer cannot safely exit the vehicle and (or) physically walk the observation reach, the user should make the best judgement on determining the flow status on the part of the observation reach that is visible.

11. **Special Conditions:**

Option 11.1 Tributary Junctions pose a special challenge in that three potentially different stream channels all connect at a single point. FLOwPER data can be collected from any (or all) of the three channels, but they must be labeled as shown because GPS accuracy may not correctly associate the point with the correct channel.

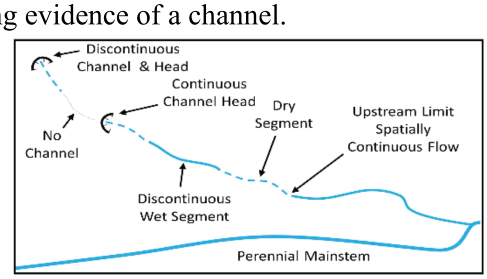
Note: Where two tributaries join to form the mainstem, the larger one should always be denoted as the "upstream mainstem." If they are of exactly equal size, the left-most tributary (looking upstream) should be denoted as the "upstream mainstem."



Option 11.2 Diversion junctions are treated similarly to tributary junctions requiring identification of the specific channel segment on which the observation is made.

Option 11.3 Note the upstream limit of spatially continuous flow on the date of observation. Accurate determination of these points will require walking a substantial portion of the channel. This is the highest point in the stream network below which flowing water is spatially continuous with the remainder of the stream network; above this point the stream is spatially intermittent.

Options 11.4 A continuous channel head is the highest point in the geomorphic channel network, below which a continuous and distinct channel (signs of scour or deposition, vegetation free, and distinct banks; may not have flowing water) connects to the remainder of the channel network. A discontinuous channel head marks the upper most extent of any geomorphic channel that is separated from the continuous channel network downstream by an area lacking evidence of a channel.



12. **Judgement Calls**

In some stream survey protocols, observers use indicators to estimate expected condition at late summer low flow. Locations where late summer conditions are estimated must be identified here and kept distinct from observed conditions recorded in the field at the time of the survey.

OPTIONAL DATA:

Collection of the following variables is optional. We think that these will improve our ability to model the break-point between perennial and intermittent stream reaches. However, we also recognize that these values may be difficult to estimate (or measure in the case of maximum depth) and may become too time consuming.

A Note on Channel & Valley Floor Width:

Channel widths can be estimated. The focus of the variables is to provide an "index" of the capacity of the valley-floor sediment to conduct subsurface flows. Deep and coarse sediment in a steep and wide valley allows substantial subsurface flow and, for a given drainage area, these streams are more likely to be dry. Conversely, if the valley floor is scoured to bedrock, any flow will be visible on the surface so that bedrock channels will be more likely to be perennial.

13. **Bankfull (or Active) Channel Width:**

The stream channel lying below bankfull stage. The channel typically shows signs of recent scour and is free of perennial vegetation (it may be colonized each year by annuals). Recent large floods or debris flows may dramatically increase the width of the scoured zone; scour lines from such events do not represent the true width of the bankfull channel.

Typical indicators of the bankfull stage include (1) The height of depositional features, especially the top of point bars such as gravel bars on the inside of a meander bend, which define the lower possible water level for bankfull stage; (2) a change in vegetation, especially the lower limit of perennial species; (3) a slope break from the flat floodplain to the steeper bank; (4) a change in the particle size of bank material, such as the boundary between coarse cobble or gravel of the streambed with fine-grained sand or silt of the floodplain; (5) undercuts in the bank, which usually reach an interior elevation slightly below bankfull stage; and (6) stain lines or the lower extent of lichens on boulders (modified from Harrelson and others, 1994).

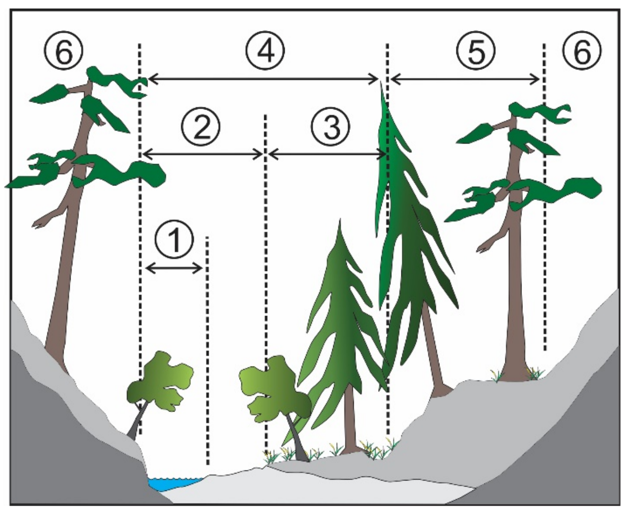
14. **Active Valley Floor Width:**

The portion of the valley floor that can be inundated during floods and where scour and (or) deposition of sediment can occur. The active valley floor includes both the active floodplain and the bankfull channel. Note that floodplains may be discontinuous, present on only one side of the channel, or completely absent (modified from Harrelson and others, 1994). Floodplains can be difficult to identify in steep mountain streams, and in some locations, the active channel may encompass the entire width of the valley so that no floodplain is present.

A Note on Maximum Wetted Depth:

Maximum depth within the wetted channel is measured with a ruler. This will be the deepest single point within the reach. If it is not safe to wade in the stream, or if the water is too deep, then measure the deepest point you can measure safely and enter "Max depth exceeds recorded value" for the "Type of depth observation."

Road-based observers will not be able to collect maximum water depth observations. Leave the null-value of 10,000 and enter "none" for the "Type of depth observation."



Example of a headwater valley showing: (1) wetted channel; (2) bankfull channel; (3) active floodplain; (4) active valley floor; (5) terrace; and (6) uplands / hillslopes. [This example, typical of a small western Oregon stream, shows an unvegetated gravel bar within the bankfull channel and slight differences in vegetation among the other surfaces. Note that the bankfull channel width is included in the width of the active valley floor as shown in this figure, and in this case, the active valley floor is approximately two times the width of the bankfull channel.]

Publishing support provided by the U.S. Geological Survey
Science Publishing Network, Tacoma Publishing Service Center

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Jeager and others—**FLOwPER User's Guide—For Collection of FLOw PERmanence Field Observations**—Open-File Report 2020–1075

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20201075