



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
<i>Author:</i> Nick Harrison	<i>Revision:</i> D

NEON USER GUIDE TO WADEABLE STREAM MORPHOLOGY (DP4.00131.001)

PREPARED BY	ORGANIZATION
Nick Harrison	AQU
Kaelin M. Cawley	AQU
Zachary Nickerson	AQU

CHANGE RECORD

REVISION	DATE	DESCRIPTION OF CHANGE
A	12/07/2017	Initial Release
B	07/17/2020	Included general statement about usage of neonUtilities R package and statement about possible location changes.
B.1	04/20/2021	Updated information on the data tables published in this data product that are not involved with the interannual geomorphology surveys (rapid habitat assessment data and AIS site survey data). Removed information on the data tables that are no longer published in this data product, but are now published in the Stage-discharge rating curves (DP4.00133.001) and Continuous discharge (DP4.00130.001) data products.
C	03/08/2022	Updated section 4.5 Data Revision with latest information regarding data release
D	10/06/2022	Added information pertaining to rapid habitat assessment data



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
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TABLE OF CONTENTS

1	DESCRIPTION	1
1.1	Purpose	1
1.2	Scope	1
2	RELATED DOCUMENTS AND ACRONYMS	2
2.1	Associated Documents	2
2.2	Acronyms	2
3	DATA PRODUCT DESCRIPTION	3
3.1	Spatial Sampling Design	3
3.2	Temporal Sampling Design	3
3.3	Variables Reported	3
3.4	Spatial Resolution and Extent	4
3.5	Temporal Resolution and Extent	4
3.6	Associated Data Streams	4
3.7	Product Instances	5
3.8	Data Relationships	5
3.9	Special Considerations	8
3.9.1	Downloading Stream Morphology Data	8
4	DATA QUALITY	8
4.1	Data Entry Constraint and Validation	8
4.2	Using Google Earth to View .KMZ Maps	9
4.3	Automated Data Processing Steps	9
4.4	Manual Data Processing Steps	9
4.5	Data Revision	9
4.6	Uncertainty	9
4.7	Quality Flagging	10



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
<i>Author:</i> Nick Harrison	<i>Revision:</i> D

LIST OF TABLES AND FIGURES

Table 1	L4 data packages available via direct download from the NEON portal	6
Table 2	Files used in L4 and L0 rapid habitat assessment data packages	6
Table 3	Files used in L4 and L0 geomorphology survey data packages	7



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
<i>Author:</i> Nick Harrison	<i>Revision:</i> D

1 DESCRIPTION

1.1 Purpose

This document provides an overview of the data included in this NEON Level 4 data product, the quality controlled product generated from raw Level 0 data, and associated metadata. In the NEON data products framework, the raw data collected in the field, for example, total station survey data derived from a single geomorphology survey, are considered the lowest level (Level 0). Raw data that have been quality checked via the steps detailed herein, as well as simple metrics that emerge from the raw data are considered Level 4 data products.

The text herein provides a discussion of measurement theory and implementation, data product provenance, quality assurance and control methods used, and approximations and/or assumptions made during L4 data creation.

1.2 Scope

This document describes the steps needed to generate the L4 data product, Wadeable Stream Morphology - the characterization of stream channel geometry and demarcation of biological habitats and stream channel features within NEON aquatic stream reaches - and associated metadata from input data. This document also provides details relevant to the publication of the data products via the NEON data portal, with additional detail available in the file, NEON Data Variables for Wadeable Stream Morphology (DP4.00131.001) (AD[05]), provided in the download package for this data product.

This document describes the process for ingesting and performing automated quality assurance and control procedures on the data collected in the field pertaining to AOS Protocol and Procedure: Wadeable Stream Morphology (AD[06]). The raw data that are processed in this document are detailed in the file, NEON Raw Data Validation for Wadeable Stream Morphology (DP0.00131.001) (AD[03]), provided in the download package for this data product. Please note that raw data products (denoted by 'DP0') may not always have the same numbers (e.g., '00131') as the corresponding L4 data product.



2 RELATED DOCUMENTS AND ACRONYMS

2.1 Associated Documents

AD[01]	NEON.DOC.000001	NEON Observatory Design (NOD) Requirements
AD[02]	NEON.DOC.002652	NEON Data Products Catalog
AD[03]	Available with data download	Validation csv
AD[04]	Available with data download	Variables csv
AD[05]	NEON.DOC.001152	NEON Aquatic Sample Strategy Document
AD[06]	NEON.DOC.003162	AOS Protocol and Procedure: Wadeable Stream Morphology
AD[07]	NEON.DOC.000008	NEON Acronym List
AD[08]	NEON.DOC.000243	NEON Glossary of Terms
AD[09]	NEON.DOC.004825	NEON Algorithm Theoretical Basis Document: OS Generic Transitions
AD[10]	Available on NEON data portal	NEON Ingest Conversion Language Function Library
AD[11]	NEON.DOC.004857	NEON Standard Operating Procedure: Post-processing of Wadeable Stream Morphology Data from NEON Wadeable Streams
AD[12]	Available on NEON data portal	NEON Ingest Conversion Language
AD[13]	Available with data download	Categorical Codes csv

2.2 Acronyms

Acronym	Definition
DP	Data Product
GPS	Global Positioning System
L0	Level 0
L4	Level 4
UTM	Universal Transverse Mercator



Title: NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	Date: 10/06/2022
Author: Nick Harrison	Revision: D

3 DATA PRODUCT DESCRIPTION

The wadeable stream morphology data product provides raw survey data, maps, shapefiles, and metric tables that quantify stream channel geomorphology and bed composition and delineate biological habitats within the aquatic reach boundaries (approximately 1,000 meters in stream length) of wadeable streams at NEON aquatic sites. Raw survey data is collected with high-resolution total station survey equipment at each NEON wadeable stream site. Survey maps and channel metrics are produced and calculated using raw survey data (Level 0) that is geo-referenced to a global coordinate system (Level 4).

3.1 Spatial Sampling Design

Geomorphology surveys encapsulate the entirety of the aquatic reach, which at most NEON sites is equivalent to approximately 1,000 meters in stream length.

As much as possible, sampling occurs in the same locations over the lifetime of the Observatory. However, over time some sampling locations may become impossible to sample, due to disturbance or other local changes. When this occurs, the location and its location ID are retired. A location may also shift to slightly different coordinates. Refer to the locations endpoint of the NEON API for details about locations that have been moved or retired: <https://data.neonscience.org/data-api/endpoints/locations/>

3.2 Temporal Sampling Design

All survey data is reported at the temporal resolution of a single survey, which, depending on the complexity of the aquatic reach and/or environmental conditions during the survey, can last 3-10 days.

3.3 Variables Reported

All variables reported from the field (L0 data) are listed in the file, NEON Raw Data Validation for Wadeable Stream Morphology (DP0.00131.001) (AD[03]). All variables reported in the published data (L4 data) are also provided separately in the file, NEON Data Variables for Wadeable Stream Morphology (DP4.00131.001) (AD[04]).

Field names have been standardized with Darwin Core terms (<http://rs.tdwg.org/dwc/>; accessed 16 February 2014), the Global Biodiversity Information Facility vocabularies (<http://rs.gbif.org/vocabulary/gbif/>; accessed 16 February 2014), the VegCore data dictionary (<https://projects.nceas.ucsb.edu/nceas/projects/bien/wiki/VegCore>; accessed 16 February 2014), where applicable. NEON AOS spatial data employs the World Geodetic System 1984 (WGS84) for its fundamental reference datum and Earth Gravitational Model 96 (EGM96) for its reference gravitational ellipsoid. Latitudes and longitudes are denoted in decimal notation to six decimal places, with longitudes indicated as negative west of the Greenwich meridian.

Some variables described in this document may be for NEON internal use only and will not appear in downloaded data.



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
<i>Author:</i> Nick Harrison	<i>Revision:</i> D

3.4 Spatial Resolution and Extent

A raw survey data file includes each of the individually mapped points collected by the total station during the geomorphology survey. Each point contains a Northing, Easting, and elevation coordinate relative to fixed benchmarks installed at the downstream extent of the reach (where the surveys typically begin). Mapped points are distributed at a high resolution (typically less than 1m) throughout the extent of the aquatic reach. Points are mapped along the main channel to capture thalweg (or the deepest part of the stream) elevation, along the edge of water to capture wetted width, and along select transects that run perpendicular to the channel in order to capture cross-sectional area. Additional points are collected at stream features that locally influence fluvial processes (i.e. large woody debris jams, mid-channel bars, etc.).

Northing, Easting, and elevation data contained in raw survey files are relative to a local Cartesian coordinate plane (X,Y, and Z, respectively) defined by the fixed benchmark used to orient the total station at the beginning of the survey. Fixed benchmark locations are globally referenced (WGS 84 reference coordinate system) and locally projected (UTM Zone xNorth) using global positioning instrumentation to an accuracy of 10-30 centimeters of elevation. The degree of additional uncertainty associated with each survey will vary and is dependent on operator error, site-specific conditions, and environmental factors. Uncertainty associated with each survey is included within the data product package. During post-processing, GPS data is utilized to convert Northing and Easting values to latitude and longitude and elevation values to meters above mean sea level. All geo-referenced survey data is considered Level 4.

3.5 Temporal Resolution and Extent

Geomorphology surveys are conducted at each site once every five years or immediately following a storm event deemed to have significantly altered stream morphology within the aquatic reach. Geomorphology surveys conducted immediately after a stochastic event will assess event magnitude by quantifying changes in channel geometry, bed composition, and biological habitat.

During each year there is not a geomorphology survey, there will be a rapid habitat assessment in the same reach that includes a pebble count survey and geo-referencing and characterization of each habitat unit in the morphology reach.

3.6 Associated Data Streams

Cross-section survey data measured at the stream-discharge transect, staff gauge elevation measured during geomorphology surveys, and rating curve identification metadata are collected during geomorphology surveys and published in the Stage-discharge rating curves data product (DP4.00133.001) and Continuous discharge data product (DP4.00130.001) in order to identify, assess, and/or validate potential shifts in stage-discharge relationships at given sites and to relate streamflow to stage level, respectively.



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
<i>Author:</i> Nick Harrison	<i>Revision:</i> D

3.7 Product Instances

A minimum of one geomorphology survey will be conducted at each NEON aquatic site with a wadeable stream every five years. This will result in approximately seven geomorphology surveys per year across the NEON Observatory. Additional surveys will occur at each site between 5-year rotations following qualifying stochastic events. One rapid habitat assessment will be conducted at each NEON aquatic site with a wadeable stream each year there is not a geomorphology survey.

3.8 Data Relationships

Geomorphology survey and rapid habitat assessment data consist of two separate sets of files, which are stored and accessed differently. One set of files is available by download from the NEON data portal. These files contain links pointing to the cloud-storage locations of the other set of files.

File availability within both direct download and cloud-based packages may vary by site and survey date. For example, if sensors were not present at the site during the survey the sensor.shp, S1S2habitatIDS.csv, and S1S2Length.csv files will not be present in the cloud-based package as those data were not captured during the survey. Similarly, if a missing line workflow was not performed during a given survey the geoMissingLine.CSV file will not be present in the direct download package.

Each data file corresponds with specific characteristics of the aquatic reach and many are inter-related. For example, the thalwegLongProfile.csv file details thalweg elevation throughout the reach and the thalwegByHabitatID.csv file details how different habitat unit types comprise the long profile. Using ArcGIS software, data contained in the .csv files can be spatially represented by associated shapefiles.

Data downloaded from the NEON Data Portal are provided in separate data files for each site and month requested. The neonUtilities R package contains functions to merge these files across sites and months into a single file for each table described above. The neonUtilities package is available from the Comprehensive R Archive Network (CRAN; <https://cran.r-project.org/web/packages/neonUtilities/index.html>) and can be installed using the install.packages() function in R. For instructions on using neonUtilities to merge NEON data files, see the Download and Explore NEON Data tutorial on the NEON website: <https://www.neonscience.org/download-explore-neon-data>

L4 and L0 data packages available from cloud-based storage locations using URL paths contained in direct download files (see “Special Considerations” section for access instructions).



Table 1: L4 data packages available via direct download from the NEON portal

File Name	File Format	File Description
geo_mappedPointErrors	.CSV	Data associated with mapped points that contain errors
geo_pebbleCount	.CSV	Data associated with pebble count surveys
geo_featureInfo	.CSV	Data associated with mapped geomorphic features
geo_totalStation	.CSV	Data associated with each total station location utilized during the survey
geo_missingLine	.CSV	Data associated with the missing line workflow utilized to orient the total station at the beginning of the survey
geo_surveyFieldData	.CSV	Data associated with the survey and the large woody debris count
geo_resultsFile	.CSV	Data that contains basic information about the survey and URLs to access cloud-storage data packages
geo_rapidHabitatResultsFile	.CSV	Data that contains basic information about the annual Rapid Habitat Assessment survey and URLs to access cloud-storage data products

Table 2: Files used in L4 and L0 rapid habitat assessment data packages

File Name	File Format	File Description
RAW data file	.SSF	All raw rapid habitat assessment data collected on a Trimble GPS
PROCESSED data file	.CSV	All survey data, geo-referenced and organized by habitat unit



Table 3: Files used in L4 and L0 geomorphology survey data packages

File Name	File Format	File Description
featureCount	.CSV	Type and frequency of geomorphic features
processedSurveyPts	.CSV	All survey data, geo-referenced and organized by mapCode
S1S2habitatIDs	.CSV	Geo-referenced location and habitat unit of each sensor set
S1S2Length	.CSV	Stream length and slope between sensor sets
thalwegLongProfile	.CSV	Geo-referenced thalweg survey data
thalwegByHabitatType	.CSV	Stream length, area, and percent of total reach length per each habitat unit type delineated. Also provides summation of stream length and total area of each habitat unit type as well as the total reach slope
thalwegByHabitatID	.CSV	Stream length, area, and percent of total stream length of each individual habitat unit delineated
transectBankfullWidths	.CSV	Bankfull width of each measured transect
processedTrimbleData	.CSV	Documents spatial uncertainty values associated with global positioning instrumentation (Trimble) data
geomorphicFeaturePoints	.SHP	Shapefile that displays all geomorphic features delineated using single points (i.e. upstream/downstream waterfall boundaries and tributary locations)
geomorphicFeaturePolygons	.SHP	Shapefile that displays all geomorphic features delineated using polygons (multiple points) (i.e. mid-channel bars, islands, large woody debris jams, beaver dams, etc.)
habitatUnits	.SHP	Shapefile that displays habitat unit boundaries throughout the reach
sensors	.SHP	Shapefile that displays sensor set locations within reach
thalweg	.SHP	Shapefile that displays thalweg line throughout reach
transects	.SHP	Shapefile that displays transect locations throughout reach
siteMap	.PDF	PDF map of the aquatic reach that features the reach boundary, transect, aquatic sensor, and staff gauge locations as well as biological habitat delineations along the thalweg line
siteMap	.KMZ	KMZ map of the aquatic reach that can be viewed using Google Earth software. This map features habitat unit delineations, sensor set and transect locations, the thalweg profile, and all geomorphic feature points and polygons mapped during the survey
geomorphReadMe	.TXT	Text file that documents site specifications and/or survey deviations



Title: NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	Date: 10/06/2022
Author: Nick Harrison	Revision: D

3.9 Special Considerations

3.9.1 Downloading Stream Morphology Data

To download L4 and L0 stream morphology and rapid habitat assessment data packages:

1. Access the NEON data portal and select the desired data product (Stream Morphology Map in Eco-Hydrology and Land Use, Land Cover, and Land Processes Data Products), date range, and location (state and site).
2. Download the L4 dataset and open the **geo_resultsFile.csv** or **geo_rapidHabitatResultsFile.csv**. The full formatted name of these zipped files will appear as “NEON.DOM.SITE.DP4.00131.001.geo_resultsFile.YYYY-MM.basicstranitionDate.csv” or “NEON.DOM.SITE.DP4.00131.001.geo_rapidHabitatResultsFile.YYYY-MM.basicstranitionDate.csv”. Note that “DOM” is the NEON Domain number and “YYYY-MM” is the year and month of the date range specified.
3. To access cloud-based L4 data products, links to the location are provided in the **dataFilePath** field of the **geo_resultsFile.csv** and **geo_rapidHabitatResultsFile.csv** files. To access cloud-based L0 data products, links to the cloud-storage location are provided in the **rawDataFilePath** field.
4. Copy the URL provided in the **dataFilePath** field into a web browser to initiate the download of the L4 survey data package.
5. Copy the URL provided in the **rawDataFilePath** field into a web browser to initiate the download of the L0 survey data package.

4 DATA QUALITY

4.1 Data Entry Constraint and Validation

Data entry constraint and validation apply solely to the metadata associated with this data product. Many quality control measures are implemented at the point of data entry within a mobile data entry application. For example, data formats are constrained and data values controlled through the provision of dropdown options, which reduces the number of processing steps necessary to prepare the raw data for publication. An additional set of constraints are implemented during the process of ingest into the NEON database. The product-specific data constraint and validation requirements built into data entry applications and database ingest are described in the document NEON Raw Data Validation for Wadeable Stream Morphology (DP0.00131.001), provided with every download of this data product. Contained within this file is a field named ‘entryValidationRulesParser’, which describes syntactically the validation rules for each field built into the data entry application. Data entry constraints are described in Nicl syntax in the validation file provided with every data download, and the Nicl language is described in NEON Ingest Conversion Language (NICL) specifications ([AD[10]]).



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
<i>Author:</i> Nick Harrison	<i>Revision:</i> D

4.2 Using Google Earth to View .KMZ Maps

Geomorphic feature polygon layers may not be immediately visible while using Google Earth software to view .KMZ morphology maps. Controlling the way multiple layers are drawn into Google Earth is a known issue and (to date) a solution has not been identified to stack layers in a customized manner. Therefore geomorphic feature polygons may be hidden by habitat unit polygons (sometimes a black outline of the geomorphic feature polygon is present). To fully view geomorphic feature polygons, turn off the habitat units polygons by unchecking the box to the left of the feature name.

4.3 Automated Data Processing Steps

Following the entry of metadata into a mobile application or web user interface, the steps used to process the data through to publication on the NEON Data Portal are detailed in the NEON Algorithm Theoretical Basis Document: OS Generic Transitions (AD[09]).

4.4 Manual Data Processing Steps

Manual data processing transforms survey data from raw L0 data to an L4 data product. During this time QA/QC procedures are performed. QA/QC procedures include a careful evaluation of field survey notes (contained in the metadata) that document errors that occurred during the survey. If notes indicate that L0 needs to be altered or deleted during post-processing these changes are addressed and subsequently expressed in the L4 product. Field survey errors may include mis-labeled points, elevation errors due to an incorrect height of rod, mapped points that require deletion, or a variety of other instances. Additional post-processing procedures (including raw survey data transformation, polyline and polygon file creation, and metric generation) are detailed in NEON Standard Operating Procedure: Post-Processing of Wadeable Stream Morphology Data from NEON Wadeable Streams (AD[11]).

4.5 Data Revision

All data are provisional until a numbered version is released. Annually, NEON releases a static version of all or almost all data products, annotated with digital object identifiers (DOIs). The first data Release was made in 2021. During the provisional period, QA/QC is an active process, as opposed to a discrete activity performed once, and records are updated on a rolling basis as a result of scheduled tests or feedback from data users. The Issue Log section of the data product landing page contains a history of major known errors and revisions.

4.6 Uncertainty

Spatial datasets are not a seamless representation of real-world phenomena. Spatial uncertainty varies within each survey and is reported within the metadata package (aos_stream_morphology_prod_station.csv) and within the L4 data package (DOM_SiteID_processedTrimbleData.csv).



<i>Title:</i> NEON User Guide to Wadeable Stream Morphology (DP4.00131.001)	<i>Date:</i> 10/06/2022
<i>Author:</i> Nick Harrison	<i>Revision:</i> D

A HILTI POS 180 Robotic Total Station and POC data collector are used to spatially map the aquatic reach during geomorphology surveys. The POS 180 contains angle measurement accuracy (DIN 18723) of 3", a distance measurement accuracy of $\pm 2 \text{ mm} + 2 \text{ ppm}$ and a magnification of 31x. The measurement range of the instrument is 79" to 9843'. Standard deviation values are reported and documented for each total station setup throughout the survey. The best effort is made to minimize standard deviations to $\leq 5 \text{ mm}$ per total station setup, however this is not always possible given certain site conditions (i.e. unstable ground surfaces or extreme weather).

A Trimble GeoXH 6000 or 7000 series GPS unit with Tornado antenna is used to collect survey grade GPS locations at benchmarks or control points throughout the geomorphology survey. Differential correction is applied during post-processing to improve GPS accuracy and reduce atmospheric errors by comparing the time signature at a fixed base station (typically CORS [Continuously Operating Reference Station]) nearby the rover file from the Trimble unit. The resulting file defines a horizontal and vertical accuracy using the root mean square error based on a 68% confidence level. NEON has aimed to utilize post-processed GPS positions that are within a horizontal and vertical precision of 10cm. Due to dense canopy at some sites and/or distance from base stations, not all GPS points surveyed fall within the desired range.

4.7 Quality Flagging

A geomorphReadMe.txt file is included in the L4 data package documents site if specifications and/or survey deviations specific to the product were documented during post-processing of the L0 data.

Records of land management activities, disturbances, and other incidents of ecological note that may have a potential impact are found in the Site Management and Event Reporting data product (DP1.10111.001)