

# Package ‘StreamNetworkTools’

October 10, 2018

**Title** Characterizing Topology and Planform Geometry of NHDPlusV2  
Stream Networks

**Version** 1.0.0.000

**Description** An R package to derive covariates from the NHDPlusV2 dataset and facilitate continental scale analyses of river networks.

**Depends** R (>= 3.4.2)

**License** Ask Mike

**Encoding** UTF-8

**LazyData** true

**Imports** foreign, sf, sp, rgdal, rgeos, dplyr, reshape2

**RoxygenNote** 6.1.0

**Suggests** knitr, rmarkdown

**VignetteBuilder** knitr

**NeedsCompilation** no

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cat_shp	<i>Catchment Shape</i>
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**Description**

Calculates metrics related to catchment shape very slowly.

**Usage**

```
cat_shp(netcat)
```

**Arguments**

netcat                      output from [net\\_cat](#)

**Value**

data.frame: group.comid root COMID of network; net.comid COMID upstream of root COMID, indexes catchments; \$basin\_len length of basin, longest distance between two catchment vertices; \$basin\_area area of catchment; \$basin\_width basin\_area / basin\_len

**Examples**

```
# identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
# identify catchments
c <- net_cat(netdelin = b, vpu = "01", nhdplus_path = getwd(), dissolve = "N")
calculate basin shape
d <- cat_shp(netcat = c, vpu = "01", nhdplus_path = getwd())
```

---

net_calc	<i>Network Topology Metrics</i>
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**Description**

Calculates stream network topology metrics

**Usage**

```
net_calc(netdelin, vpu, nhdplus_path)
```

**Arguments**

netdelin                      output from `net_delin`  
vpu                            NHDPlusV2 Vector Processing Unit  
nhdplus\_path                  Directory for NHDPlusV2 files ([net\\_nhdplus](#))

## Details

Requires /NHDPlusAttributes directory (see [net\\_nhdplus](#))

Length and area measures are scaled by M values

## Value

data.frame: \$group.comid stream network root COMID; \$vpu NHDPlusV2 vector processing unit; M Position of sampling point on COMID, as proportion of COMID from upstream end; WS.ord strahler order for root node; \$head.h2o number of headwater reaches; \$trib.jun number of tributary junctions; reach.cnt number of reaches in network; diver.cnt count of divergent flow paths; \$AREASQKM drainage area (km<sup>2</sup>); \$LENGTHKM total length of network flowlines (km); drain.den drainage density (LENGTHKM / AREASQKM)

## Examples

```
# identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
calculate topology summary
c <- net_calc(netdelin = b, vpu = "01", nhdplus_path = getwd())
```

---

net_cat	<i>NHDPlus Catchment</i>
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## Description

Identifies catchments associated with network COMID

## Usage

```
net_cat(netdelin, vpu, nhdplus_path, dissolve)
```

## Arguments

netdelin	output from link{net_delin}
vpu	NHDPlusV2 Vector Processing Unit
nhdplus_path	Directory containing NHDPlusV2 see (net_nhdplus)
dissolve	dissolve catchments (Y/N)

## Details

catchment polygons can be used to associate landscape attributes to NHDPlusV2 flowlines (COMID).

Requires NHDPlusCatchment directory

see ([http://www.horizon-systems.com/NHDPlus/NHDPlusV2\\_documentation.php](http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php)) for information about Watershed boundary dataset and its use in NHDPlusV2 Only catchments matching network COMID are returned in sf object

## Value

named list: `$sf_obj` is simple features object; `$group.comid` root COMID of network; `$net.comid` COMID upstream of root COMID; `vpu` NHDPlusV2 Vector Processing Unit. `$na_cat` contains comids without catchment `$na_cat` records comid's without catchment (see Details)

## Examples

```
#' # identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
c <- net_cat(netdelin = b, vpu = "01", nhdplus_path = getwd(), dissolve = "N")
#plot catchments
plot(st_geometry(c$sf_obj))
#write sf object as shapefile
sf::write(c$sf_obj, paste(getwd(), "c.shp", sep = ""))
```

---

net\_clim

*Network Climate Metrics*

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## Description

Climate metrics derived from PRISM 1971-2001 mean monthly and mean annual temperature and precipitation normals in NHDPlusV2 value added attribute extension tables

## Usage

```
net_clim(nhdplus_path, vpu, netdelin)
```

## Arguments

nhdplus_path	Directory for NHDPlusV2 files ( <a href="#">net_nhdplus</a> )
vpu	NHDPlusV2 Vector Processing Unit
netdelin	output from <a href="#">net_delin</a>

## Details

See (<http://www.worldclim.org/bioclim>) for more informaton on climate metrics

Requires "/VPUAttributeExtension" directory see([net\\_nhdplus](#))

## Value

data.frame: `$net.id` Unique identifier of network; `$group.comid` Root COMID of network; `$vpu` NHDPlusV2 Vector Processing Unit; `$MISSDATAA.x` area of missing temperature data; `$TEMPVC` mean annual temperature (deg C); `$seasonality_t` Coefficient of variation of mean monthly temperatures; `$warm_mo` 2-digit warmest month; `$warm_mo_t` mean temperature of warmest month; `$cold_mo` 2-digit coldest month; `$cold_mo_t` mean temperature of coldest month; `$diff_t` difference between warm and cold monthly temperatures; `$warm_q_t` mean temperature of warmest quarter; `$warm_q` 2-digit warmest quarter; `$cold_q_t` mean temperature of coldest quarter; `$cold_q` 2-digit coldest quarter; `$MISSDATAA.y` area of missing precipitation data; `$PRECIPVC` cumulative mean

annual precipitation (mm); \$wet\_mo 2-digit wettest month; \$wet\_mo\_p cumulative mean precipitation of wettest month; \$dry\_mo 2-digit driest month; \$dry\_mo\_p cumulative mean precipitation of driest month; \$seasonality\_p coefficient of variation of mean monthly precipitation; \$wet\_q\_p cumulative mean precipitation of wettest quarter; \$wet\_q 2-digit wettest quarter; \$dry\_q\_p cumulative mean precipitation of driest quarter; \$dry\_q 2-digit driest quarter; \$dry\_q\_t mean temperature of driest quarter; \$wet\_q\_t mean temperature of wettest quarter; \$warm\_q\_p cumulative mean precipitation of warmest quarter; \$cold\_q\_p cumulative mean precipitation of coldest quarter

## Examples

```
# identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
# derive climate summary
c <- net_clim(netdelin = b, vpu = "01", nhdplus_path = getwd())
```

---

net_comid	<i>Identify NHDPlusV2 COMID</i>
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## Description

Identifies NHDPlusV2 COMID closest to sampling point

## Usage

```
net_comid(sample_points, CRS, nhdplus_path, vpu, maxdist)
```

## Arguments

sample_points	location data.frame. fields must be ordered and named as "SITE_ID", "X" and "Y"
CRS	coordinate reference system of locations (see Details)
nhdplus_path	directory for NHDPlusV2 files
vpu	NHDPlusV2 vector Processing Unit
maxdist	search radius around points (m)

## Details

NHDSnapshot and NHDPlusAttributes are required NHDPlusV2 files (see [net\\_nhdplus](#))

CRS examples: CRS = 4269 = NAD83 (see <https://epsg.io/4269>); CRS = 5070 = NAD83/CONUS Albers (see <https://epsg.io/5070>)

## Value

data.frame with site information (i.e. \$SITE\_ID, \$X, and \$Y) and \$snap\_dist distance (m) to nearest COMID; \$snap\_x, \$snap\_y, coordinates of nearest COMID vertex; \$M Position of sampling point on COMID, as proportion of COMID from upstream end; COMID common identifier of NHDPlusV2 flowline; GNIS\_NAME Geographic Names Information System name of COMID; ApproxTOTDASQKM drainage area at COMID outlet, may overestimate drainage area if \$M < 1; and STREAMORDE Stream order from NHDPlusV2 Value Added Attributes.

## Examples

```
#read example locations from VPU 11
ExLoc <- read.csv("Sample_Locations.csv")
# reorder and rename location data.frame
ExLoc <- ExLoc[,c("SiteName", "W", "N")]
names(ExLoc) <- c("SITE_ID", "X", "Y")
#find nearest NHDPlusV2 COMID
sam_pts <- net_comid(sample_points = ExLoc, CRS = 4269,
                     nhdplus_path = getwd(), vpu = 11, maxdist = 200)
```

---

net\_conflu

*Network Confluence Attributes*

---

## Description

Calculates metrics related to network confluences

## Usage

```
net_conflu(netdelin, nhdplus_path, vpu)
```

## Arguments

netdelin	output from net_delin
nhdplus_path	directory containing NHDPlusV2 <a href="#">net_nhdplus</a>
vpu	NHDPlusV2 Vector Processing Unit

## Details

requires "/NHDPlusAttributes" directory [net\\_nhdplus](#)

netdelin projection is transformed to Lambert Conformal Cone (crs = 102004) to preserve angles Seybold et al. (2017)

Complex confluences are given value of NA

CRS examples: CRS = 4269 = NAD83 (see <https://epsg.io/4269>); CRS = 5070 = NAD83/CONUS Albers (see <https://epsg.io/5070>)

## Value

data.frame: \$net.id unique network identifier; \$group.comid root COMID for network; \$net.comid COMID for upstream reaches \$vpu Vector Processing Unit; \$CRS coordinate reference system; \$X and \$Y confluence coordinates; trib\_order order of COMID downstream of confluence; area\_ratio drainage areas ratios (i.e. Tributary Drainage Area / Mainstem Drainage Area); trib\_area drainage area upstream of confluence; junction\_num is a concatenation of of strahler stream orders of confluence reaches (e.g 11 is confluence of 2 first orders, and 23 is a second order joining a third order); alpha is the angle of (degrees) tributary junction; complex indicates complex tributary junction

## Examples

```
# identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
# calculate confluence metrics
h <- net_conflu(netdelin = c, vpu = "01", nhdplus_path = getwd())
```

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net\_delin

*Network Delineation*


---

## Description

Identifies all flowlines within a stream network upstream of a NHDPlusV2 COMID (see [net\\_sample](#) or [net\\_comid](#)).

## Usage

```
net_delin(group_comid, nhdplus_path = getwd(), vpu, M = NULL,
  snap_xy = NULL)
```

## Arguments

group_comid	a vector of NHDPlusV2 COMIDs
nhdplus_path	Directory for NHDPlusV2 files ( <a href="#">net_nhdplus</a> )
vpu	NHDPlusV2 Vector Processing Unit
M	Position of sampling point on COMID (optional). Generated from <a href="#">net_comid</a>
snap_xy	coordinates of sampling point on COMID (optional). Generated from <a href="#">net_comid</a>

## Details

see NHDPlusV2 Documentation [http://www.horizon-systems.com/NHDPlus/NHDPlusV2\\_data.php](http://www.horizon-systems.com/NHDPlus/NHDPlusV2_data.php))

Requires /NHDPlusAttributes and NHDSnapshot directories (see [net\\_nhdplus](#))

All input COMID are delineated. Nested COMIDs occur when two input comid are in the same network. If nested comids are unexpected or unwanted, remove from \$SF\_Obj and \$Network before proceeding

## Value

Named list (\$Network, \$Nested\_COMIDs, \$SF\_Obj). \$Network stores COMID as data.frame: \$Network\$group.comid Root COMID for network; \$Network\$net.comid COMID's upstream of root; \$Network\$vpu Vector Processing Unit; \$Network\$M Position of sampling point on COMID, as proportion of COMID from upstream end; \$Network\$net.id unique identifier for stream network. \$Nested\_COMIDs vector of comids in same stream network. \$SF\_Obj Simple Features Object: \$SF\_Obj\$group.comid Root COMID of network; \$SF\_Obj\$COMID same as \$Network\$net.comid COMID's upstream of root; \$SF\_Obj\$VPUID same as \$Network\$vpu Vector Processing Unit; \$SF\_Obj\$Meas same as \$Network\$M Position of sampling point on COMID; \$SF\_Obj\$Meas same as \$Network\$net.id unique identifier for stream network

## Examples

```
# process sampling ponits
a <- net_comid(sample_points = z, CRS = 4269, nhdplus_path = getwd(), vpu="01", maxdist = 100)
# or select random networks
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 3, n = 5)
# delineate upstream reaches
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
#write stream network as shpfile
sf::write_sf(b$SF_Obj, paste(getwd(), "/network.shp"))
```

---

net\_flow

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Network Discharge and Veolcity Summary

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## Description

Network flow summaries derived form NHDPlusV2 EROM mean annual and mean monthly discharge (Q0001E) and velocity (V0001E) estimates

## Usage

```
net_flow(nhdplus_path, vpu, netdelin)
```

## Arguments

nhdplus_path	Directory for NHDPlusV2 files ( <a href="#">net_nhdplus</a> )
vpu	NHDPlusV2 Vector Processing Unit
netdelin	output from <a href="#">net_delin</a>

## Details

Requires /VPUAttributeExtension directory see ([net\\_nhdplus](#))

If M value is supplied, discharge (Q0001E) values are scaled proportionally. Velocity (V0001E) and RUNOFFVC are values for COMID outlet [net\\_delin](#)

## Value

data.frame: \$RUNOFFVC cumulative mean annual runoff (mm); \$MAQ0001E Mean Annual discharge (cf); \$minMMQ0001E minimum mean monthly discharge; \$maxMMQ0001E maximum mean monthly discharge (cf); \$covMMQ0001E coefficient of variation of mean monthly discharge; \$V0001E mean annual velocity (cfs); minMMV0001E minimum mean monthly velocity (cfs) maxMMV0001E maximum mean monthly velocity; covMMV0001E coefficient of variation in mean monthly velocity estimates.

## Examples

```
# identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
# derive discharge and velocity estimates
c <- net_flow(netdelin = b, vpu = "01", nhdplus_path = getwd())
```



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net_hort	<i>Horton Laws</i>
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## Description

calculates network area, length and bifurcation ratios, using `lm(...)`

## Usage

```
net_hort(netdelin, vpu, nhdplus_path)
```

## Arguments

netdelin	output from <code>net_delin</code>
vpu	vector processing unit
nhdplus_path	Directory for NHDPlusV2 files ( <a href="#">net_nhdplus</a> )

## Details

requires `/NHDPlusAttributes` directory (see `net_nhdplus`)

Horton estimates (`$Horton_est`) include network - 1 (i.e `$ohm`) because a given `group.comid`, may not include the whole stream order

## Value

named list: `$topology` is data used to estimate horton laws: `$group.comid` root COMID for steam network; `$str_ord` stream order; `$str_num` count of stream reaches, `str_len` Mean reach length; `str_area` mean drainage area. `$horton_est` are estimated horotn ratios: `ohm` is the strahler order of the network - 1 (see Details. `$Rb`, `$Rl`, `$Ra` are bifurcation, length and area ratios, respectively. `Rb.r2`, `Rl.r2`, `Ra.r2` are  $R^2$  values from `lm(...)`.

## Examples

```
# identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
# estimate horton ratios
c <- net_hort(netdelin = b, vpu = "01", nhdplus_path = getwd())
```

---

net_lc	<i>NLCD2011 Landcover Percentages</i>
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**Description**

Percent of watershed covered by NLCD2011 landcover class

**Usage**

```
net_lc(netdelin, vpu, nhdplus_path)
```

**Arguments**

netdelin	output from <a href="#">net_delin</a>
vpu	NHDPlusV2 Vector Processing Unit
nhdplus_path	Directory for NHDPlusV2 files ( <a href="#">net_nhdplus</a> )

**Details**

Requires VPUAttributeExtension directory see([net\\_nhdplus](#))

**Value**

data.frame of NLCD2011 classification codes ([https://www.mrlc.gov/nlcd11\\_leg.php](https://www.mrlc.gov/nlcd11_leg.php)). Each record is percentage of catchment area

**Examples**

```
#identify sample comid
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
#delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
#calculate NLCD2011 Landcover summaries
net_lc(netdelin = b, vpu = "01", nhdplus_path = getwd())
```

---

net_nhdplus	<i>NHDPlusV2 Download</i>
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---

**Description**

Downloads 7-zip files from NHDPlusV2 webpage to "NHDPlus" sub-directory

**Usage**

```
net_nhdplus(nhdplus_path = getwd(), download = "http", vpu = "01",
  files = c("NHDPlusAttributes", "NHDSnapshot", "NHDPlusCatchment",
    "VPUAttributeExtension", "VogelExtension", "EROMExtension"),
  zip_7 = "C:/Program Files/7-Zip")
```

**Arguments**

nhdplus_path	parent directory for download
download	transfer protocol ("http" or "ftp")
vpu	NHDPlusV2 Vector Processing Unit
files	NHDPlusV2 data file names. Default are used for SNT functions. See details
zip_7	Location of the 7-zip program

**Details**

7-zip (<https://www.7-zip.org/download.html>) must be installed. Note location for zip\_7 argument

see [http://www.horizon-systems.com/NHDPlus/NHDPlusV2\\_documentation.php](http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php) for NHDPlusV2 file names and descriptions. Options for file argument are c("FdrFac", "FdrNull", "FilledAreas", "Hydrodem", "NEDSnapshot", "EROMExtension", "NHDPlusAttributes", "NHDPlusBurnComponents", "NHDPlusCatchment", "NHDSnapshotFGDB", "NHDSnapshot", "VogelExtension", "VPU-AttributeExtension", "WBDSnapshot").

All raster processing units (RPU) within the vpu will be downloaded and can take considerable time

Includes `system` commands which may not work outside Windows OS

**Value**

NHDPlusV2 data files are downloaded to "NHDPlus" directory

**Examples**

```
net_nhdplus(nhdplus_path = getwd(), download = "http", vpu = "01", files =
c("NHDPlusAttributes", "NHDSnapshot", "NHDPlusCatchment", "VPUAttributeExtension",
"VogelExtension", "EROMExtension"), zip_7 = "C:/Program Files/7-Zip")
```

---

net_sample	<i>Random NHDPlusV2 COMID</i>
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---

**Description**

Generates random COMID vector of a specified Strahler order. Can serve as root of stream network (see [net\\_delin](#)).

**Usage**

```
net_sample(nhdplus_path, vpu, ws_order, n)
```

**Arguments**

nhdplus_path	directory for NHDPlusV2 files <a href="#">net_nhdplus</a>
vpu	NHDPlus V2 vector processing unit
ws_order	Strahler order of desired COMID
n	number of COMID's selected

**Details**

"/NHDPlus" must be a subdirectory of nhdplus\_path.  
NHDPlusAttributes and NHDSnapshot are required NHDlus downloads (see [net\\_nhdplus](#))

**Value**

vector of NHDPlusV2 COMID's.

**Examples**

```
net_sample(nhdplus_path=getwd(), vpu = "01", ws_order = 6, n = 5)
```

---

net_segid	<i>Identify Network Segments (Deprecated)</i>
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---

**Description**

modifies [net\\_delin](#) by creating an index (seg.id) for multiple comids occuring between confluences

**Usage**

```
net_segid(netdelin, nhdplus_path, vpu)
```

**Arguments**

- netdelin            output from [net\\_delin](#)
- nhdplus\_path      nhdplus\_path directory for downloaded NHDPlus files ([net\\_nhdplus](#))
- vpu                vector processing unit

**Details**

seg.id are arbitrarily assigned to network segments (i.e. there is no up/down stream ordering to seg.id with a network)  
requires /NHDPlusAttributes directory (see [net\\_nhdplus](#))  
optional with respect to other functions within StreamNetworkTools

**Value**

modifies link{net\_delin} with additional field seg.id.

**Examples**

```
net_segid(netdelin = b, nhdplus_path = getwd(), vpu = "01")
```

---

net_sinu	<i>Sinuosity and Slope</i>
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---

## Description

Calculates sinuosity and slope for each reach within a NHDPlusV2 network

## Usage

```
net_sinu(netdelin, nhdplus_path, vpu)
```

## Arguments

netdelin	output from net_delin
nhdplus_path	Directory containing NHDPlusV2 <a href="#">net_nhdplus</a>
vpu	NHDPlusV2 vector processing unit

## Details

Can aggregate(...) reach values to network-scale using group by \$net.id

\$MaxElevSM, \$MinElevSM \$SlopeNHDPlus are values at the outlet of group.comid. tot.len, str.len, sinuosity are scaled by M value

warning message: In st\_cast.sf(netdelin\_Prj, "LINESTRING") : repeating attributes for all sub-geometries for which they may not be constant is from changing MULTILINE to LINESTRING geometry

## Value

data.frame: \$net.comid upstream reaches from group.comid; \$group.comid network root COMID; \$tot.len length of reach; \$str.len is straight line length of reach; \$sinuosity tot.len / str.len; \$MaxElevSM maximum elevation of reach; \$MinElevSM minimum elevation of reach; \$SlopeNHDPlus slope of reach

## Examples

```
# identify NHDPlusV2 COMID
a <- net_sample(nhdplus_path = getwd(), vpu = "01", ws_order = 6, n = 5)
# delineate stream network
b <- net_delin(group_comid = as.character(a[, "COMID"]), nhdplus_path = getwd(), vpu = "01")
# calculate sinuosity and slope
c <- net_sinu(netdelin = b, vpu = "01", nhdplus_path = getwd())
```

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