

May 30<sup>th</sup>, 2025

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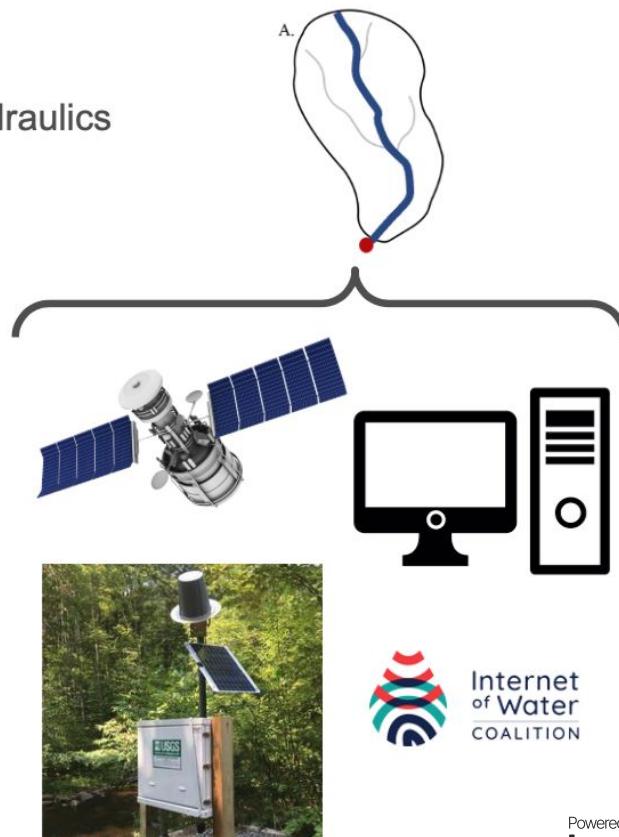
# DevCon 2025: Towards a reproducible; robust; flowline-based; community; hydrofabric infrastructure

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Mike Johnson, Justin Singh, Arash Modaresi Rad, Jim Coll  
Lynker

## What is a “Hydrofabric”

- 1) Features **define** the *computational elements* for hydrology/hydraulics
- 2) Topologies **link** data together for space/time processing
  - a) (modular elements that act as a whole)
- 3) Attributes **provide** the *information* for model execution
  - a) (physics based, conceptual and ML/AI)
- 4) Software and data models **develop** community standards, reproducibility, and flexibility to support analysis at scale



# Goals for Workshop...

## 1. Where have we been...

History of hydrography and emergent challenges, history of NextGen data efforts

## 2. Where are we going...

Version 3.0 of the hydrofabric will fundamentally change NextGen, but provide new opportunities

## 3. What can you expect to see this year...

Automated hydrofabric builds

Multiresolution Networks

FIM integration

Infrastructure for community contributions

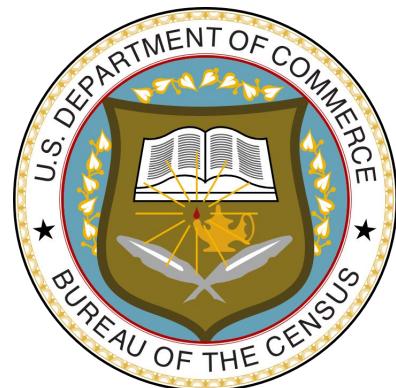
Command Line Tools for local experimentation

# Context and Early Digital Efforts

- **Census Bureau (1990):**
  - Introduced a **digital hydrography theme** to Census data.
  - Created **Digital Line Graphs (DLGs)** at **1:100,000 scale**, based on USGS topo maps.
- **Concurrent EPA Initiative (1990):**
  - Developed **Reach File 1 (RF1)** at **1:250,000 scale**.
  - Focused on documenting **flow connectivity** in GIS.

Recognition of synergy between these lead to the goal of integrating geometry and flow data at **1:100,000 scale**

## Outcome: National Hydrography Dataset (NHD)



## Launch of the NHD (~2002)

- First national product combining: Hydrography (flowpath only) geometry with flow network modeling capability
- Foundation for national-scale hydrologic analysis still heavily used today!
- Released for the **U.S. and Territories (excluding Alaska)**



# Evolving Needs → Higher Resolution

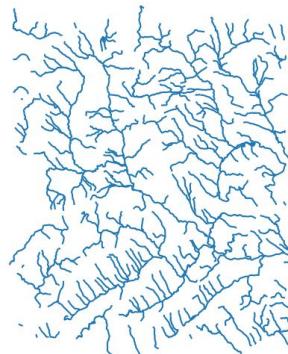
Following the release of the NHD...

1. The **USGS** began work on **NHDHighRes** at **1:24,000 scale**
2. The **EPA** started **statistical streamflow modeling** at reach level

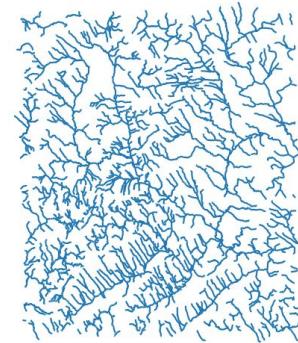
## Challenge:

Both required **divide polygons** for each flowline representing the contributing area / incremental portion of the watershed. Sought out a 1:1 incremental area to flowpath relationship.

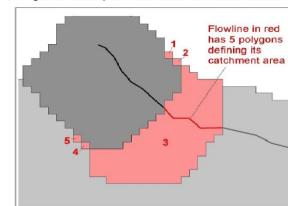
NHDPlus Medium Resolution



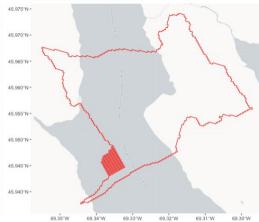
NHDPlus High Resolution



A. Figure A-6 Adopted from NHDPlus Users Manual



B. COMID: 1702414



C. COMID: 1023400

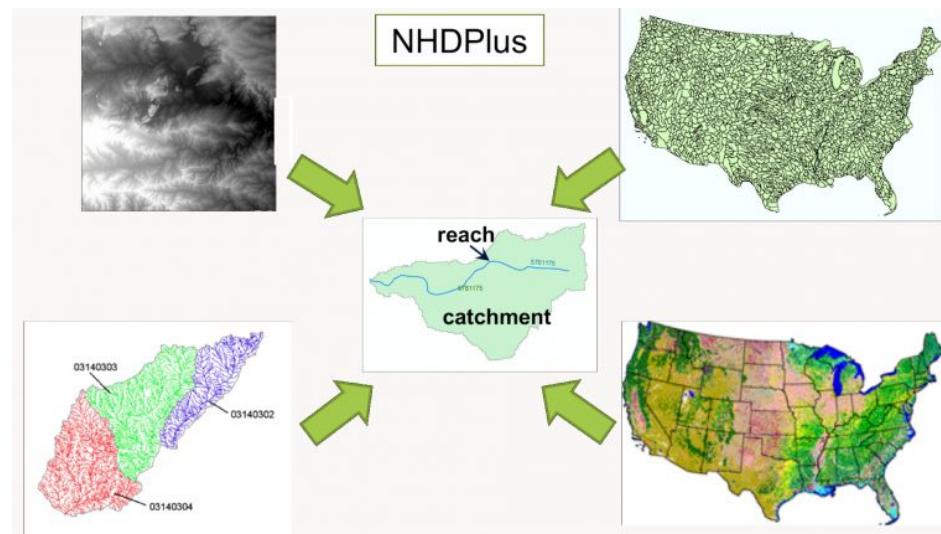


D. COMID: 1032555



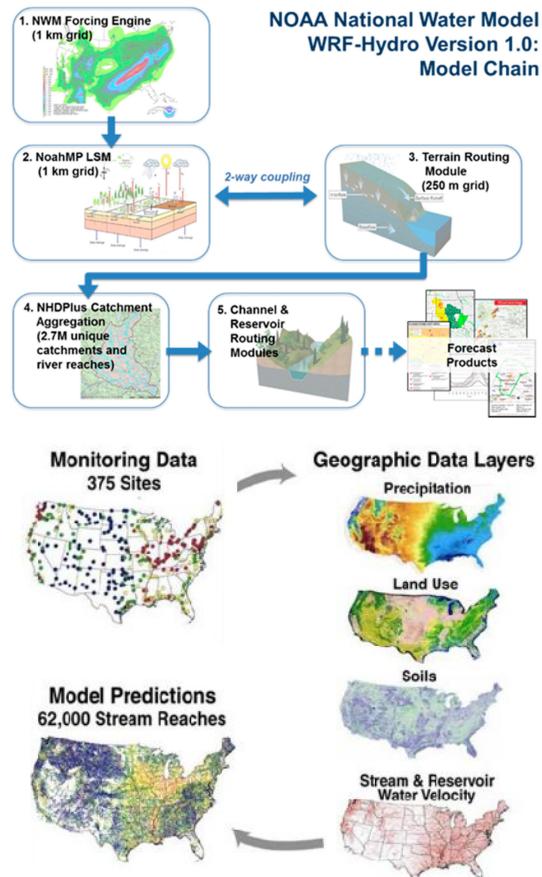
# Emergence of NHDPlus

- Developed to meet integrated modeling needs through an application-ready geospatial suite
- Combines:
  - **NHD**
  - **Elevation data (NED / 3DEP)**
  - **Watershed Boundary Dataset (WBD)**
- Introduces:
  - **Catchments**
  - **Value Added Attributes (VAA)**
  - **Improved flow networking**



# Foundation for National Applications

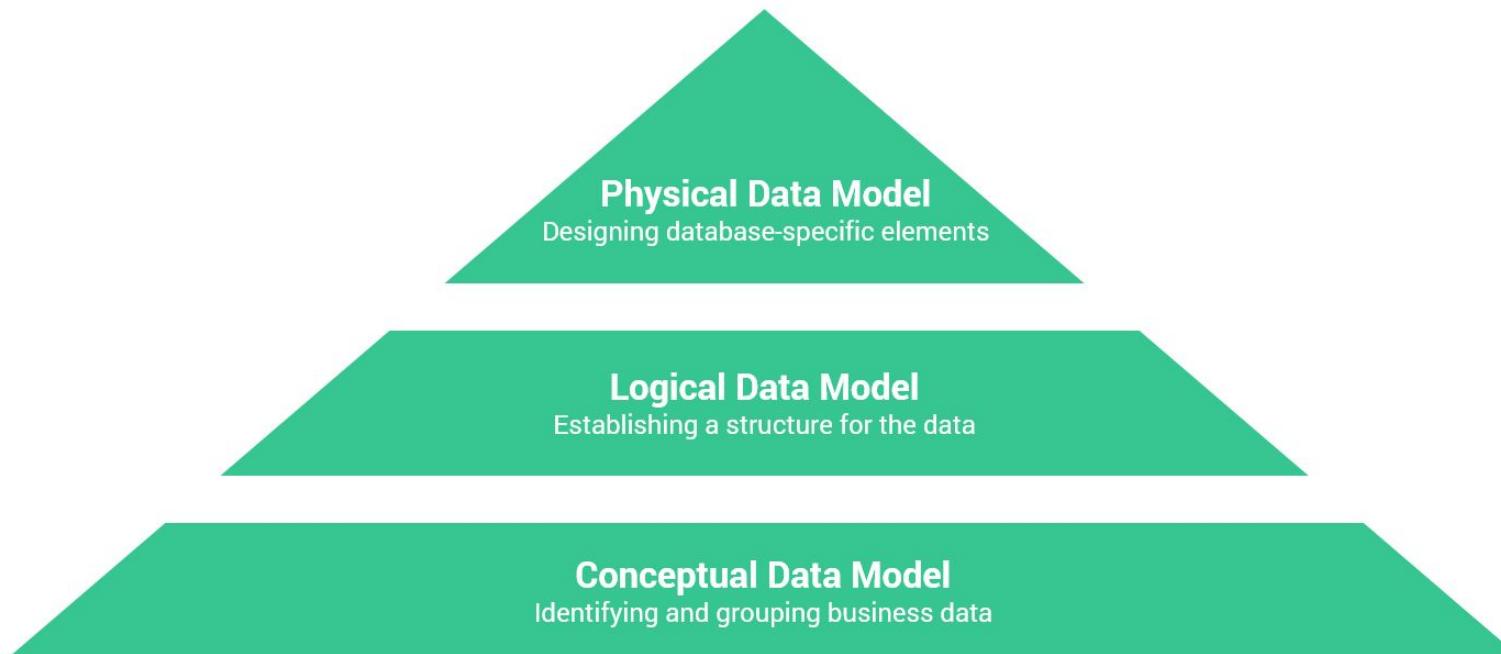
- **Geospatial Fabric for NHM** (Bock et al.)
- **Hydrofabric for National Water Model** (Cosgrove et al., 2020)
- **National Flood Interoperability Experiment** (Maidment, 2016)
- **WRF-Hydro / National Water Model** (Gochis et al., 2016)
- **SPARROW models** (Brakebill & Schwarz, 2016)
- **EPA StreamCat** (Hill et al., 2016)
- 1,000s of other local projects!



# But there are challenges ...

1.  **Static and Siloed:** NHD/NHDPlus is static and often locally modified without changes flowing back to a central source.
2.  **Mixed Stewardship Success:** User engagement efforts—like the stewards program—had uneven traction across states.
3.  **Conflicting Contributions:** Multiple organizations (USGS, NOAA, NCAR, universities) made independent edits, sometimes conflicting with each other.
4.  **Legacy Tool Limitations:** Early catchment delineation tools were limited by outdated software, causing topological issues and unnecessary complexity—barriers to modern, cloud-native, open-source workflows.
5.  **Fixed Network Scale:** The network scale was rigid, making it hard to densify or generalize for different applications.
6.  **Lack of Supporting Tools:** The absence of robust supporting tools stalled improvements and broader community adoption.
7.  Tons of short, inefficient reaches (24% ~ .5km, mostly around junctions), ok for cartography but bad for modeling...

## What does it mean to provide a modeling fabric?



NextGen R&D



USGS/NOAA  
collaboration

International  
Standards

Mainstems: A logical data model  
implementing *mainstem* and *drainage basin*  
feature types based on WaterML2 Part 3: HY  
Features concepts

David Blodgett <sup>a</sup> , J. Michael Johnson <sup>b</sup> , Mark Sondheim <sup>c</sup> , Michael Wieczorek <sup>a</sup> ,  
Nels Frazier <sup>d</sup>

OGC® WaterML 2: Part 3 - Surface Hydrology  
Features (HY\_Features) - Conceptual Model

Open Geospatial Consortium  
Submission Date: 2017-08-17  
Approval Date: 2017-10-16  
Publication Date: 2018-01-08  
External identifier of this OGC® document: <http://www.opengeospatial.org/doc/18-081>  
Internal reference number of this OGC® document: 14-1116  
Category: OGC® Implementation Standard  
Editor: David Blodgett, Irina Dornblut

Hydrologic Modeling and River Corridor  
Applications of HY\_Features Concepts

Publication Date: 2023-03-06  
Approval Date: 2022-10-06  
Submission Date: 2022-09-13  
Reference number of this document: OGC 22-040  
Reference URL for this document: <http://www.opengeospatial.org/doc/18-081/HydroFabric-er>  
Category: OGC Public Engineering Report  
Editor: David Blodgett, J. Michael Johnson  
Title: Hydrologic Modeling and River Corridor Applications of HY\_Features Concepts  
*OGC Public Engineering Report*

[OGC® WaterML 2: Part 3 - Surface Hydrology Features \(HY\\_Features\) - Conceptual Model](#)

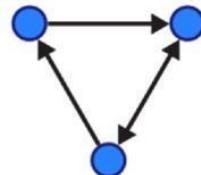
[Hydrologic Modeling and River Corridor Applications of HY\\_Features Concepts](#)

# Reference Fabric

In collaboration, NOAA, the USGS and Lynker developed a singular reference fabric aiming fix the structural errors in the NHD snapshot. This dataset consists of three main products:

## Reference

**Updated Network**  
**Attributes**  
Based on the E2NHD and NWM networks.



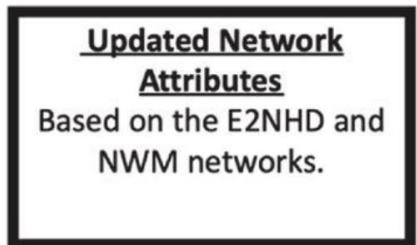
**Reference**  
**Catchments**  
Simple, valid, POLYGON representation



**Reference Flowlines**  
NHD Flowlines with headwaters adjusted to the burn lines

**Community POIs**  
Community driven thematic and structural points of interest from the community





- COMID/FEATUREIDs adopted from the NHDPlusV2
- Levelepath Mainstems sequentially derived
- Mainstem ID seed the [IoW Geconnex System](#)

Updated CONUS river network attributes based on the E2NHDPlusV2 and NWMv2.1 networks [View](#)

**Dates**  
Publication Date : 2022-09-06

**Citation**  
Blodgett, D.L., 2022. Updated CONUS river network attributes based on the E2NHDPlusV2 and NWMv2.1 networks. U.S. Geological Survey data release, <https://doi.org/10.5066/P9W78Q>.

**Summary**  
Note: this data release has been superseded by version 2.0, available here: <https://doi.org/10.5066/P97KCVT>.  
The comid field of these data can be used to join to the NHDPlus version 2 flowline comid or catchment featureid attributes. The included attributes follow the same data model as the NHDPlusV2 but include numerous updates and improvements to network connectivity. All attributes that depend on network connectivity have been recalculated.  
These attributes are based on the National Hydrography Dataset Plus Version 2.1 (NHDPlusV2) network geometry and modifications retrieved from the National Water Model Version 2.1 (NWMv2.1) and "E2NHDPlusV2\_us: Database of Ancillary Hydrologic and Modified Routing for NHDPlus Version 2.1 Flowlines" (E2NHDPlusV2) datasets.  
These attributes are available in three formats: csv, fsl, and parquet. "fsl" is a high performance format for use with the R programming language "fsl" package. "parquet" is a high performance format for use with multiple programming languages (including python) that support the Apache Arrow Parquet format.

[... show more ...](#)

**Map** [Map](#)

**Communities**  
• USGS Data Release Products

**Associated Items**  
• related to National Hydrologic Reference and Derived Hydrofabrics  
• related Mainstems Rivers of the Contiguous United States  
• succeededBy Updated CONUS river network attributes based on the E2NHDPlusV2 and NWMv2.1 networks (ver. 2.0, February 2023)  
[View Associated Items](#)



Environmental Modelling & Software

Volume 165, July 2023, 105726

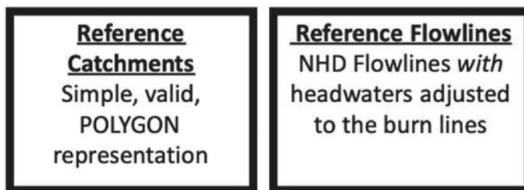


Generating a reference flow network with improved connectivity to support durable data integration and reproducibility in the coterminous US

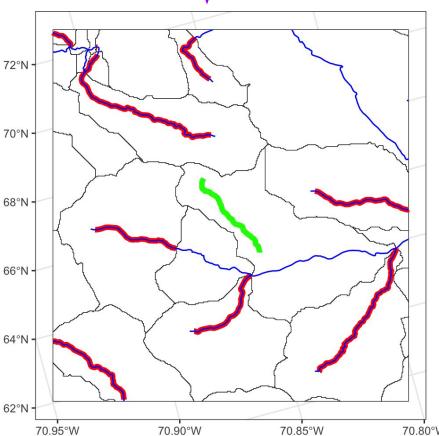
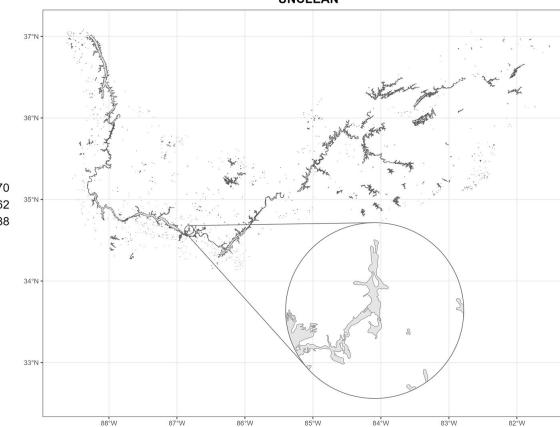
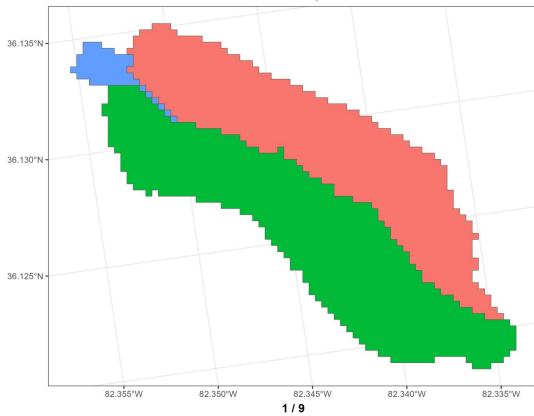
David Blodgett <sup>a</sup> , J. Michael Johnson <sup>b</sup> , Andy Bock <sup>a</sup>

Show more

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UNCLEAN



# Hydrolocations

1. USGS has created a set of community POIs, we only use a subset of them!

```
community_hl_types     <-  c('huc12', 'gages', 'te', 'nid',
                           "resops", "hilarri", "wabout", "wbin",
                           "ar", "term")
```

**Community POIs**  
Community driven thematic and structural points of interest from the community



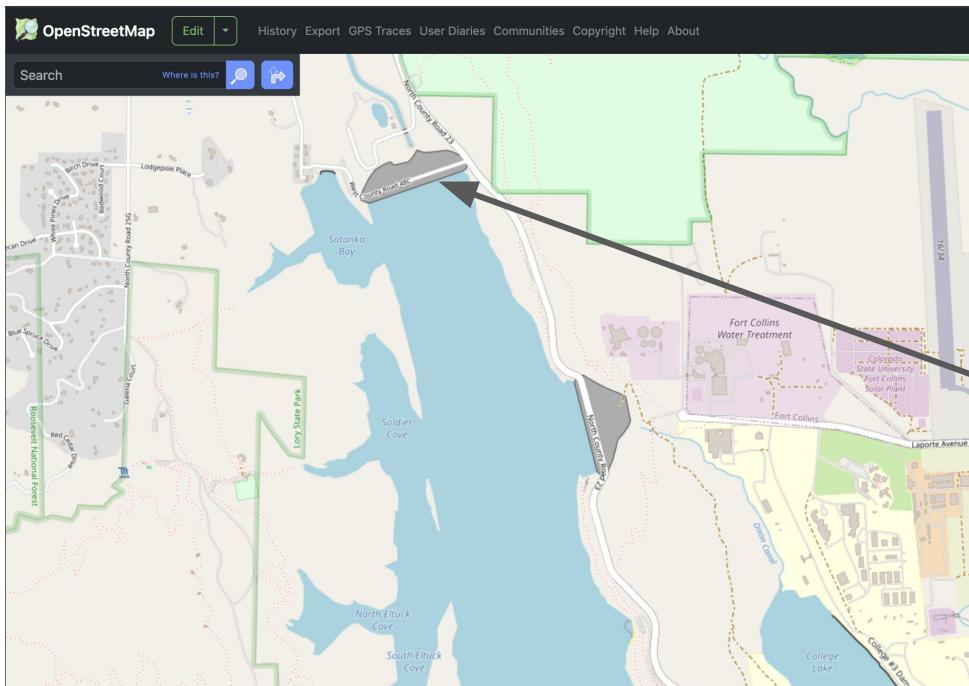
2. NOAA has created a set of internal POIs

- Coastal ← Provided by the coastal team
- LAKES, reservoirs ← Latest release of NWM on NOMADS
- NWS/FIM LID (location Identifiers)

3. **YOU** might have a set of POIs

- For example, we are adding all bridges that span water (motivated by the great work at UTexas)

- Hydrolocations store the source, identifier, and index of a critical location
- Points of Interest (POIs) aggregate co-located hydrolocations to singular network locations



### 5 Hydrolocations

1. HUC12
2. WBout
3. Gage
4. NID
5. NWS LID

1 POI

Google hydrofabric

AI Mode All Images Videos Shopping Short videos News More Tools

 GitHub [https://github.com/NOAA-OWP/ hydrofabric](https://github.com/NOAA-OWP/hydrofabric) ::

**NOAA-OWP/hydrofabric**

Modular **Hydrofabric** Processes: This package offers a collection of R packages specifically designed for hydroscience applications, akin to the tidyverse suite ...



People also ask ::

What is hydrofabric?

What is a hydrofabric? The first question generally raised is, "what is a hydrofabric?" To date, the term has been used to describe **artifacts as narrow as a set of cartographic lines, all the way to the entire spatial data architecture needed to map and model the flow of water and flood extents.**

 GitHub Pages <https://noaa-owp.github.io/articles/01-intro-deep-dive>

**Introduction • hydrofabric - GitHub Pages**

What is the concept of hydrologic modeling?

Feedback

Google what is a hydrofabric X | Microphone Camera Search

All Images Videos Short videos Shopping Forums More Tools

Search Labs | AI Overview

A "hydrofabric" refers to a spatial data architecture that represents the surface hydrologic features of an area, including flowpaths, catchments, and points of interest. It's essentially a digital blueprint of the interconnectedness of water bodies and land surface, allowing for mapping, modeling, and analysis of water flow and flood extents.

Here's a more detailed breakdown:

**Foundation for Hydrologic Modeling:**

The hydrofabric provides the base data needed for hydrologic models to run, including the landscape and flow network, connectivity, and attributes for modeling and routing.

**Connectivity and Topology:**

It establishes the connection and layout of features like rivers, streams, and drainage basins, ensuring that water flow is accurately represented.

**Data Infrastructure:**

The hydrofabric also serves as a system of linked data and Web infrastructure that can relate to and extract from other sources of information.

**Scale and Resolution:**

Hydrofabrics can be created at various scales and resolutions, from small basins to entire countries.

**NextGen Hydrofabric:**

A specific type of hydrofabric is the NextGen Hydrofabric, developed by the NOAA and USGS, which is used in the Next Generation Water Resources Modeling Framework (NextGen).

**Reference Hydrofabric:**

A core component of the NextGen Hydrofabric, the reference hydrofabric provides a standardized representation of water bodies and flowpaths across the United States.

**Applications:**

Hydrofabrics are used in a variety of applications, including flood inundation mapping, hydrologic modeling, and river corridor analysis.

Learn more

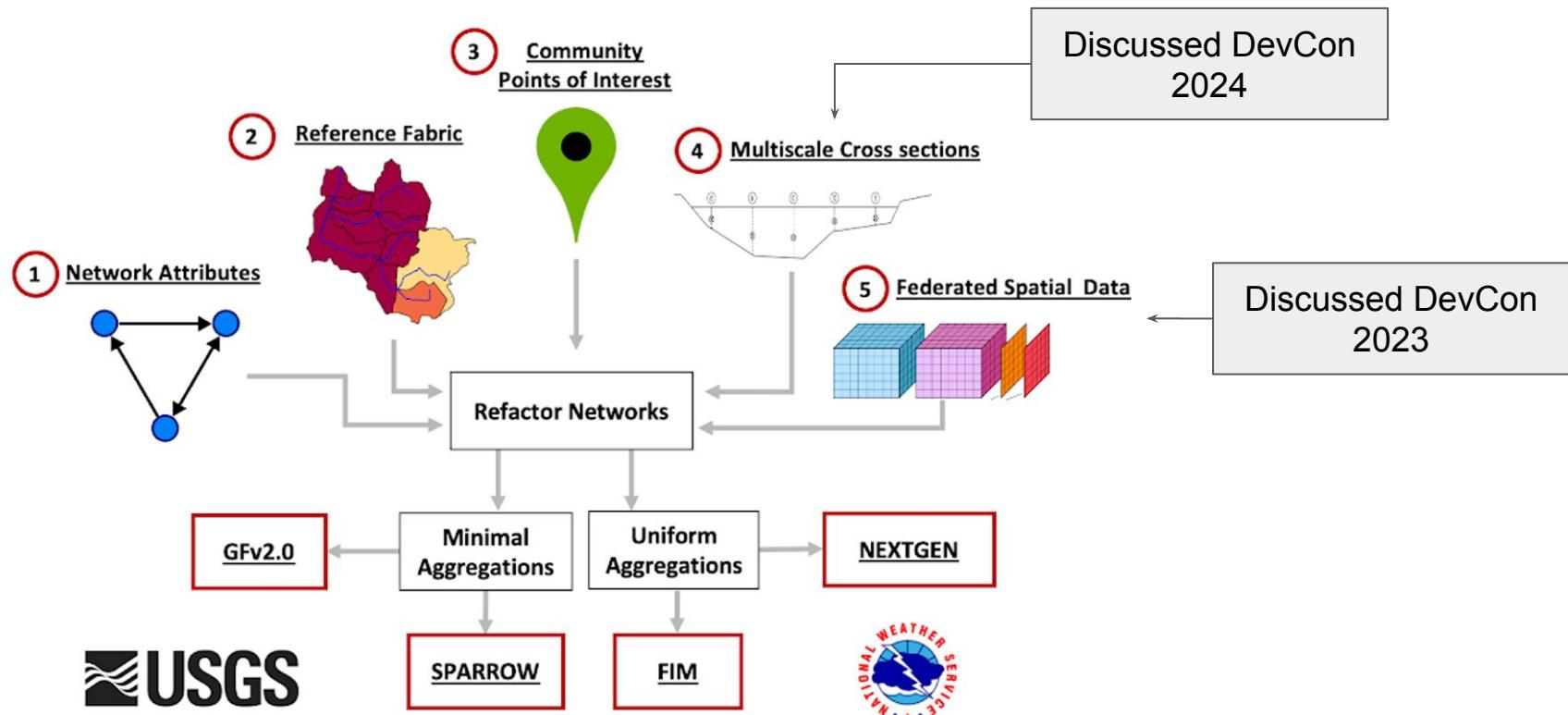
Progress Toward a Reference Hydrologic Geospatial Fabric for the United States I... Dec 12, 2022 (https://waterdata.usgs.gov)

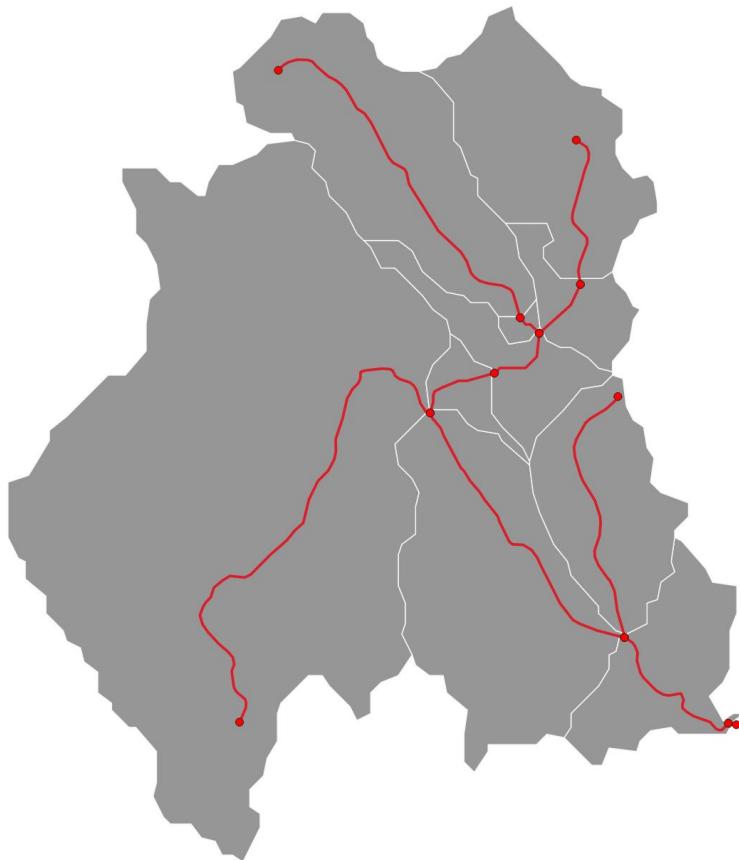
NextGen Hydrofabric Mike Johnson

Introduction • hydrofabric - GitHub Pages What is a hydrofabric? The first question generally raised is, "what is a hydrofabric?" To... GitHub Pages

Show all

# Reference Fabric





### Baseline: Reference

Provides a drop in replacement for the NHDPlus with corrected geometries, topology, and headwater representation

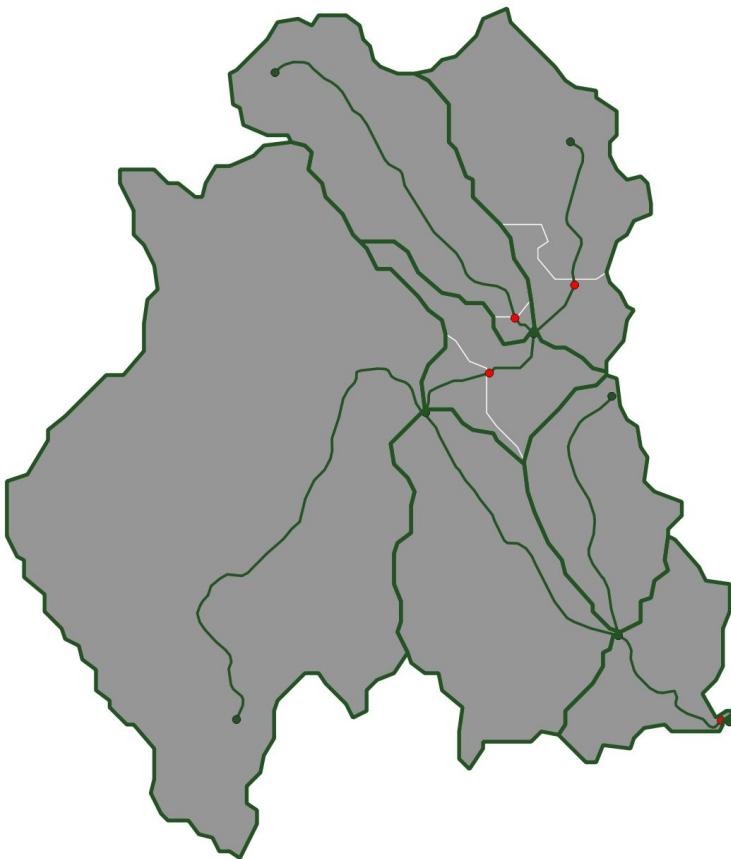
It is 1:1 with the NHDPlus except where the NHDPlus is wrong

### Topology:

Flowpath → Flowpath

↔  
 $\{1:1, 1:0, 0:1\}$  relationship

Divide → Divide



## Step 1: Refactor

- Refactoring collapses short flowpaths near junctions, and splits excessively long divides using the Flow Direction/Accumulation grids
- No path length is lost when refactoring
- The aim of refactoring is to:
  - (1) reduce the modeled feature count, and
  - (2) remove small incremental areas
- POIs can be enforced as breaks in the network.

## Topology:

Flowpath → Flowpath

↑  
 $\{1:1, 1:0, 0:1\}$  relationship

Divide → Divide

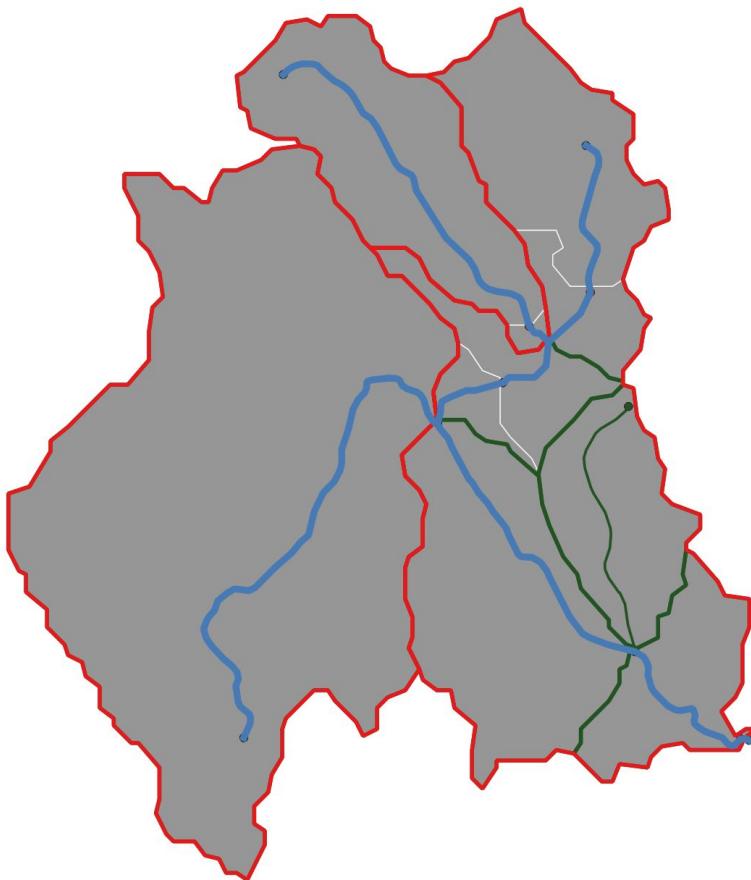
## Uniform Refactor: CONUS

- Processed VPU by VPU, local IDs assigned & cross walk built
- Enforce Hydrolocations locations in network
- Global IDs and IBTs corrects afterwards.
- Returns dendritic system only

`hydrofab::refactor(...)` →

- Reference fabric input
- `split_flines_meters = 10,000`
- `collapse_flines_meters = 1,000`
- `collapse_flines_main_meters = 1,000`
- `s3://lynker-spatial/gridded-resources/fac.vrt`
- `s3://lynker-spatial/gridded-resources/fdr.vrt`
- POIs {optional}





## Step 2: Aggregation

- Networks are aggregated to meet a desired divide size (defined by distribution)
- The algorithm works by merging across mainstems, then collapsing tributaries inward
- In needing to retain a 1:1 flowpath:divide relation, aggregation loses network resolution!
- POIs can be enforced as breaks in the network.  
The same POI set used in the refactor is not required

## Topology:

Flowpath → Flowpath

↓  
 $\{1:1, 1:0, 0:1\}$  relationship

Divide → Divide

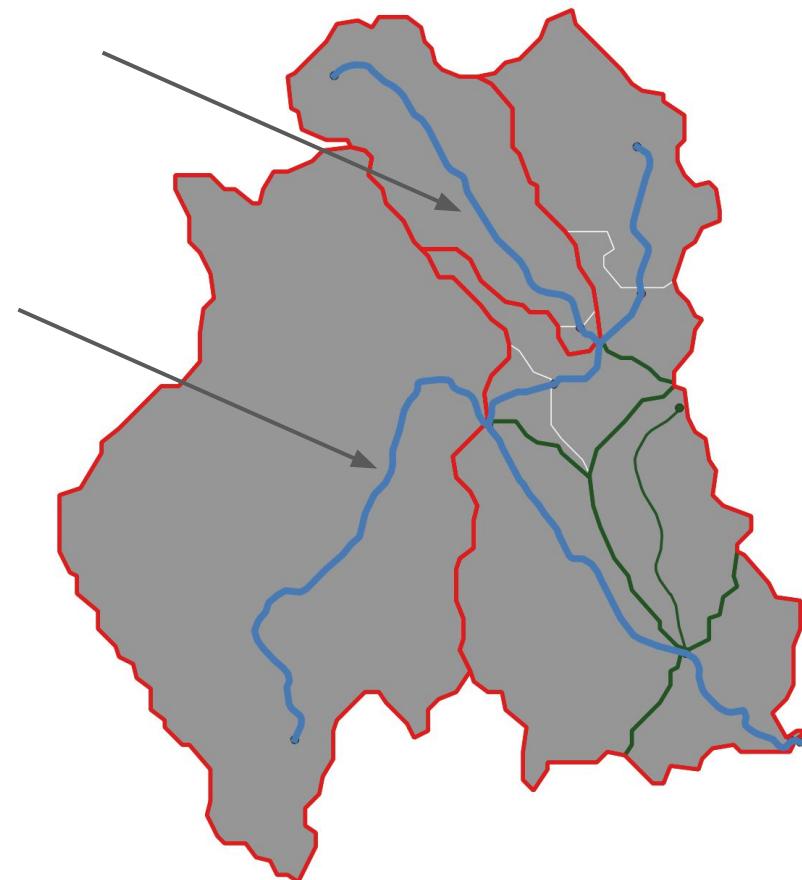
## Uniform Aggregation: CONUS

- Processed VPU by VPU, local IDs assigned & cross walk built
- Collapse Hydrolocations to POIs
- Global IDs and IBTs corrects afterwards.
- Returns dendritic system only

`hydrofab::aggregate_to_distribution(...)` →

- Refactored network
- `ideal_size_sqkm = 10`
- `min_length_km = 1`
- `min_area_sqkm = 3`
- POIs {optional}
- Read in reference, add `hydrofab::add_nonnetwork_divides`
- Coastal Divides are aggregated by HUC12 using [CW](#)
- Inland sinks are aggregated into contiguous polygons.



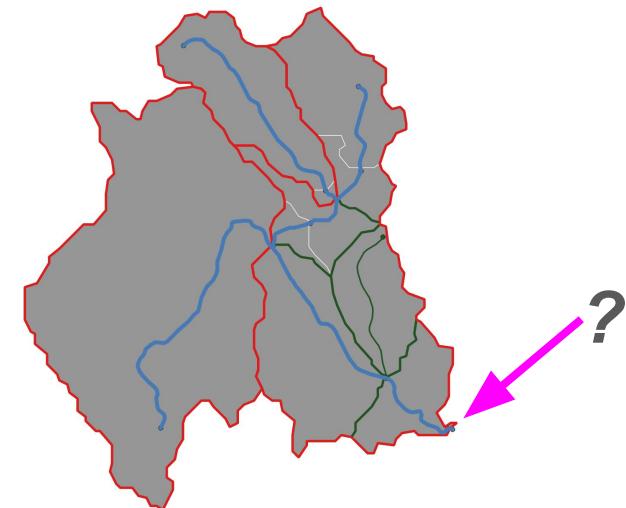
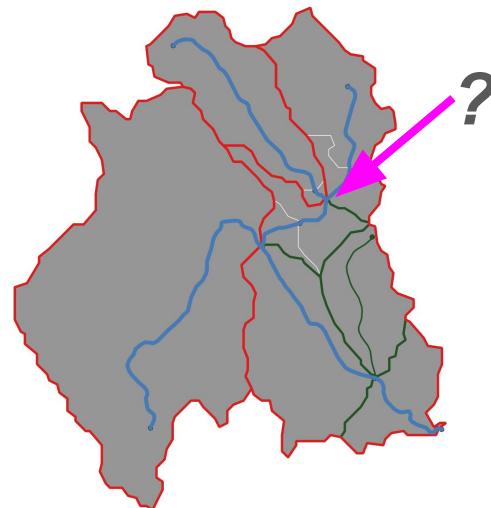
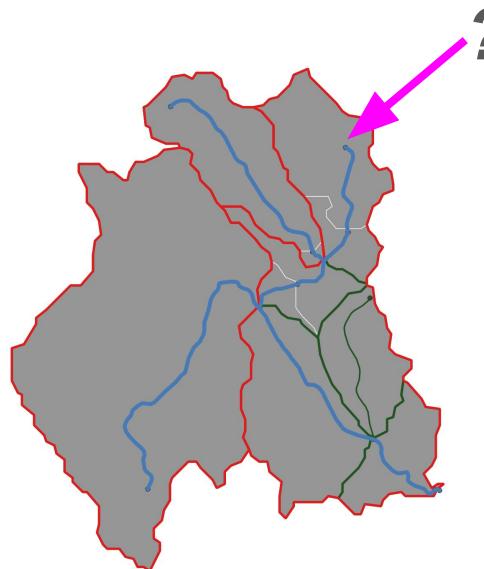


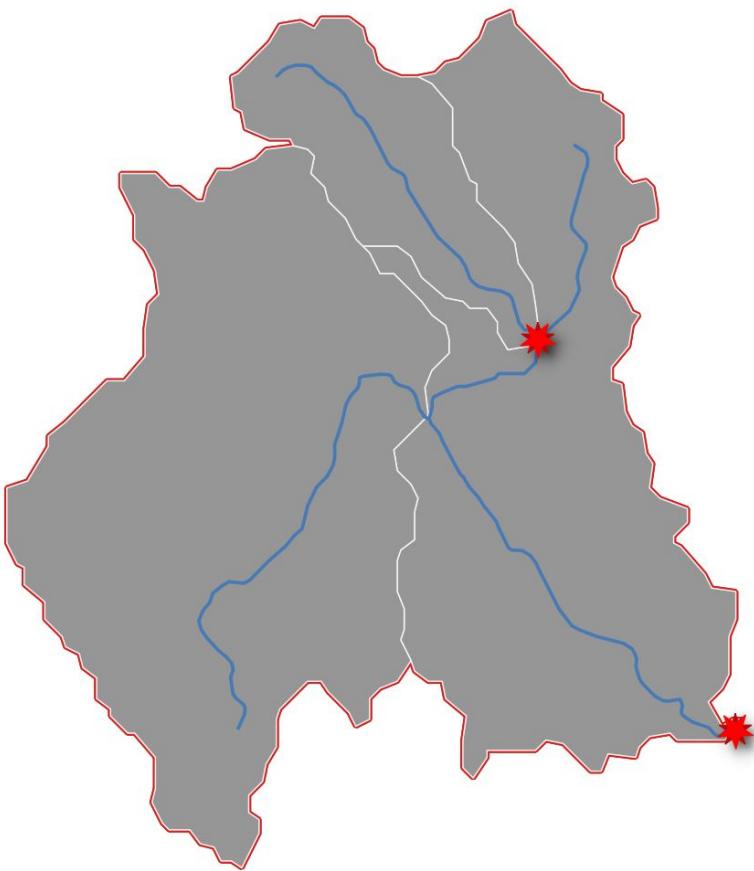
## Quirks in Aggregation

- Anytime an inter-reach junction occurs, multiple flowpaths have the same “toID”.
- In this example, 2 upper tributaries both flow to the lower mainstem ...

## Where to “physically” collect water?

When multiple contributing reaches share the same toID, there is a computational choice needed about where to collect water in order to route it through the network...





### Step 3: Generate a NextGen Network

In NextGen Nexus locations define the points of data exchange in the model

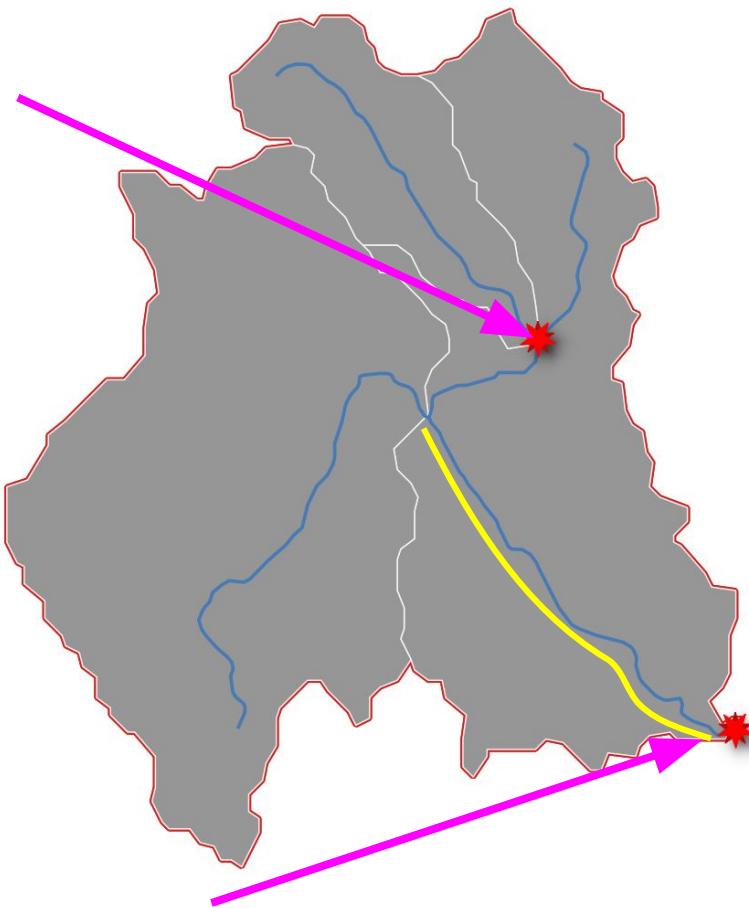
Nexus locations are materialized anywhere there is a 1 inflow to 1 outflow relation, or, at the first junction-based inflow to the reach.

#### Topology:

Flowpath → Nexus

↑  
*{1:1, 1:0, 0:1} relationship*

Divide → Nexus



## NextGen Network

Still a fundamental question of where to put flow, this introduces the “flying water” problem.

Currently, water is routed to the most downstream nexus, and a parallel length is computed. I don't think NextGen uses the parallel length!

# Persistent Identifiers

**Reference ID (COMID)** is the identifier of the minimal hydrofabric elements

**mainstem** = the sequential level path sequence

**POI** = Point of interest Identifier



# Not Persistent Identifiers

**Nextgen IDs** (cat-, wb-, nex-) are ephemeral!

They cannot (and should not) be tracked across versions

Everything can walk back to the reference fabric and all accounting is done in the geoprocessing.

## nextgen

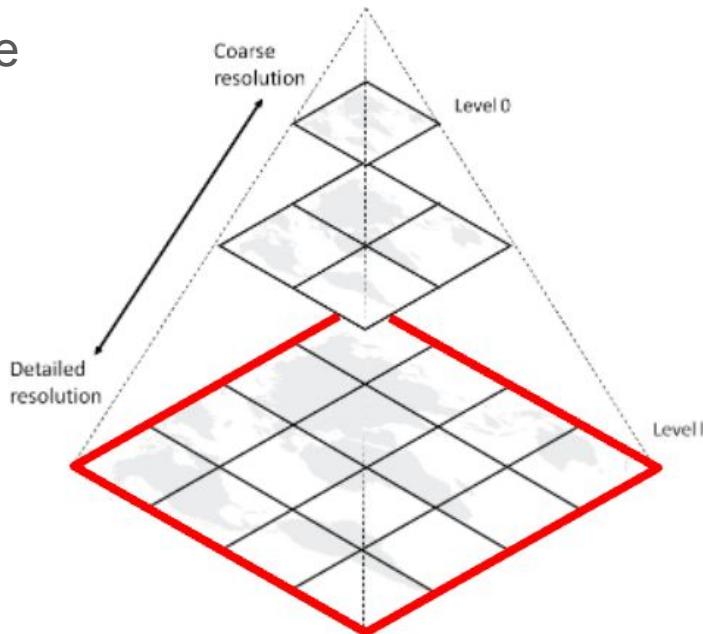
Aggregated to the scale appropriate for the hydrologic process being represented

## refactor

Manipulated to provide computationally stable and more homogenous features size for hydraulics

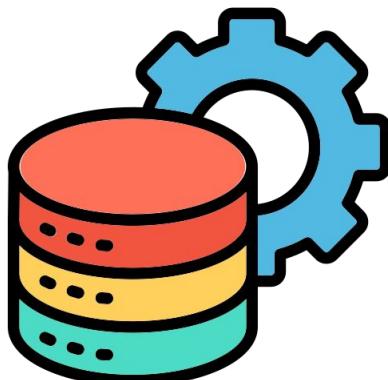
## Reference

Backbone to interrelate all “past” and “future” work through a robustly validated and evolving network





<https://noaa-owp.github.io/hydrofabric/>



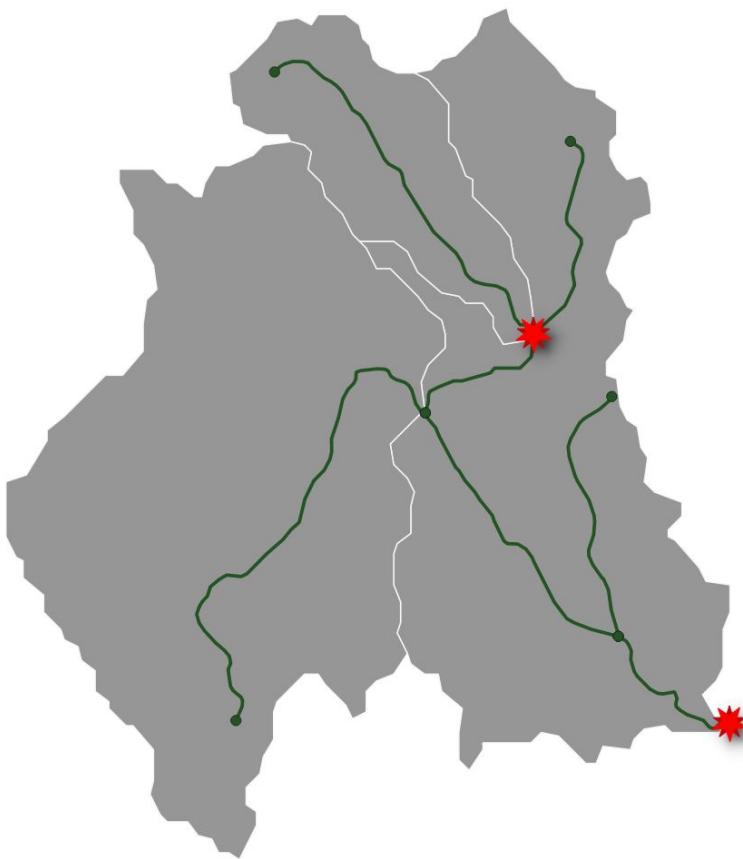
<https://www.lynker-spatial.com/data/hydrofabric/v2.2/>

s3://lynker-spatial/hydrofabric/v2.2/conus/conus\_reference.gpkg

protocol      root      type      version      domain      resource

# Hydrofabric v3.0

1. Adding multi-resolution capabilities through a **flowline** concept
2. Synergizing FIM with NextGen
3. Expanding 3D representation
4. Increasing access and usability
5. Soliciting community improvements

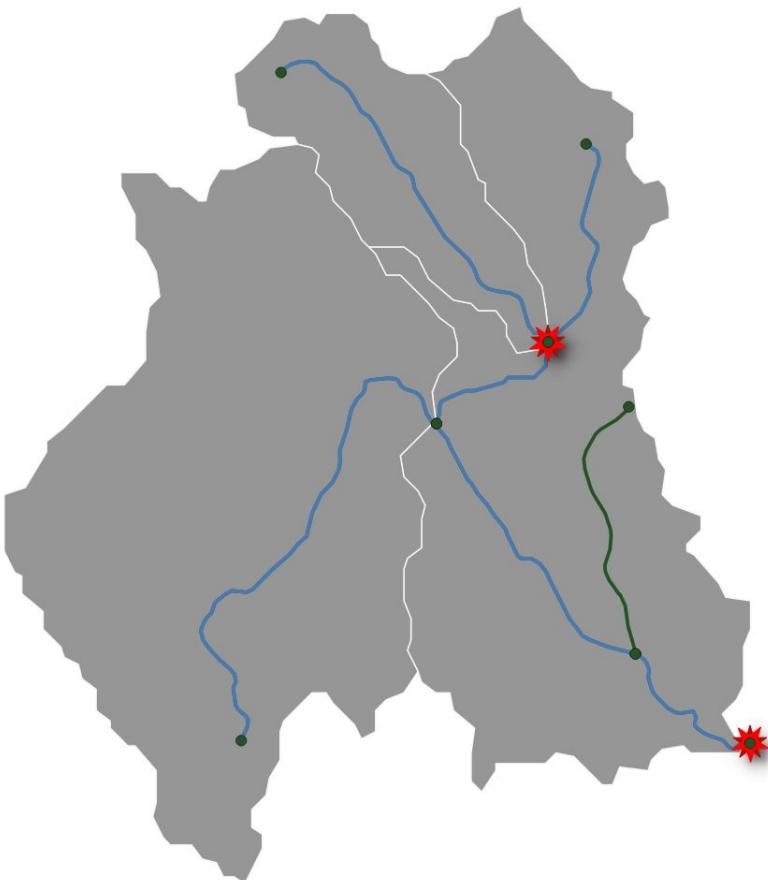


## Hydrofabric 3.0: Inclusion of flowlines

- (1) Support FIM
- (2) Provide congressionally mandated resolution in NextGen NWM
- (3) Provide the capacity to use any resolution of network

The underlying refactored flowpaths provide an existing nested hierarchy with computationally efficient features, and 1:1 geometry (neither are required to work but are helpful)

Nexus locations can pin the three networks together.



## Hydrofabric 3.0: Inclusion of flowlines

- (1) Supporting FIM
- (2) Providing congressionally mandated resolution in NextGen NWM
- (3) Provide the capacity to use any resolution of network

### Topology:

Flowline → Flowline (green)

↑  
*{many:1, 1:1} relationship*

Flowpath → Nexus (blue, red)

↓  
*{1:1, 1:0, 0:1} relationship*

Divide → Nexus (grey, red)

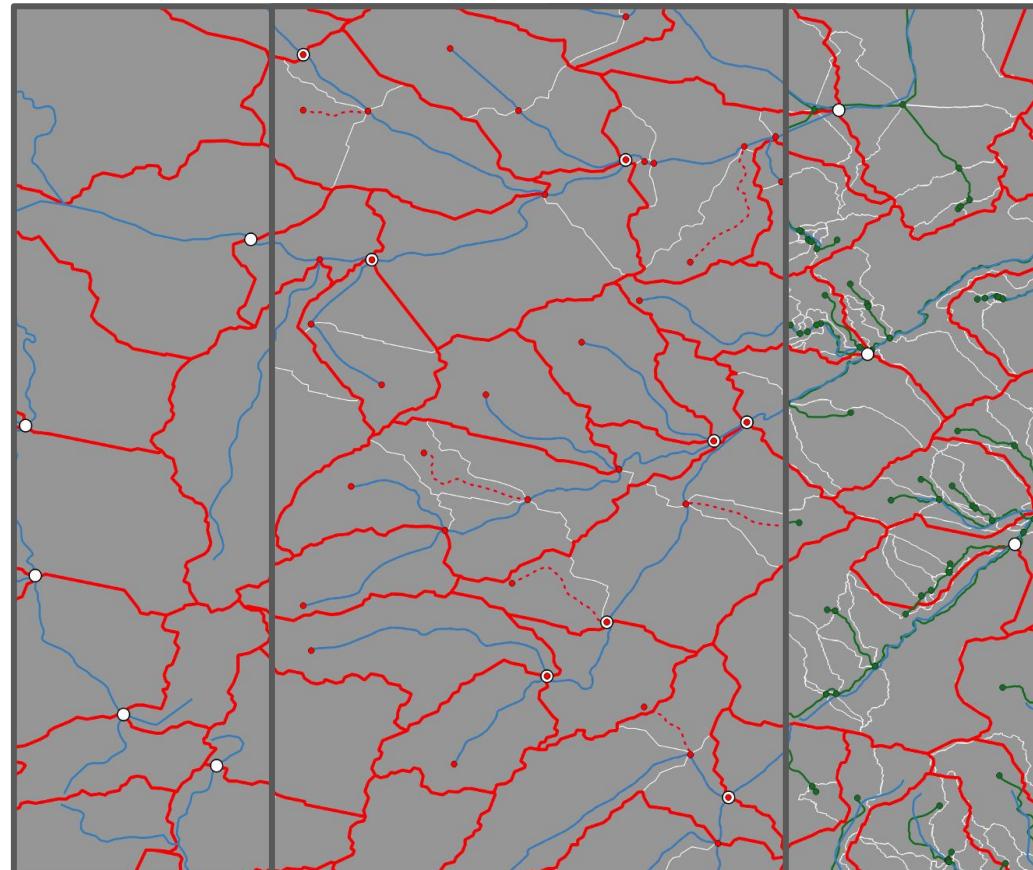
History

v2.2

v3.0

hftools

community.fabric



v2.X

v3.0

R&D

History

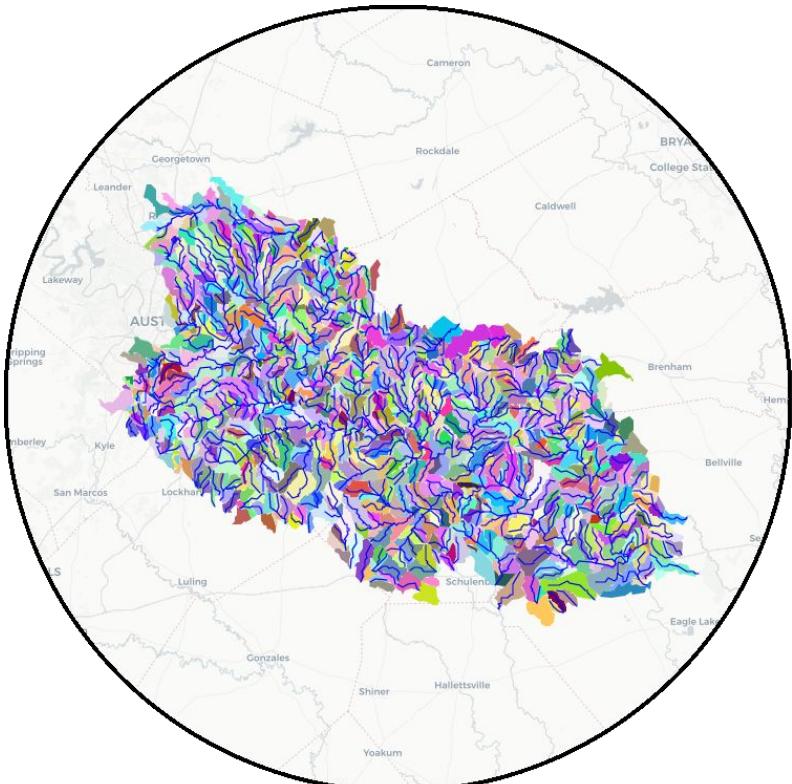
v2.2

v3.0

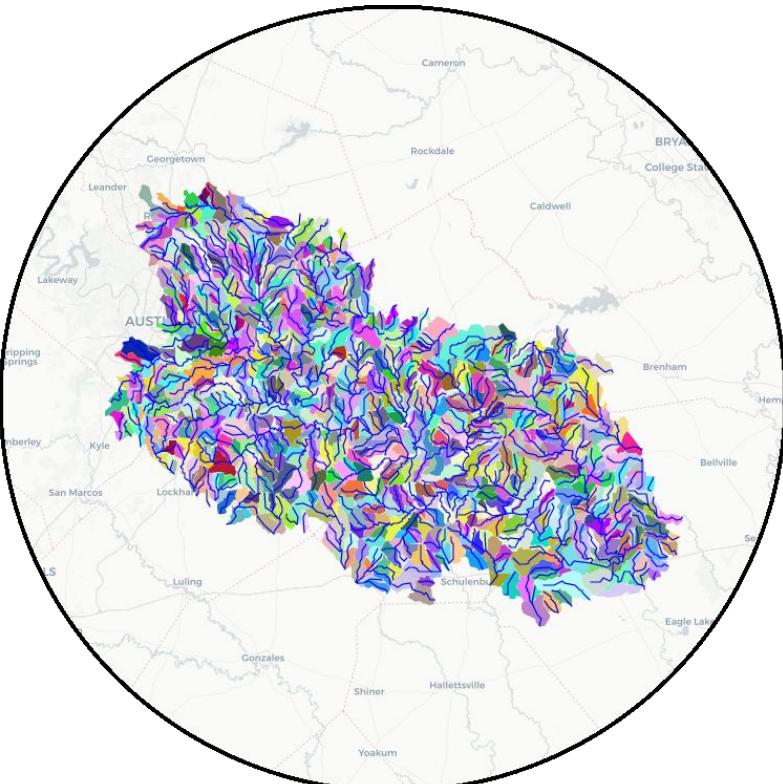
hftools

community.fabric

## Current FIM



## Prototype v3.0



**Hydrofabric Surfaces STAC Catalog**

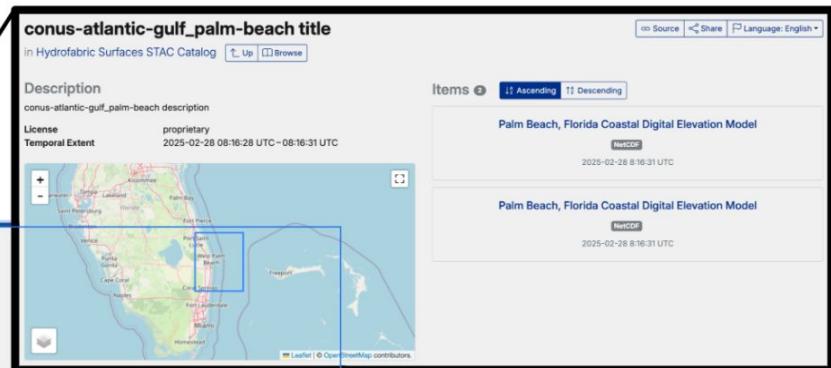
[Browse](#)

**Description**  
A STAC catalog containing diverse hydrologic surfaces

Catalogs 66 [Tiles](#) [List](#) [Ascending](#) [Descending](#)

Filter catalogs by title, description or keywords

alaska_alaska title alaska_alaska description 2025-02-28 08:18:42 UTC	conus-atlantic-gulf_north-carolina title conus-atlantic-gulf_north-carolina description 2025-02-28 08:16:01 UTC - 08:16:09 UTC	conus-pacific_garibaldi-oregon title conus-pacific_garibaldi-oregon description 2025-02-28 08:17:44 UTC - 08:17:47 UTC
albemarle-sound_albemarle-sound title	conus-atlantic-gulf_northeast-sandy title conus-atlantic-gulf_northeast-sandy description 2025-02-28 08:16:09 UTC - 08:16:10 UTC	conus-pacific_grays-harbor-washington title
chesapeake-bay_chesapeake-bay title	conus-atlantic-gulf_palm-beach title conus-atlantic-gulf_palm-beach description 2025-02-28 08:16:28 UTC - 08:16:31 UTC	conus-pacific_northern-california title conus-pacific_northern-california description 2025-02-28 08:17:07 UTC
	conus-atlantic-gulf_rima title	



Each improved resource is integrated in an evolving STAC catalog. STAC allows downstream users to find, integrate and access collections of data in a seamless way helping us provide the most up to date, accurate, and representative data in a non disruptive way.



Research Article | [Open Access](#)



## Enhancing River Channel Dimension Estimation: A Machine Learning Approach Leveraging the National Water Model, Hydrographic Networks, and Landscape Characteristics

Arash Modaresi Rad ✉, J. Michael Johnson ✉, Zahra Ghahremani, James Coll, Nels Frazier

First published: 25 November 2024 | <https://doi.org/10.1029/2024JH000173>

[DOWNLOAD PDF](#) ▾ 419 66

## Enhancing Synthetic Rating Curve Development Through Empirical Roughness Built for Hydrofabric Datasets

GEOGRAPHY HYDROLOGY

FLOOD INUNDATION MAPPING HYDROFABRIC MACHINE LEARNING RATING CURVE

ROUGHNESS SYNTHETIC RATING CURVE

J. Michael Johnson ✉ Damilola Eyelade, Justin Singh-Mohudpur , Arash Modaresi Rad , James Coll, Ryan Spies, Lilit Yeghiazarian

A. Dataset Comparison to Benchmark (OSM)

SI_SWOR_Widt	CSI_Landsat_Width_Med	best_estimate
0.94	0.92	0.94
0.94	0.91	0.94
0.77	0.75	0.88
0.76	0.73	0.99
0.76	0.74	0.99
0.76	0.73	0.97

C. Suggested Width Map

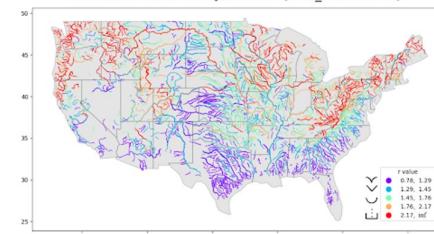


B. Reference Fabric Plus Top Width Estimates

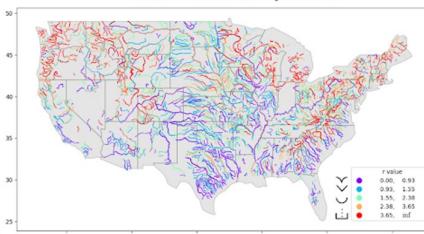
Reference\_CWUS\_WidtEstimate - Features Total: 2644123, Filtered: 2644123, Selected: 0

DA_Pl_Widt	rec_Ml_cwpt_Widt	recCh_Pl_Widt	elgdata_Ml_Widt	SWORD_Widt	andout_Widt	MvGd_Average_Widt	OSM_Skip	suggested_Method_Suggested_Width
106	88.85	244.40405357...	209	85.6197	105	108	99	MILL_MILL
123	88.87	81.6959915161...	209	85.6197	105	170	NULL_MILL	SWORD_Widt
134	88.82	81.2207781230...	209	85.6197	105	108	99	MILL_MILL
481	87.73	79.2120771282...	119	100.412169999...	105	108	81	MILL_MILL
716	87.63	83.8712191270...	NULL	100.412169999...	105	108	NULL_MILL	SWORD_Widt
716	87.63	81.8114624032...	NULL	100.412169999...	105	108	81	MILL_MILL

Predicted r values for HydroSWOT (vote\_meta model)



Actual r values for HydroSWOT



C. Mapping Roughness

Single Value Optimized



Hydrographic GBM



# Breaking Changes

In v2.2, *id/toid* were used as a generic for the shared 1:1 divide/flowpath pair in the dendritic system. Now, we will have explicit:

{**flowpath\_id**, **flowpath\_toid**}

{**divide\_id**, **divide\_toid**}

{**nexus\_id**, **nexus\_toid**}

{**flowline\_id**, **flowline\_toid**}

Pairs

While more explicit, it complicates crosswalking, and existing logic in many tools ...

# Breaking Changes

- Accounting for the ID change, the **flowpath/divide/nexus/network** layers of v3.0 will mirror the current v2.2 data structure and everything currently doable
- Additionally, a new **flowline** layer can optionally be used.
  - You can route along flowline system or flowpath system
    - Maybe MC on flowlines and DW on flowpath?
  - You can use them as headwater seeds for FIM

# Breaking Changes

In v3.0, the **network** table will expand to include the implicit crosswalk between:

`hf_*` (*persistent* reference ID)

`flowline_*` (*ephemeral* refactored ID)

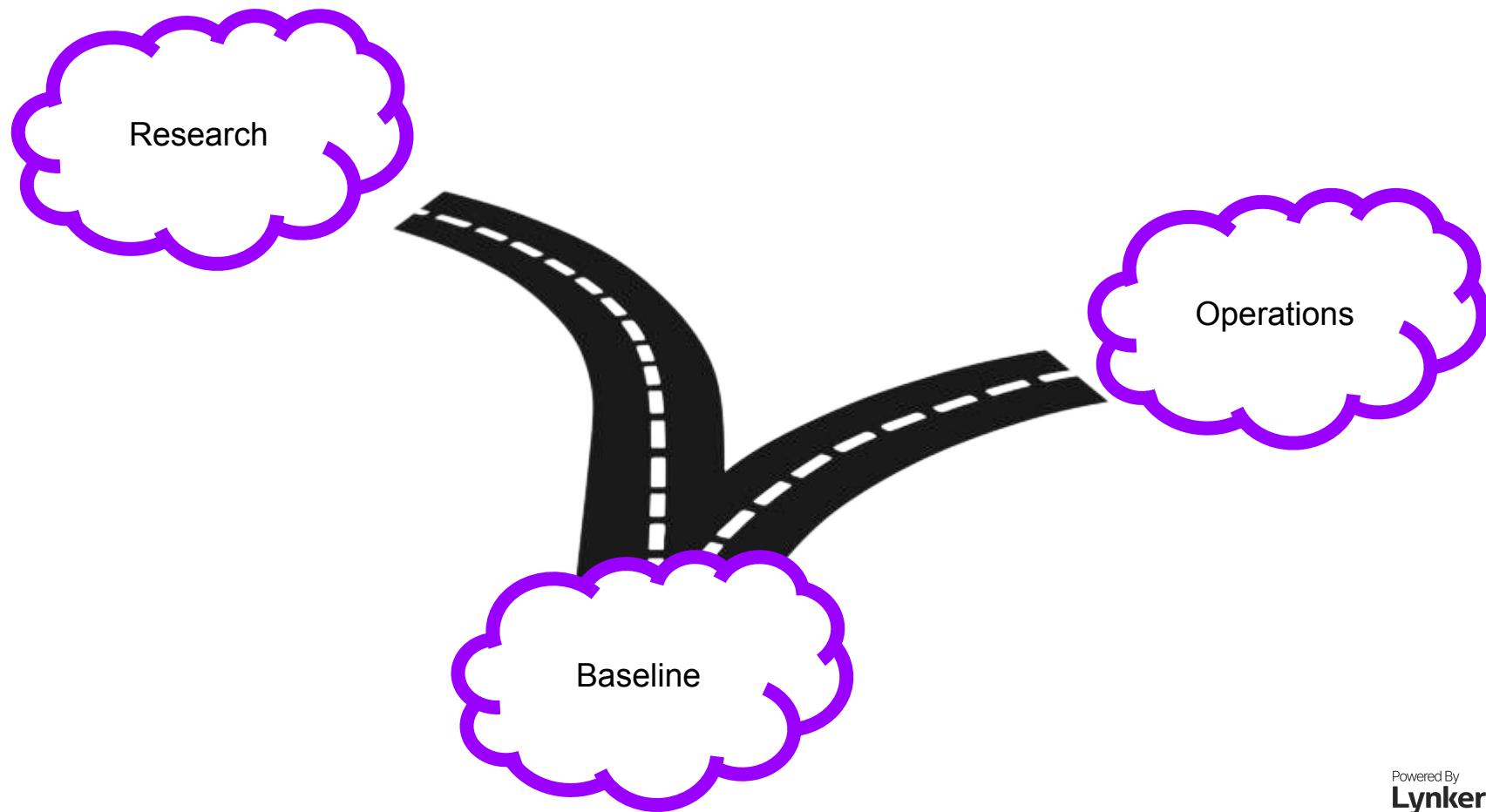
`flowpath_*` (*ephemeral* aggregation)

`poi_*` (*persistent POI ID, linked to contained hydrolocations*)

# Breaking Changes

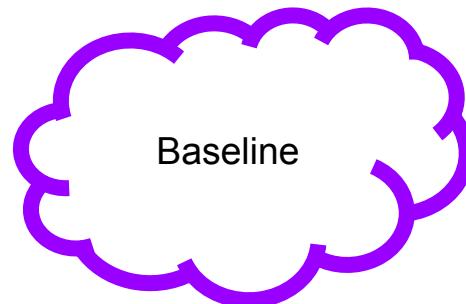
*Routing, Engine, and other downstream tools are not yet equipped to work across detached hydrologic and hydraulic networks...*

*Ongoing work is exploring limitations and opportunities....*



## Service 1: reference.fabric

- Automating the creation of the reference fabric and the shared NOAA/USGS refactored network (one set of parameters to feed NextGen and NHM).
- There are significant differences in how to run hydrofab at a local scale vs a national scale (Interbasin transfers, global identification, grid handling)
- Orchestrating the national resource, with mechanisms for ingesting (but validating) users contributions is necessary.



# What is targets

An R package for **reproducible workflows**

Automates and manages **pipeline execution**

Ensures results are **up to date** and **only recomputed when necessary**

Similar to [Make](#), but designed specifically for **data science**

Our friends at CUAHSI presented a [great introduction at ESIP!](#)



# Why we Use **targets**

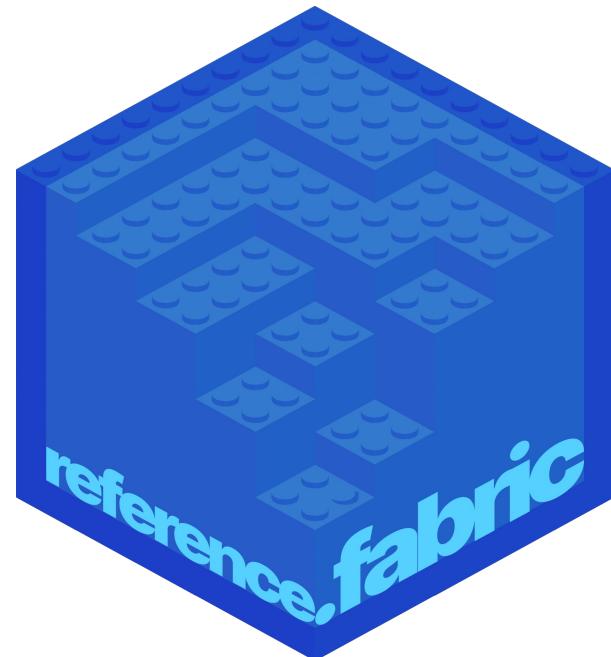
Tracks **dependencies** between steps (data and software)

**Skips** steps that don't need updating

Reduces runtime in iterative analysis

Allows us to separate “research” for “operations” code patterns making the former easier to use and the latter more sustainable.

Makes this massive project **more maintainable, scalable, reproducible** and **trackable**



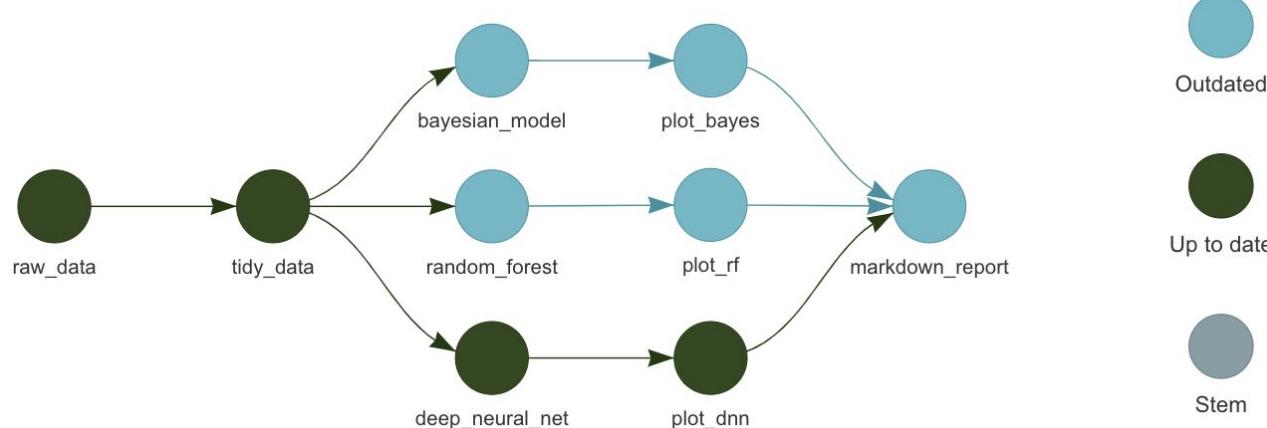
# Key Concepts

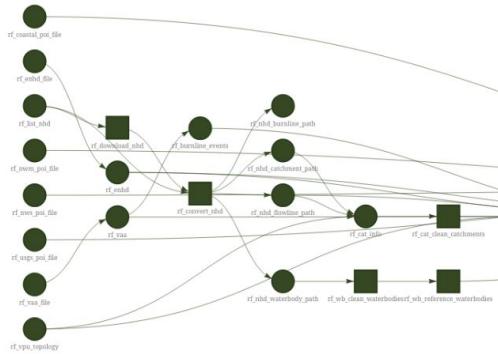
**Target:** A step in your workflow (e.g., a dataset, model, or plot)

**Pipeline:** A network of targets and dependencies

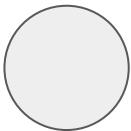
**Manifest:** A plan showing all targets and their status

Uses **R scripts** for workflows rather than YAML or CLI

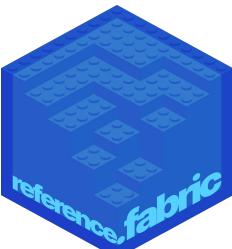
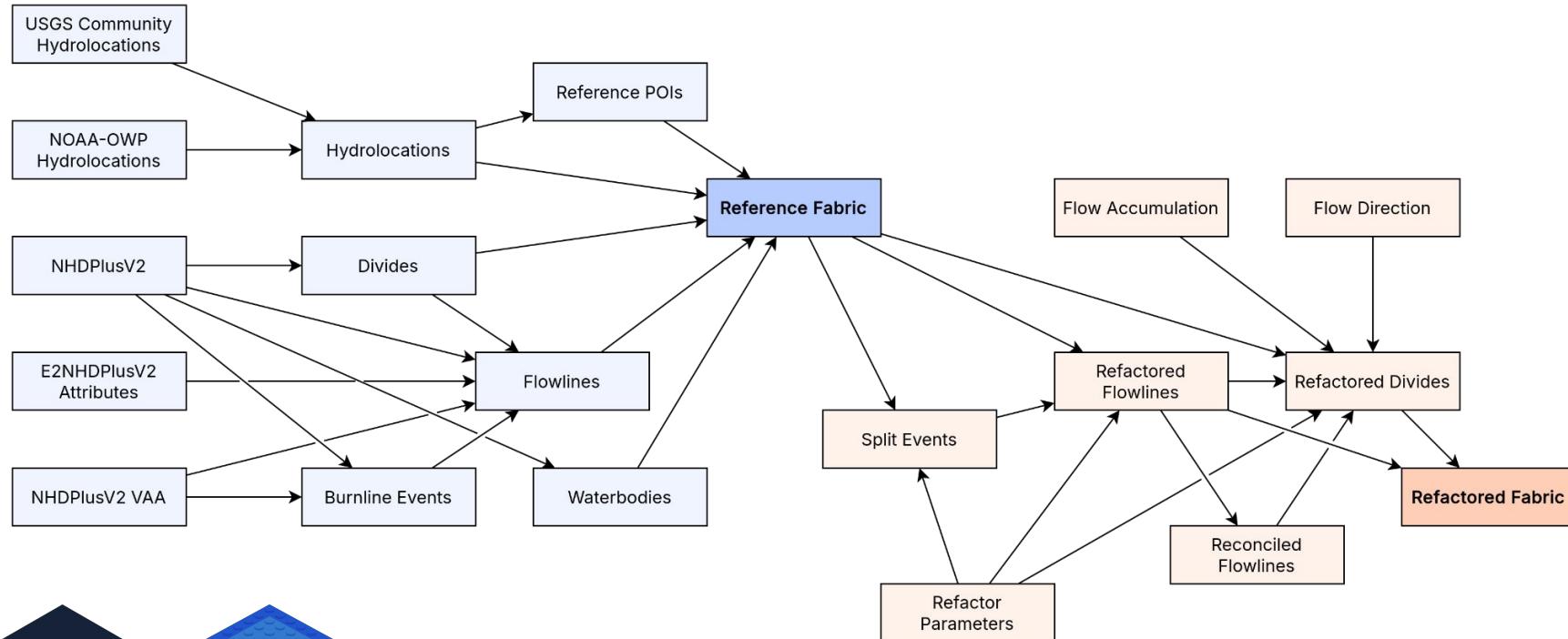




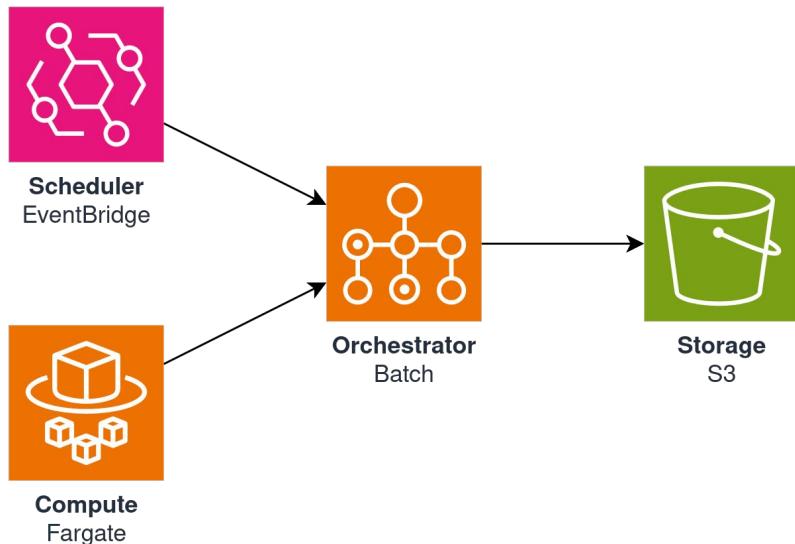
## Map over VPUs



## Individual targets



*To come... aggregation, nextgen formatting, attribute population*



## Continuous Deployment

- Schedule deployments cyclically using **EventBridge**
- Orchestrate workflow runs using **Batch** on top of **Fargate**
- Allows for periodic refreshes of the data updating only the needed components in each iterative release based on changes in the source data, code, or reported errors
- Period is undetermined, likely quarterly or biannual

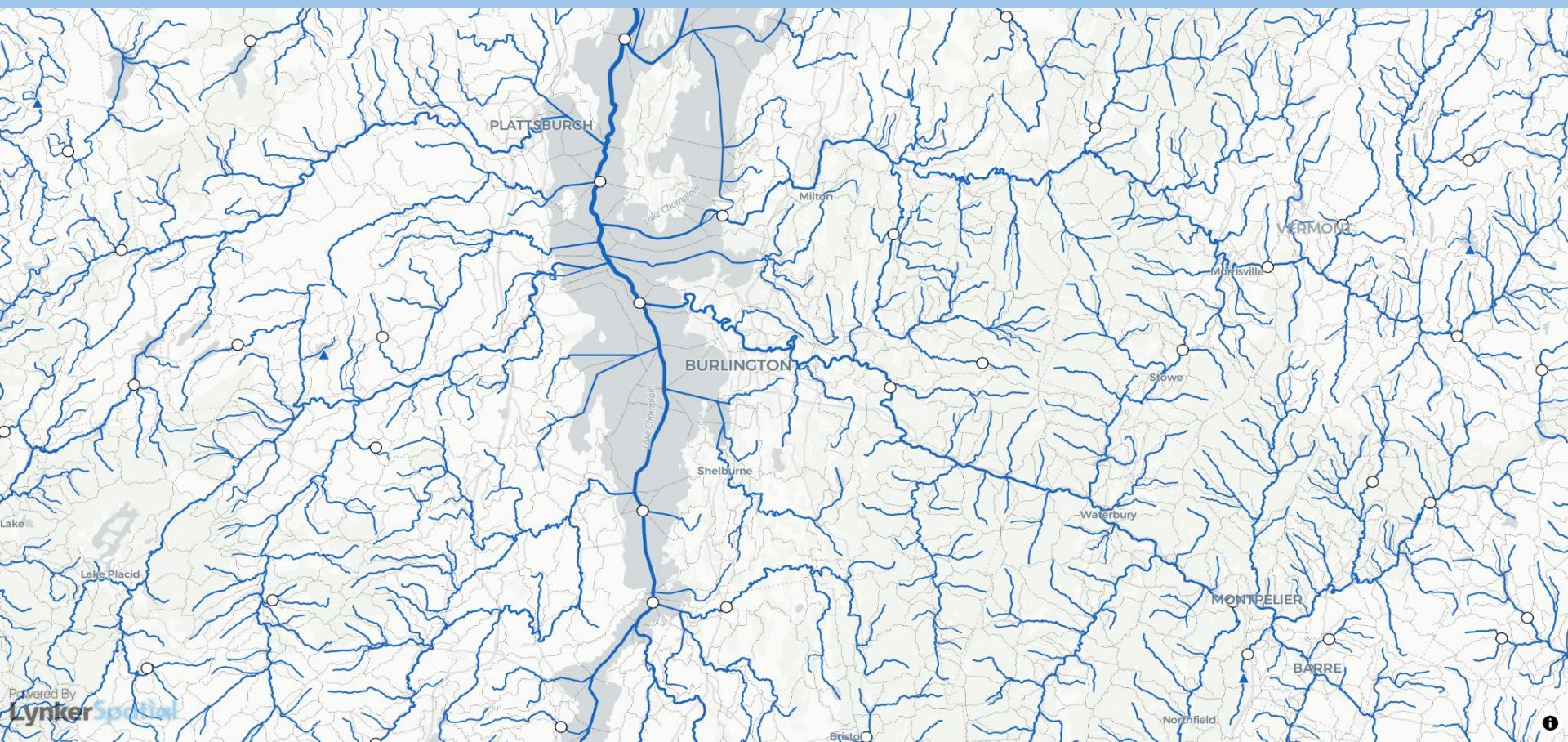
History

v2.2

v3.0

hftools

community.fabric



Powered By  
**Lynker Spatial**

<https://staging.lynker-spatial.com/hfview.html>

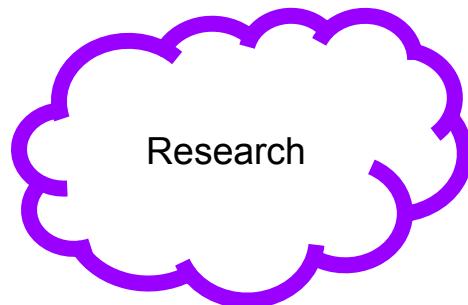
Powered By  
**Lynker Spatial**

## Service 2: hftools - on demand subsetting, refactoring, aggregation

Expediting access and manipulation of hydrofabric data for research, testing, and local solutions

Every local solution does not (should not?) make it back into a national model

In these cases, being able to rapidly and confidently test and evaluate



All base code is still  
written in R ...

But!



# hftools: CLI suite

- Go Client + R API service
- All cloud oriented, reproducible, open and accessible
- Reduce cost, time, latency and corruption potential of large gridded data
- Can be built into existing applications (e.g. NGIAB, Datastream)
- Can be used to test compliance of proposed changes (more to come ... )
- Multi platform use with capacity of multi language integration
- Requester pays using AWS presigned URLs



```
hftools <command> <arguments...>
```

```
hftools subset <fabric> <type> <identifier> <layers...>
```

```
hftools refactor <gpkg> <split_flines_meters> <collapse_flines_meters>  
<collapse_flines_main_meters> <pois>
```

```
hftools aggregate <gpkg> <ideal_size_sqkm> <min_length_km> <min_area_sqkm>
```



# hftools:

Modifiable in place, chainable, expressions for exploration...

```
hftools subset -o domain.gpkg v3.0 reference 101 divides flowpaths network |  
hftools refactor 10000 1000 1000 mypois.gpkg |  
hftools aggregate 10 1 3
```

```
hftools subset -o domain.gpkg v3.0 refactor 101 divides flowpaths network |  
hftools aggregate 10 1 5
```

```
hftools subset -o domain.gpkg v3.0 nextgen 101 divides flowpaths network nexus
```

Swagger  
Supported by SMARTBEAR

Hydrofabric Tools API 0.1.0a OAS3

<https://hftools.lynker-spatial.com/openapi.json>

Interact and operate on versioned hydrofabrics.

Servers

<https://hftools.lynker-spatial.com/api/> ▾

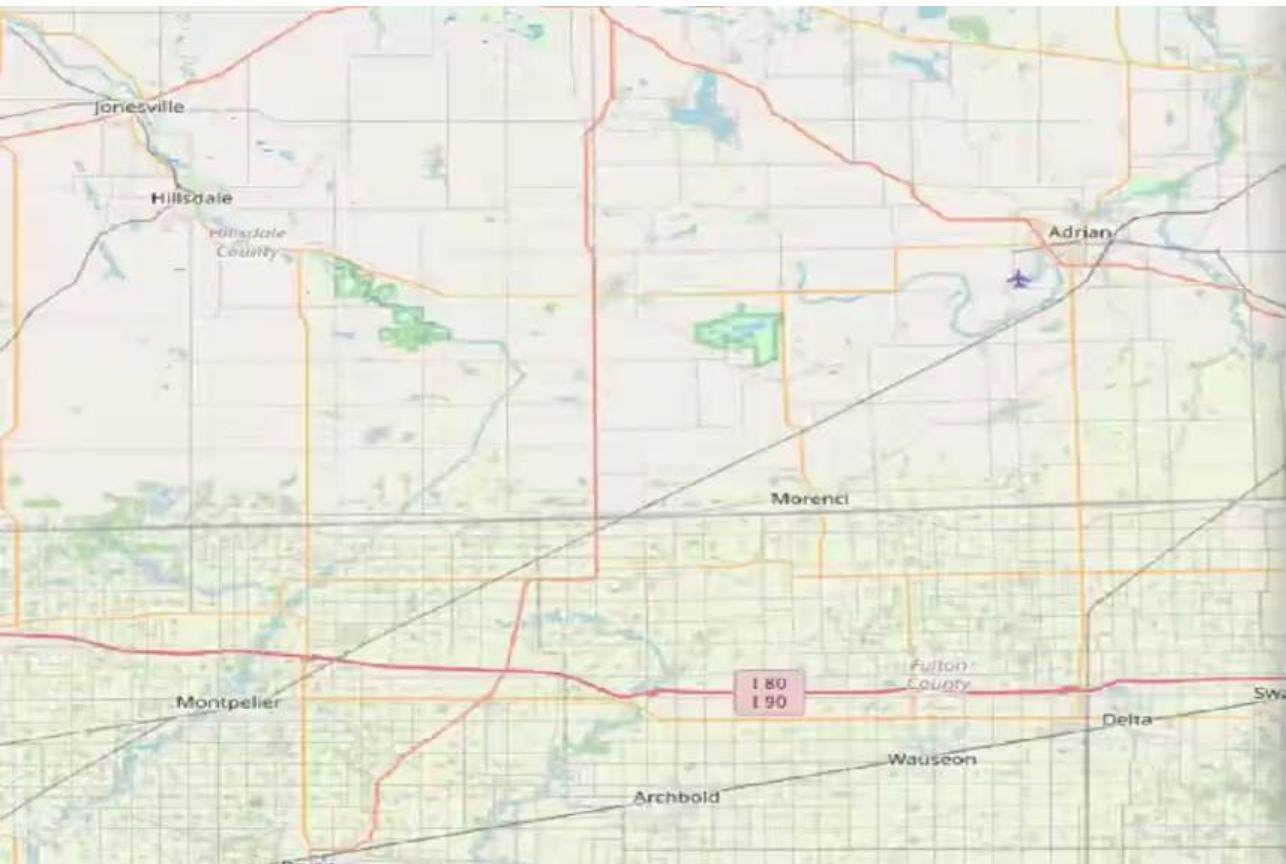
**subset** Subset operations ^

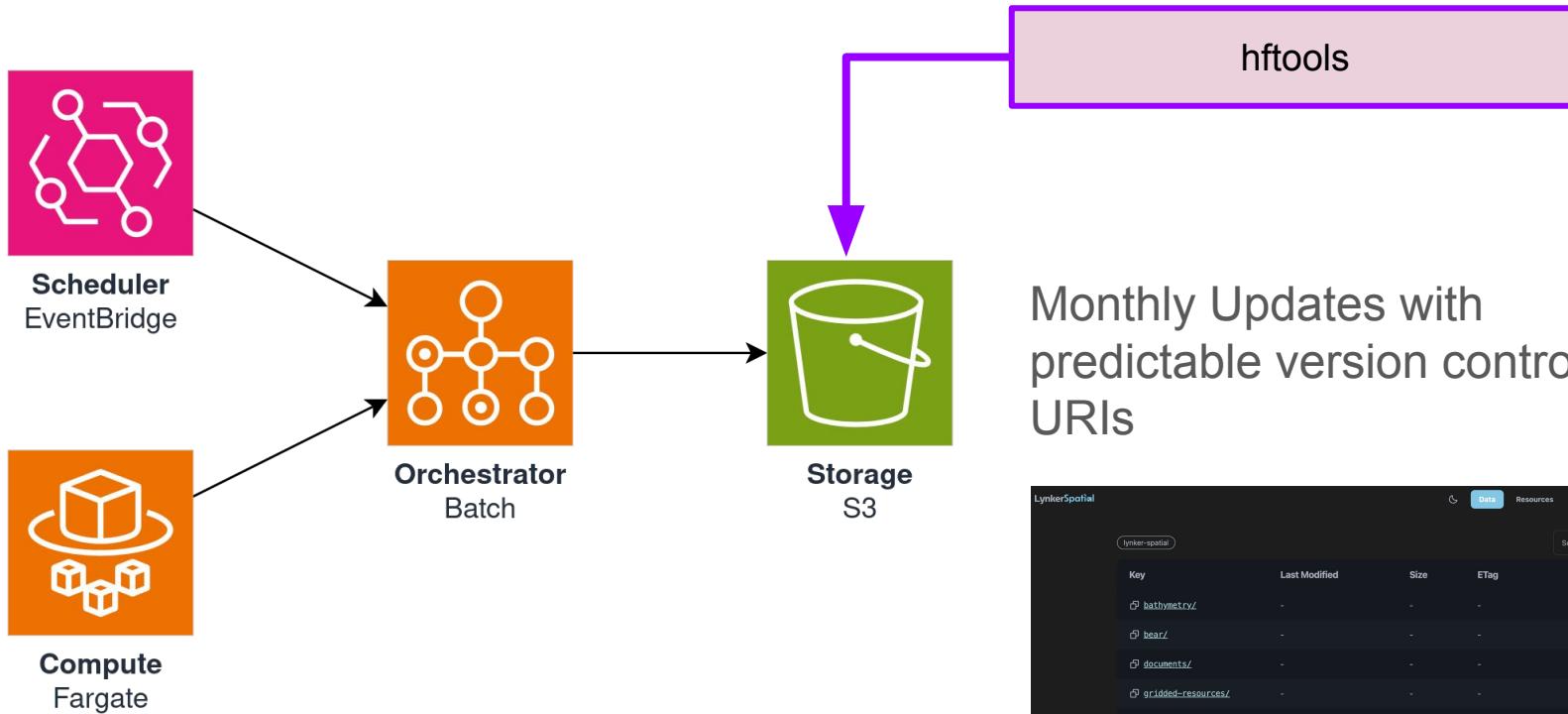
**GET** /subset/init/{fabric}/{type}/{identifier} Initiate a subset request ▾

**POST** /subset/{terminal} Fetch a hydrofabric subset ▾

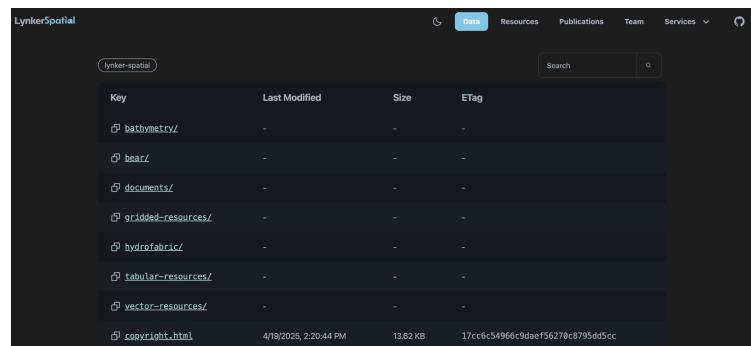
**status** ^

**GET** /ping Ping the API ▾





Monthly Updates with  
predictable version controlled  
URLs



## Service 3: community.fabric

In other cases, changes at a local scale should make it into the operational fabric.

1. Error corrections
2. New POIs
3. New attribute data (flowline, divide, flowpath)
4. ...



## Community Hydrofabric Issue Tracking

Export Hydrofabric Issues no status issues 0 open

- [Flowpaths, Topo Fixes:](#) open Hydrofabric-topo-fixes issues 0
- [Flowpaths, Merge Flowpaths:](#) open Hydrofabric-merge-flowpaths issues 0
- [Flowpaths, Remove Flowpaths:](#) open Hydrofabric-remove-flowpaths issues 0
- [Divides, Reid Divide:](#) open Hydrofabric-reid-divide issues 0
- [Divides, Union Divides:](#) open Hydrofabric-union-divides issues 0
- [Hydrolocations, Hydrolocation Additions:](#) open Hydrofabric-hydrolocation-additions issues 0
- [Hydrolocations, Hydrolocations Adjustments:](#) open Hydrofabric-hydrolocation-adjustments issues 0
- [Data, Large Data Submission:](#) open Hydrofabric-large-data-submission issues 0



- [Introduction](#)
- [How It Works](#)
- [Identifying Features](#)
- [Issue Types & Templates](#)
  - [Flowpaths: Topo Fixes](#)
  - [Flowpaths: Merge Flowpaths](#)
  - [Flowpaths: Remove Flowpaths](#)
  - [Divides: Reid Divide](#)
  - [Divides: Union Divides](#)
  - [Hydrolocations: Hydrolocation Additions](#)
  - [Hydrolocations: Hydrolocation Adjustments](#)
  - [Data: Large Data Submission](#)
- [How to Report an Issue](#)
  - [Selecting the Right Template](#)
  - [Filling Out the Template](#)
  - [Multi-Instance Reporting](#)
  - [Tips for Reporting](#)
- [Tutorials](#)
- [Automation & Validation](#)
- [CSV Export](#)
- [Additional Information](#)

<https://github.com/lynker-spatial/community.fabric>

# Existing Structural Issues:

## Flowpaths: Topo Fixes

incorrect flow direction, or other structural problems

### Flowpaths: Merge Flowpaths

merging of multiple existing flowpaths within a divide

### Flowpaths: Remove Flowpaths

removal of specific flowpaths that are erroneous, redundant, or no longer representative

### Divides: Reid Divide

re-identify an existing catchment divide

### Divides: Union Divides

unioning of multiple existing catchment divides into a single, new divide

### Hydrolocations: Hydrolocation Additions

new locations should be included in hydrolocations

### Hydrolocations: Hydrolocation Adjustments

a POI is on the correct flowpath but its snapped point (lat/lon) needs adjustment

Data: Large

Data

Submission

datasets too extensive for direct submission

Report your own!

# Reporting an issue

## 1. Find or Verify Feature Information:

Use the [Hydrofabric Viewer](#) to locate or confirm the reported features and their associated identifiers.

## 2. Report an Issue:

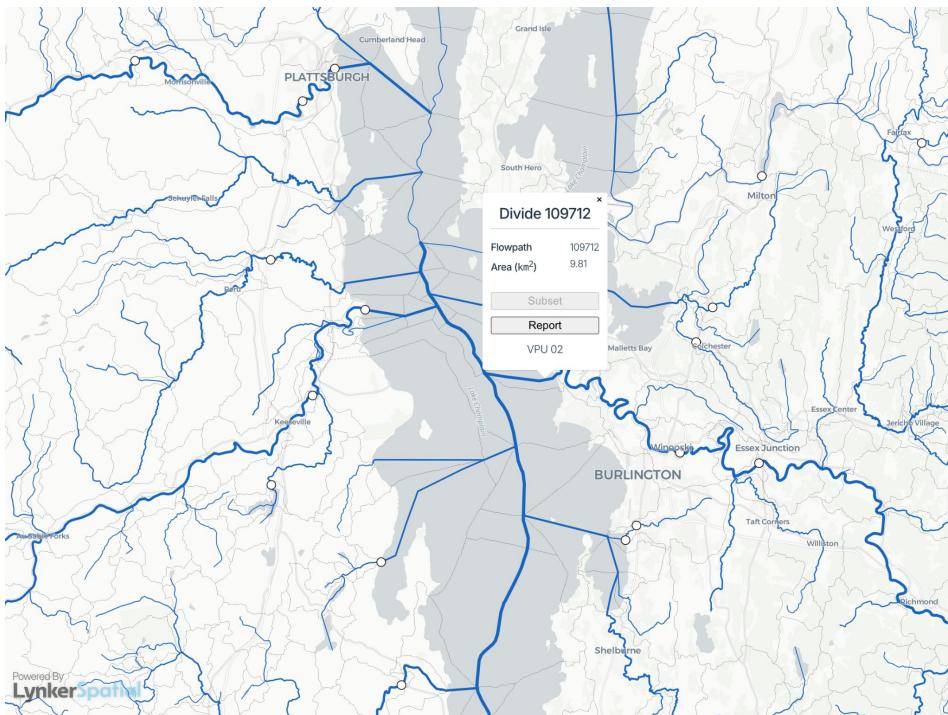
Select the appropriate issue template and complete all required fields with accurate details.

### ★ Tips for gold star reports

**Be Specific:** The more precise your information, the easier it is to address the issue.

**Use the Map:** Refer to the [Hydrofabric Viewer Map](#) to get accurate IDs and VPUs. Using out of date versions will miss any of the improvements already submitted and rectified in the newest release.

**Screenshots** and additional relevant documentation will ensure the correction is accurate and applied as intended.



# Example: Hydrolocations - Additions

There is a critical locations that needs to be included in the hydrolocations

The steps you'd take:

- 1) Select **Hydrolocations: Additions** issue template
- 2) Fill the issue and provide a screenshot

Add a title \*

The title will be automatically updated based on the "HL Link (Internal ID)" you provide below. Use this template to propose new hydrolocations to be added to the hydrofabric. Please provide the required details below. Use this map to extract extra information if needed: [Map](#).

Hydrofabric Version \*

Select the hydrofabric version this addition applies to.

v2.2

Report Mode \*

Select if you are proposing a single new hydrolocation or multiple.

Report a single new hydrolocation

VPU(s) \*

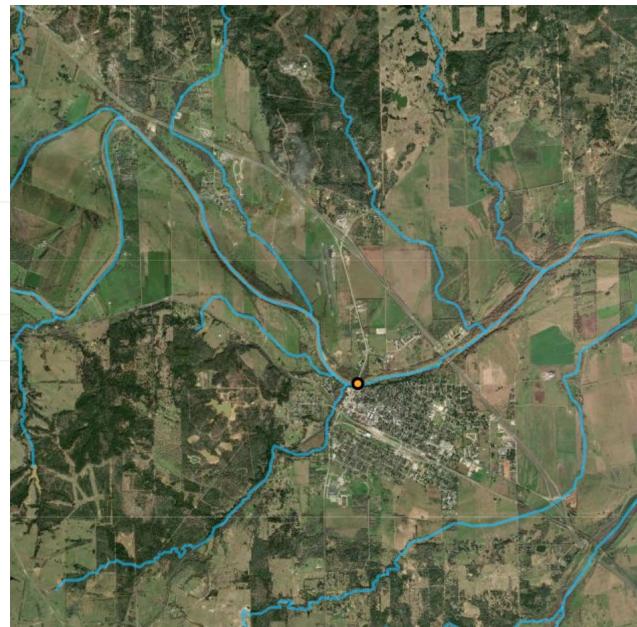
The VPU(s) where the new hydrolocation(s) should be located (e.g., 01). If Report many..., paste one VPU per line.

01  
02

HL Reference(s) \*

The reference source for the hydrolocation (e.g., usgs-gage, state-agency-id). One per line if reporting many.

usgs-gage  
lid



# Example: Remove Flowpaths

Issue: Mainstem 1970573. A single flowpath crosses two divides with an extra dangler hanging out (ID 10016831). To correct this we need to both...

- **Remove:** flowpath 10016831

The steps you'd take:

- Select Flowpaths: Remove Flowpaths issue template
- Fill the issue and provide a screenshot

- **Merge:** catchments 10016831 and 10016708, keep ID 10016708

The steps you'd take:

- Select Divides: Union Divides issue template
- Fill the issue and provide a screenshot

Add a title \*

[Hydrofabric] Topology <Item Identifier> Remove Flowpaths

The title should not be changed and will be automatically updated based on the Item Identifier.  
Thanks for reporting a hydrofabric issue!  
Please provide the required details below.  
Use this map to identify the item: [Map](#).

Hydrofabric Version \*

Select the type of hydrofabric version.

v2.2

Report Mode \*

Select if you are reporting a single flowpath for removal or multiple flowpaths.

Report a single flowpath for removal

VPU(s) \*

The VPU(s) where the flowpath(s) to be removed are located (e.g., 01). If 'Report many flowpaths' is selected, paste one VPU per line, corresponding to the flowpath(s) to be removed.

01  
01  
02

Item Identifier(s) to Remove \*

The flowpath id(s) to be removed (e.g., 620629). If 'Report many flowpaths' is selected, paste one identifier per line.

620629  
730510  
840220

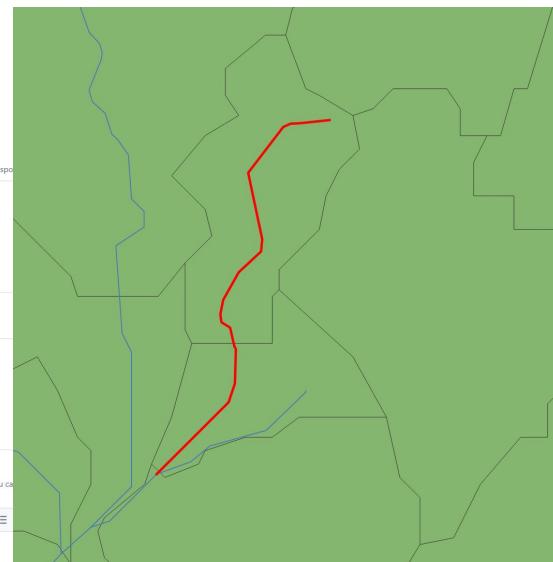
Describe why these flowpaths should be removed

Provide a summary of why these flowpath(s) need to be removed. This description applies to all flowpaths if reporting many. Optional: You can drop files into this description box or by using the 'Attach files' feature below.

E.g., these flowpaths are redundant, incorrect, or no longer exist...

Paste, drop, or click to add files

Create more  



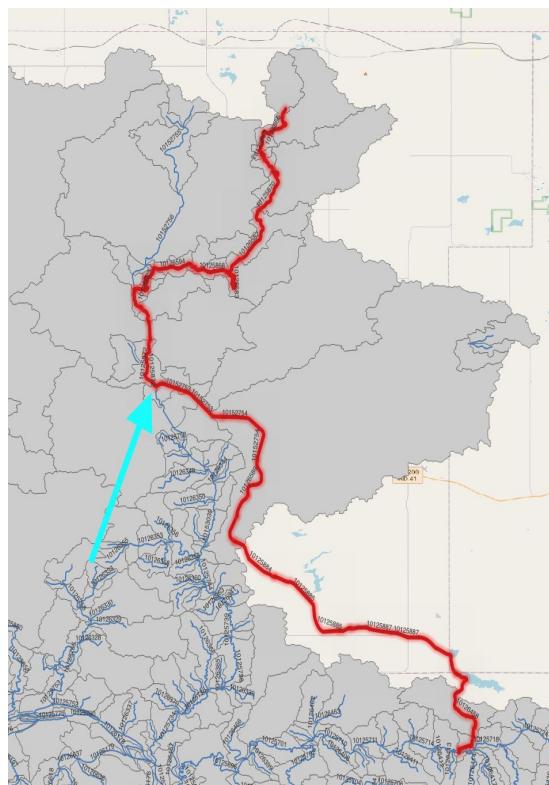
# Example: Remove Flowpaths

Issue: Mainstem: 1060393, ~1/2 of mainstem 1060393 is an artificial path that drains internal sink divides. The result is many flowlines without a divide.

- **Remove:** many flowpath

The steps you'd take:

- Select Flowpaths: Remove Flowpaths issue template
- Fill the issue and provide a screenshot



Add a title \*

(hydrofabric) Topology <item-identifier> Remove Flowpaths

The title should not be changed and will be automatically updated based on the item Identifier.  
Thanks for reporting a hydrofabric issue!  
Please provide the required details below.  
Use this map to identify the item: [Map](#).

Hydrofabric Version \*

Select the type of hydrofabric version.

v2.2

Report Mode \*

Select if you are reporting a single flowpath for removal or multiple flowpaths.

Report a single flowpath for removal

VPU(s) \*

The VPU(s) where the flowpath(s) to be removed are located (e.g., 01). If 'Report many flowpaths' is selected, paste one VPU per line, corresponding to each item identifier.

10U

Item Identifier(s) to Remove \*

The flowpath id(s) to be removed (e.g., 620629), if 'Report many flowpaths' is selected, paste one identifier per line.

10152753  
10152754  
10126589  
10125886  
10125883  
10125884  
10125885  
10125874

Describe why these flowpaths should be removed

Provide a summary of why these flowpaths need to be removed. This description applies to all flowpaths if reporting many. Optional: You can upload an image by dragging and dropping it into this description box or by using the Attach file feature below.

Write Preview

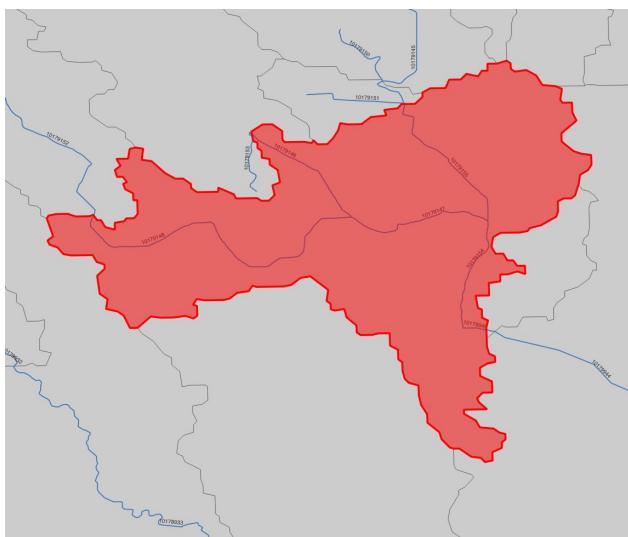
E.g., these flowpaths are redundant, incorrect, or no longer exist...

# Flowpaths: (Topo)logic Fixes

Issue: the topologic relationship of features divide\_id: 1941128, nex-1865691, and wb-1865691 needs to be corrected. Feature 10179149 should flow as 10179145 > 10179831 > 10179145

## Requires:

- Merge flowpaths
- Merge divides
- Remove flowpaths
- Change topology



Add a title \*

The title should not be changed and will be automatically updated based on the item identifier.  
Thanks for reporting a hydrofabric issue!  
Please provide the required details below.  
Use this map to identify the item: [Map](#).

Hydrofabric Version \*

Select the type of hydrofabric version.

v2.2

Report Mode \*

Select if you are reporting a single instance or multiple instances.

Report a single instance

VPU(s) \*

The VPU(s) where the issue(s) occur (e.g., 01). If 'Report many instances' is selected, paste one VPU per line (copy and paste column as plain text without header), corresponding to each Item Identifier. Ensure the number of lines matches the Item Identifiers.

10U  
10U

Item identifier(s) \*

The identifier(s) of the item(s) (e.g., 1455862). If 'Report many instances' is selected, paste one identifier per line (copy and paste column as plain text without header). Each line will become a separate entry in the CSV.

10179149  
10179831

Topology toid(s) \*

The toid(s) of the feature(s) (e.g., 1455862). If 'Report many instances' is selected, paste one toid per line (copy and paste column as plain text without header), corresponding to each Item Identifier. Ensure the number of lines matches the Item Identifiers.

10179145  
10179145

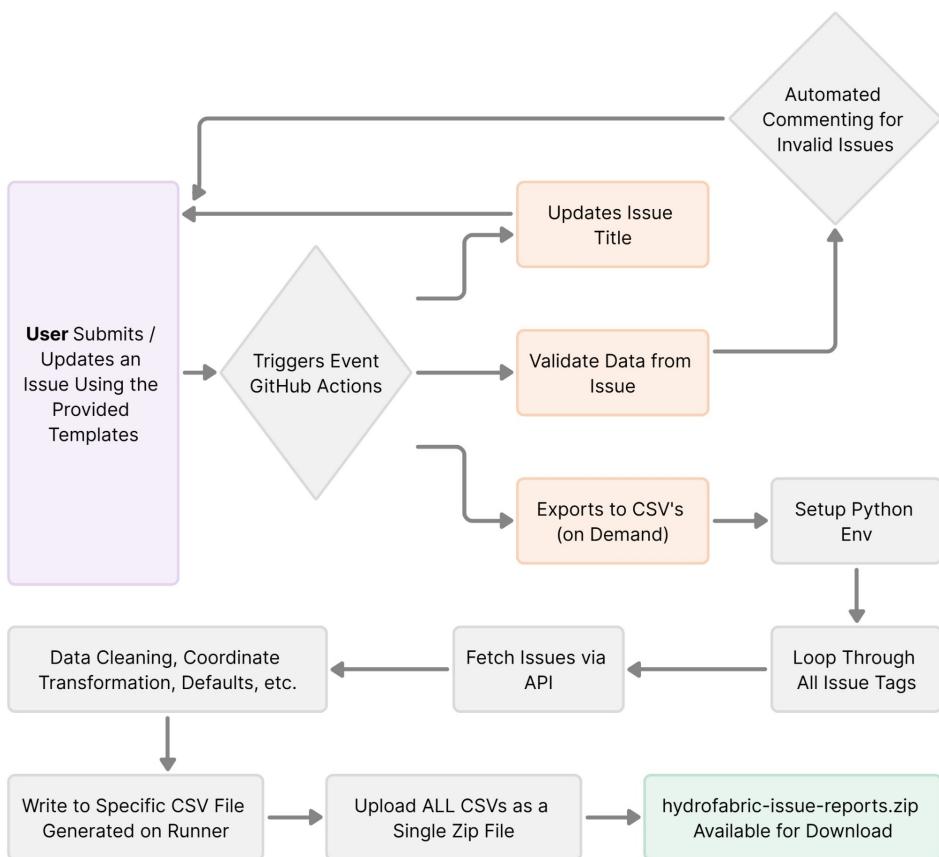
Describe the issue(s)

Provide a summary of the issue(s). This description applies to all instances if reporting many. Optional: You can upload an image by dragging and dropping it into the issue description or by using the 'Attach files' feature below.

Write Preview

The topology of the flowline should be fixed both instances should drain to 10179145

# What happens to reports:



## 1. Automatic Title Update:

The issue title will be automatically updated based on the primary identifier you provide in the form.

## 2. Submission Validation:

A GitHub Actions workflow will validate your submission against the template requirements. If any issues are detected, a comment will be added to with guidance.

## 3. You get credit!

The URI component of the underlying data infrastructure can attribute / link your contributions

Add a title \*

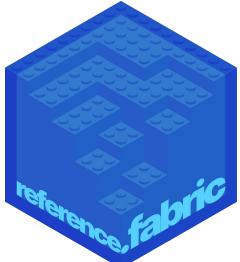
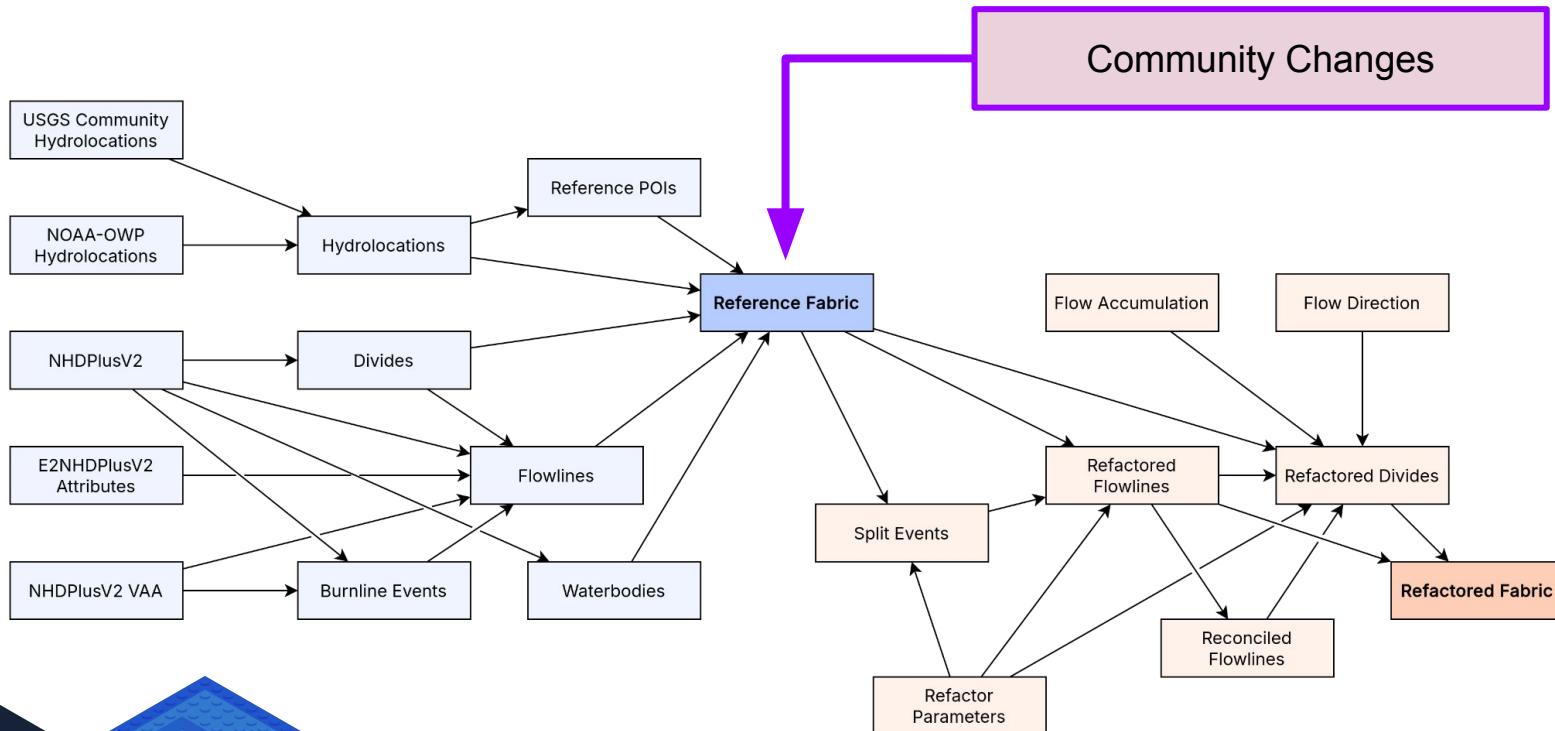
The title should not be changed and will be automatically updated based on the item Identifier.  
Thanks for reporting a hydrofabric issue!  
Please provide the required details below.  
Important Note: the new divide identifier needs to be the most downstream of the IDs to merge.  
Use this map to identify the item: [Map](#).

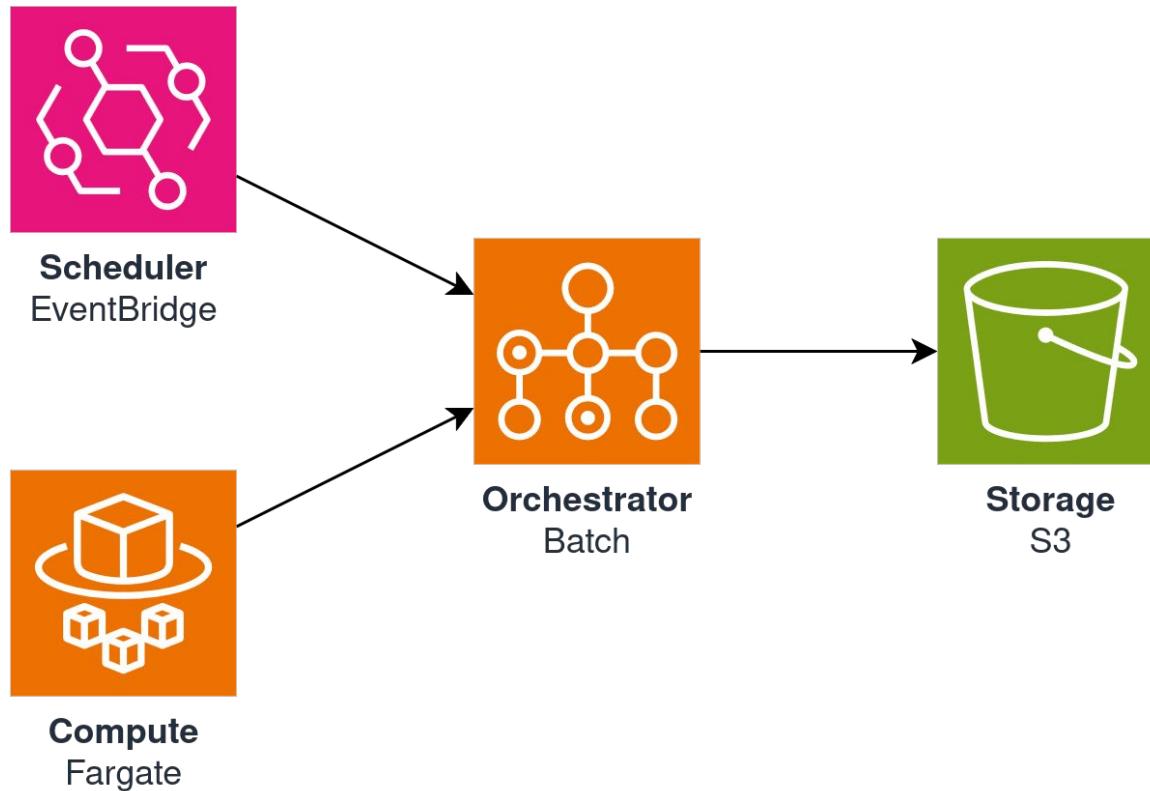
Hydrofabric Version \*

Select the type of hydrofabric version.

v2.2

Report Mode \*





- **Open-source software eliminates vendor lock-in**, avoiding the constraints historically imposed by Horizon Systems Corporation/Esri in the NHDPlus framework.
- **A baseline reference fabric, paired with supporting infrastructure**, enables the creation of a self-validating, living dataset. Experience has shown that both components are essential.
- **Reproducible geoprocessing tools and downstream software designed to work with ephemeral IDs** allow external applications to evolve alongside the fabric.
- **Command-line interfaces (CLI) break down system and language barriers**, fostering efficient data access, processing, and integration.
- **GitHub serves as a collaborative hub for contributions to the National Fabric**, while also supporting exploration and experimentation with local fabrics—aligning with Research-to-Operations (R2O) goals.
- **Edit accreditation ensures contributors receive recognition**, promoting transparency, traceability, and community trust.
- **Cost spreading across to the community makes it affordable for everyone**

# Approximate Timeline

**July: 2.3 will be released**

- superCONUS, National Bridge Inventory, refined hydrolocation assumptions
- v3.0 schema for the flowpath, divide, nexus layers
- hftools APIs release {subset, refactor}
- hfview reporting enabled
- Begin rolling in community contributions

**August: v3.0 beta will be released for superCONUS**

hftools {aggregate, nextgen-formatting}

**September: v3.0 beta will be released for oCONUS**

hftools {aggregate, nextgen-formatting}

**December: Illustrate full integration with FIM**

FIM services available in hftools integrated with hydrofabric3D

