River Runner

Navigating and Indexing Hydrologic Data with Open Standards

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USGS
science for a changing world

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What is the Hydro Network-Linked Data Index (NLDI)?

- A RESTful web service for discovering indexed hydrologic information
- A river navigation tool providing geospatial representations of stream flowlines, catchments, and water monitoring locations
- An open-source project used by United States Geologic Survey (USGS)

How does the NLDI work?

Value-Added Attributes (VAAs): a set of pre-calculated network characteristics of the NHDPlus High Resolution and Merit-Hydro

Community Contributed Features: a set of features provided by an organization that are indexed to the NHDPlus High Resolution

https://www.usgs.gov/national-hydrography/value-added-attributes-vaas

Stream Level

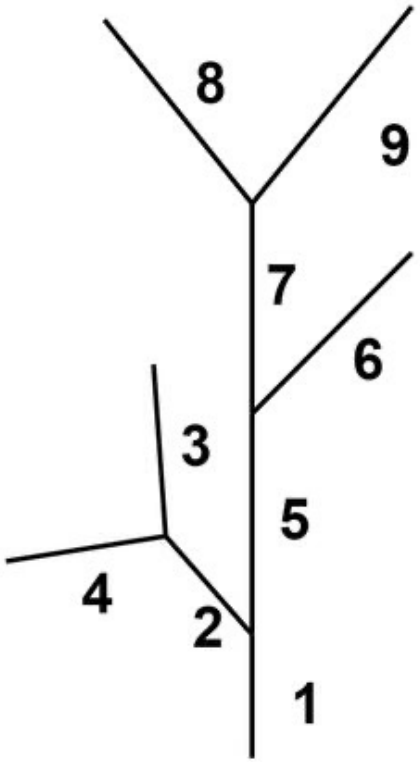
- A simple and logical stream routing system
- STREAMLEVE = 1 for all flowlines flowing into the ocean
- Flowlines feeding into Level 1 are assigned STREAMLEVE = 2

[from https://doi.org/10.1016/j.envsoft.2023.105726]

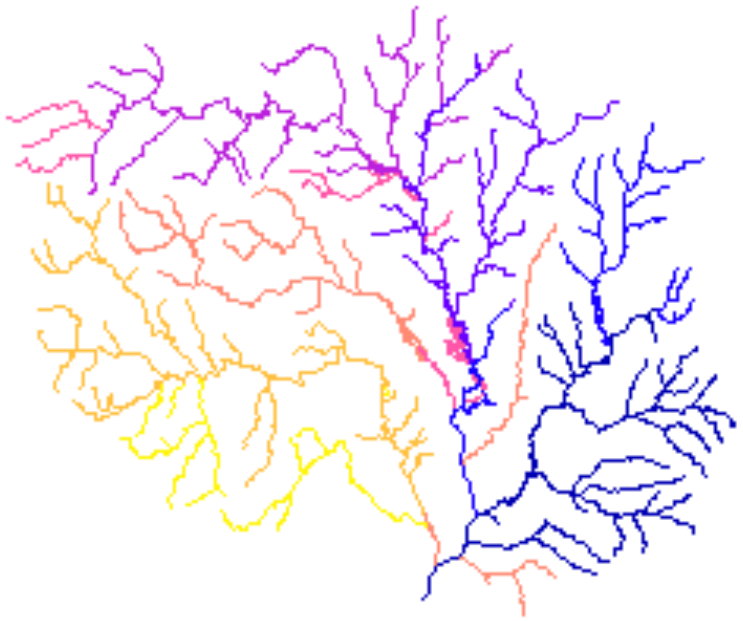
[from USGS Value-Added Attributes]

Hydrologic Sequence

- Unique sequence number that places each stream flowline in hydrologic order
- HYDROSEQ numbers increase from downstream to upstream

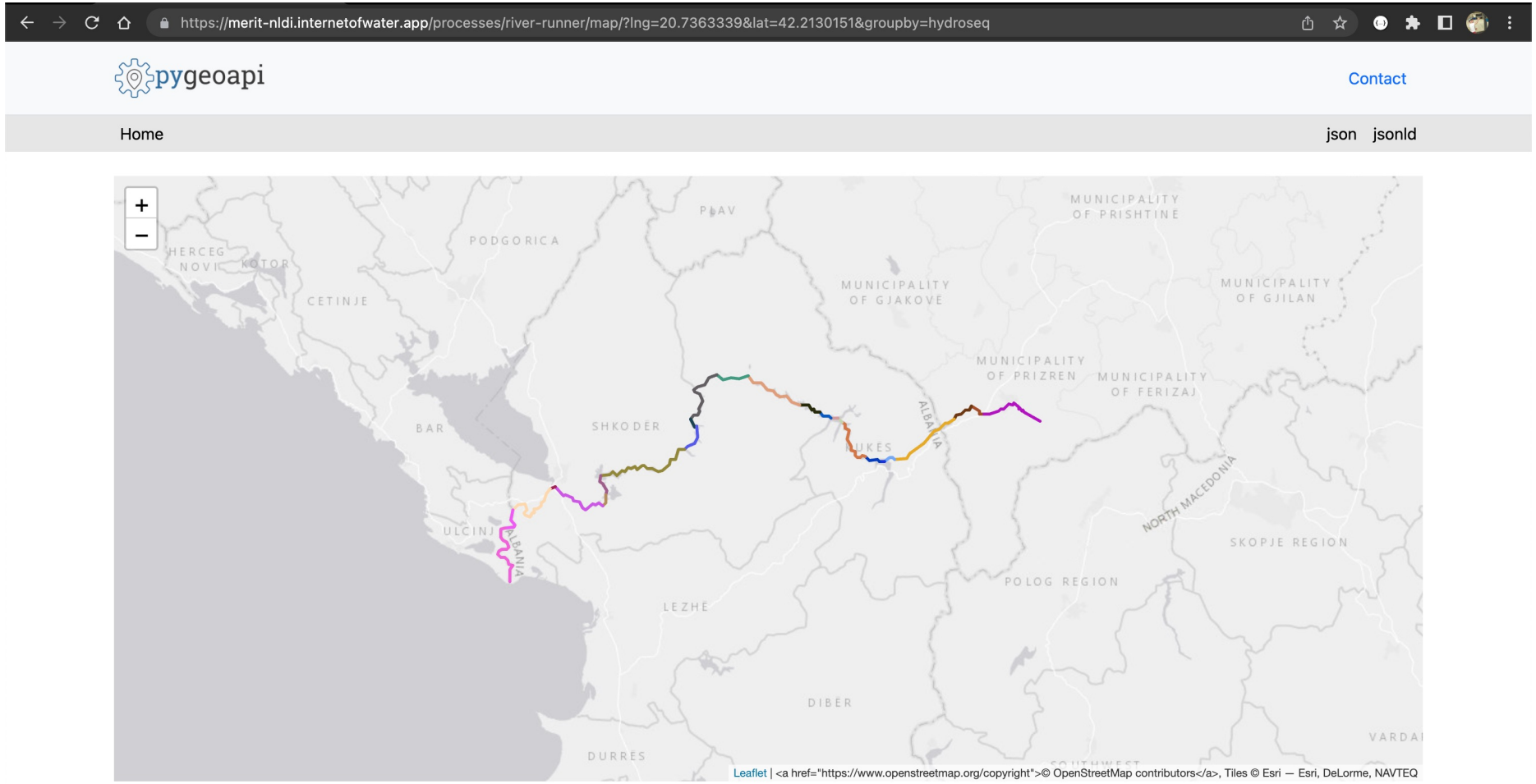


[from USGS Value-Added Attributes]



[from Advanced Network Attributes]

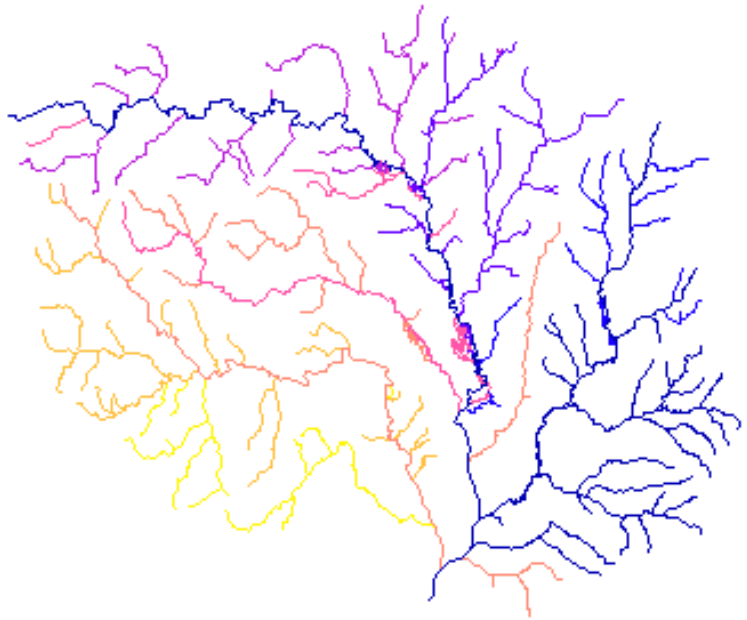
Value-Added Attributes in context – Hydrologic Sequence



https://merit-nldi.internetofwater.app/processes/river-runner/map/?lng=20.7363339&lat=42.2130151&groupby=hydroseq

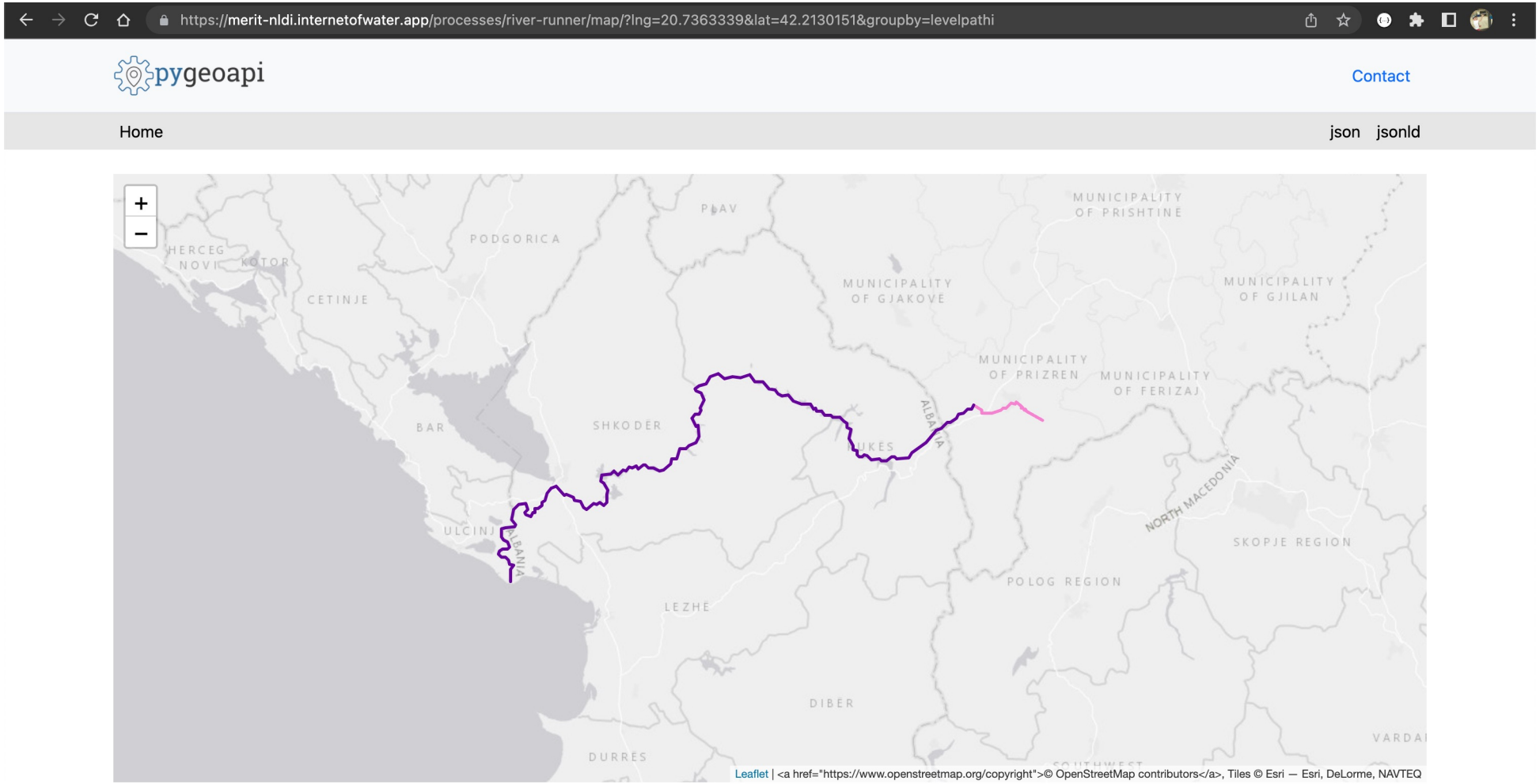
Level Path Identifier

- Unique identifier assigned to the set of flowlines that comprise a stream from its headwater to its mouth
- LEVELPATHI is the hydrologic sequence number assigned to the furthest downstream flowline on the stream level path



[from Advanced Network Attributes]

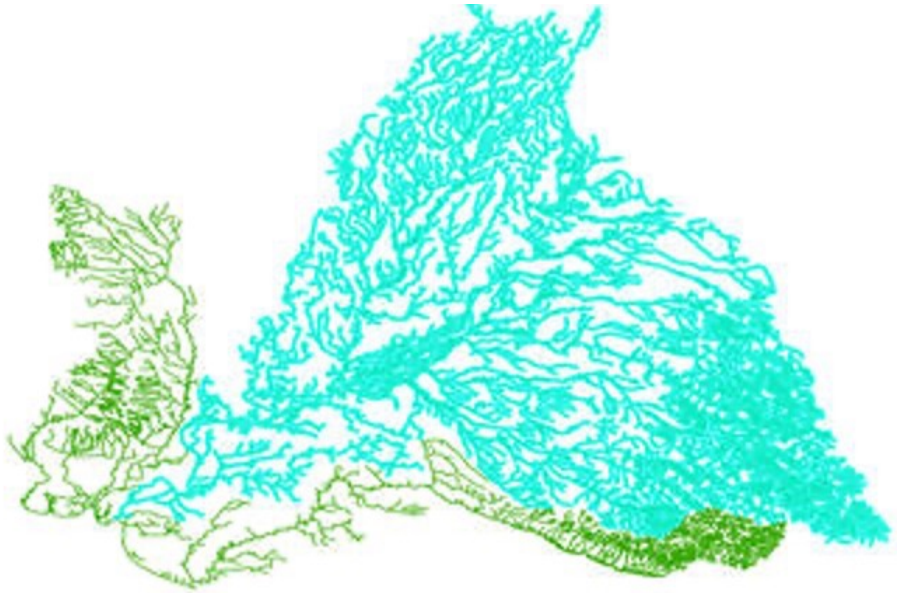
Value-Added Attributes in context – Level Path Identifier



https://merit-nldi.internetofwater.app/processes/river-runner/map/?lng=20.7363339&lat=42.2130151&groupby=levelpathi

Terminal Path Identifier

- The Hydrologic Sequence of last or “terminal” flowline in any part of the network.
- TERMINALPA can be used to identify all the flowlines that flow to a terminal flowline.



[from USGS Value-Added Attributes]

Value-Added Attributes in context – Terminal Path

pygeoapi

Contact

Home / Collections / merit / Items

json jsonld

merit

Items in this collection.

https://merit-nldi.internetofwater.app/collections/merit/items/?limit=401&terminalpa=1420165

… and many more VAAs

pygeoapi Contact

Home / Collections / merit / Items json jsonld

merit

Items in this collection.

id	areasqkm	terminalfl	terminalpa	streamlev	comid	hydroseq	riverid	levelpathi	down_levelpaths	tocomid
654804	16.5883865444377	0	1420165	2.0	21006858	1420252	None	1420170	1420165	2100807
654805	0.114109510449158	0	1420165	3.0	21006859	1420260	None	1420260	1420170,1420165	2100685
654808	24.7182461602339	0	1420165	4.0	21006862	1420264	None	1420264	1420260,1420170,1420165	2100685
654878	9.21957347851557	0	1420165	1.0	21006932	1420406	None	1420165		2100816
654894	22.3808106832436	0	1420165	2.0	21006948	1420446	None	1420446	1420165	2100693
654906	9.26422794264064	0	1420165	2.0	21006960	1420448	None	1420446	1420165	2100694
654913	21.7103085043078	0	1420165	2.0	21006967	1420450	None	1420446	1420165	2100696
654921	152.708838752655	0	1420165	2.0	21006975	1420452	None	1420446	1420165	2100696
654927	32.8367221804796	0	1420165	3.0	21006981	1420251	None	1420251	1420170,1420165	2100807
654980	32.3782327243848	0	1420165	1.0	21007034	1420407	None	1420165		2100693
654986	26.8125545985071	0	1420165	1.0	21007040	1420417	None	1420165		2100703
654998	14.2822327979875	0	1420165	2.0	21007052	1420437	None	1420437	1420165	2100704
655002	76.3149698233607	0	1420165	2.0	21007056	1420408	None	1420408	1420165	2100703

Putting it all together

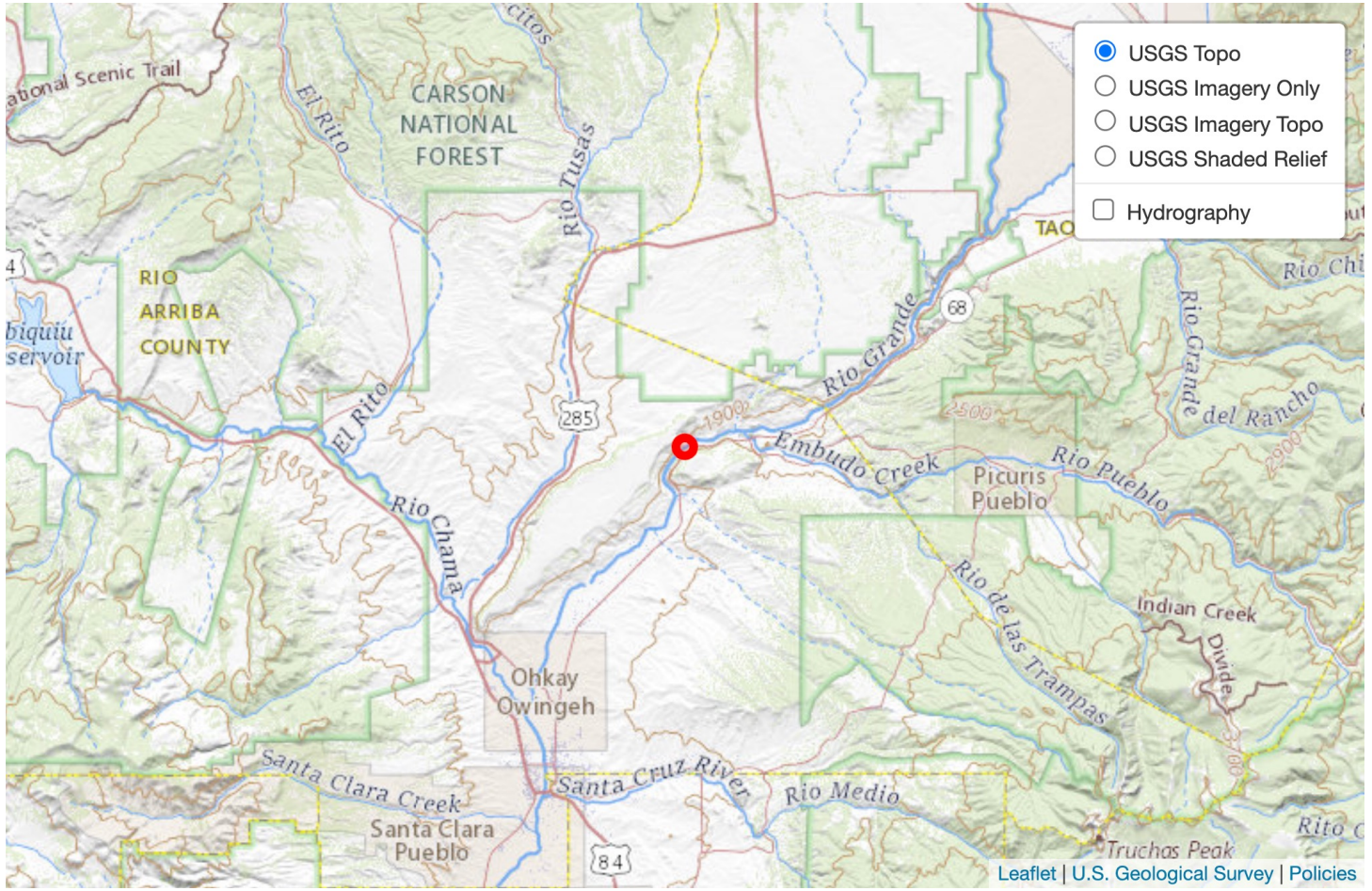
https://river-runner-global.samlearner.com/?lng=20.7363339&lat=42.2130151

More than just a visualization

- The NLDI is both a river navigation tool and a service to discover indexed information
- Data can be indexed to a Flowline in a Basin
- Able to navigate Upstream Tributaries, Upstream Mainstem, Downstream Mainstem, and Downstream Diversions

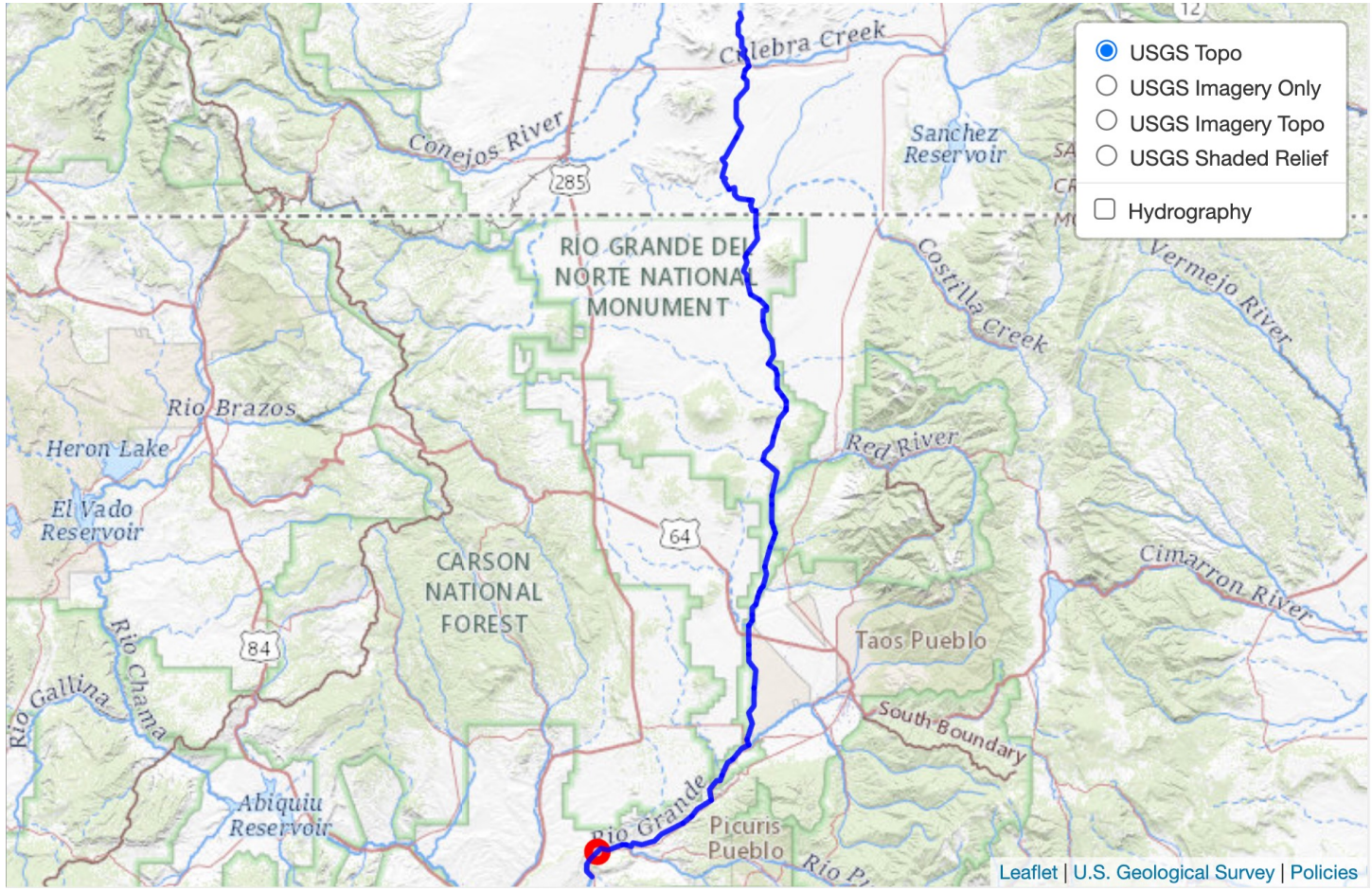
What does this look like?

Starting with an NWIS Site



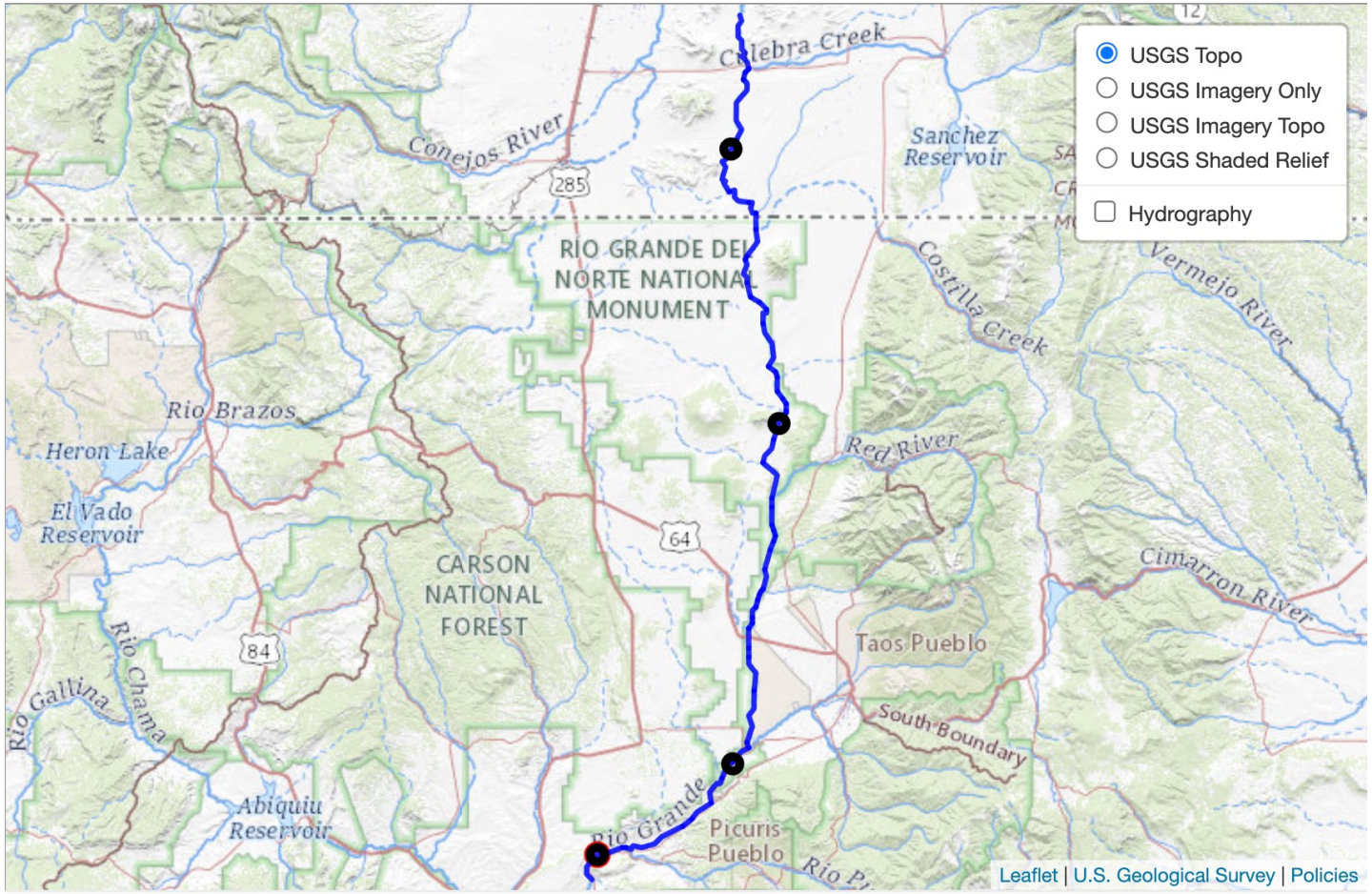
https://labs.waterdata.usgs.gov/api/nldi/linked-data/nwissite/USGS-08279500

Query Upstream Mainstem



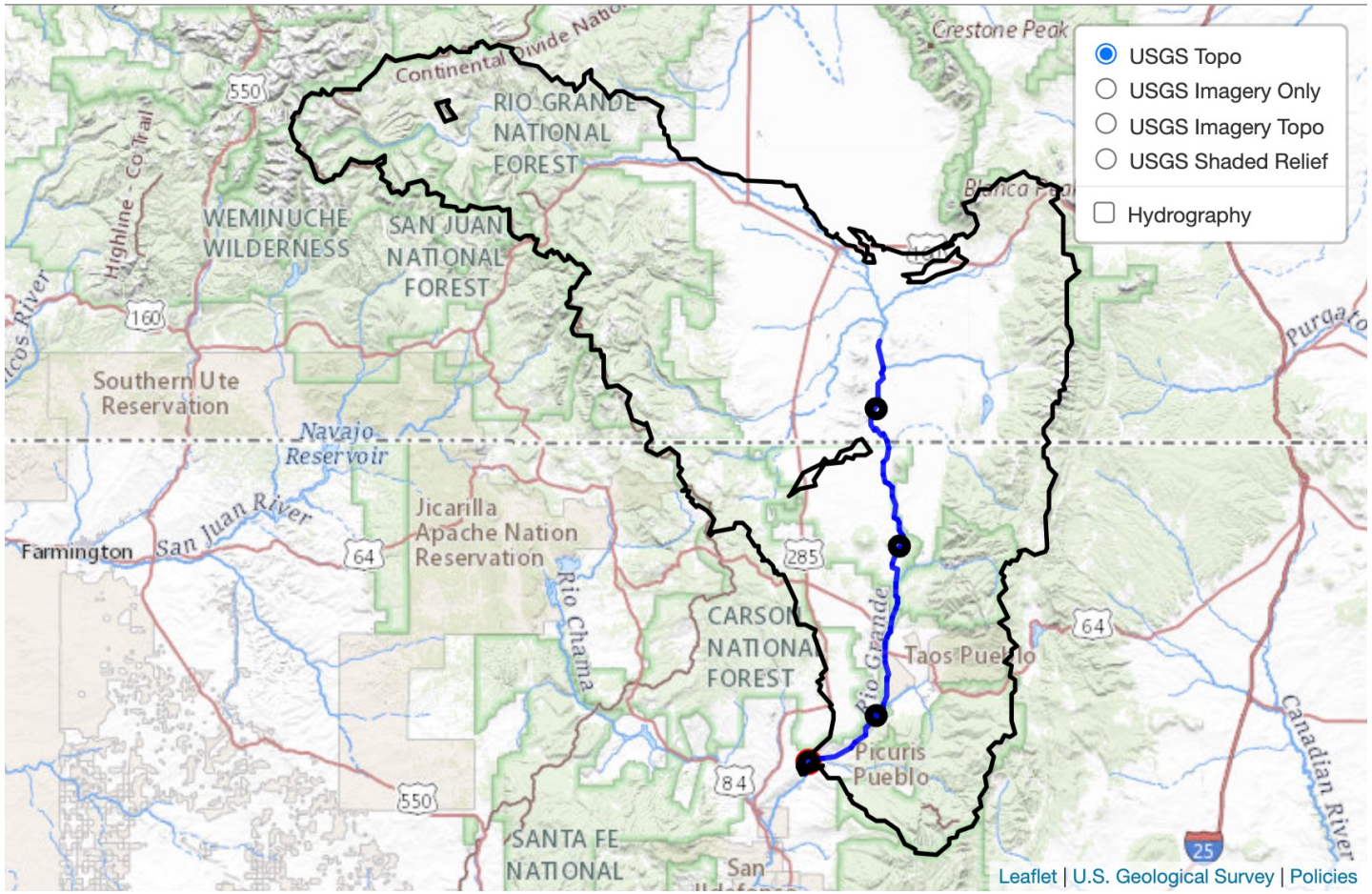
https://labs.waterdata.usgs.gov/api/nldi/linked-data/nwissite/USGS-08279500/navigation/UM/flowlines?distance=150

Query NWIS Sites on Upstream Mainstem



https://labs.waterdata.usgs.gov/api/nldi/linked-data/nwissite/USGS-08279500/navigation/UM/nwissite?distance=150

Query Basin of NWIS Site

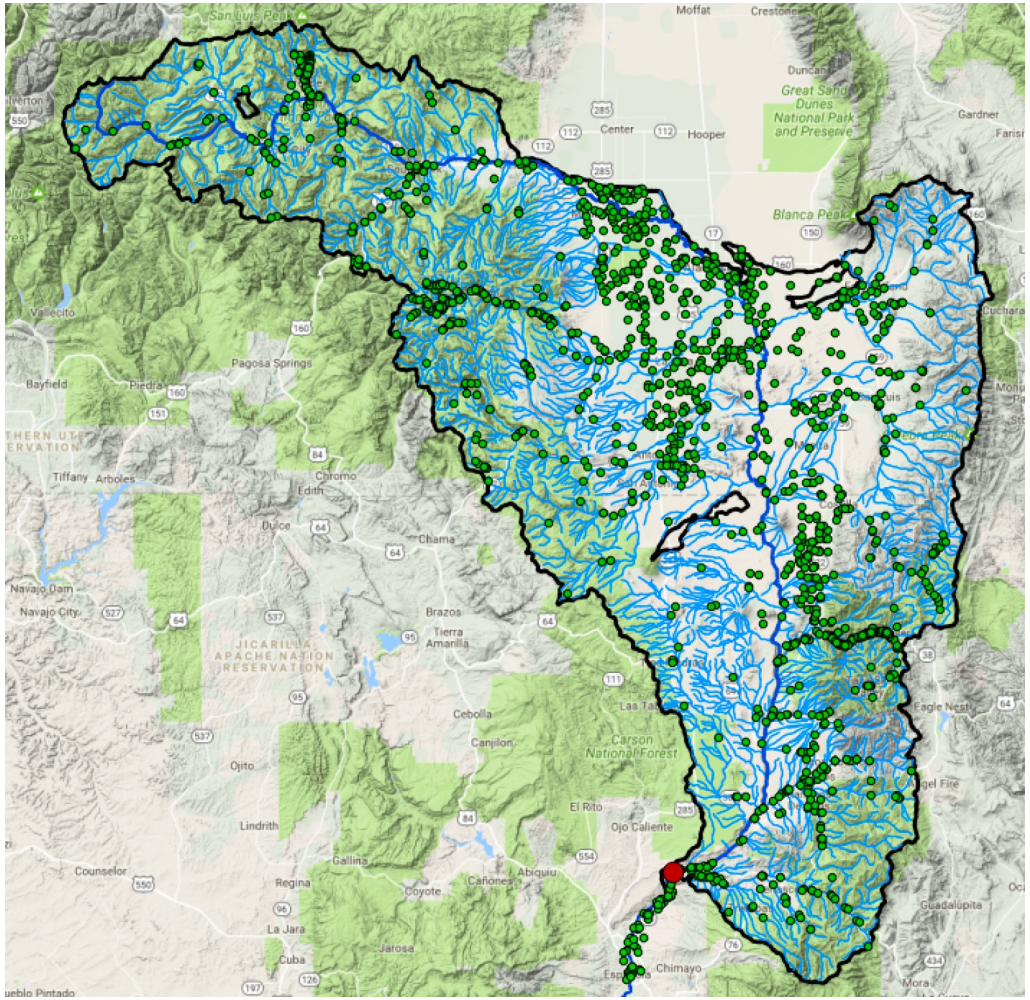


https://labs.waterdata.usgs.gov/api/nldi/linked-data/nwissite/USGS-08279500/basin

Query Upstream Water Quality Portal Sites

Combining NLDI Queries

1. NWIS site
2. The Basin of NWIS site
3. Upstream Mainstem
4. Upstream Tributaries
5. Upstream WQP Sites



NLDI in National Water Quality Monitoring

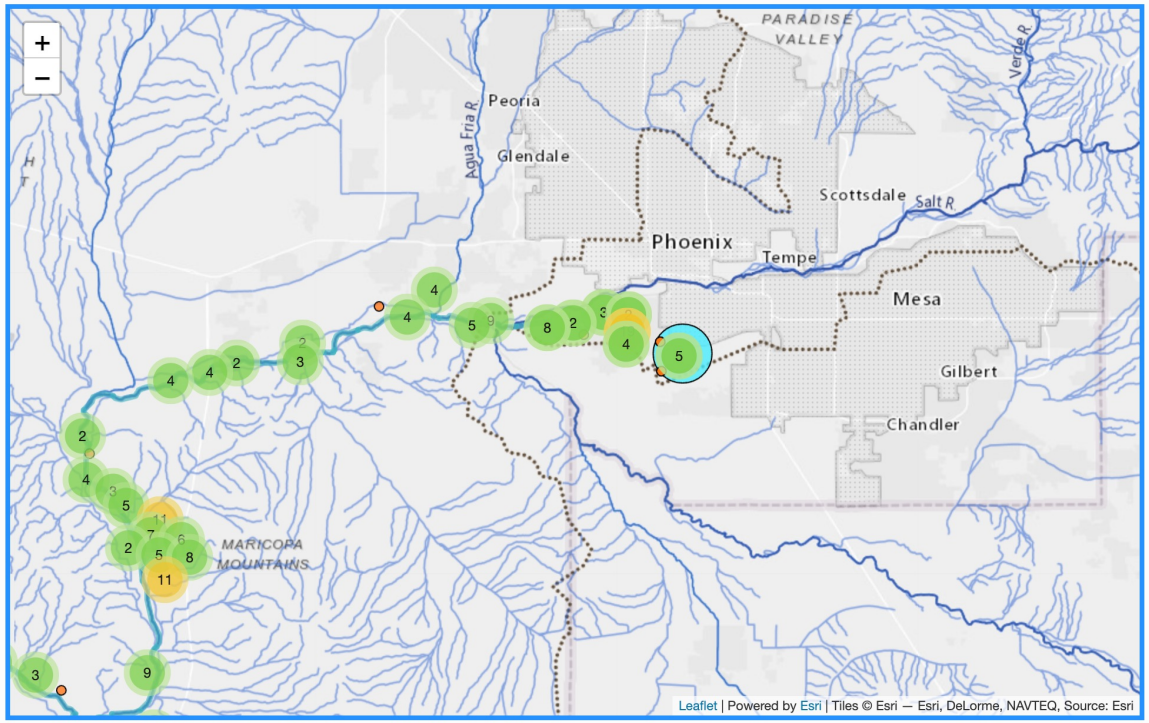
https://www.waterqualitydata.us/provider/NWIS/USGS-AZ/USGS-332109112041401/

ID" box under Site Parameters

What other monitoring locations are upstream or downstream from this one?

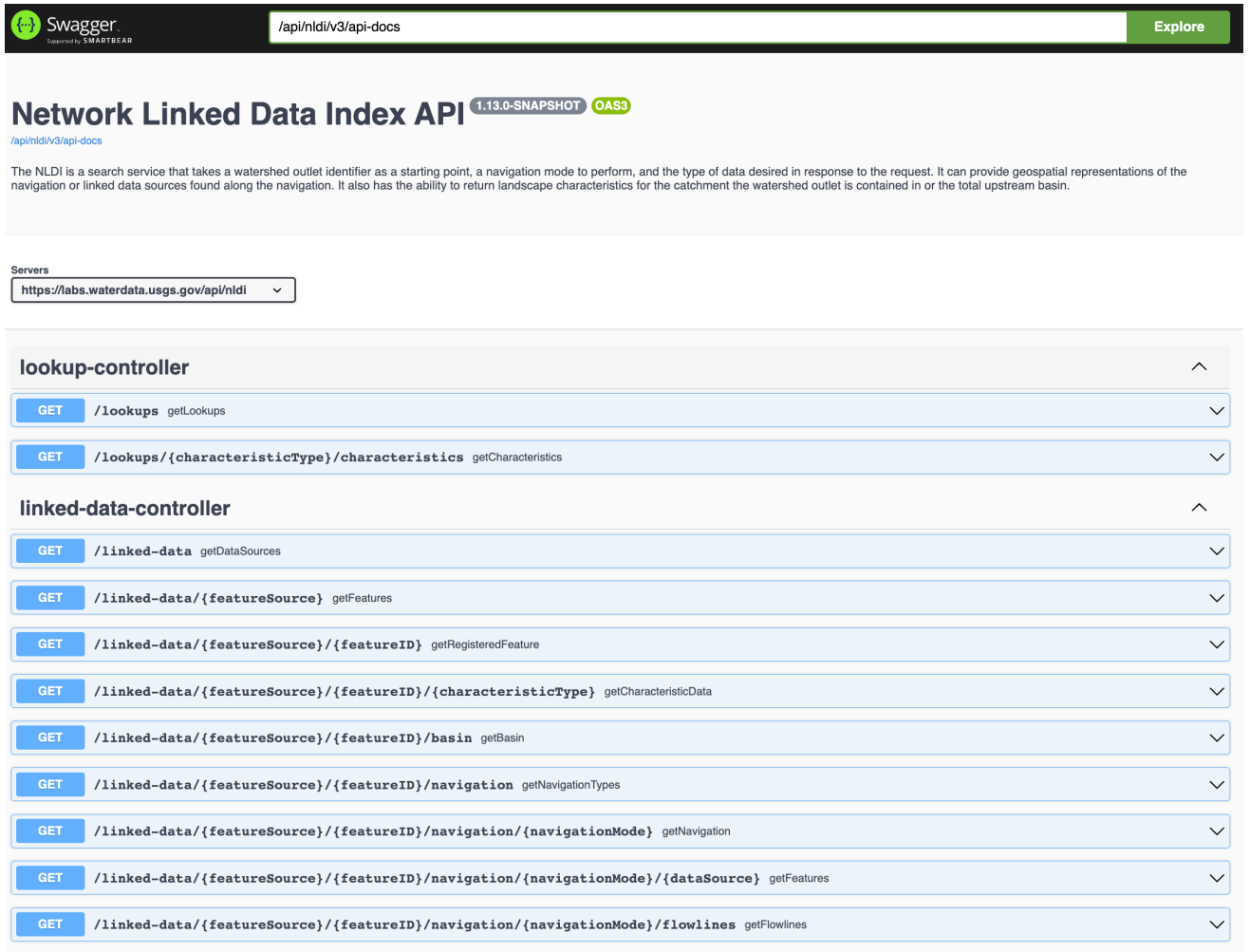
Upstream and downstream locations

This map shows all Water Quality Portal stations that are 10 miles upstream (dashed dark blue) and 10 miles downstream (solid light blue) of this monitoring location (indicated by the large blue circle). The upstream and downstream functionality is provided by the Network Linked Data Index.



Current state of the CONUS NLDI

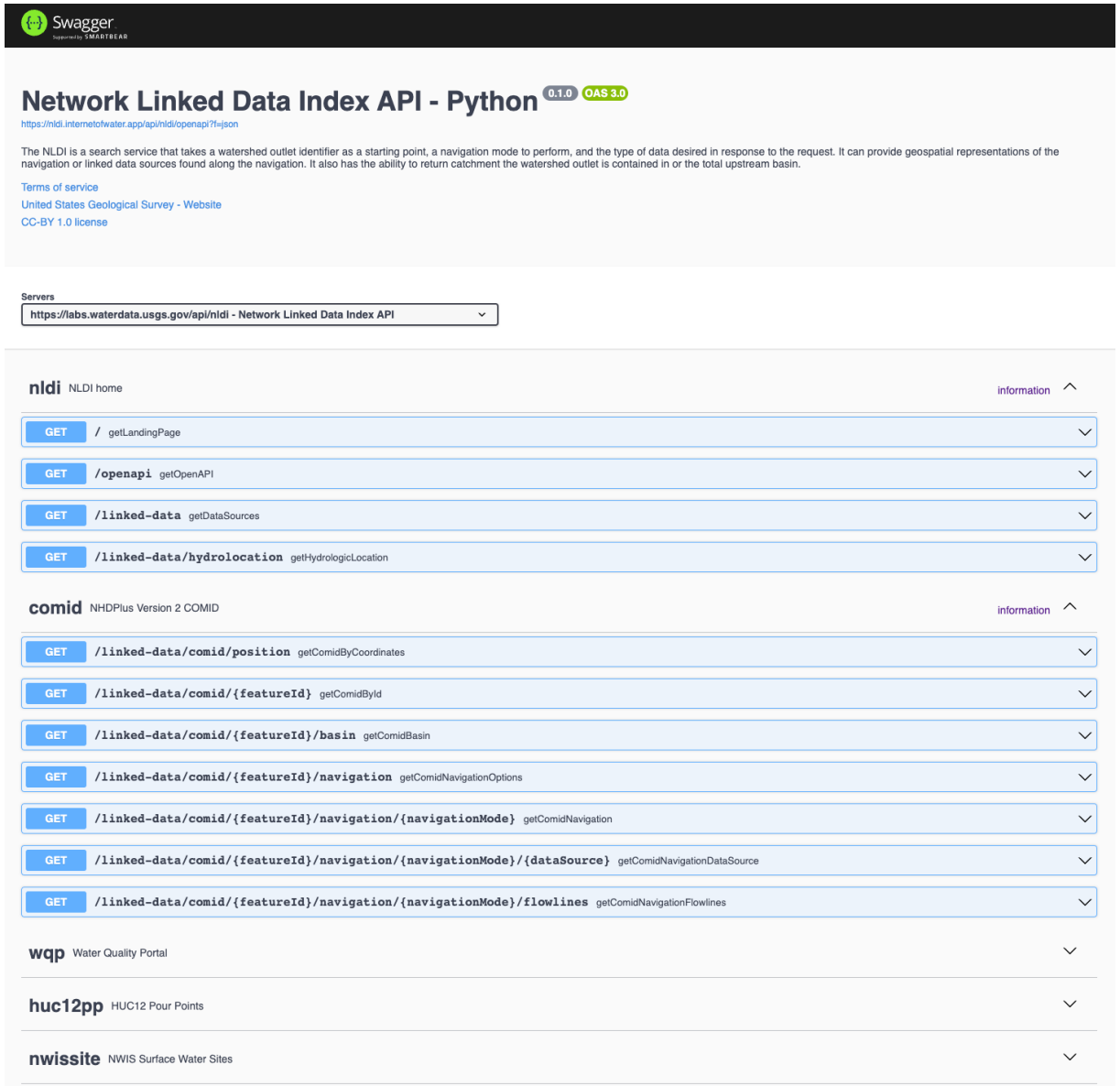
- The US NLDI is implemented in Java with an OpenAPI Document
- Can index any data to the NHDPlus HR
- Open Sourced on GitHub



https://labs.waterdata.usgs.gov/api/nldi/swagger-ui/index.html#/

Future direction of the CONUS NLDI

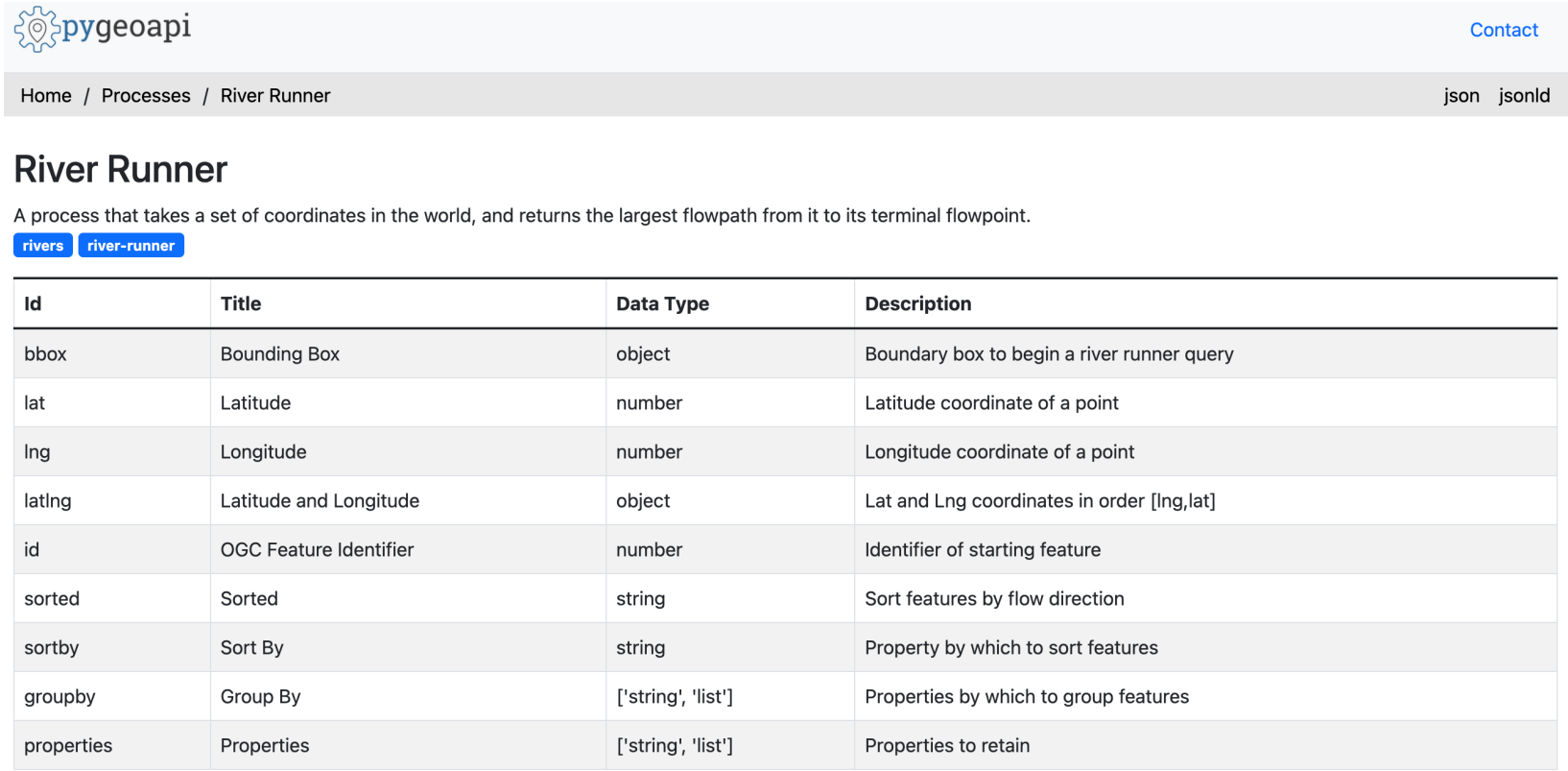
- The NLDI is being rewritten in Python
- Updated OpenAPI Document that enumerates indexed data
- Extending the NLDI beyond the continental US to include Alaska



https://nldi.internetofwater.app/api/nldi/openapi?f=html

Current state of the Global NLDI

The Global NLDI cannot index related hydrologic data and only supports downstream flowlines as a OGC API – Process via pygeoapi.



Id	Title	Data Type	Description
bbox	Bounding Box	object	Boundary box to begin a river runner query
lat	Latitude	number	Latitude coordinate of a point
lng	Longitude	number	Longitude coordinate of a point
latlng	Latitude and Longitude	object	Lat and Lng coordinates in order [lng,lat]
id	OGC Feature Identifier	number	Identifier of starting feature
sorted	Sorted	string	Sort features by flow direction
sortby	Sort By	string	Property by which to sort features
groupby	Group By	['string', 'list']	Properties by which to group features
properties	Properties	['string', 'list']	Properties to retain

Future direction of the Global NLDI

- Capacity to add querying by Upstream Mainstems, Upstream Tributaries, and Downstream Diversions
- Capacity to explore indexing of data to the river network
- Cover river name gaps from Natural Earth
- Extending the community of practice to index data globally

Further Reading

- **US NLDI Intro:** https://waterdata.usgs.gov/blog/nldi-intro/
- **US River Runner:** https://river-runner.geoconnex.us/
- **US NLDI Feature Source:** https://www.sciencebase.gov/catalog/item/60c7b895d34e86b9389b2a6c

- **Global NLDI Intro:** https://ksonda.github.io/global-river-runner/
- **Global River Runner:** https://river-runner-global.samlearner.com/
- **Global NLDI Feature Source:** https://www.sciencebase.gov/catalog/item/614a8864d34e0df5fb97572d

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