NHDPlus Catchments and WBD Hydrologic Units as building blocks for Stream-Water-Quality Modeling Analysis and Reporting

Topics covered in this article include: descriptions of the National Hydrologic Dataset Plus (NHDPlus), the Watershed Boundary Dataset (WBD) and how the datasets and their applications differ. Also covered are our attempts to integrate these two datasets, and why the resultant crosswalk between these two datasets is not perfect.

National Hydrologic Dataset Plus (NHDPlus)

NHDPlus is built as a *framework for modeling* of streamflow and stream water quality. It is a digital stream network with an integrated suite of geospatial data. NHDPlus medium resolution is built upon the National Hydrography Dataset (NHD, 1:100,000 scale). It provides a detailed network, with a National Seamless Database of topographically derived catchments, and "Value Added Attributes" (VAAs) built specifically for modeling purposes. These modeling specific attributes include:

1. Hydrologic sequence number
2. Identification of the primary path
3. Fraction of flow at diversions
4. From and to nodes for navigation
5. Terminal identifier

By identifying the main path at divergences as well as the fraction of flow at divergences (where known) NHDPlus has the structure to handle divergences and non-dendritic flow. There are, in fact, *66,137* flowlines identified in NHDPlus as being secondary paths *immediately* downstream from, and connected to, the node where the diversion occurs. This constitutes *2.45%* of all networked flowlines in the nation.

Additionally NHDPlus has estimates of mean annual stream flows and velocities necessary for determining decay. For reservoirs and lakes NHDPlus has

replacement time estimates, as well as the reciprocal areal hydraulic load (the ratio of waterbody surface area of the impoundment segment (m^2) / outflow discharge (m^3/day). Both of these are useful predictors of decay of nutrients in lakes.

NHDPlus was built to provide the framework for both streamflow modeling and stream-water-quality modeling. The National Water Quality Assessment (NAWQA) program within the U.S. Geological Survey has used and is continuing to use the NHDPlus to develop regional nutrient stream-water-quality SPARROW models throughout the United States.

Watershed Boundary Dataset (WBD)

Similar to NHDPlus catchments, typically at a more generalized scale, the Watershed Boundary Dataset (WBD) 12-digit Hydrologic Units (HU) define all or part of the areal extent of surface water drainage to a hydrologic feature such as a point along a stream, stretch of coastline, or to features such as a playa which serves as a sink in a closed watershed.

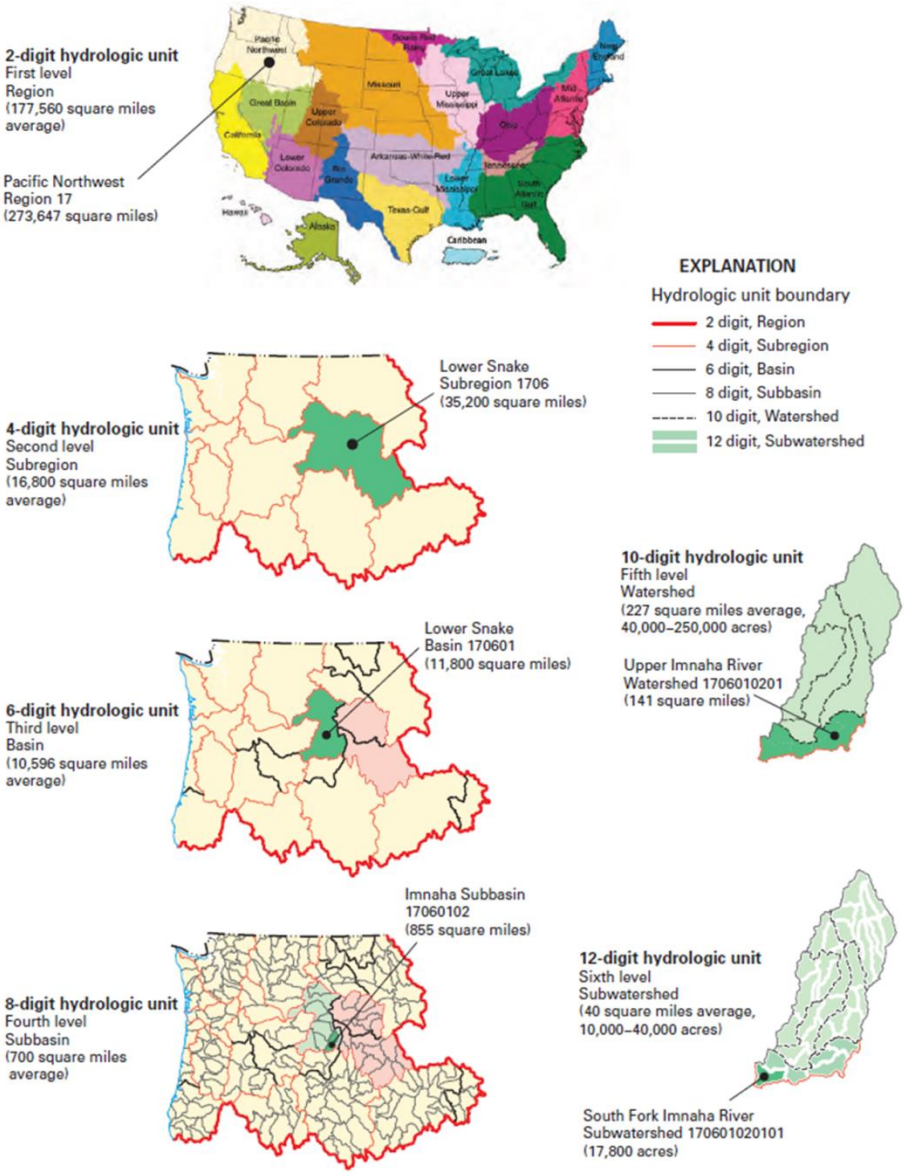

Figure 1. Nesting of WBD Hydrologic Units from HUC-12 units, into HUC-10, HUC-8, HUC-6, HUC-4, and HUC-2 units.

HUs with a 12-digit code (HUC-12) are nested into larger drainage area units of the WBD. According to the WBD model a “typical” HUC-12 non-playa and non-coastal watershed is assumed to have just one outlet. Everything within that HUC-12 is assumed to drain to a single point. Additionally, all the flow from each HUC-12 drains down to the identified next downstream HUC-12. A single

attribute of the HUC12 identifies the next downstream HUC-12. Dendritic flow is thus assumed at the HUC-12 level.

Alignment Efforts between NHDPlus and WBD

Efforts to align these two datasets for stream-water-quality modeling analysis and reporting include the following:

1. Identification of WBD HUC-12 outlets and NHDPlus flowlines that best define the outlets of each WBD HUC-12
2. Aggregation of collections of NHDPlus catchments into WBD HUC12-equivalent units by navigating the NHDPlus network
3. National comparison between NHDPlus-based HUC-12 and WBD HUC-12 units. Areas of difference between NHDPlus based HUC12 units and WBD HUC12 units are thus identified (see figure).

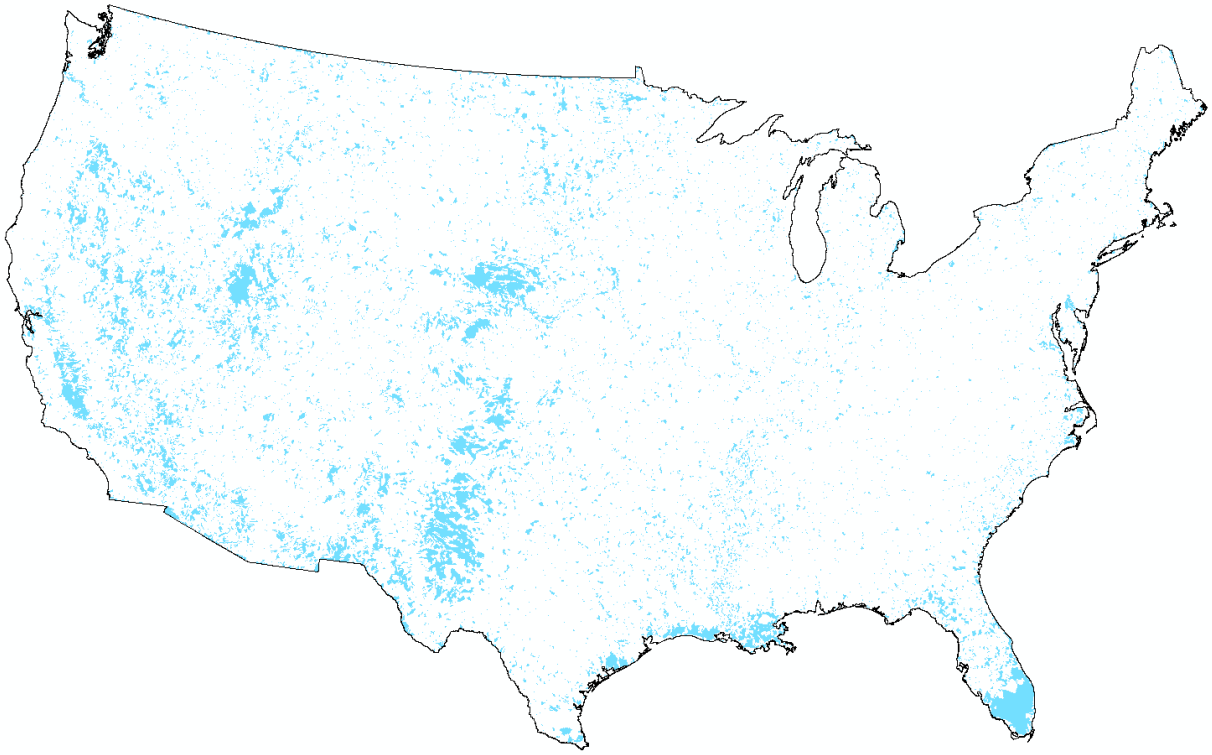

Figure 2. Blue areas are areas of disagreement between HUC-12 units of the WBD and similar units aggregated from NHDPlus catchments. In predominantly white areas the two datasets align well.

Blue areas (figure 2) are areas of disagreement between HUC-12 units of the WBD and similar units aggregated from NHDPlus catchments. This constitutes 7.6% of the 48 contiguous United States.

Reasons for these areas of misalignment between the two datasets are:

1. Errors in either the NHD or WBD (Neither dataset is perfect!)
2. Non-dendritic flow (Remember 2.45% of the flowlines in NHDPlus represent the start of secondary paths. The NHDPlus model depicts a more realistic representation of a stream network. NHDPlus allows for divergent

flow. This violates the concept of a dendritic network, which is assumed in the WBD network model.

3. Multiple outlets from a HUC-12 can exist. And these can go to different downstream HUCs.
4. Outlet flowline for a given HUC can extend well into the downstream HUC. NHDPlus flowlines at the outlet of a HUC-12 can be long and cross the boundary of the HUC-12s. Subdividing the NHDPlus HUC-12 outlet flowlines could remedy this shortcoming.
5. In arid areas NHDPlus catchments can often exceed the size of the HUCs_12s and can contain multiple HUC-12 units.
6. Likewise, in Southern Florida the NHDPlus catchments exceed the size of the HUCs_12s and can contain multiple HUC-12 units. This is due to the lack of networked flowlines because of limited knowledge regarding the direction of streamflow.

For these reasons, the integration of these two datasets is far from perfect. Care should be given when choosing the most appropriate network for any given application.

Depending upon the application, NHDPlus catchments and WBD HUC-12 units can be used together. For example SPARROW model results, developed using the NHDPlus network, can be summarized by HUC-12. In some cases, however, the two datasets may not work well together. For example, a hydrologic investigation may be of an area of poor alignments between catchments and HUC12 units or where non-dendritic conditions exist at the HUC-12 level.

NHDPlus is designed for modeling. For this reason, NHDPlus handles network complexities, such as non-dendritic flow that exist at many locations. WBD HUC units were designed primarily for reporting and evaluating hydrologic conditions at multiple scales, by evaluating nested areas that are typically larger than NHDPlus catchments.

Crosswalk between NHDPlus and WBD

Depending upon the location there can be good alignment between aggregated NHDPlus catchments and WBD HUC-12 units. Areas of white, or lacking in blue, in figure 2, represent areas where NHDPlus and WBD work well together. These are areas where the flows and chemical or nutrient loads that are accumulated leave the HUC-12 at its outlet and are passed down to the next HUC-12 downstream (or to the coast) as is assumed in the WBD model. A crosswalk table between NHDPlus flowline (COMID) and WBD (HUC-12) is provided nationally, for 48 states. It should be used, however, with caution in areas with blue in figure 2.

The crosswalk provides a WBD HUC12 assignment for every networked flowline and a separate table is included for isolated sinks within the 48 contiguous United States. In this way the network developed for navigation and modeling, NHDPlus, is aligned with accounting units of the WBD HUC12s as best as the two databases allow given the assumptions that were made in creating each. In some areas the alignment works well and some areas it does not. The sink cross-walk was produced by a simple overlay process where the sinks were assigned HUC-12 values based on their position relative to the WBD HUC-12s.

On the flip side, areas of blue on the map (figure 2) are likely areas where efforts can be spent to improve data. For example, with NHD, a better definition of flow direction of the flowlines in Southern Florida would result in more flowlines being included in the “networked” flowlines with catchments, and that in turn would result in better alignment between NHDPlus catchments and HUC-12s. By further examining the areas of blue on the map, errors in either the NHD or WBD will likely be found and could be corrected.

A second pass through the data is also planned to take into account any secondary outlet from each HUC-12. The location of a secondary outlet with a significant drainage from that HUC will be identified in the alignment with NHDPlus. This will result in a reduction in areas of mismatch as well as an improved crosswalk table.

Both datasets, NHDPlus and WBD HUC-12s, have a lot to offer as building blocks for stream-water-quality modeling analysis and reporting. Each has its strengths and weaknesses. Care and an understanding of these networks should be considered when employing appropriate applications.