Fact Sheet: Mapping WOTUS

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With the proposed WOTUS rule change, there are many statements being made about the pattern and location of ephemeral, intermittent, and perennial streams in the US. The objective of this fact sheet is to provide basic information on how stream typing is determined, and the various map products being used to describe the pattern and location of specific stream types. We provide special attention to the limitations of those map products and alternative mapping approaches to address those limitations.

1. Field surveys, not map products, will ultimately determine if a specific waterway or stream is included or excluded from the jurisdiction of the WOTUS rule.

- Intermittent and ephemeral streams are identified in the field based on observable characteristics such as a presence of a stream channel for conveying water and the frequency, magnitude, timing, and duration of streamflow in that channel in response to precipitation.

2. For mapping streams nation-wide, two USGS National Hydrography Dataset products are available. Both have important limitations/errors in typing specific streams in different geographies (see 3), but the high resolution NHD is the best available source for approximating location and flow characteristics of streams nationally.

- The main sources of map information used to describe the location and flow characteristics of streams in the continental US are two versions of USGS' National Hydrography Dataset (NHD) – the "medium resolution" NHD and the "high resolution" NHD.
- Both map products were produced by cartographers interpreting aerial photographs to create topographic maps.
- The medium resolution NHD (also referred to as the "NHD Plus") is based on 1:100,000 scale topographic maps. The high resolution NHD (also referred to as the "NHD Plus HR") is based on more detailed 1:24,000 scale topographic maps. Figure 1 shows an example of the medium and high resolution NHD in central PA. Because it is based on a finer-scale, higher-resolution source aerial photographs, the high resolution NHD will show more stream features than the medium resolution NHD (Fig 1). As a result, the high resolution NHD should be considered the best available single dataset for characterizing the location and flow characteristics of streams in the continental US. (The medium resolution NHD can still be useful for describing summary stream network characteristics at coarser scales, e.g., the density of headwater streams as in the forthcoming review of headwater streams by AFS, but see #3).

3. There are major inconsistencies/omissions in the way that stream types are mapped across the country in the NHD products. This is especially true for ephemeral stream types, which are underestimated across the nation, to varying degrees depending on geographic region.

- A stream reach is the basic unit of both NHD products. Each stream reach is "typed" as perennial, intermittent, or ephemeral based on how the streams were depicted in the original topographic maps, which were produced by cartographers interpreting aerial photographs. As a result, you can often see artefacts of the original aerial photo interpretation in both datasets. For example, the density of streams or pattern of stream typing can vary starkly based on the

footprint of the source topographic map or based on administrative boundaries (Fig 2). Additionally, the typing of common features in both NHD products may not be the same (Fig 1).

- Relevant to the WOTUS rule, ephemeral stream types are inconsistently mapped in the NHD products. For example, even though ephemeral stream channels exist within all stream networks, there are **no** ephemeral stream reaches mapped in many eastern states (Fig 2). As a result, any summary statistics at the national level which rely solely on the medium *or* high resolution NHD are incomplete or skewed by those geographic inconsistencies and underestimate ephemeral stream types (see 4).

4. Many ephemeral streams present on the ground are absent from the high resolution NHD

- Ephemeral stream channels visible in field surveys may not be present in the high resolution NHD due to limitations in the scale and resolution of the source topographic maps used to produce the high resolution NHD. For example, a study of headwater streams in forestlands in Oregon found that maps generated using field data included *twice as many total stream miles* as the high resolution NHD[1], while another study in the Mohave Desert of California estimated *nine times as many stream miles* exist on the ground vs. mapped in the high resolution NHD.[2] Most of the unmapped features in both studies were ephemeral streams.

5. Until new, updated national map products are available from USGS, alternative mapping approaches can be used to identify the likely location of ephemeral streams

- Individual states have coordinated efforts to update stream typing information in the NHD products and create higher resolution versions of the NHD to better reflect conditions on the ground and for greater consistency across regions, but these efforts are not comprehensive or complete nation-wide.
- To approximate the pattern of ephemeral streams in the continental US more inclusively, TU has applied a simple method using elevational maps for delineating these streams to supplement the NHD products. Based on additional data from the USGS[3], we map ephemeral streams as any stream channel with at least 11 acres of upstream watershed area not mapped as a stream reach (any type) in the high resolution NHD (Fig 1, red lines). Peer-reviewed science describes ephemeral stream channels initiating with 2 acres of upstream watershed area in steep landscapes and up to 24 acres in flat landscapes.[4,5] We selected 11 acres as a conservative mid-point using these values and masked areas with slopes equal 0%. This approach will likely under-map ephemeral streams in mountainous landscapes and over-map ephemeral streams in flat landscapes but is a reasonable approximation of ephemeral stream locations until new or updated national products are available from USGS. From this analysis, TU estimates that the average subbasin in the continental US has 1.5 miles of unmapped ephemeral streams for every

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[1] Fritz, K.M., et al. 2013. Comparing the extent and permanence of headwater streams from two field surveys to values from hydrographic databases and maps. *JAWRA Journal of the American Water Resources Association*, *49*(4).
[2] Hamada, Y., et al. 2016. Mapping ephemeral stream networks in desert environments using very-high-spatial-resolution multispectral remote sensing. *Journal of Arid Environments*, *130*, pp.40-48.
[3] Source: USGS Elevational Derivatives for National Applications (EDNA) Flow Accumulation raster
[4] Montgomery, D.R. and Foufoula-Georgiou, E., 1993. Channel network source representation using digital elevation models. *Water Resources Research*, *29*(12).
[5] Vandaele, K., et al. 1996. Geomorphic threshold conditions for ephemeral gully incision. *Geomorphology*, *16*(2).

mile of mapped stream in the high resolution NHD (all stream types). In aggregate (as national sum), 0.8 miles of unmapped ephemeral streams exist for every mile of mapped stream.

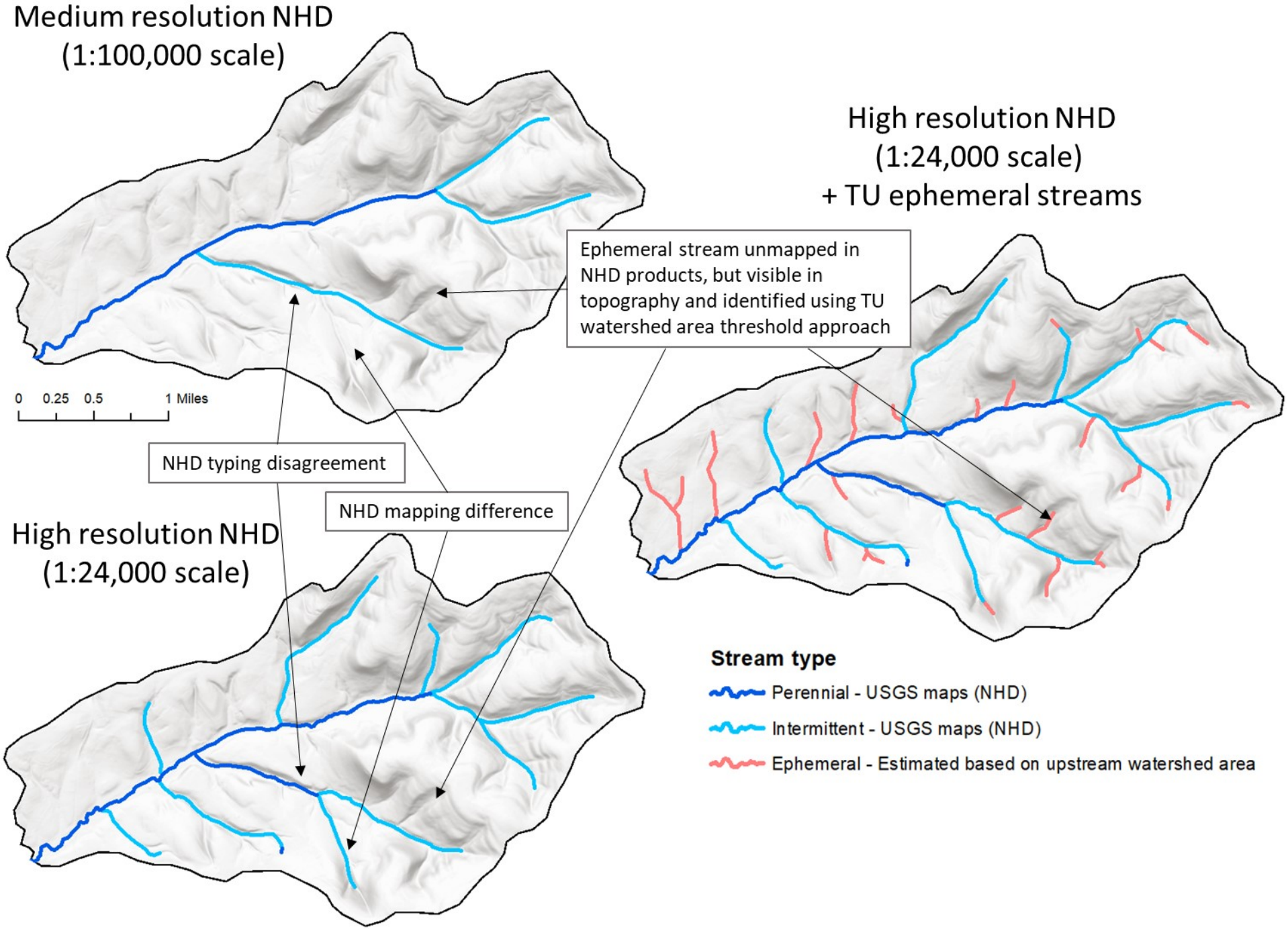

Figure 1: Example of NHD medium and high resolution map products and TU's ephemeral stream mapping in a central PA watershed

Ephemeral, Intermittent, and Perennial Stream locations in High Resolution NHD (1:24,000 scale)

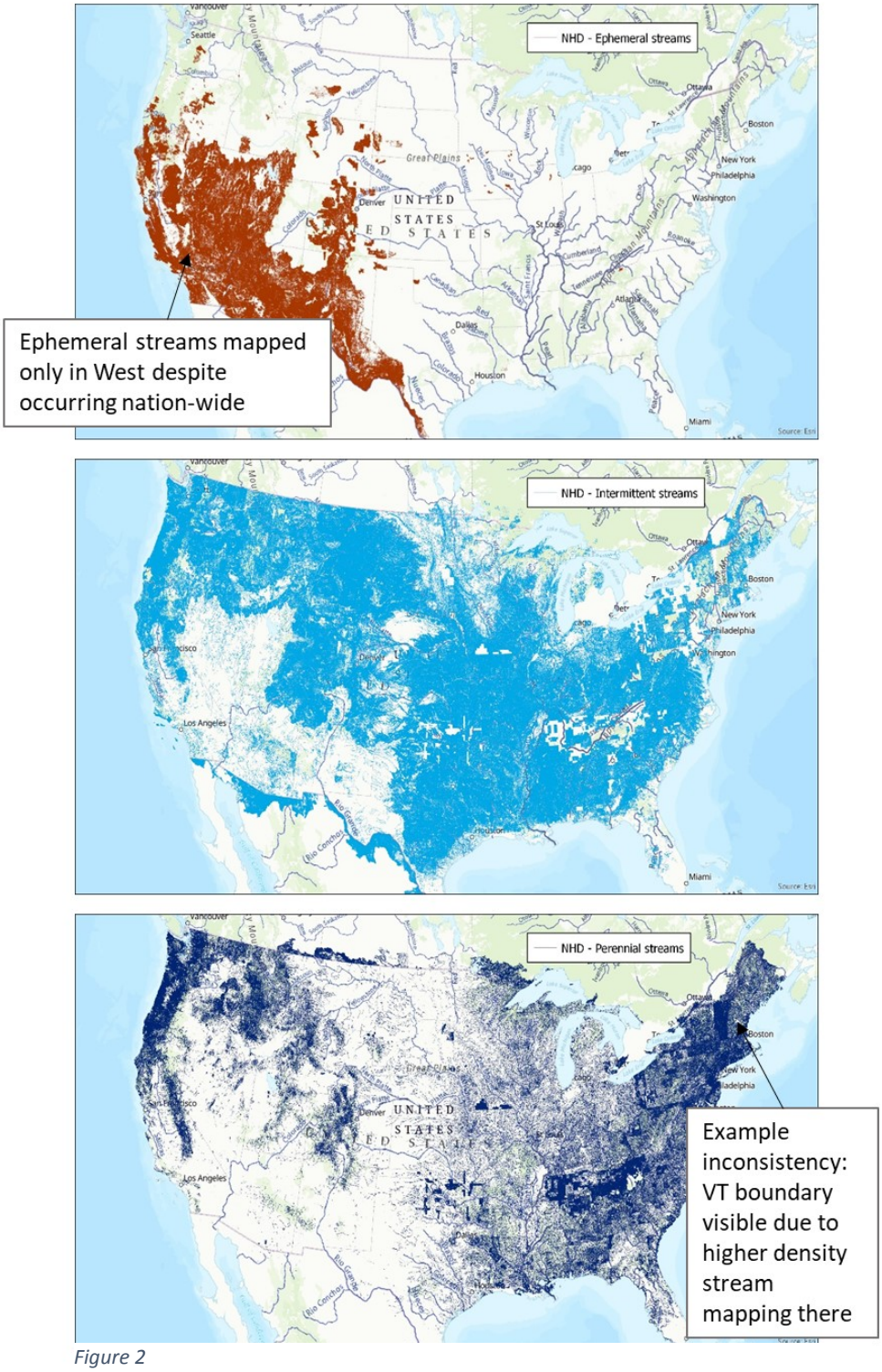

Figure 2