# Comment on Revised Definition of Waters of the United States (WOTUS)

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We are a group of scientists from Colorado State University writing to oppose (1) the exclusion of ephemeral streams from protection as WOTUS and (2) determining the regulatory status of streams on the basis of flow regime rather than channel geomorphology.

## 1. Ephemeral streams should be protected as WOTUS

To protect the water quality of navigable waterways, the waters that contribute pollutants to these waterways must also be protected. Restricting the definition of tributaries to only perennial and intermittent streams would **arbitrarily remove protection from many streams that can cause downstream pollution**. Multiple lines of evidence show that ephemeral streams have a significant nexus to downstream navigable waters. Ephemeral streams supply water, sediment, and nutrients to intermittent and perennial streams (Goodrich et al. 2018). They are often the sources of large sediment pulses to downstream waters during storms (Reid and Laronne 1995), can transport bedload sediment more efficiently than their perennial counterparts (Laronne and Reid 1993), and can have extremely high suspended sediment concentrations (Graf et al. 1996; Billi 2011). The sediments transported can contain adsorbed contaminants including metals from abandoned mines (Mackay and Taylor 2013), radionuclides from uranium mines and tailings ponds (Graf et al. 1996), and plutonium from decades old wastewater (Reneau et al. 2004). Such contaminants can be transported during flash floods and pose long-term risks to downstream water quality (Malmon et al. 2005). When ephemeral streams flow, they also bring with them nutrients and organic matter that accumulated in uplands of watersheds during dry periods from aeolian deposition, decomposition, and other processes (Meixner et al. 2007; Brooks et al. 2007).

Restricting the definition of tributaries to only perennial and intermittent streams would create substantial **regional variability in Clean Water Act jurisdiction**. In more humid regions such as the eastern, midwestern and northwestern U.S., drainage areas less than 50 acres (0.1 mi$^2$) can sustain perennial flow (Jaeger et al. 2007; Roy et al. 2009). In such areas ephemeral streams may represent less than half of the mapped stream length (Goodrich et al. 2018). In contrast throughout most of the arid and semiarid western U.S., the majority of stream length is ephemeral (Goodrich et al. 2018). In Utah, New Mexico, Nevada, and Arizona, ephemeral streams represent 79-94% of the mapped stream length (Goodrich et al. 2018). If these streams are not considered WOTUS, then **most streams in the dry interior west would not be protected under the Clean Water Act**. The proposed rule would also exclude perennial and intermittent stream segments that are upstream from ephemeral channels as well as those that flow into endorheic (closed) basins that do not contain navigable waters. Such stream types are common in the western U.S., particularly in the Great Basin area.

## 2. Agencies should continue to use geomorphic features to define WOTUS

The Revised Definition solicited comments on using flow regime indicators such as seasonality, connection to the water table, typical year flow, and other aspects of flow regimes to define WOTUS. Such definitions are presumably under consideration as alternatives to geomorphic indicators of streams: bed, banks, high water mark. The problem with using flow regime to determine whether a stream is considered part of WOTUS is that **flow regimes are unknown for the vast majority of tributary streams**. Identifying flow regimes of tributaries requires long-term data that capture changes in flow over time for a wide range of stream types.

*Snapshot of USGS streamflow gauging network ([https://maps.waterdata.usgs.gov/mapper/index.html](https://maps.waterdata.usgs.gov/mapper/index.html)) illustrating the low density of monitoring sites in the arid interior west.*

Headwater tributaries with small drainage areas are most likely to be ephemeral, but they are not well-represented in the streamflow gauging network (Hapuarachchi et al. 2011). Only 20% of the basins smaller than 500 mi$^2$ are gaged in the conterminous U.S.; in the Rio Grande, Lower Colorado, and Great Basin less than 10% of basins smaller than 500 mi$^2$ are gaged (Kiang et al. 2013). Streams in dry areas of the U.S. also have high inter-annual variability in flow (Dettinger and Diaz 2000; Fassnacht 2006) and therefore require long time periods of data collection to quantify the flow regime. While the streamflow gaging network of the U.S. is extensive, it underrepresents small and ephemeral streams because the priorities for monitoring have been larger waterway issues such as flood forecasting, transboundary water issues, power production, and navigation (Eberts et al. 2018). A gauging network that best supports prediction of stream type would need to stratify monitoring by climate, geology, soils, land use, water use, drainage area, and other attributes that change flow regimes (Yadav et al. 2007; Kennard et al. 2010).

Researchers are actively working to develop methods for defining flow regimes on ungauged streams, continuing on the decade of work on Prediction in Ungauged Basins (Sivapalan et al. 2003; Emmerik et al. 2015). Yet even after decades of work on hydrologic modeling, **hydrologic models are not always reliable for predicting flow regimes in ungauged areas** (Wagener and Montanari 2011; Parajka et al. 2013; Long et al. 2015). A review of studies predicting streamflow in ungauged catchments identified efficiency coefficients ranging from -4.3 to 0.87, with a median of 0.54 in arid and 0.66 in humid climates (Parajka et al. 2013). An efficiency coefficient of 1.0 indicates a perfect fit, and values <0.5 are considered unsatisfactory (Moriasi et al. 2007). Maps of stream types (perennial, intermittent, ephemeral), can also be inaccurate, particularly for headwater streams where researchers have found 39-70% disagreement between field observations and mapped stream types (Fritz et al. 2013).

Mapping stream types and modeling streamflow remains challenging because the factors determining streamflow are so complex and variable. **Developing reliable classifications of streams as ephemeral, intermittent, or perennial will require more extensive monitoring** than is currently in place. Monitoring can include traditional stream gauge sensor networks, low cost sensors that detect flow presence or absence (Chapin et al. 2014), citizen science observations of streamflow presence or absence (Turner and Richter 2011; Kampf et al. 2018), and/or satellite or aircraft remote sensing image analysis (Höfle et al. 2009; Mueller et al. 2016). Where sufficient measurements are available in space and time, these can be used to develop improved maps of stream types (Jaeger et al. 2019).

In contrast to flow regime, geomorphic indictors of stream characteristics (bed, banks and high water marks) are visible, enduring features that can be measured in the field using surveying, GPS, ground-based or airborne LiDAR; structure from motion photogrammetry, or any other source of fine-resolution topographic data (French 2003; Passalacqua et al. 2012; Westoby et al. 2012; Sofia et al. 2015). It is feasible to identify locations of channels during single field visits or airborne surveys. Geomorphic indicators can be used to differentiate recent, more frequently occurring flows from rare historic high flows (Baker et al. 1988). These indicators have long been used by state and federal personnel, and detailed training manuals have been developed to facilitate these analyses (e.g. Harrelson et al. 1994; Lichvar and McColley 2008).

## 3. Summary statement

In summary, **ephemeral streams should continue to be protected** under the Clean Water Act as Waters of the United States. These streams constitute the majority of stream length in much of the country, and they can be major sources of sediments and contaminants to downstream navigable waterways. Further, **a definition of WOTUS based on a stream's flow regime (ephemeral, intermittent, perennial) would result in substantial ambiguity in which streams are or are not regulated** under the Clean Water Act. Although researchers are actively working to improve methods for predicting stream flow regimes, the current streamflow monitoring network is insufficient for developing and testing these methods. Consequently we **recommend that WOTUS continue to be defined based on channel geomorphology**.

*This comment was written by the authors and is not offered on behalf of Colorado State University*

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