ADEQ Arizona Department of Environmental Quality

WATER QUALITY DIVISION

White Paper: Application of flow gauge data utilizing a USGS approach to identify ephemeral and intermittent flow regimes in Arizona

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January 2021

Background

The State of Arizona has over 100,000 known miles of surface water at medium resolution hydrography[1]. These surface waters are divided into segments, known individually as a reach. According to the U.S. Geological Survey (USGS), a reach is a section of a stream or river along which similar hydrologic conditions exist. These hydrologic conditions are described as flow regimes in the Arizona Revised Statutes § 49-201 as follows:

- Perennial means a surface water or portion of surface water that flows continuously throughout the year.
- Intermittent means a surface water or portion of surface water that flows continuously during certain times of the year and more than in direct response to precipitation, such as when it receives water from a spring, elevated groundwater table or another surface source, such as melting snowpack.
- Ephemeral means a surface water or portion of surface water that flows or pools only in direct response to precipitation.

ADEQ assigns each surface water reach, lake, pond or other type of surface water an identification number known as a Waterbody Identification Number or WBID. Through analysis of available and credible data, the Arizona Department of Environmental Quality (ADEQ) assigns each WBID one of the flow regimes. A WBID with insufficient data to determine flow regime is assigned an "Undetermined" flow regime. If there is no flow regime data for the WBID, it is assigned as "Null'. As of August 2021, approximately 23 percent of WBIDs in Arizona are assigned a perennial, intermittent or ephemeral flow regime.

With about 77 percent of Arizona WBIDs with an "Undetermined" or "Null" flow regime, ADEQ recognized that additional analysis of available and credible data could be critical to assigning additional flow regimes and verifying the others. After a thorough review of peer-reviewed research conducted by the USGS, ADEQ determined a methodology for application of credible flow gauge data as an indicator for estimating intermittent or ephemeral flow regimes.

Research and Analysis

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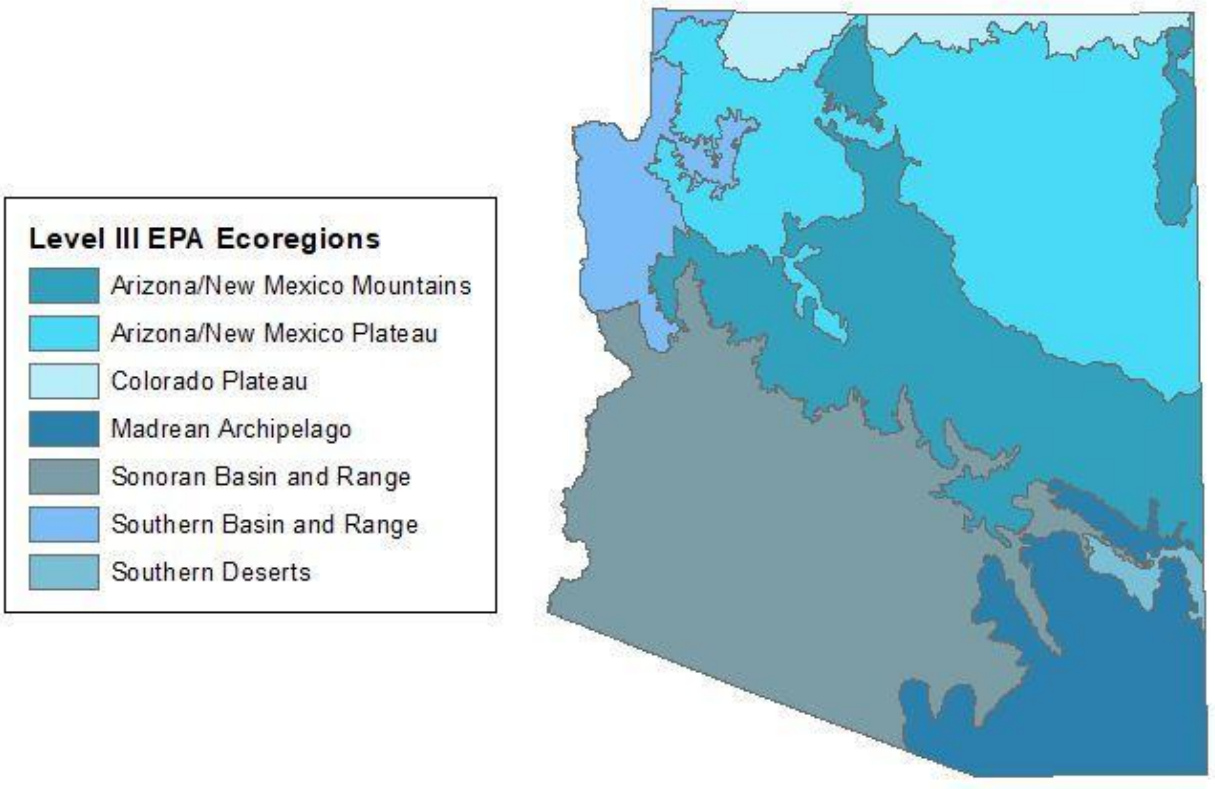
1 https://www.usgs.gov/national-hydrography/national-hydrography-dataset?qt-science_support_page_related_con=0#qt-science_support_page_related_con

Granato et al. (2017) identified a breakpoint between ephemeral and intermittent flow regimes as a percent of zero-flow days. A daily mean streamflow less than the detection limit of the gauge defines zero-flow. Through statistical analysis of daily stream flow gauge data from 1901 – 2015, Granato et al. (2017) determined ephemeral flow regimes are described by greater than 81 percent zero-flow days in very humid regions to greater than 99 percent zero-flow days in arid regions. However, even in arid regions, such as Arizona, there can be a range of percent of zero-flow days due to the varying ecoregions (i.e. drier desert basins in southern Arizona versus wetter higher elevation mountain ranges in eastern and northern Arizona). Methodology in Granato (2010) accounts for these variations.

Granato (2010) established thresholds between intermittent and ephemeral flow regimes by correlating precipitation data to the probability of stormflow events in surface waters for ecoregions defined by the U.S. Environmental Protection Agency (EPA), seven of which are found in Arizona (Figure 1). Precipitation events generating flow are defined as being caused by a minimum of one hour of precipitation equal to or greater than 0.1 inches with an interevent time of 6 hours or more. The use of this threshold is in line with guidance for stormflow modeling (EPA 2009).

Figure 1. EPA Level III Ecoregions found at least partially in Arizona (Granato 2010, EPA 2013)



Granato (2010) analyzed hourly precipitation data from National Oceanic and Atmospheric Administration (NOAA) weather stations by ecoregion in the conterminous United States, including ecoregions at least partially found in Arizona, with at least 25 years of data collected during the 1965−2006 period to calculate the average number of precipitation events per year potentially producing flow. The resulting numbers or thresholds can then be correlated to flow gauge data to assign a probable flow regime. Where gauge data suggests flow occurring for a number of days less than or equal to the average number of precipitation-inducing flow events, the associated WBID is assigned an ephemeral flow regime. If the gauge data suggests flow occurring for a number of days greater than the expected number of precipitation-inducing flow events, the associated reach is assigned an intermittent flow regime. The breakpoints for ecoregions found in Arizona are listed in Table 1.

Table 1. Intermittent vs Ephemeral thresholds for ecoregions found at least partially in Arizona

Ecoregion	Number of Rain Gauges	Average Number of Precipitation Events Producing Flow Per Year, as a Threshold for Intermittency	Percent of zero-flow days for ephemeral status
Arizona/New Mexico Mountains	26	26	92.9%
Madrean Archipelago	4	22	94.0%
Colorado Plateau	16	21	94.2%
Arizona/New Mexico Plateau	25	20	94.5%
Southern Deserts[2]	29	19	94.8%
Sonoran Basin and Range	16	13	96.4%
Southern Basin and Range[3]	14	10	97.3%

Assumptions and Future Research Recommendations

As noted in Granato (2010), the minimum time between events for highway and urban-runoff studies is 6 hours without measurable precipitation. Theoretically, there may be as many as four independent events in one 24-hour period. In applying the Granato (2010) methodology, ADEQ assumes only one precipitation event occurs in a 24-hour period.

[2] The Southern Deserts in Granato (2010) is listed as the Chihuahuan Deserts in EPA (2013).
[3] The Southern Basin and Range in Granato (2010) is listed as the Mojave Basin and Range in EPA (2013).

ADEQ recognizes that the agency's application of thresholds for intermittent and ephemeral flow differs from the intent of Granato (2010), which is focused on informing the Federal Highway Administration (FHA). Specifically, a minimum precipitation depth of 0.1 inch per hour was set as the depth threshold for flow-generating precipitation events. This is in line with minimum rainfall expectations for realizing runoff from highly impervious highway and urban land in line with the FHA goals of understanding potential impacts from hard surfaces. Given this context, ADEQ recognizes that the 0.1 inch per hour rainfall depth threshold may not be representative of flow-inducing precipitation events across Arizona ecoregions, particularly in rural or wildland settings where infiltration may lead to greater depth thresholds for runoff. As a result, and based on input from ADEQ field staff and input from external hydrologists with expertise in Arizona, the thresholds derived from Granato (2010) may be biased high for all ecoregions. Consequently, the overall approach may overclassify some potentially intermittent reaches as ephemeral. Future research should utilize updated and Arizona-specific datasets to refine rainfall depth thresholds for surface water runoff in Arizona ecoregions with varying ground cover.

ADEQ also recognizes that the thresholds do not reference seasonal intermittent flow conditions or duration. Additional analysis, tools or processes for identification of seasonal flow conditions representing the range of intermittency should be considered for future application. Until a seasonal flow can be identified, definitive flow regimes are not assigned using these thresholds. Flow records are analyzed and compared against these thresholds as an indicator of flow regime for a WBID. To assign a flow regime, ADEQ requires additional information, including, but not limited to, data and analysis indicating seasonal flow conditions such as information from field visits, analysis of imagery (i.e. game cameras, satellite imagery, etc.), or results of a streamflow duration assessment methodology (SDAM) survey. In other words, ADEQ requires additional empirical data to formally assign a flow regime. Results of the tool can assist ADEQ with prioritization of additional data gathering efforts.

Conclusion

Knowledge of flow regimes is critical for federal and state jurisdictional evaluations of Arizona surface waters. With no flow regime assigned to about 77 percent of Arizona WBIDs, ADEQ needs tools to assist with these evaluations for purposes of assessing and permitting surface waters. Research and data indicate the methodology applied by the USGS is effective for estimating flow regimes of Arizona WBIDs. This methodology is one of multiple tools ADEQ utilizes for this purpose.

References

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