ADEQ Arizona Department of Environmental Quality

WATER QUALITY DIVISION

White Paper: Analysis of percent riparian vegetation for estimating flow regimes in Arizona

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Background

The State of Arizona has over 100,000 known miles of surface water at medium resolution hydrography (USGS, n.d.). 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[1]. After a thorough review of peer-reviewed research and analysis of readily available data specific to Arizona, ADEQ established a methodology for estimating intermittent or ephemeral flow regimes through analysis of

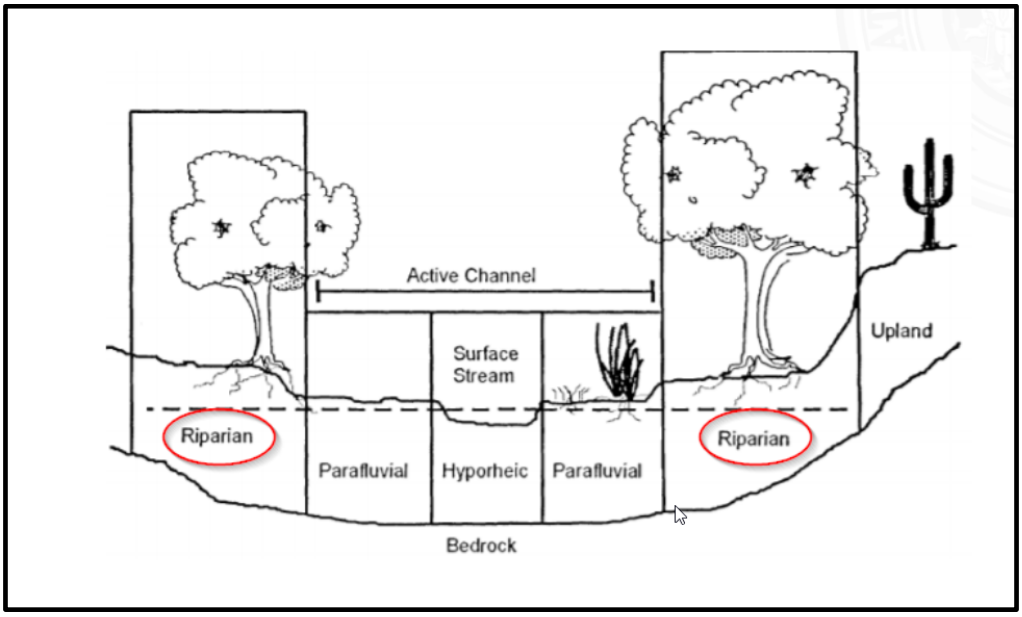
[1]Flow regimes are not static and can change based on, but not limited to, analysis of additional credible data, shifts in climate, and changes in water use, such as diversion or new discharges to a WBID. The WBIDs in this white paper were assigned the referenced flow regime as of August 2020.

riparian vegetation in and along a streambed channel. This methodology is applied in the Riparian Vegetation Tool.

Research and Analysis

In arid lands, riparian vegetation can be found where surface water or shallow groundwater provide a reliable water source for growth and propagation. Within the active channel, vegetation generally stands much taller and denser than the plant life seen in the surrounding landscape, creating a visible corridor of thriving plant life in another wise sparse desert landscape (Figure 1).

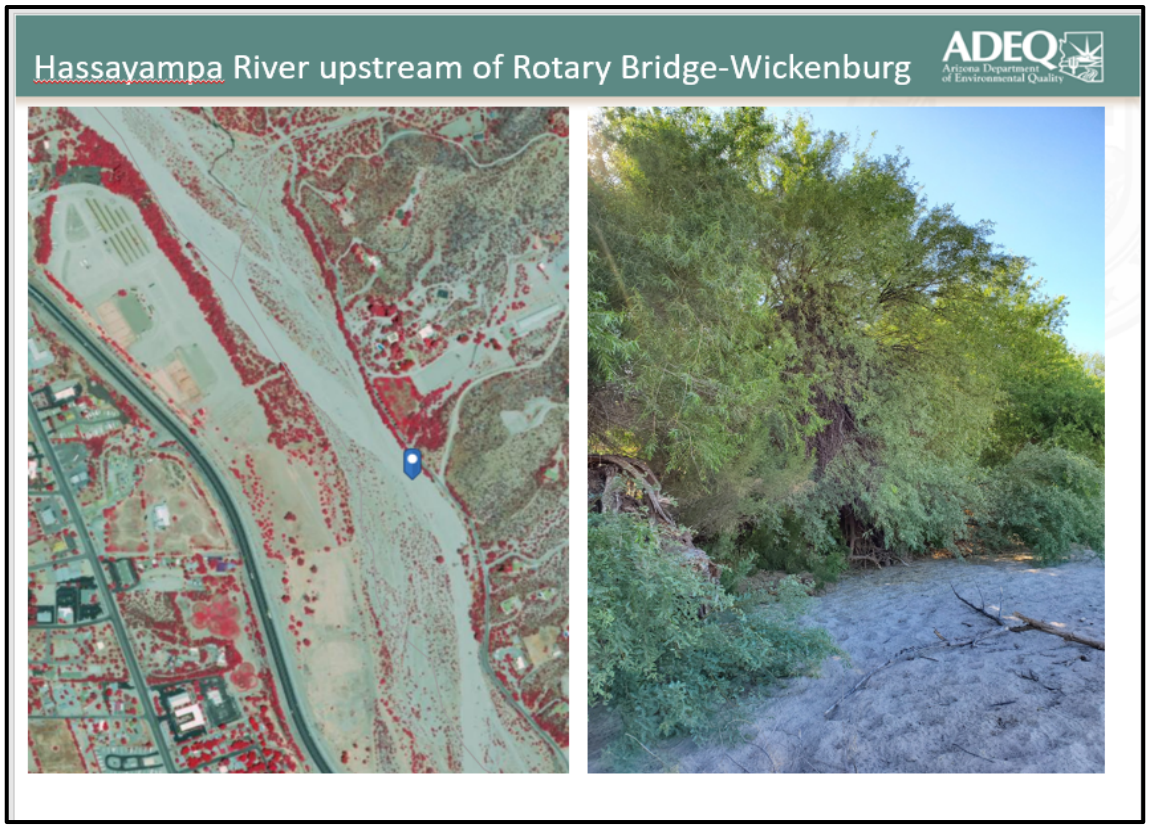
Figure 1. Riparian area cross-section view (Holmes et al., 1994).



Typical riparian trees in Arizona consist of cottonwoods and willows at low elevations; and alder, willow, ash, box elder and other species at mid to upper elevations. Some desert streams also have distinct xeroriparian corridors, which consist of the same vegetation as the upland but with much denser growth. Generally, xeroriparian corridors consist of mesquite, Palo Verde and other desert tree species.

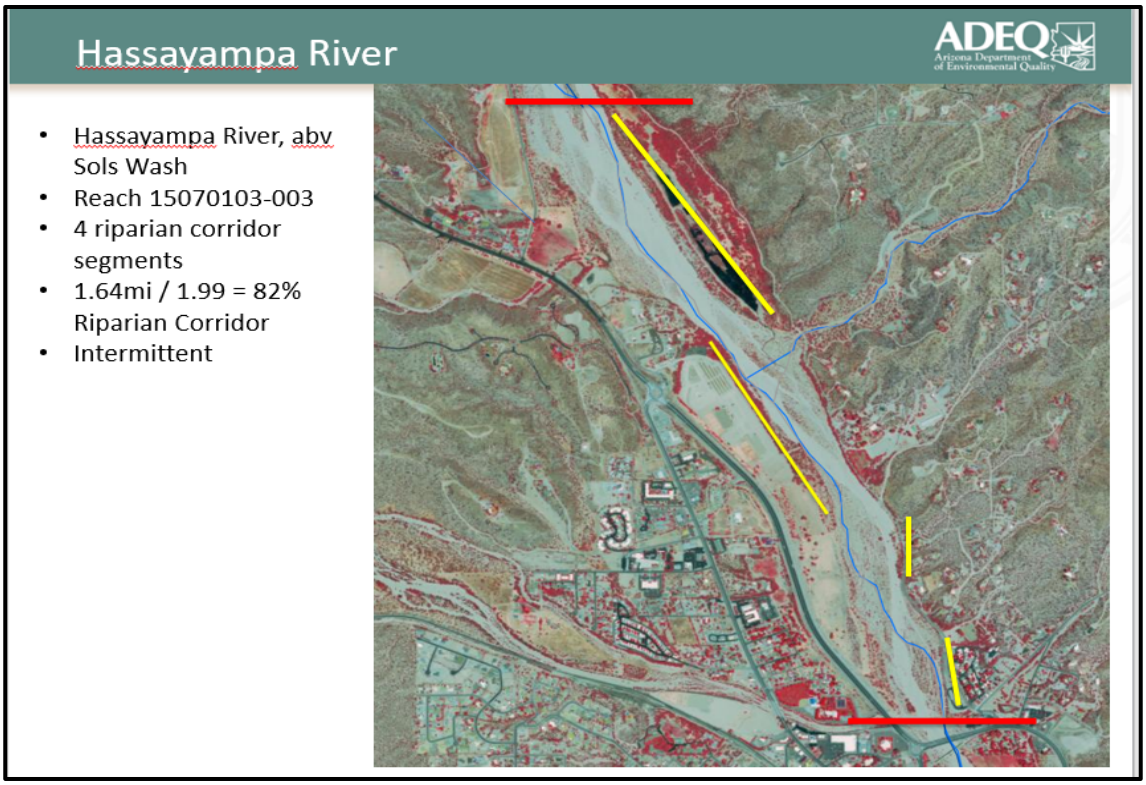
Research shows the presence of riparian or xeroriparian vegetation corridors in arid environments is indicative of shallow groundwater and signals an increased potential for above ground seasonal or intermittent flow in a surface water (Nadeau & Megdal, 2012; Stromberg & Merritt, 2016; Manning et al., 2020; Mazor et al., 2021). The density of vegetation in these riparian areas compared to the surrounding area is often visible to the naked eye and can be seen in National Agriculture Imagery Program (NAIP) satellite imagery. The NAIP acquires satellite imagery during the agricultural growing season in both natural color or near infrared color. In the infrared imagery, riparian vegetation appears bright red (Figure 2). ADEQ determined NAIP infrared imagery could be analyzed to identify potential intermittent or ephemeral flow regimes in WBIDs with unknown or null flow regimes.

Figure 2. A blue pin in the NAIP infrared imagery (left) indicates the location of the photo (right). The photo shows two riparian species, Gooddings Willow and Velvet Mesquite.



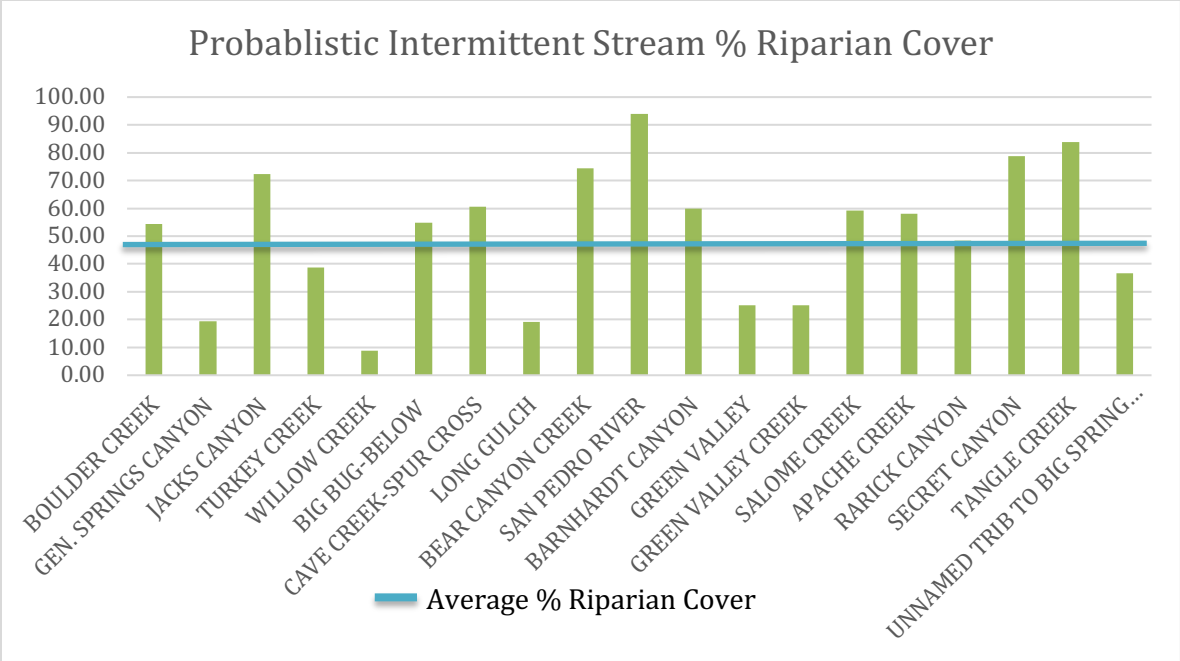
In Jones (2018), ADEQ applied time lapse photography to confirm intermittent flow regime on select WBIDs for a probabilistic study on water quality. Utilizing WBIDs with a confirmed intermittent flow regime from Jones (2018) and listed in Appendix A, ADEQ measured the length of the channel covered by riparian vegetation on NAIP imagery using a measuring tool in a Geographic Information System (GIS) application. If there was more than one segment of the WBID with a visible riparian corridor, the measurements were added together for the total. The total measured riparian corridor was then divided by the total length of the WBID to determine a percentage of the WBID with visible riparian vegetation on the NAIP imagery. An application of the measurement can be seen in Figure 3 with the yellow lines indicating the riparian corridor measurement and the red lines indicating the start and end of the WBID. This methodology is applied in the Riparian Vegetation Tool.

Figure 3. Calculation of percent riparian corridor in a stream reach, using NAIP 2017 imagery.



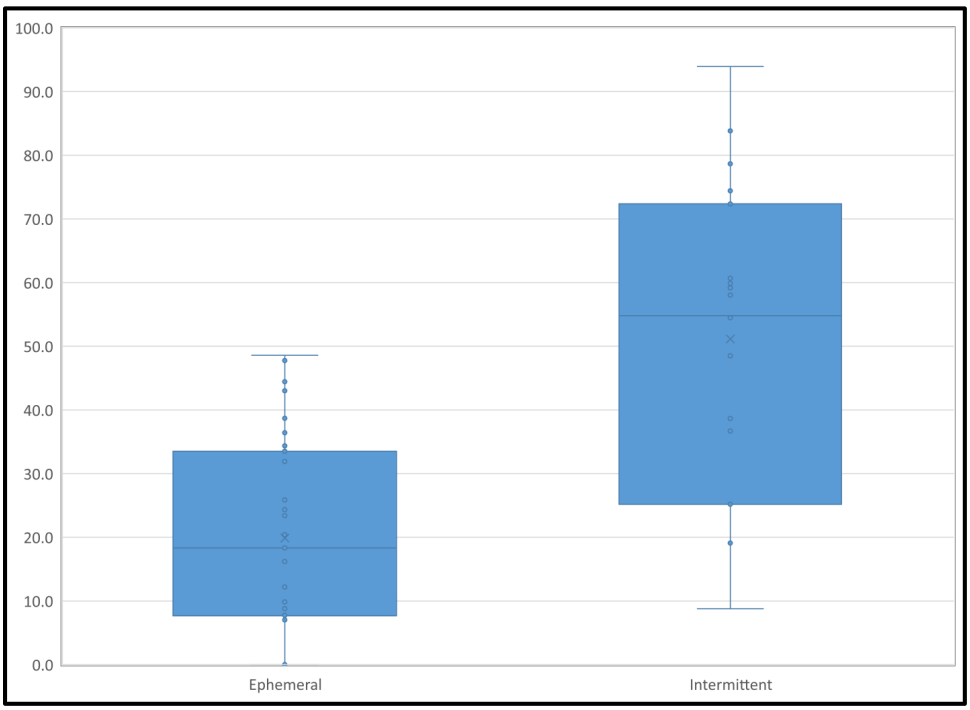
For the 19 confirmed intermittent WBIDs in Jones (2018), application of the Riparian Vegetation Tool showed a mean value for percent riparian corridor associated with the WBID was 51.1 percent (Figure 4).

Figure 4. Percent riparian corridor for confirmed intermittent WBIDs in Jones (2018).



ADEQ also applied the Riparian Vegetation Tool to 35 WBIDs with an assigned flow regime of ephemeral and listed in Appendix B. For the ephemeral WBIDs, the mean percent riparian corridor was 19.9 percent. A box plot comparison of the two datasets indicate that the intermittent and ephemeral data sets are significantly different with a Kruscal-Wallis significance test p-value <0.01 (Figure 5).

Figure 5. Boxplot showing percent riparian corridor by flow regime.



Based on these results, ADEQ selected a threshold of 50 percent or higher riparian vegetation corridor through NAIP imagery analysis to determine a potentially intermittent flow regime for a WBID. Validation of this methodology was conducted using a confusion matrix approach, whereby the results of the Riparian Vegetation Tool were compared to the identified WBIDs with known flow regimes. The methodology correctly identified known intermittent WBIDs 58 percent of the time and known ephemeral WBIDs 100 percent of the time with an average percent accuracy of 85 percent (Table 1).

Table 1. Confusion matrix of correct identifications of known intermittent and ephemeral flow regimes using the Riparian Vegetation Tool.

	Known Intermittent	Known Ephemeral
Estimated Intermittent	11	0
Estimated Ephemeral	8	35
Percent Accuracy	58%	100%
Overall Accuracy	85%	

Application of the Tool

ADEQ applies the Riparian Vegetation Tool to WBIDs with an unknown flow regime. If the estimated extent of the riparian vegetation along the length of the WBID is 50 percent or greater, then the flow regime is estimated to be potentially intermittent; if less than 50 percent, the flow regime is estimated to be potentially ephemeral.

Through application of the tool, ADEQ identified there is some error in the analysis when riparian vegetation in higher elevation WBIDs looks similar to upland vegetation in NAIP imagery. To account for potential uncertainty, definitive flow regimes are not assigned using the tool. The Riparian Vegetation Tool is only an indicator of flow regime for a WBID, until further verification work is completed. To assign a flow regime, ADEQ requires additional empirical data, including, but not limited to, flow gauge data, information from field visits, analysis of imagery (i.e. game cameras, satellite imagery, etc.), or results of a streamflow duration assessment methodology (SDAM) survey. 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 in the Riparian Vegetation Tool is effective for estimating flow regimes of Arizona WBIDs. The Riparian Vegetation Tool is one of multiple tools ADEQ utilizes for this purpose.

References

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Appendix A. WBIDs with a confirmed intermittent flow regime from Jones (2018).

Waterbody ID	Stream Name	Average % Riparian Cover
15020008-011	Willow Creek	8.8
15070102-591	Long Gulch	19.1
15020008-521	General Springs Canyon	19.4
15060105-023	Green Valley	25.2
15060105-023	Green Valley Creek	25.2
15060202-614	Unnamed Trib To Big Spring Canyon	36.7
15020008-580	Turkey Creek	38.7
15060202-009	Rarick Canyon	48.5
15030202-005B	Boulder Creek	54.5
15070102-034B	Big Bug-Below	54.8
15060201-019	Apache Creek	58.0
15060103-022	Salome Creek	59.2
15060105-455B	Barnhardt Canyon	59.9
15060106B-026A	Cave Creek-Spur Cross	60.7
15020008-004	Jacks Canyon	72.4
15050302-018	Bear Canyon Creek	74.4
15060202-499	Secret Canyon	78.7
15060203-028	Tangle Creek	83.8
15050201-299	San Pedro River	93.9

Appendix B. WBIDs with an assigned flow regime of ephemeral as of August 2020.

Waterbody ID	Stream Name	Average % Riparian Cover
15070102-007B	Agua Fria River	0
15050100-012C	Mineral Creek	0
15050302-003	Rillito Creek	0
15050203-008	San Pedro River	0
15070102-078	Trilby Wash	0
15070102-234	Unnamed Trib To Big Bug Cr	0
15030203-4291	Unnamed Trib To Copper Basin Wash	0
14080204-006-I	Chinle Wash	7.1
15070102-007A	Agua Fria River	7.7
15050302-004	Pantano Wash	7.8
15060203-989A	Ashbrook Wash	8.8
15050301-642	Unnamed Trib (UA3) To Alum Gulch	9.1
15050302-005	Pantano Wash	11.9
15050301-002	Santa Cruz River	12.6
15050100-003I-I	Gila River	12.8
15060106B-179	Indian Bend Wash	16.2
15020100-00333	Unnamed Ephemeral Trib to Black Canyon Lake	16.7
15070102-001B	Agua Fria River	18.2
15070102-004	New River	20.4
15070103-363	Star Wash	21.0
15010004-004	Cataract Creek	23.1
15050301-003A	Santa Cruz River	23.8
15070102-001A	Agua Fria River	24.3
15050301-653	Bond Canyon	24.7
15070102-003	Skunk Creek	27.0
15060201-486	Unnamed Trib To Williamson Valley Wash	31.9
15060106-001C	Salt River	33.5
15050301-475	Peck Canyon Creek	34.4
15070102-081	Wolf Creek	36.8
15020008-580	Turkey Creek	38.3
15070102-910	Unnamed Trib To Turkey Creek	43.3
15010001-020A	Bright Angel Creek	43.4
15020007-001	Puerco River	44.4
15050301-025B	Harshaw Creek	47.7
15070102-002	New River	48.6