Location and Status of Unsupplemented, Foresummer Surface Water on Pima County Conservation Lands, 2011-2017

Final Report
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Stream reach in Buehman Canyon

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Executive Summary

Surface water is a rare and limiting resource in desert environments. For animals in the Sonoran desert, surface water during the dry foresummer season is particularly important because of the increased demand for water at that time and because the extent of surface water is at its minimum. This report summarizes seven years of surveys to map the location of all naturally occurring (i.e., unsupplemented) surface water (stock tanks and dams, springs, and streams) throughout Pima County's extensive system of conservation lands. Unsupplemented surface water was extremely rare and often spatially and temporally variable. Specifically, staff made 145 visits to 58 sites: 42 had surface water in at least one year, but only 20 sites (5 stock tanks, 6 springs, and 9 streams) with visits in two or more years had surface water present on each visit. At sites that consistently had water in the foresummer, their spatial extent was very limited and subject to high variability between years.

Though surface water plays a critical role in maintaining local species diversity, threats to unsupplemented features abound, most importantly the current and persistent drought and climate change. Management actions such as improving water-holding capacity of select features, sound management of contributing uplands, and assertion of County-held water rights can help ensure the persistence of unsupplemented surface waters. Pima County will continue to monitor key surface water sites during the arid foresummer as part of the Pima County Ecological Monitoring Program, a key element of the Multi-species Conservation Plan (MSCP). Data from the annual surface water monitoring effort will also inform various County land management plans that are both a requirement of the MSCP and our commitment to sound stewardship of the public's resources on these conservation lands.

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Introduction

Perennial or near-perennial surface water in arid environments is essential for a host of resources including native species such as fish, frogs, and aquatic invertebrates, but also for many terrestrial animals (O'Brien et al. 2006). The importance of water was recognized in the development of the Sonoran Desert Conservation Plan (SDCP), which had a significant focus on riparian and aquatic resources (e.g., Fonseca et al. 2000; Pima County 2000b; Rosen 2000; Pima County 2002). Scarce before the SDCP planning process began in the late 1990's, surface water volume and extent has contracted even further in Pima County because of the persistent drought currently gripping the region (e.g., Powell 2013).

Protection of water resources was a driver of Pima County's most recent and significant land acquisition program, which began in 2005 as a result of voter-approved bonds. Since then the County has purchased over 50,000 acres of fee lands and leased over 135,000 acres of state and federal lands. Other funding (e.g., Floodprone Land Acquisition Program) and donations have brought the total acres under Pima County and Regional Flood Control District ownership and management to over 225,000; collectively, these lands are referred to as Pima County conservation lands. Despite the County's due diligence efforts at the time of each property acquisition, however, very little was known about the location, extent, and condition of key natural resources on these lands. Particularly lacking has been information on surface water.

While surface water can be—and in some cases is—inventoried and monitored at various times throughout the year in our region, June is considered the peak of the dry foresummer in the Sonoran Desert and is an ideal time to survey for the presence of surface water (Turner and Richter 2011); sites that consistently maintain surface water through to the start of the monsoons can often be considered truly perennial. Information about surface water can be used for a host of management applications including creation or enhancement of features to hold more water, water rights assertions, and application of water quality standards (e.g., Outstanding Arizona Waters).

Monitoring the inter-annual variation in foresummer surface water can help to understand and predict the impacts of prolonged drought and climate change on wide range of ecosystem structures and functions, from groundwater recharge to plant and macroinvertebrate community composition (e.g., Bogan and Lytle 2011; Katz et al. 2012). The emerging fields of disturbance and "temporary-river" ecology (Larned et al. 2010) are providing new insights into—and showing value of—dynamic perennial, intermittent, and ephemeral aquatic systems of the arid southwest (e.g., Bogan et al. 2015) and potential management responses to changes (Lacher et al. 2014). Managing systems for environmental flows that sustain basic ecological and hydrological structures and functions is an area of particular importance given the climatic and land-use changes of the Anthropocene (Tharme 2003; Arthington et al. 2006; Acreman et al. 2014).

Pima County's Surface-water Monitoring Efforts

Pima County and the Pima Association of Governments have been monitoring surface water since the 1980s at the Cienega Creek Natural Preserve (Pima Association of Governments 2009; Powell 2013), and inventory and monitoring efforts have expanded in recent years with the County's land acquisitions and leases. The first effort to document the location of foresummer surface waters on County conservation lands outside of Cienega Creek and Davidson Canyon was undertaken in 2011 (Powell 2011). However, with the approval of the Multi-species Conservation Plan in 2016 (MSCP; Pima County 2016), Pima County's effort to document these sites has increased significantly. That year began the Pima County Ecological Monitoring Program (EMP), which has a mandate to support the MSCP by monitoring a host of resources including select aquatic and riparian species and their habitats (Pima County 2016).

This report summarizes the most current findings from the County's ongoing inventory of surface water on County conservation lands; it focuses on stock tanks and dams, springs, and stream segments that are "unsupplemented" because they receive no direct water inputs from human-built features such as wells, pipes, and pumps. Temporally, the foci of this report is on the foresummer, thus excluding other periods of the year when surface water extent and volume might be greatest, such after storm events and during the winter.

Methods

Field surveys took place at the following feature types (Figure 1):

- Stock Tanks and Dams. These are human-made features that capture surface water runoff for use by cattle and/or wildlife. In some cases, developed waters such as tanks were built on top of—or otherwise capture—spring water, but lacking additional information, they are classified as stock tanks and dams. These features do not include "wildlife drinkers" and/or metal stock tanks. This assessment was not a comprehensive inventory of stock tanks and dams; rather the focus was on visiting those sites that had—based on observation by ranchers and County staff—the greatest likelihood of holding surface water in the foresummer.
- Springs. These are areas where groundwater discharges above the ground surface and mostly outside of a streambed or channel. Most of the springs referenced here are hillside springs, but can also include limnocrene springs (Springer and Stevens 2008) and three rheocrene springs that are only known to express very small amounts of water. As with stock tanks and dams, not all springs were visited. For example, Becky Spring (Bar-V Ranch) is a hillside spring, but is boxed and piped to the Bar-V ranch house. There are other hillside spring sites across County lands with moist soil, calcium carbonate deposits, and/or history of surface expression that were not visited during these surveys because it was determined that they would be unlikely to express surface water. The spring at Bingham Cienega is a particularly notable example.

Figure 1. Surface water features on County conservation lands include springs (A; Blacktail Spring, Sands Ranch), stock tanks and dams (B; Hopkins Tank, Rancho Seco), and stream reaches (C; Cienega Creek), which includes tinajas (D; Espiritu Canyon, A7 Ranch) and some springs.

- Streams. Anywhere where water emerges in a streambed and (typically) flows for some distance. Most rheocrene springs (Springer and Stevens 2008), where water emerges from bedrock or where shallow groundwater intersects the surface, are also included, as are tinajas (bedrock pools) that are fed from either groundwater or precipitation (via runoff).

All surveys took place between late May and early July each year. Characteristics recorded at sites included the presence of water and its location (UTM, NAD83 using a hand-held GPS receiver). Where pooled water was found (all feature types), data were recorded as a single point feature and (in most cases) the surface area (m^2) estimated[1].

For surveys along streams, observers recorded the survey beginning and end locations and the beginning and end of surface water segments (flowing or standing water) that were

[1] Data are not summarized in this report.

approximately >3m in length. The beginning of a flowing segment was always the upstream point, regardless of whether the observer was walking upstream or downstream to conduct the survey; this was important for data management. This report also summarizes stream flow length data collected by Pima Association of Governments (PAG) staff at the Cienega Creek Natural Preserve.

Point features (primarily pools and recorded as such) along streams were generally <3 m in length[2]. These features were not measured using the GPS units because the accuracy (i.e., error) of the units precluded accurate recording of the linear length of these features. Observers also noted the presence—and in some cases numbers—of aquatic or semi-aquatic vertebrates[3]: fishes (Gila topminnow, Gila chub, and longfin dace), lowland and Chiricahua leopard frogs, canyon tree frog, Sonoran mud turtle, and black-necked garter snakes. Photographs were occasionally taken, but was not a required element of the protocol.

Monitoring was undertaken by staff from three County departments: Office of Sustainability and Conservation; Natural Resources, Parks and Recreation; and Regional Flood Control District and with assistance from the Pima Association of Governments at Cienega Creek and Davidson Canyon.

Data Management. Source data for Cienega Creek and Davidson Canyon were provided by PAG as shapefiles whose features referenced various depictions of stream centerlines depending on survey date. Data from County staff were provided as GPS-collected coordinates for survey start and stop points, wet reach start and stop points, and in-channel point features. All features and positions were transferred to a linear referencing system dependent on High Resolution National Hydrography Dataset stream centerlines. A linear referencing data model allows all stream channel features to be stored as table records, which in turn reference a *single* GIS representation of a stream centerline. Linear referencing also affords linear overlay analysis. Both automated GIS tools and manual interpretation were used to create linear referencing table measures for all in-channel features. Stock tanks, dams, and springs were directly mapped according from GPS coordinates.

Pairs of measures which describe wet reaches and survey extents are called *events*. For each stream, all events by type were intersected against each other to create new linear features for both number of times a reach was surveyed and number times flowing water was observed. Finally, tallied surveys and wet reaches were intersected to yield a flow permanence layer. For example, if a reach was surveyed three times and water was present twice, the permanence value is 66%. All event tables and intersect results are stored in an

[2] PAG staff follow a slightly different protocol and do not collect data on small pools: https://www.pagnet.org/documents/water/20FtRuleGuide-2017-01-Draft.pdf
[3] Data are not summarized in this report.

enterprise geodatabase, which allows for data backups, point-in-time recovery, and multi-user editing.

Results

Stock Tanks and Dams

Staff visited 29 stock tanks and dams located on 10 properties in five years of surveys (2011, 2014-2017; Appendix A) for a total of 55 observations (Table 1). The number of visits to sites varied significantly among years and no site was visited in all years. When all visits were considered, surface water was present more times (n = 33) than sites were observed dry (n = 22). Only five sites were wet in each of two or more visits. Six sites varied between wet and dry conditions and three sites visited in two or more years were dry on all visits. There is also considerable geographic variation in the number and density of sites (Appendix A) and wet/dry condition (Table 1) by property and watershed. For example, in the Altar watershed, most stock tanks and dams were on Rancho Seco and Sopori Ranch and these sites were dry (n = 14) as often as wet (n = 14). By contrast, the sites in the San Pedro watershed were wet (n = 13) more often than dry (n = 3).

Table 1. Presence (wet) or absence (dry) of surface water at stock tanks and dams, Pima County conservation lands, 2011-2017.

			Year				
Watershed	Property	Site	2011	2014	2015	2016	2017
Altar	King 98	NAWA					Dry
	Rancho Seco	Cerro Colorado	Dry			Wet	Wet
		Compressor	Dry			Wet	Wet
		Cradle				Wet	Dry
		Honeymoon					Dry
		Hopkins	Wet			Wet	Wet
		Horseshoe					Wet
		Mud				Dry	
		Pesquiera	Dry			Wet	
	Sopori	Papalote	Dry				Dry
		Sparkplug				Dry	Dry
		Steer Pasture	Wet		Dry		Dry
		Cedar Canyon					Dry
	Verdugo	Verdugo			Wet	Wet	Wet
Cienega	Bar V	Cedar				Wet	Dry
	Clyne	Hospital	Wet	Wet		Wet	Wet
	Sands	Boulder					Dry
		Goat Well					Dry
		MacNally	Wet	Dry		Wet	Dry
San Pedro	A7	Barrow					Wet
		Jerry					Wet
		Bear		Wet			
		Big	Dry			Wet	Wet
		Upper				Wet	Wet
		Youtcy					Wet
	Six Bar	Davis Mesa		Wet			
		Lone Hill					Wet
		Split				Wet	
Tucson Basin	Carpenter	Carpenter Spring				Dry	Dry
		Unnamed				Wet	Wet

Springs

Staff visited 15 springs on ten County properties for a total of 33 observations (Table 2, Appendix A). Most springs were visited only once or twice, with the exception of Blacktail, Grapevine, and Youtcy 2, which were monitored 4-5 times each. Four sites were dry on each visit while seven sites had water on each visit. No site had an abundance of water; all sites with some surface water had either a trickle of running water (or associated small pool) or multiple small pools. Like with stock tanks and dams, there was considerable difference among watersheds, most notably that there were no known springs on County conservation lands in the Altar Valley. There were no apparent difference in presence or absence of water at springs among the three watersheds where springs occur.

Streams

Thirteen stream reaches were surveyed from 2011-2017 on seven County properties (Table 3; Appendix A, B). Only Cienega Creek, Davidson Canyon, and Youtcy Canyon were surveyed each year and total survey effort varied considerably among years in terms of number of sites (low of four in 2012 and high of 12 in 2017) and in some cases the surveyed distances varied within sites. For some sites (exclusive of Cienega Creek and Davidson Canyon), the beginning and end of surveys varied among years as staff learned more about each site.

Cienega Creek had the greatest length of surface water (0.9-1.5 miles) followed by Buehman Canyon (0.1-0.3 miles). No water was found at either Agua Verde or Geesaman washes, though survey effort was only one and two years, respectively. Most stream reaches were in the San Pedro watershed. Appendix B includes maps of survey effort and where water was observed.

Table 2. Presence (wet) or absence (dry) of surface water at springs, Pima County conservation lands, 2011-2107.

			Year					
Watershed	Property	Site	2011	2012	2014	2015	2016	2017
Cienega	Bar V Ranch	Cliff					Dry	Wet
		Mescal					Dry	
	Clyne Ranch	Turney						Wet
	Sands Ranch	Blacktail	Wet		Wet		Wet	Wet
San Pedro	A7	Unnamed			Dry			
		Grapevine	Wet		Wet		Wet	Wet
		Youtcy 2		Wet	Wet	Dry	Wet	Wet
	M Diamond	Homestead					Dry	Dry
		Peck			Wet			Wet
	Six Bar Ranch	Parker Homestead[1]	Dry					
Tucson Basin	Agua Caliente	Agua Caliente Spring					Wet	Wet
	Carpenter	Cochie[1]			Dry	Dry		
		Cottonwood Canyon[1]					Wet	Wet
	Tortolita	Tennis Spring					Wet	Wet
	Rancho Fundoshi	Fundoshi Spring					Wet	Dry

[1] These springs primarily express in drainage bottoms and so are considered rheochrene springs. However, these are very discrete sites and the larger drainage was not surveyed for surface water, as was done for streams.

Table 3. Results of stream surveys on Pima County conservation lands, 2011-2017. Data represented: miles of survey effort (Srv), miles of stream with water (wet), and number of pools (P). Pools were not recorded as part of the survey effort at Davidson Canyon or Cienega Creek.

Water-shed	Property	Site	2011			2012			2013			2014			2015			2016			2017		
			Svy	Wet	P	Svy	Wet	P	Svy	Wet	P	Svy	Wet	P	Svy	Wet	P	Svy	Wet	P	Svy	Wet	P
Altar	Rancho Seco	Sparkplug													0.1	0	1	0.1	0.1		0.1	0.1	3
Cienega	Agua Verde	Agua Verde																			0.9	0	
	Cienega Creek NP	Cienega	9.4	1.3	NA	9.4	1.2	NA	9.4	0.9	NA	9.4	0.9	NA	9.4	0.9	NA	9.4	1.9	NA	9.4	1.5	NA
	Bar-V	Davidson	3.6	0	NA	3.6	0.004	NA	3.6	0	NA	3.6	0	NA	3.6	0	NA	3.6	0.03	NA	3.6	0.1	NA
San Pedro	Buehman Canyon	Buehman	5.5	0.3	4							4.8	0.2	9	5.3	0.2	19	7.2	0.2	28	5.8	0.1	38
		Bullock	0.8	0	1							0.9	0	1	0.9	0.1	1	0.9	0.1	2	0.9	0.04	4
	Oracle Ridge	Gibb tributary	0.3	0.03	2													0.1	0	2	0.3	0.3	
		Geesaman	0.4	0	2										0.5	0							
	A7	Edgar							0.4	0.1	2	0.4	0.1	4	1.4	0.1	3	0.5	0.1	3	0.2	0.1	6
		Espiritu	0.9	0	2	0.4	0	1	0.9	0	1	0.1	0	1				3.5	0	3	1.5	0	11
		Youtcy	2.4	0.1	7	1.8	0.1	2	2.4	0	3	0.3	0	1	0.7	0.3	7	2.6	0.5	7	0.7	0.5	2
		Robles	1.0	0	1										1.0	0.03		1.0	0.04		0.2		3
		Soza	0.6	0														0.6	0	1	0.6	0	3
Total Survey Distance (miles)			24.9			15.2			16.7			19.7			22.8			29.5			24.1		

Discussion

This report summarizes 145 visits to 58 sites, thereby representing a significant increase in our knowledge of the status of surface water on County conservation lands. Though there has been a marked increase in field effort since 2011—and even the discovery of previously unknown persistent surface water features— the fundamental conclusion of the 2011 report remains: surface water is a rare resource on County conservation lands in the arid foresummer season (Table 1-3). For example, of the 58 tanks, spring, and stream sites visited at least once, 42 had surface water in at least one year, but only 20 sites (5 tanks, 6 springs, and 9 streams) with two or more visits had surface water present on each visit.

Protection and enhancement of unsupplemented surface water sources (particularly perennial streams, springs, and tinajas) was repeatedly stated to be a top management priority during the development of the SDCP (Pima County 2000a). As compared to supplemented surface water, unsupplemented features often require fewer resource inputs (e.g., time, materials) to keep a site functional as a surface water feature. However, reliance on natural processes (rainfall, runoff, recharge) to supply water can be problematic; as the data reported here clearly show (Tables 1-3, Appendix B), water permanence is not assured and can be highly variable.

While the focus of this report is to identify sites that hold water longest during the foresummer, intermittent or ephemeral surface water features also have value. Intermittent and ephemeral waters play a critical role in a host of ecosystem functions such as dispersal of aquatic animals, nutrient and carbon cycling, infiltration and recharge to support downstream perennial waters and hyporheic zones, flood attenuation, and sediment movement (Levick et al. 2008). Many formerly perennial waters in Pima County are now intermittent or ephemeral (Pima County 2000b, 2002) and some of these areas are the focus of current restoration efforts, such as the Watershed Management Group's work along Sabino, Tanque Verde, and Agua Caliente washes. These areas can be crucial resources for a wide range of resources and needs such as wildlife, livestock, and human recreation and enjoyment.

Management Implications

Data is this report are a crucial first step in the inventory and assessment of surface water features on county conservation lands. These data can have a variety of uses, from predictions about the impacts of site conditions moving from perennial to intermittent or ephemeral on important conservation targets such as vegetation (Lite and Stromberg 2005), to providing a framework for management actions. In particular, these data can provide a critical tool in the assessment of whether some of these sites should receive supplemental water or whether building other, human-constructed surface water features should be undertaken in areas with less reliable foresummer surface water. Pima County has constructed at least five wildlife water projects (i.e., supplemented water sources where livestock are excluded) in the last few years alone. Site-specific data from this effort has also informed the County's surface water rights as part of the Gila River Adjudication. Other

management actions could include enhancing surface water for greater water-holding capacity (e.g., at stock tanks) and improving upland conditions that ultimately impact downstream surface water resources.

Development of County management plans. The importance of unsupplemented surface water in our region cannot be overstated and its rarity is supported by the data in this report. Therefore, these data will be valuable in for the following management planning processes:

- The *Aquatic and Riparian Species Management Plan* is an important element of the MSCP and must be completed by July 2019. The plan will focus primarily on natural and artificial surface water sites to promote covered species occupancy where feasible and prudent. The plan will include detailed summaries of each sites regarding surface water extent and permanence.
- *Property-specific management plans* will be developed throughout the 30 years of the County's MSCP; these management plans will be focused on a host of key resources and water will play an important role in the process. The County is currently developing a management plan for Bingham Cienega Natural Preserve.
- *Coordinated Resource Management plans* support grazing on County ranches. Because of the importance of water resources for cattle and the need for the County to balance cattle grazing operations with natural resource protection, data in this report will help inform these inter-agency planning efforts.

Data Limitations and Uses

Surveys were carried out in the driest time of year when surface water extent and presence is the annual minimum extent and therefore does not represent the breadth of condition that might be found at other times of year. For example, Powell (2013) summarized streamflow length at Cienega Creek through 2011 and found that December streamflow extent was 22-60% longer than the June survey of the same year. Similarly, this report summarizes water extent from 2011-2017, a period of significant and sustained drought (Figure 3) and does not take into account the full breadth of year-to-year variations that might be evident in a longer dataset (e.g., Powell 2013).

It is also important to note that the data summarized in this report is not sufficient to establish trends in surface water except at a few sites (e.g., Cienega Creek and Davidson Canyon) that have a longer history of monitoring. Analysis of trends can be done only after more data are collected and the increase in field effort in 2016 and 2017 (Tables 1-3) provides a solid foundation for future trend assessments.

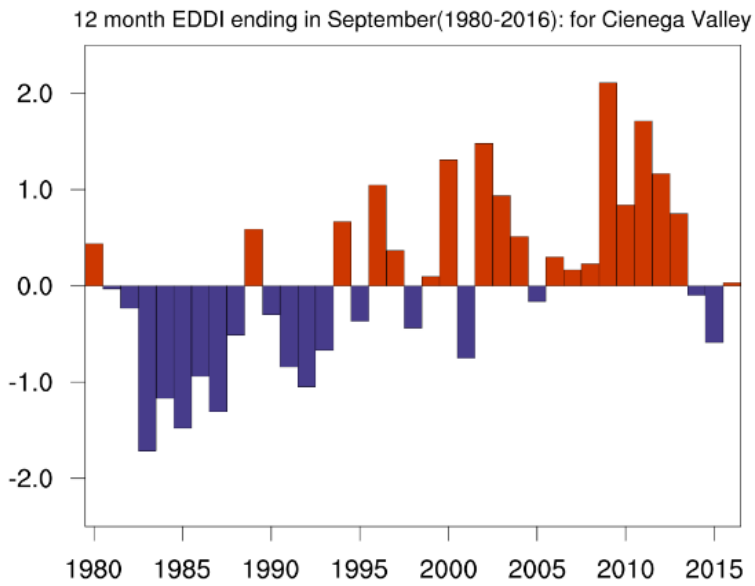

Figure 3. Evaporative Demand Drought Index from 1979-2017 for the Tucson Basin showing drought conditions in red. Drought condition during the study period (2011-2017) has been particularly severe. From Hobbins et al. (2016).

Recommendations

Despite having collected data about surface water for seven years, the County is just beginning to understand this key resource. Below are recommendations for future work to continue the inventory, monitoring, and assessment of unsupplemented perennial surface water on County conservation lands.

1) Search for previously unknown features. Despite hundreds of hours of inventory work on County conservation lands, staff continue to document previously unknown features. These inventory efforts should continue.

2) Continue pre-monsoon monitoring of key sites and refine the monitoring protocol. The annual foresummer ("wet/dry") effort that produced these data should continue with some modifications. First, the emphasis each year should be on visiting sites that have been shown to be perennial or near perennial. Sites with intermittent surface water should also be monitored, but because of the considerable time commitment needed to visit all potential sites, an alternative sampling design should be considered, for example visiting these sites every other year (or when a rainfall trigger has been met) or together with monitoring commitments associated with specific MSCP covered species. Other protocol modifications should include surveying between the same stretch of stream reach on each visit (i.e., standardizing survey reaches), taking more accurate measurement of surface water area (stock tank and dams and springs), and measuring core water-quality measures (e.g., temperature, pH, oxygen) where appropriate. Because the current survey reaches of streams is dictated by the minimal extent of flow as a result of decades of drought,

special attention will need to be directed to increasing the length of surveys during particularly wet years.

3) Standardize site names. Confucius wrote: "The beginning of wisdom is to call things by their proper name." Some of the sites referenced in this report do not have standardized names and are therefore referenced differently by County staff and cooperators. Having a single database of sites with standardized names will be critical first step in monitoring and managing these resources. Fortunately, the County is developing an integrated database of water features and the rapid implementation of that system should be a top priority for the County (see #4, below).

4) Integrate data into an online database. The County is moving towards serving up these data to a web platform (PimaMaps) where data summarized for each site could include: a photograph of each site, percentage and dates of visits when surface water was present, and vertebrate species found. This information will be helpful for both managers and to the general public (with more limited access to these data for the public).

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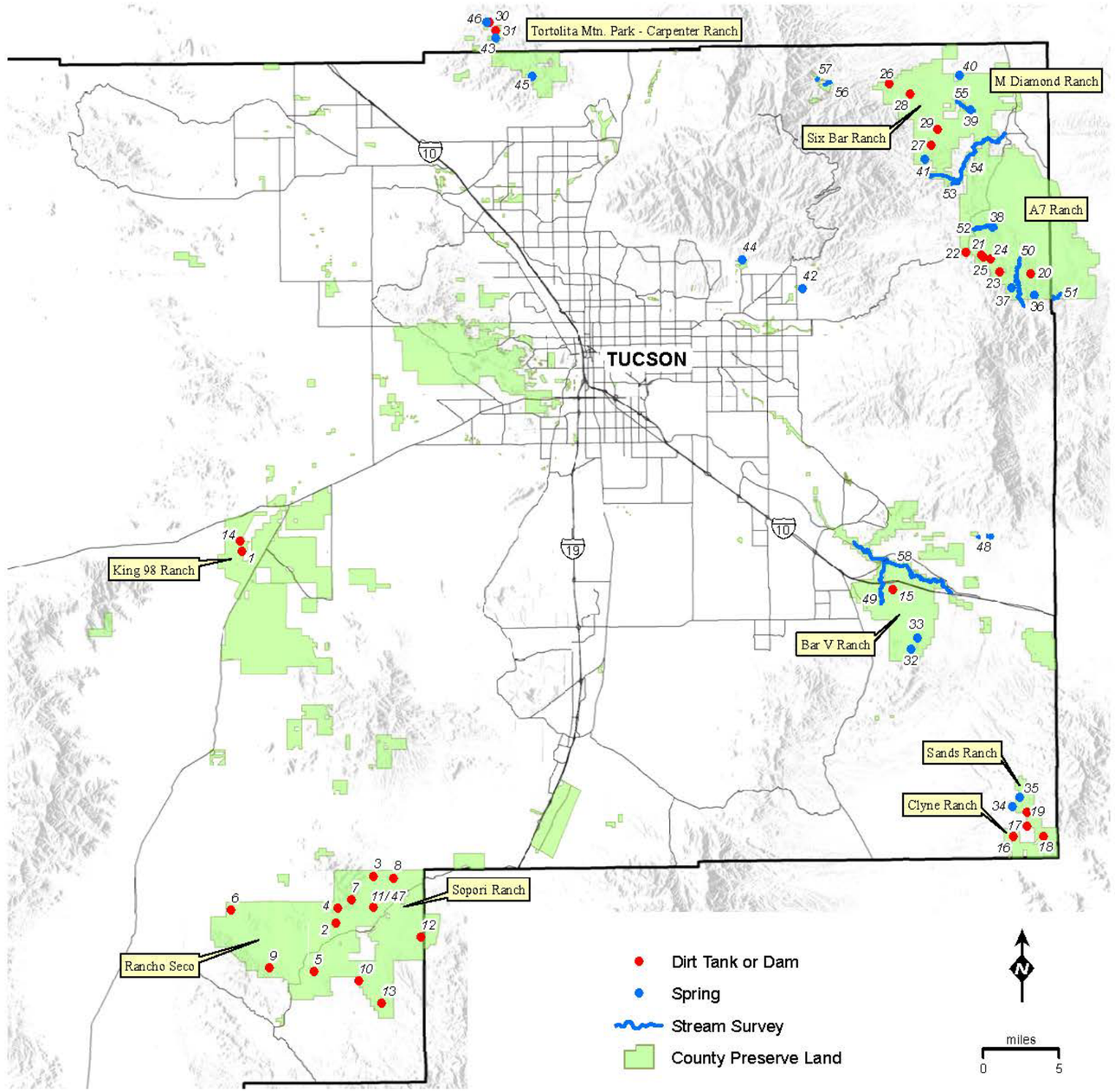
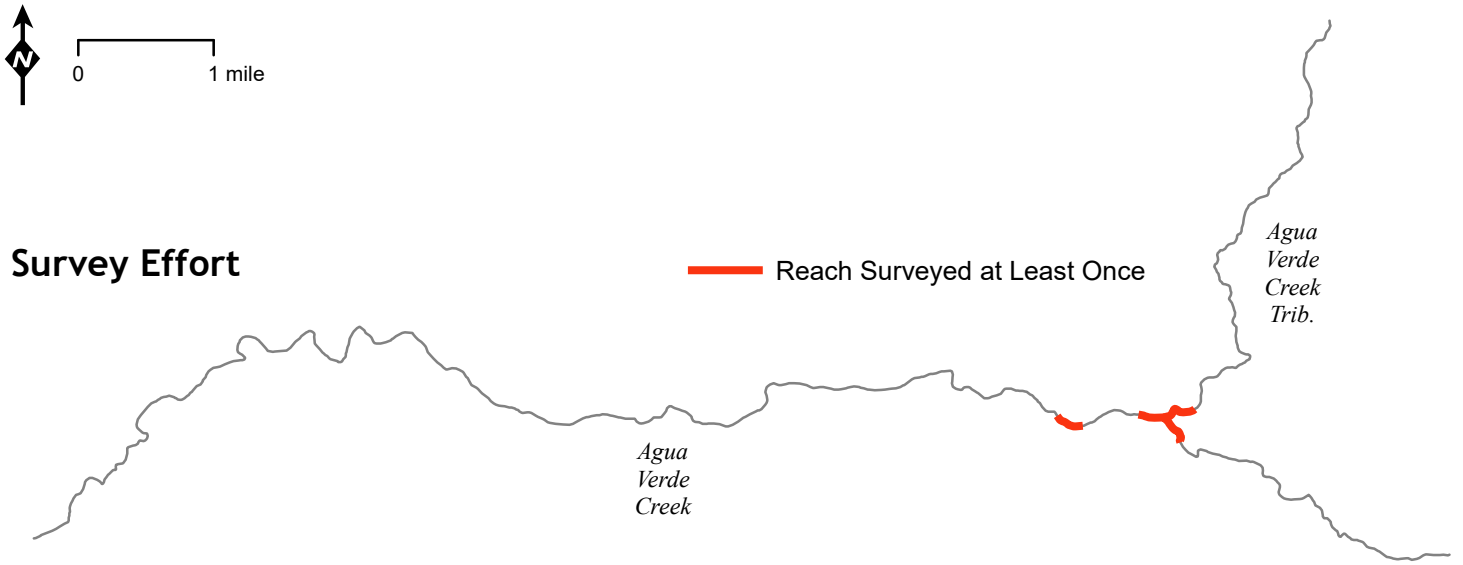
ID	Site Name
1	NAWA
2	Cerro Colorado
3	Compressor
4	Cradle
5	Honeymoon
6	Hopkins
7	Horseshoe
8	Mud
9	Pescada
10	Papalote
11	Sparkplug
12	Steer Pasture
13	Cedar
14	Verdugo
15	Cedar
16	Hospital
17	Boulder
18	Goat Well
19	MacNally
20	Bear
21	Barrow
22	Jerry
23	Big
24	Upper
25	Youtcy
26	Davis Mesa
27	Lone Hill
28	Split
29	Old Dirt Tank
30	Unnamed
31	Carpenter
32	Cliff
33	Mescal
34	Turney
35	Blacktail
36	Unnamed
37	Grapevine
38	Youtcy2
39	Homestead
40	Peck
41	Parker Homestead
42	Agua Caliente Spring
43	Cochie Spring
44	Fundoshi
45	Tennis Spring
46	Cottonwood Canyon
47	Sparkplug Tank Canyon
48	Agua Verde
49	Davidson
50	Espiritu
51	Robles
52	Youtcy
53	Bullock
54	Buehman
55	Edgar Canyon
56	Geesaman
57	Gibb
58	Cienega

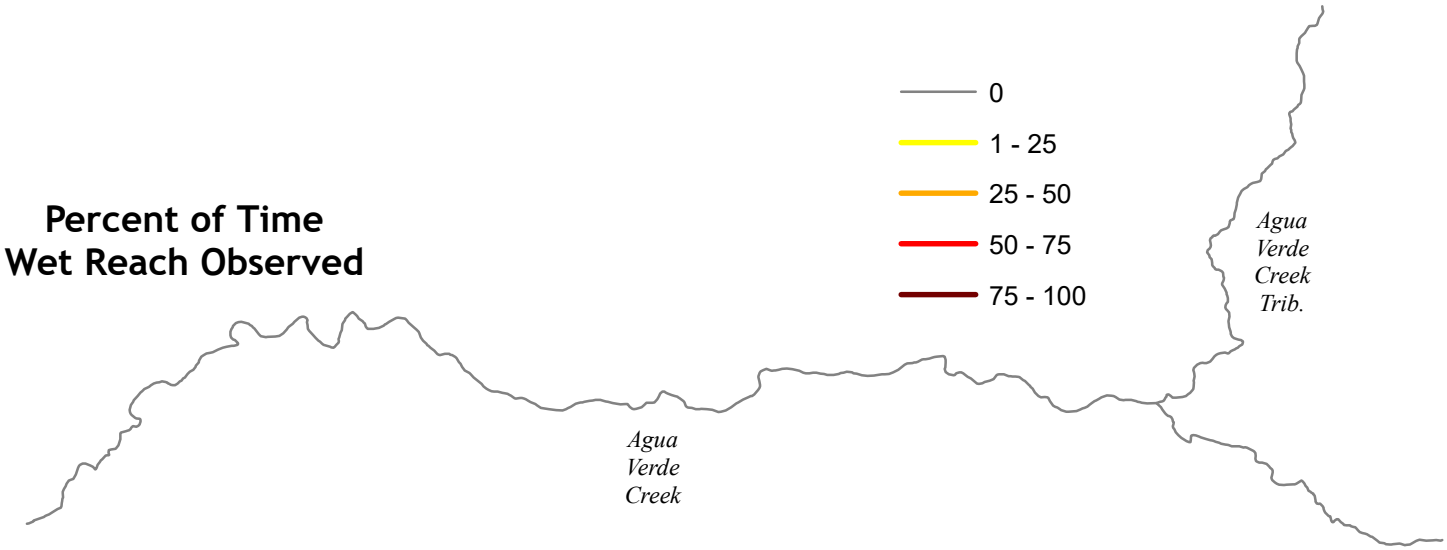


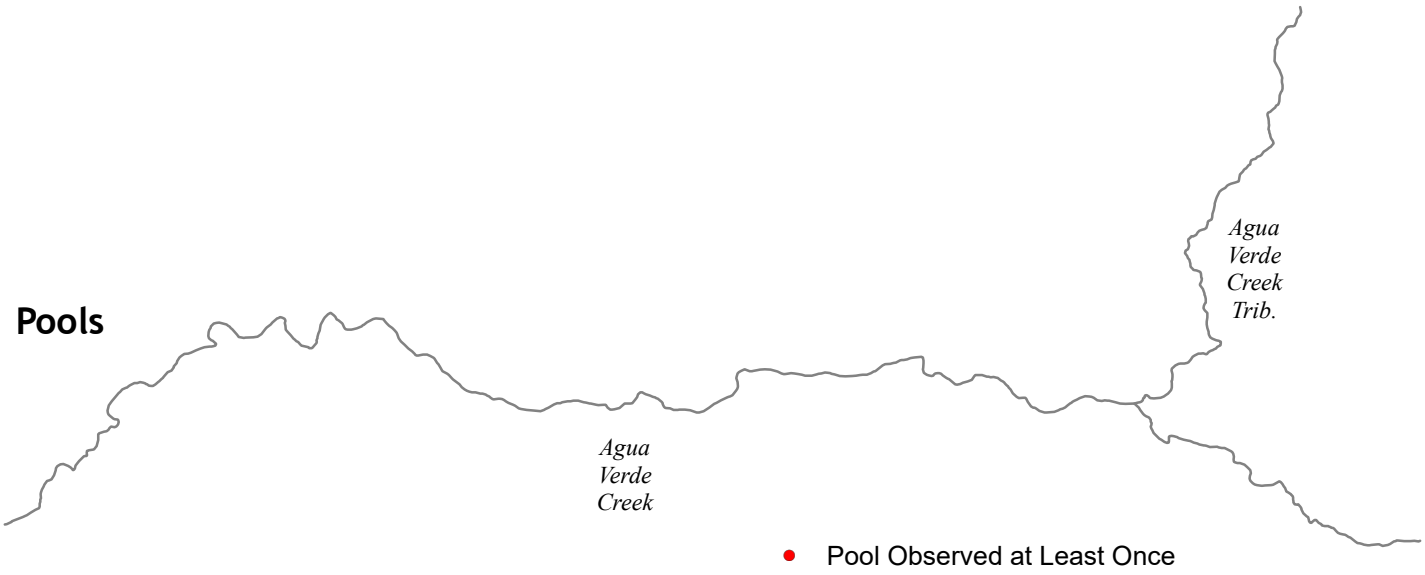
Appendix A. Location of sites with unsupplemented surface water referenced in this report.

Appendix B. Maps of stream surveyed for surface water on County lands, 2011-2017. For all streams surveyed there is one page with three maps: 1) Survey effort, which is the area surveyed at least once. 2) Areas where flowing water was observed, broken out by categories of the percentage of time that each reach had water. The potential "percent of time wet reach observed" (mapped in four categories: 0-25, 25-50, 50-75, and 75-100) varied by stream (i.e., if a stream was only surveyed once but had a flowing segment, then the "percent of time wet reach observed" would be mapped in the 75-100 percent category, whereas if a stream was surveyed on four or more years, then there is a potential for data to be mapped in each of the four percent categories). 3) Location of mapped pools. If a stream had a flowing segment and/or pools, then those data from the first set of maps are shown on aerial images.

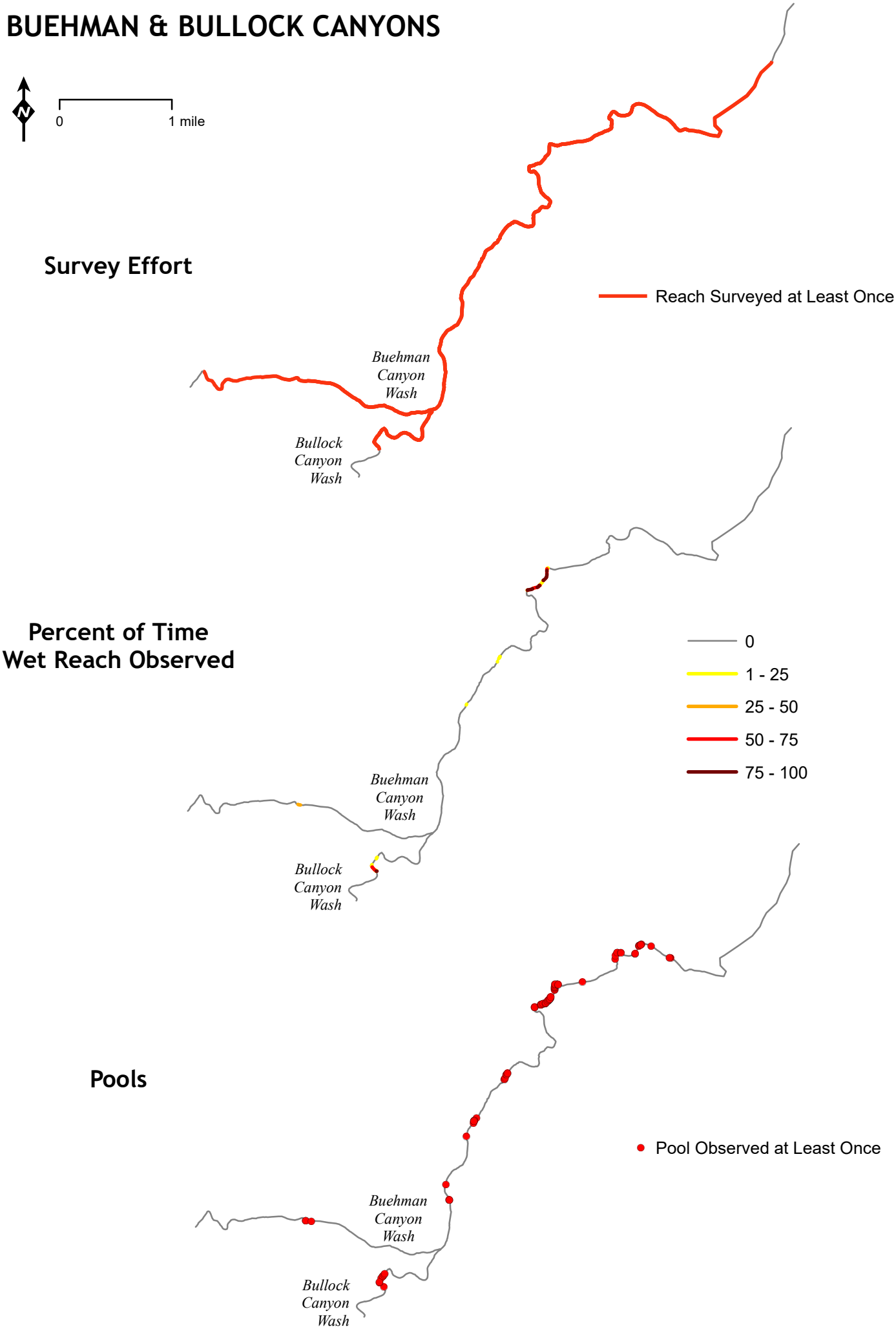
AGUA VERDE CREEK

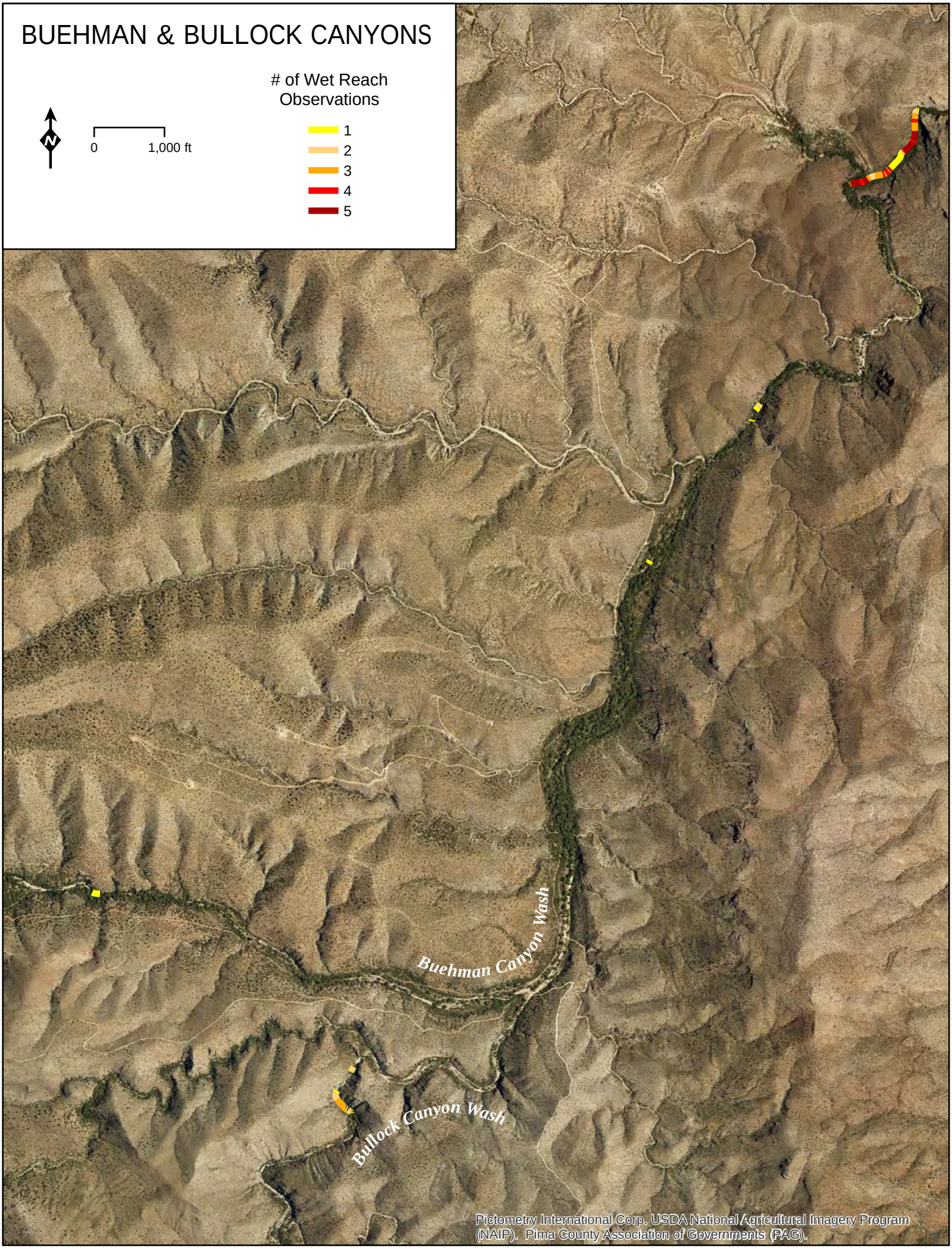




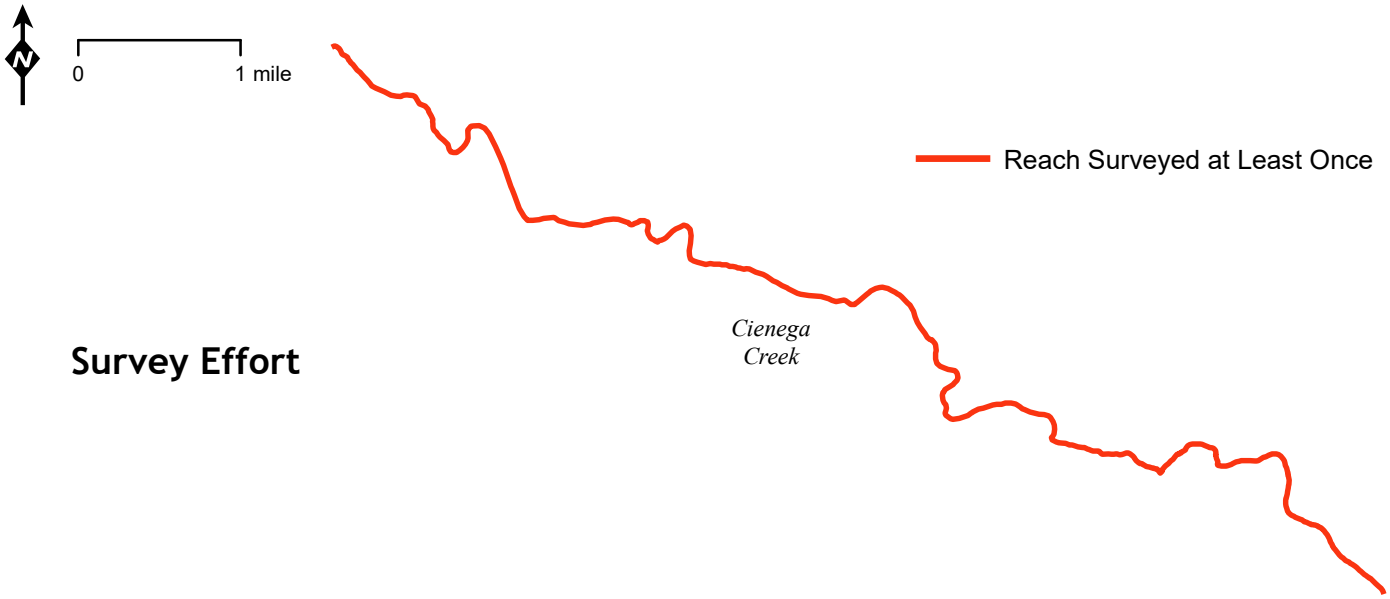


BUEHMAN & BULLOCK CANYONS

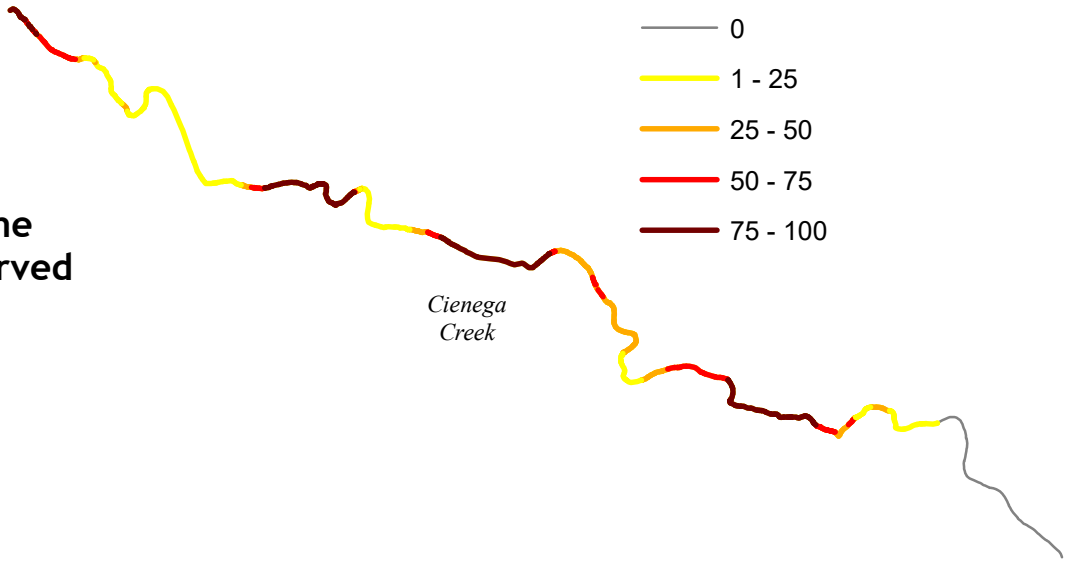



BUEHMAN & BULLOCK CANYONS
# of Wet Reach Observations
1
2
3
4
5
0
1,000 ft
N
Buehman Canyon Wash
Bullock Canyon Wash
Pictometry International Corp. USDA National Agricultural Imagery Program (NAIP). Pima County Association of Governments (PAG).

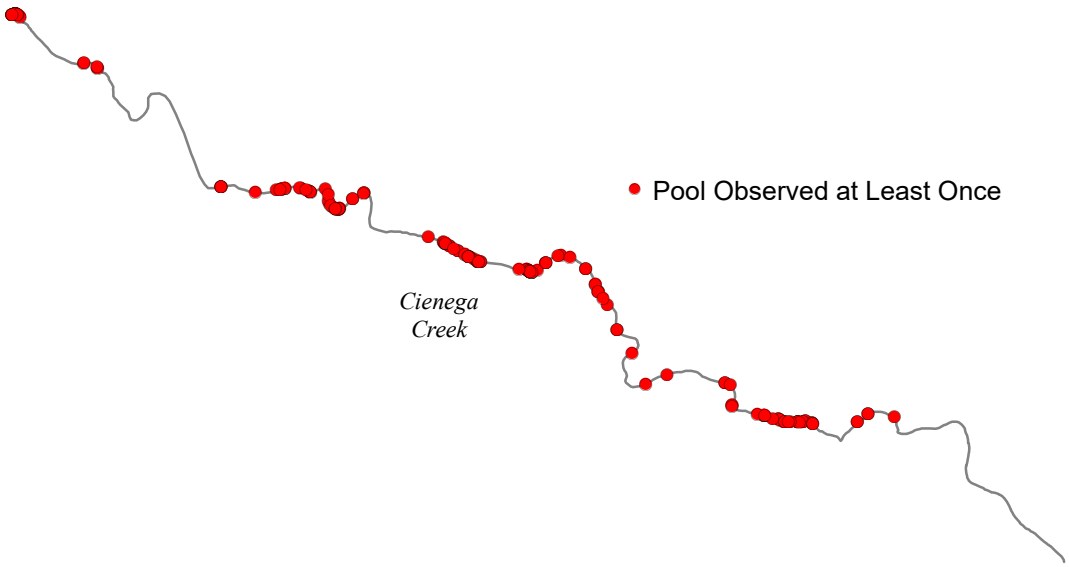
CIENEGA CREEK



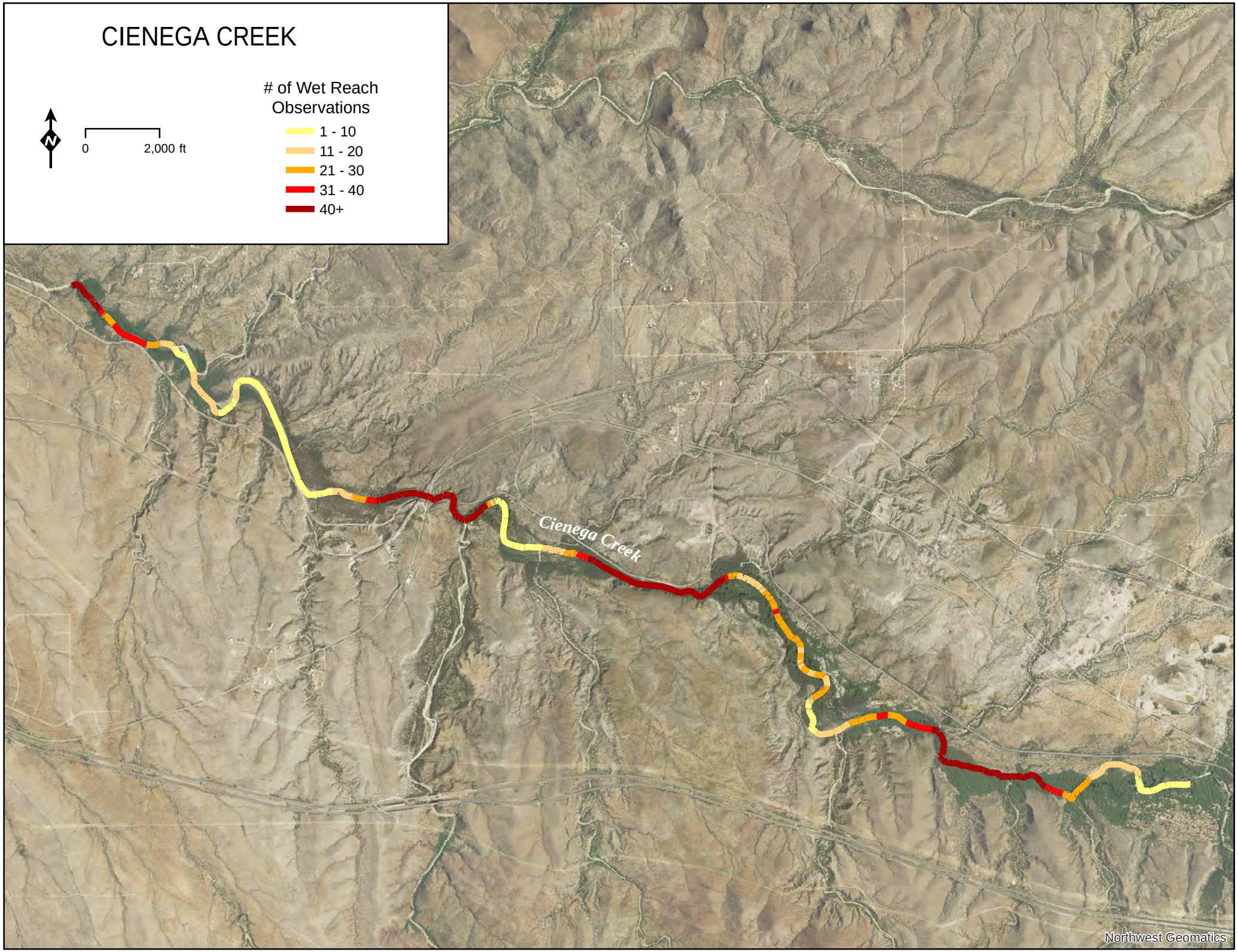
Survey Effort



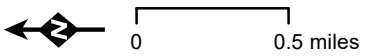
Percent of Time Wet Reach Observed

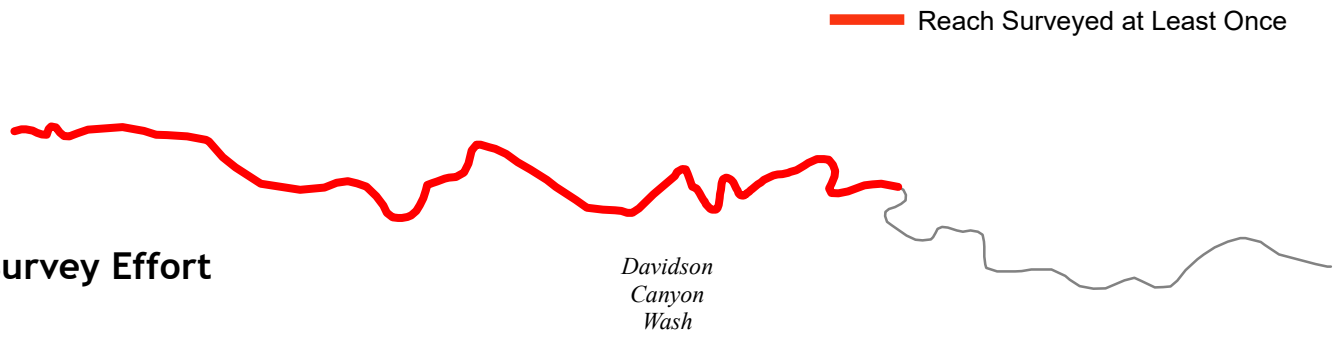


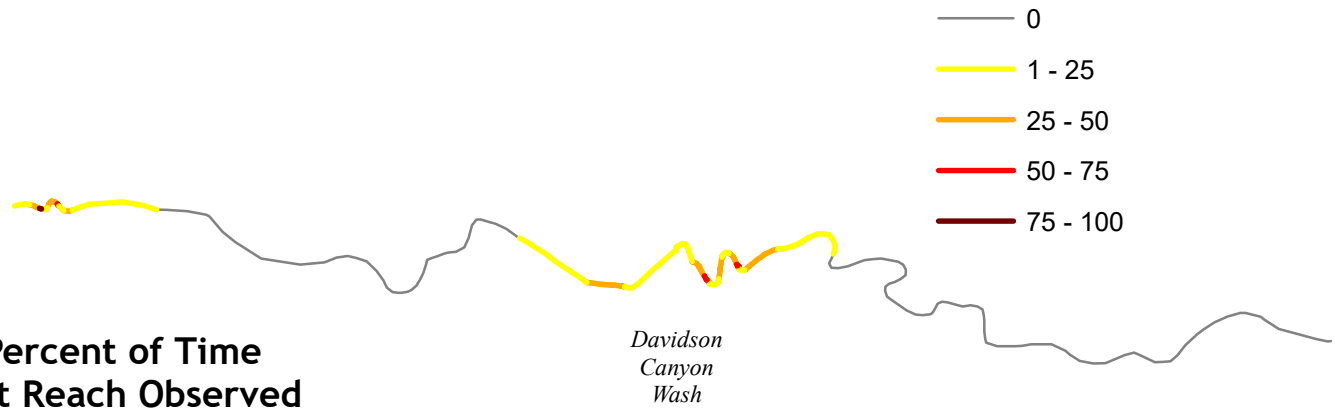
Pools

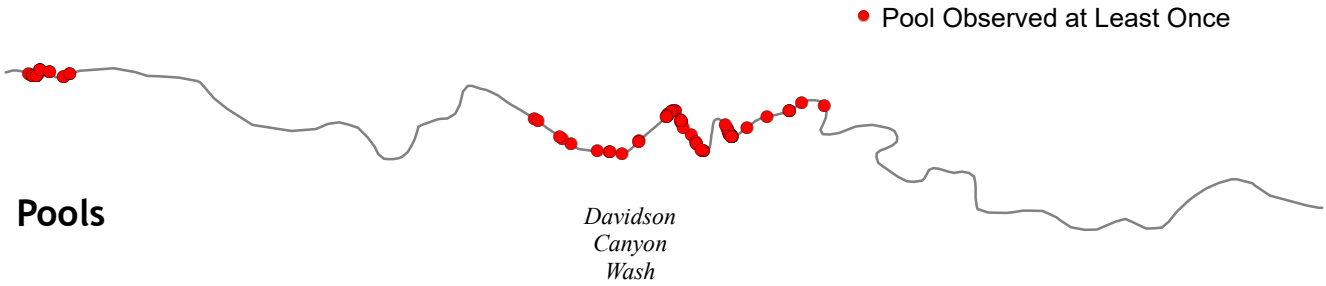

CIENEGA CREEK
# of Wet Reach Observations
1 - 10
11 - 20
21 - 30
31 - 40
40+
0
2,000 ft
Cienega Creek
Northwest Geomatics

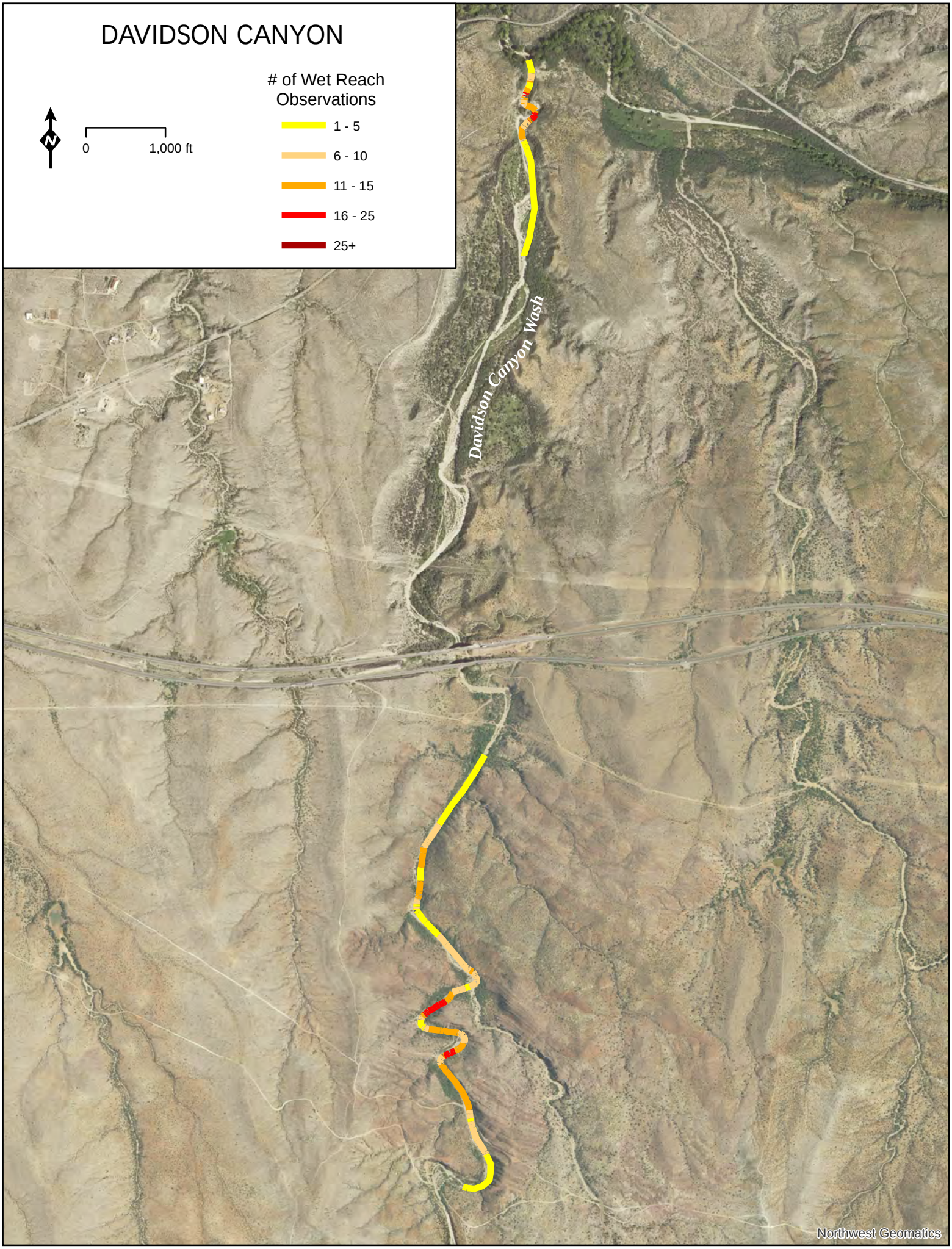
DAVIDSON CANYON



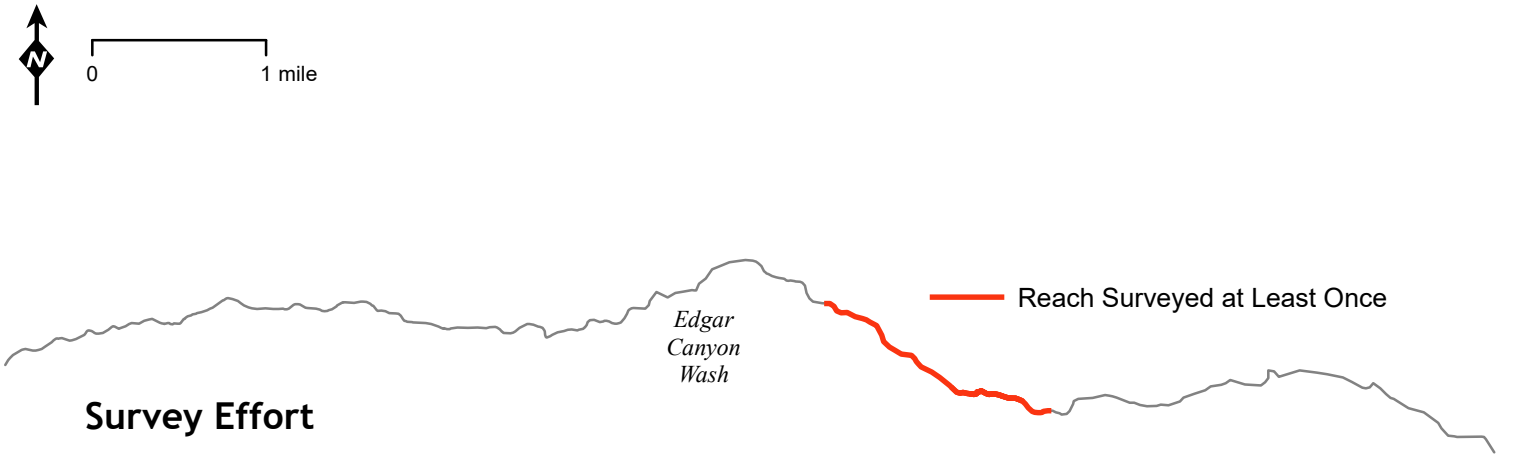


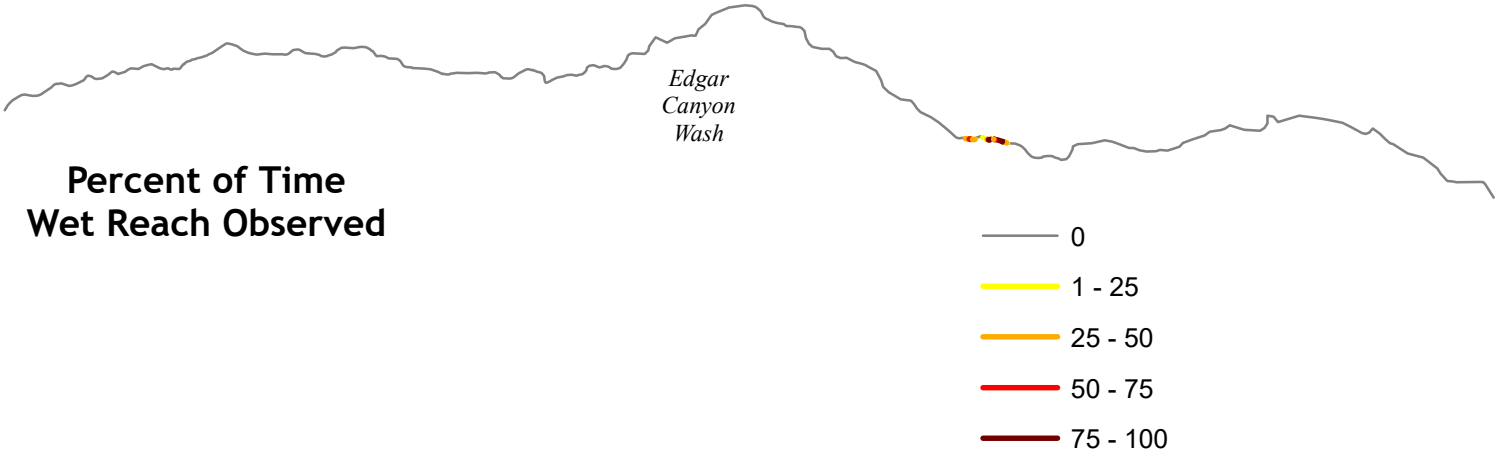


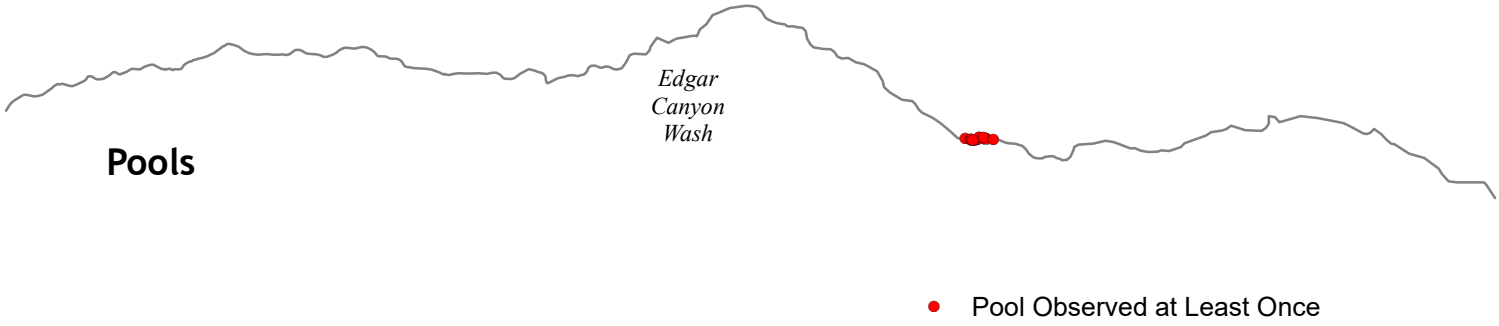


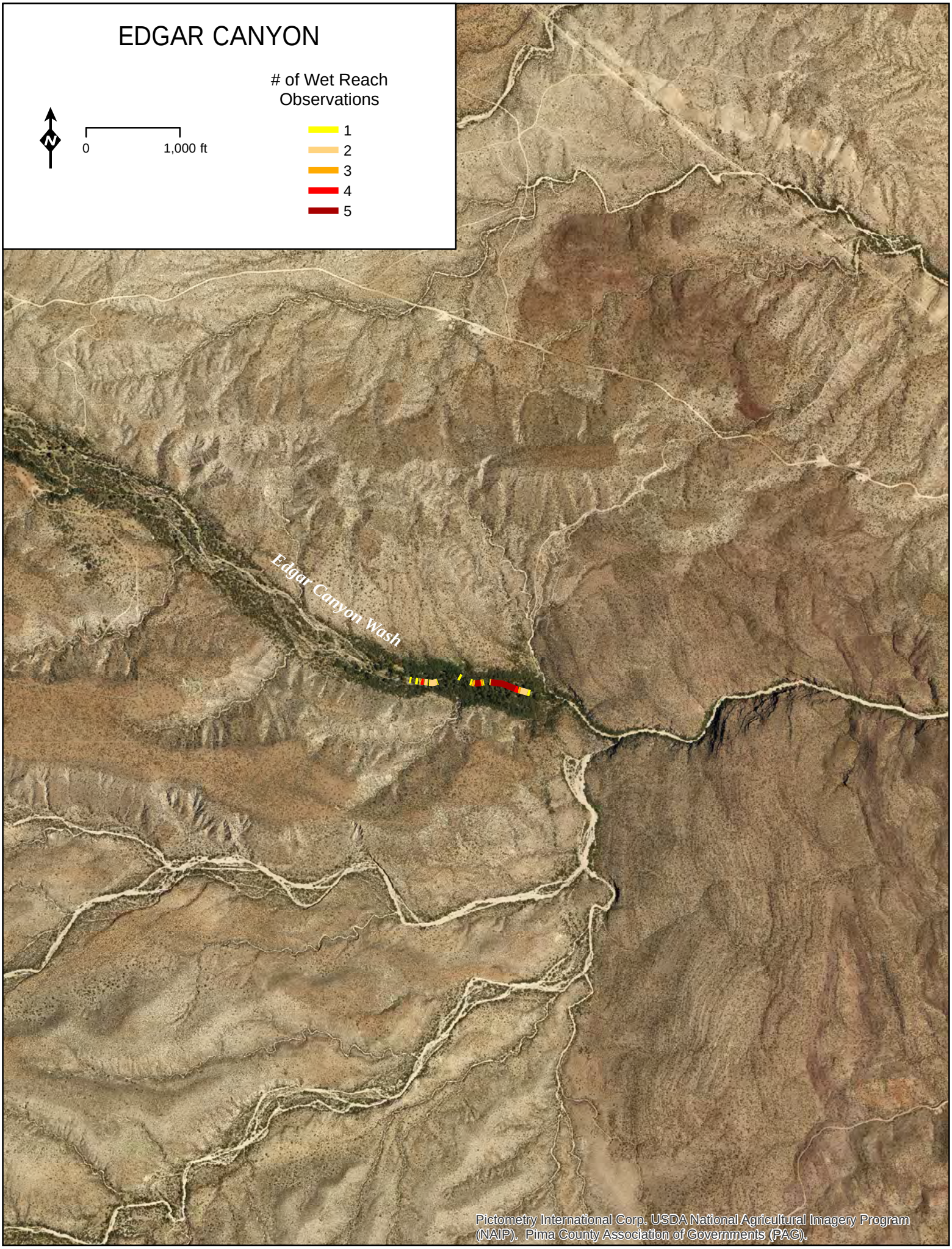

DAVIDSON CANYON
# of Wet Reach Observations
1 - 5
6 - 10
11 - 15
16 - 25
25+
0
1,000 ft
N
Davidson Canyon Wash
Northwest Geomatics

EDGAR CANYON

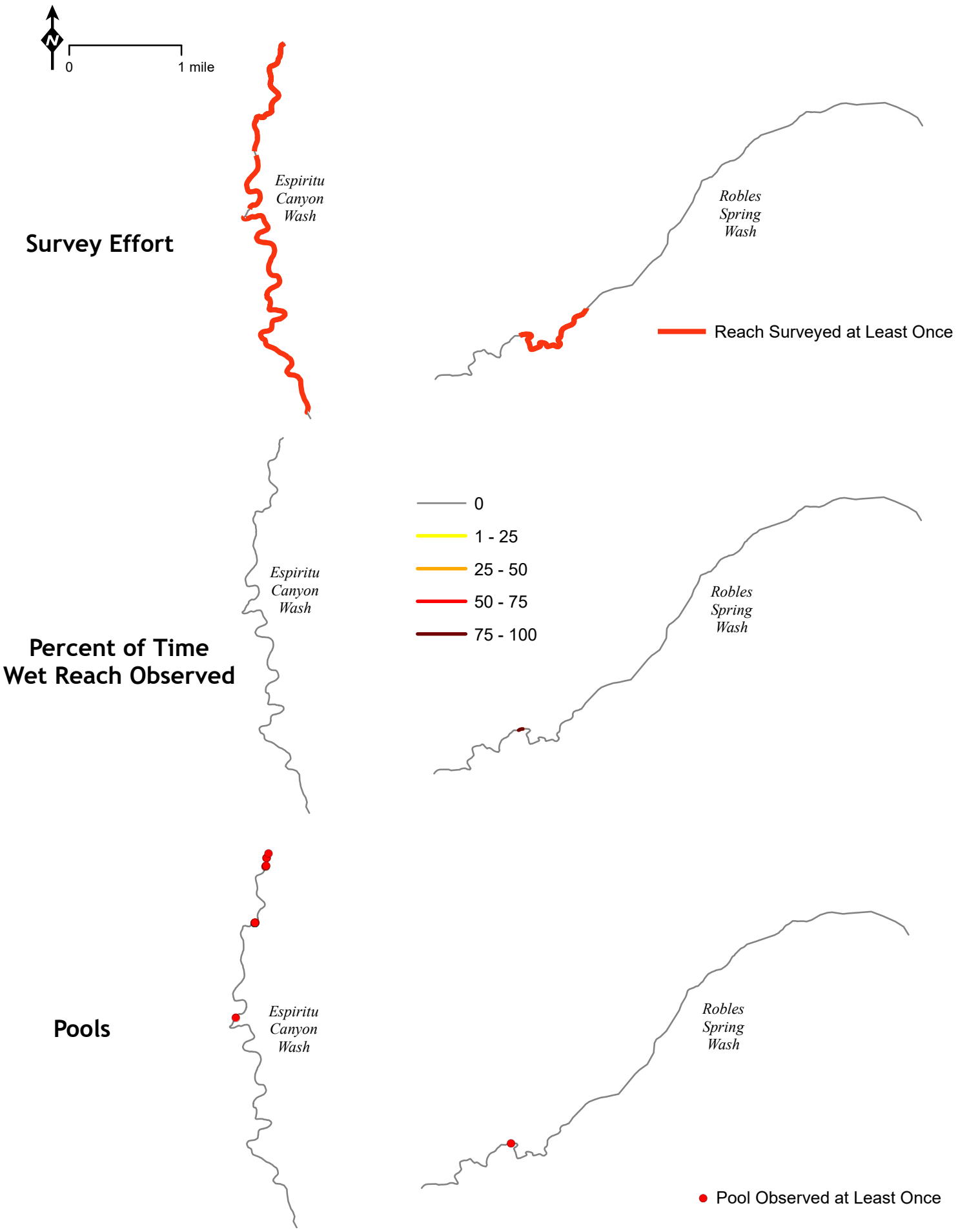


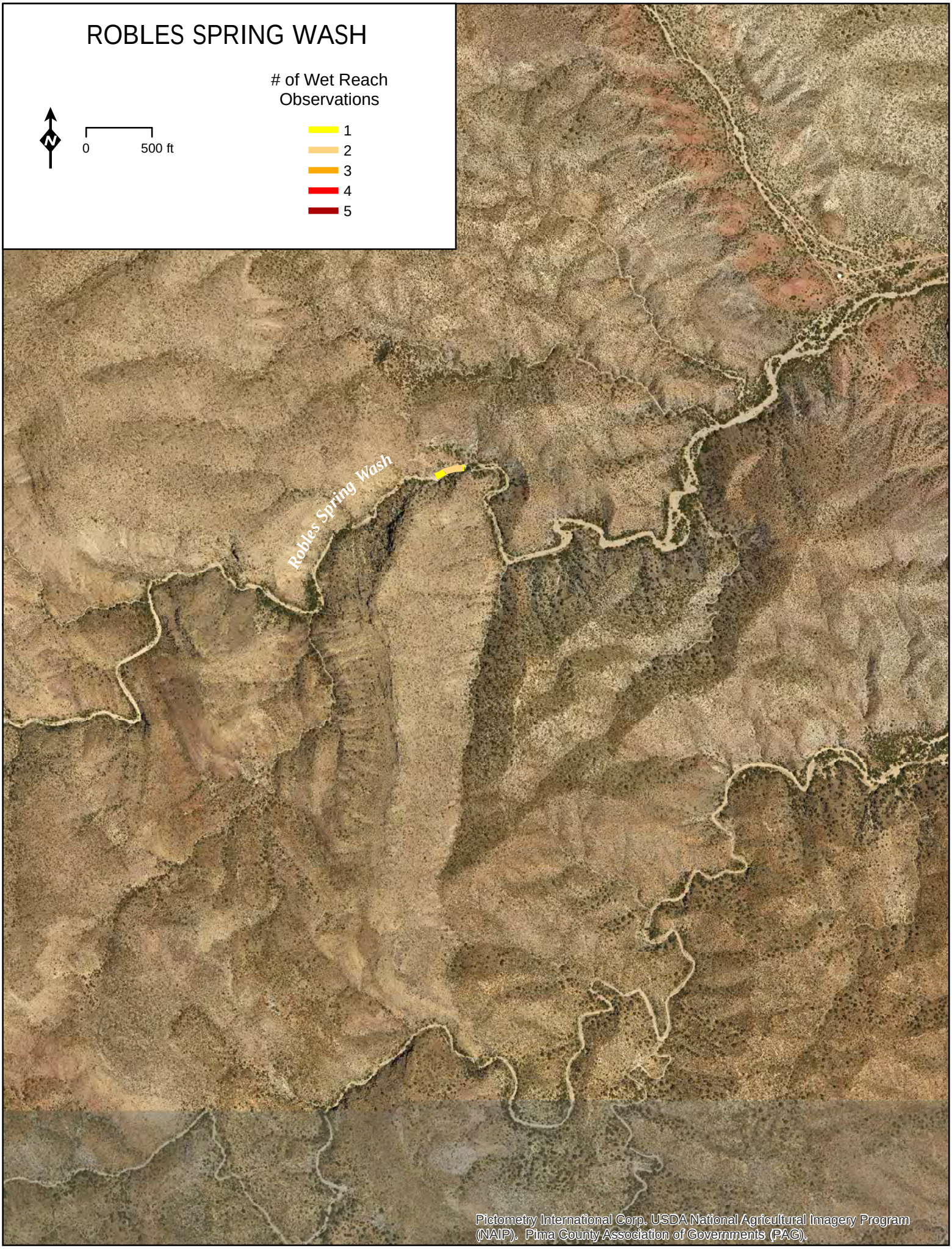




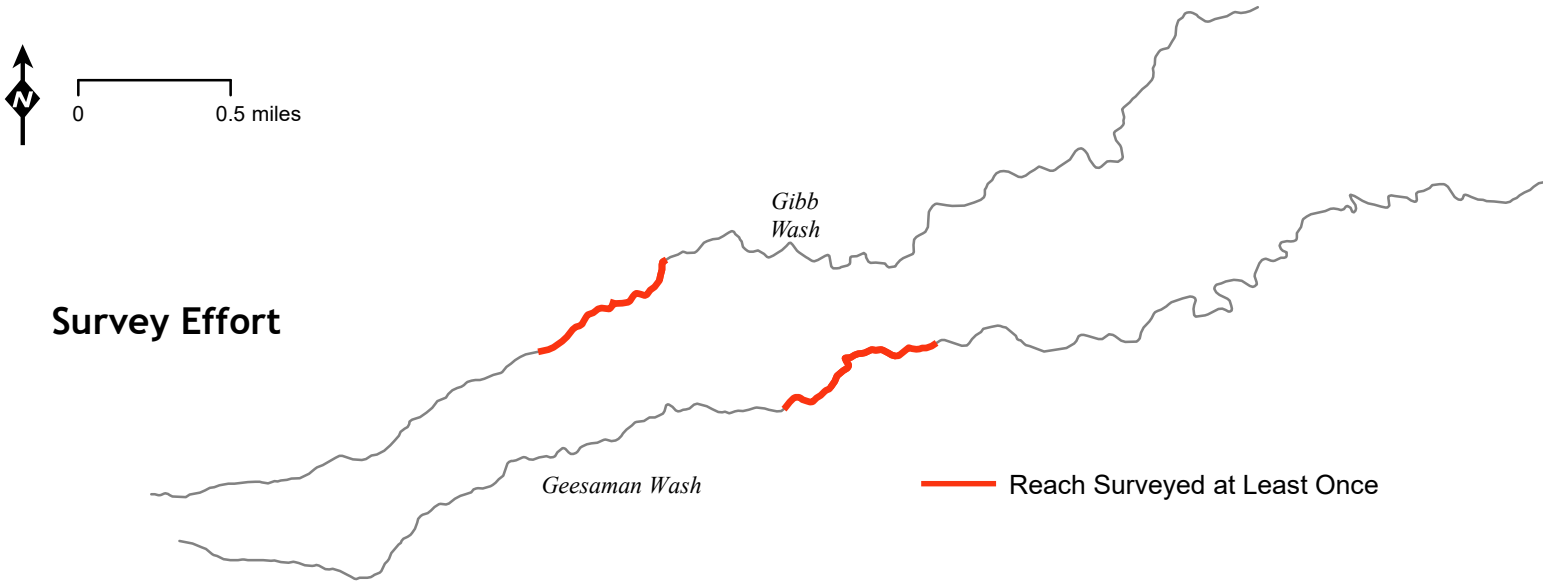

EDGAR CANYON
# of Wet Reach Observations
1
2
3
4
5
0
1,000 ft
N
Edgar Canyon Wash
Pictometry International Corp. USDA National Agricultural Imagery Program (NAIP). Pima County Association of Governments (PAG).

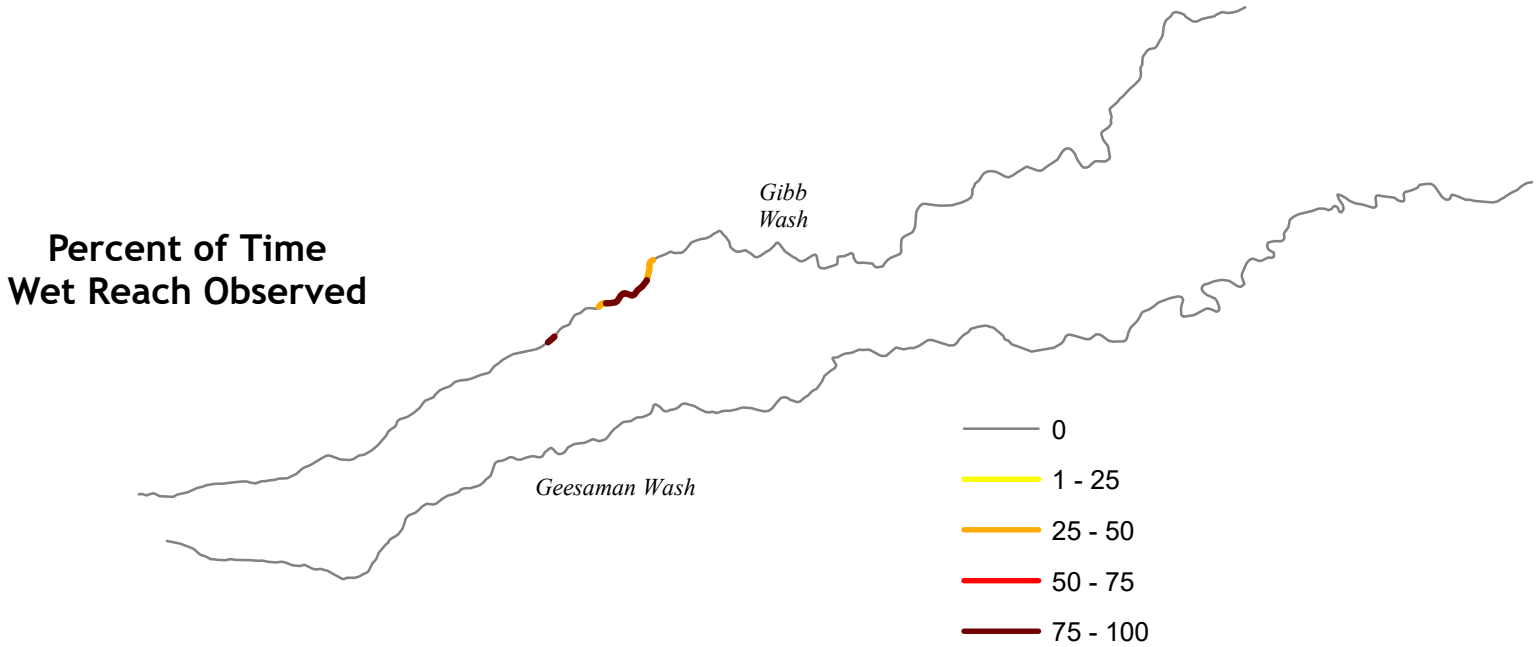
ESPIRITU CANYON & ROBLES SPRING

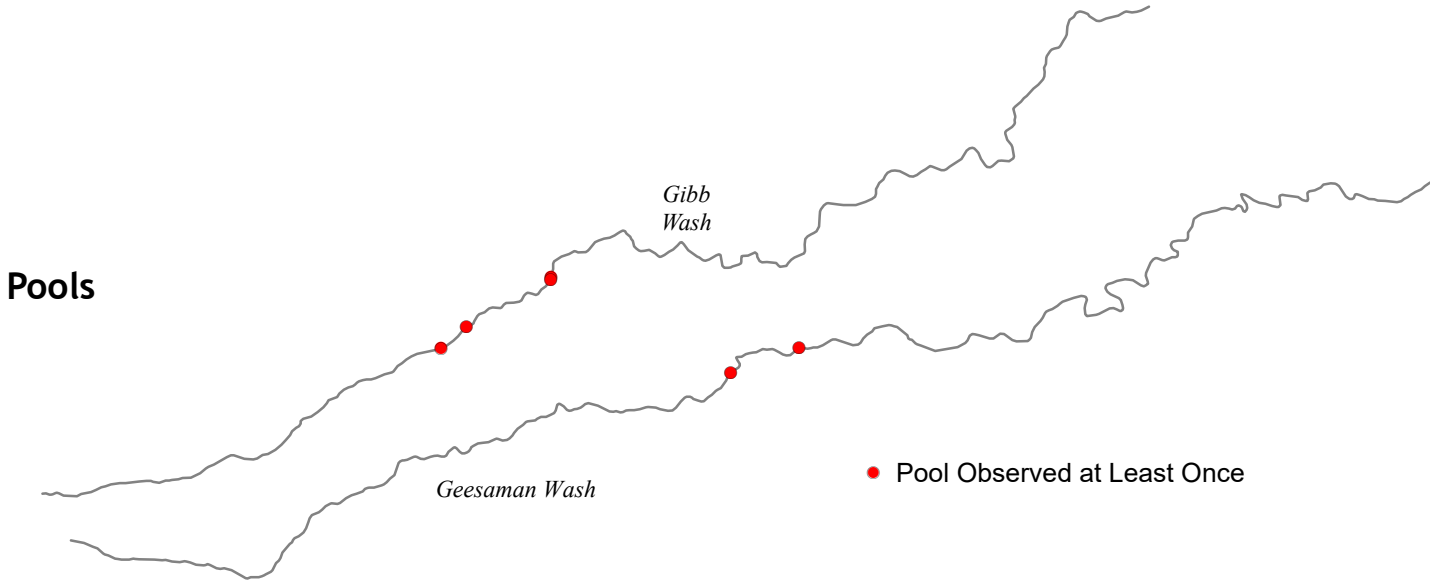


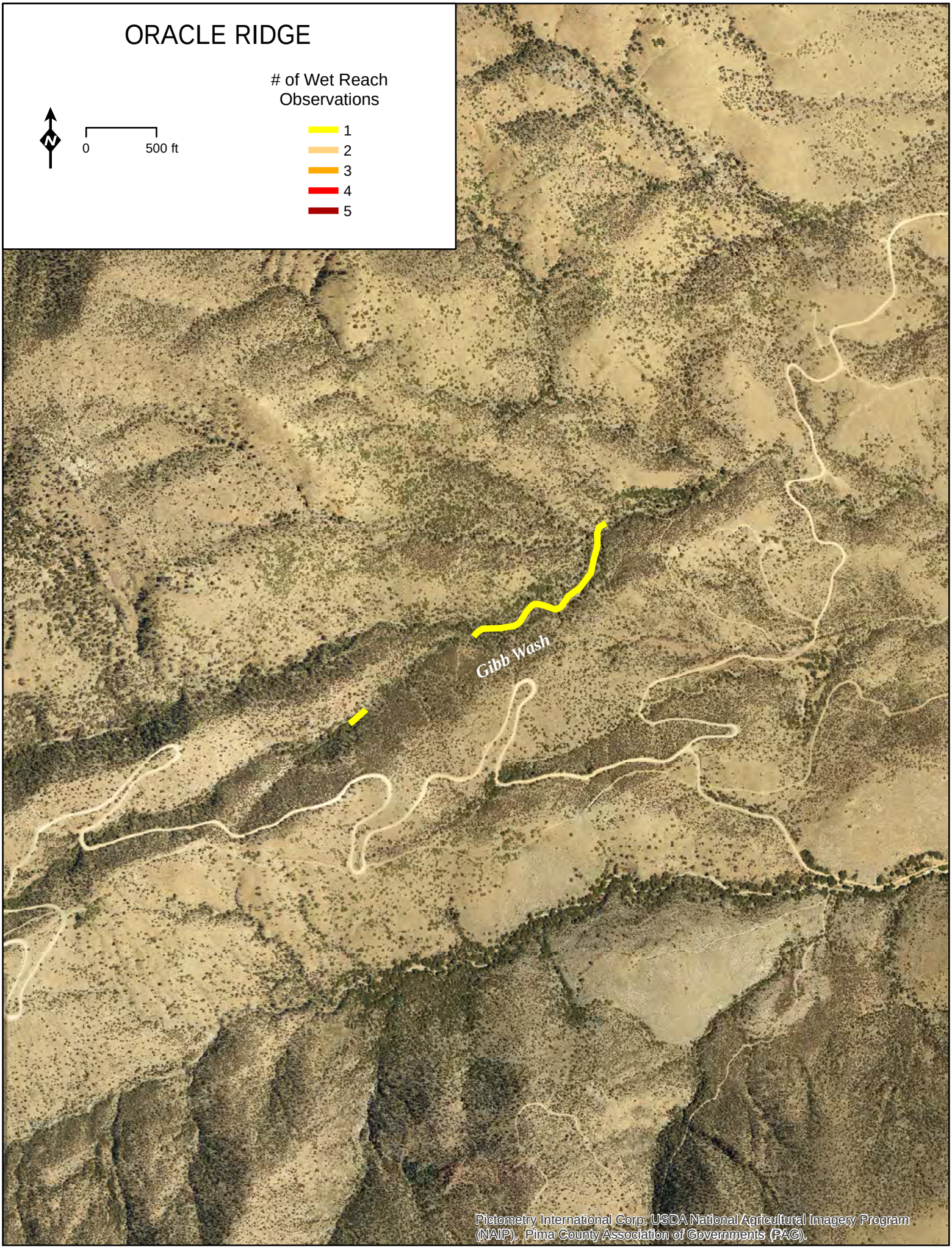

ROBLES SPRING WASH
# of Wet Reach Observations
1
2
3
4
5
0
500 ft
Robles Spring Wash
Pictometry International Corp. USDA National Agricultural Imagery Program (NAIP). Pima County Association of Governments (PAG).

ORACLE RIDGE

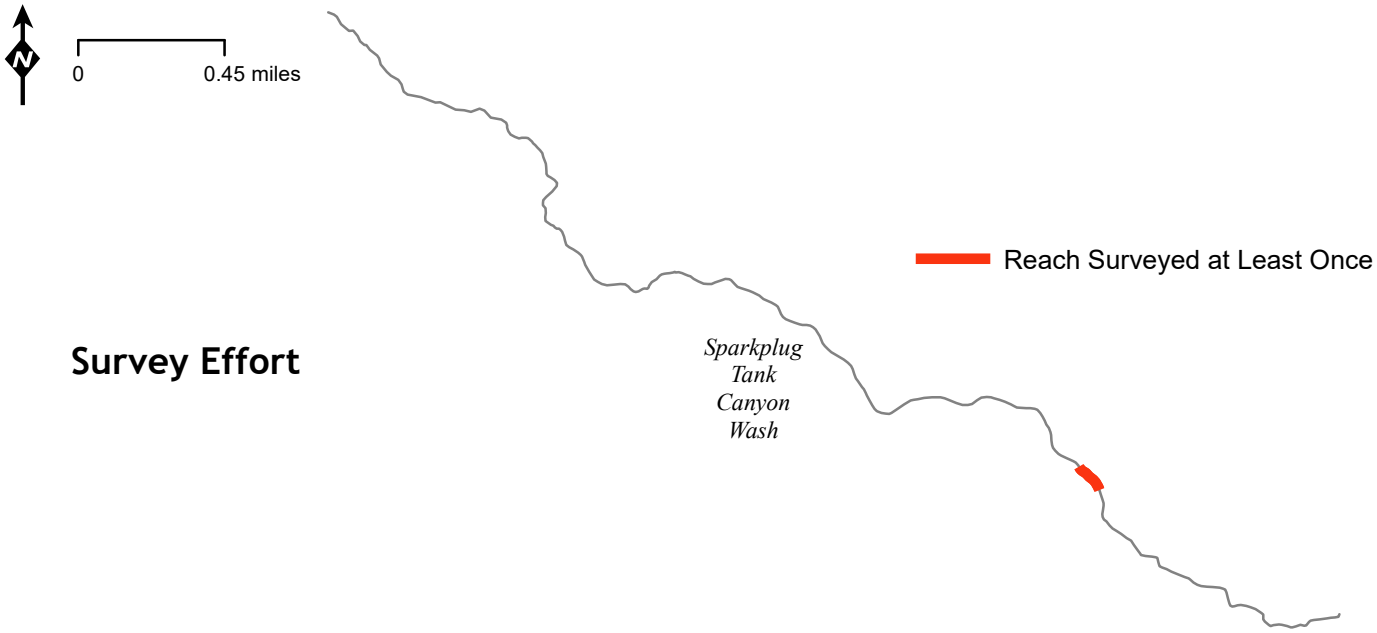


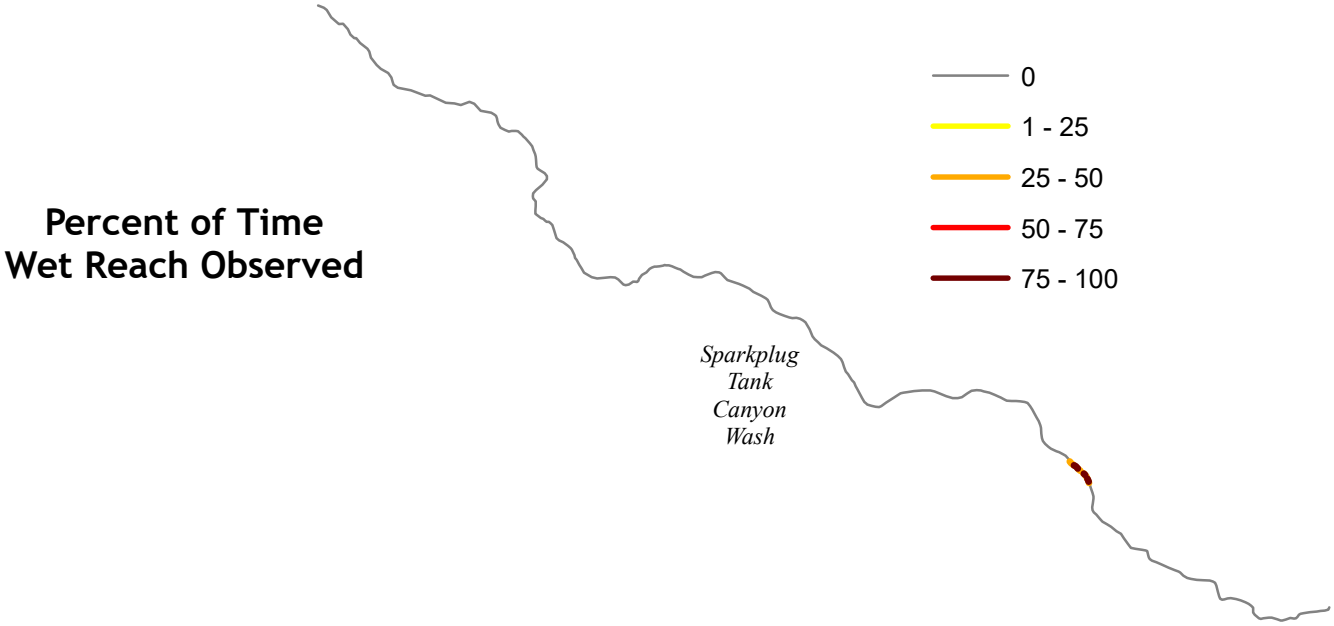


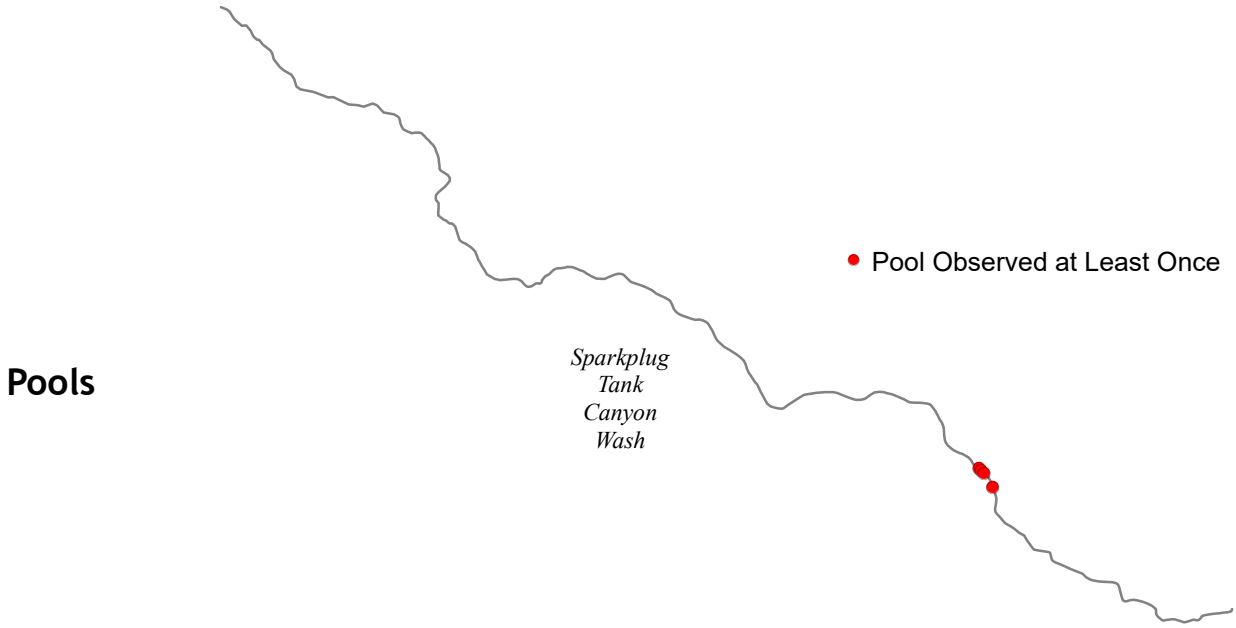


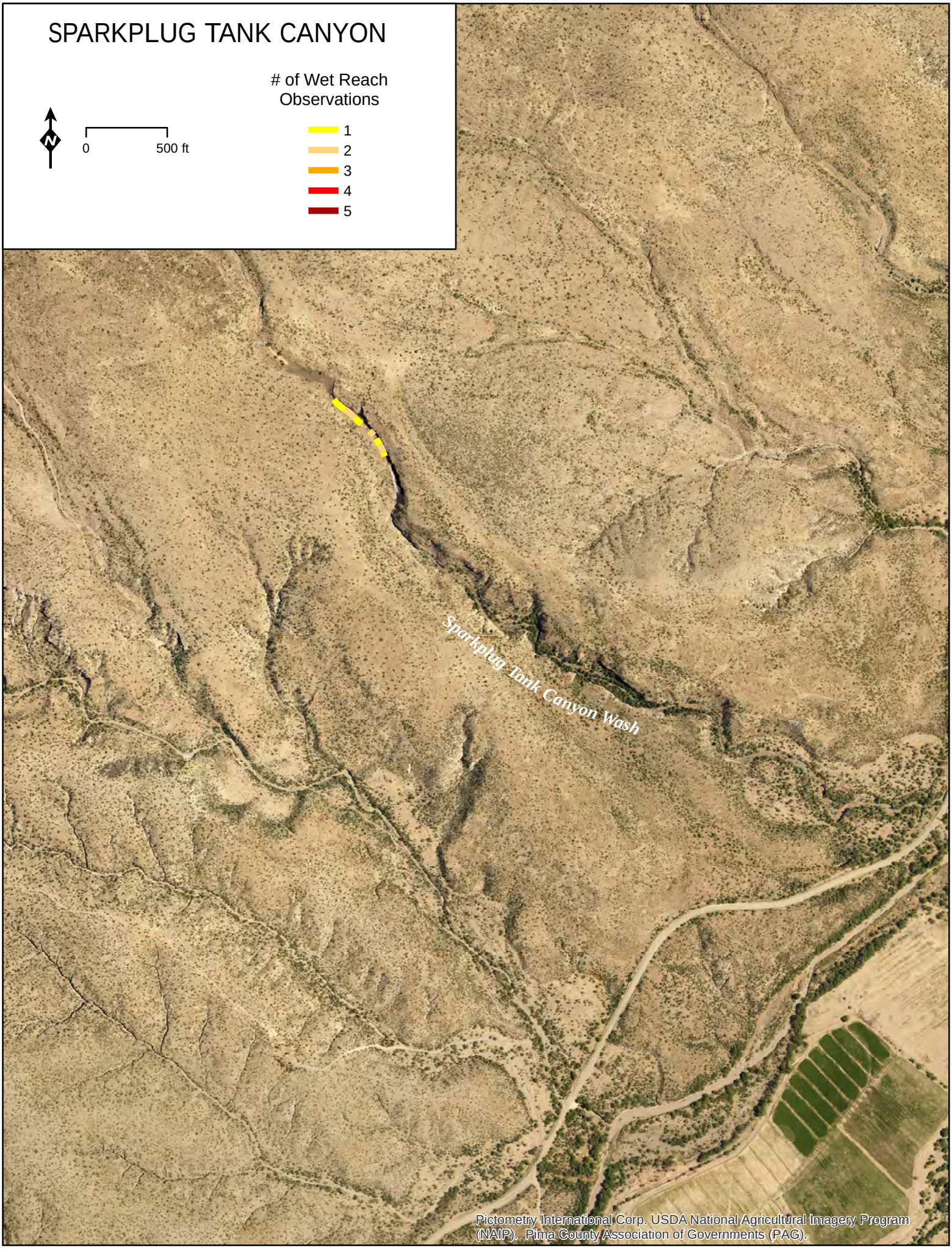

ORACLE RIDGE
# of Wet Reach Observations
1
2
3
4
5
0
500 ft
Gibb Wash
Pictometry International Corp. USDA National Agricultural Imagery Program (NAIP). Pima County Association of Governments (PAG).

SPARKPLUG TANK CANYON

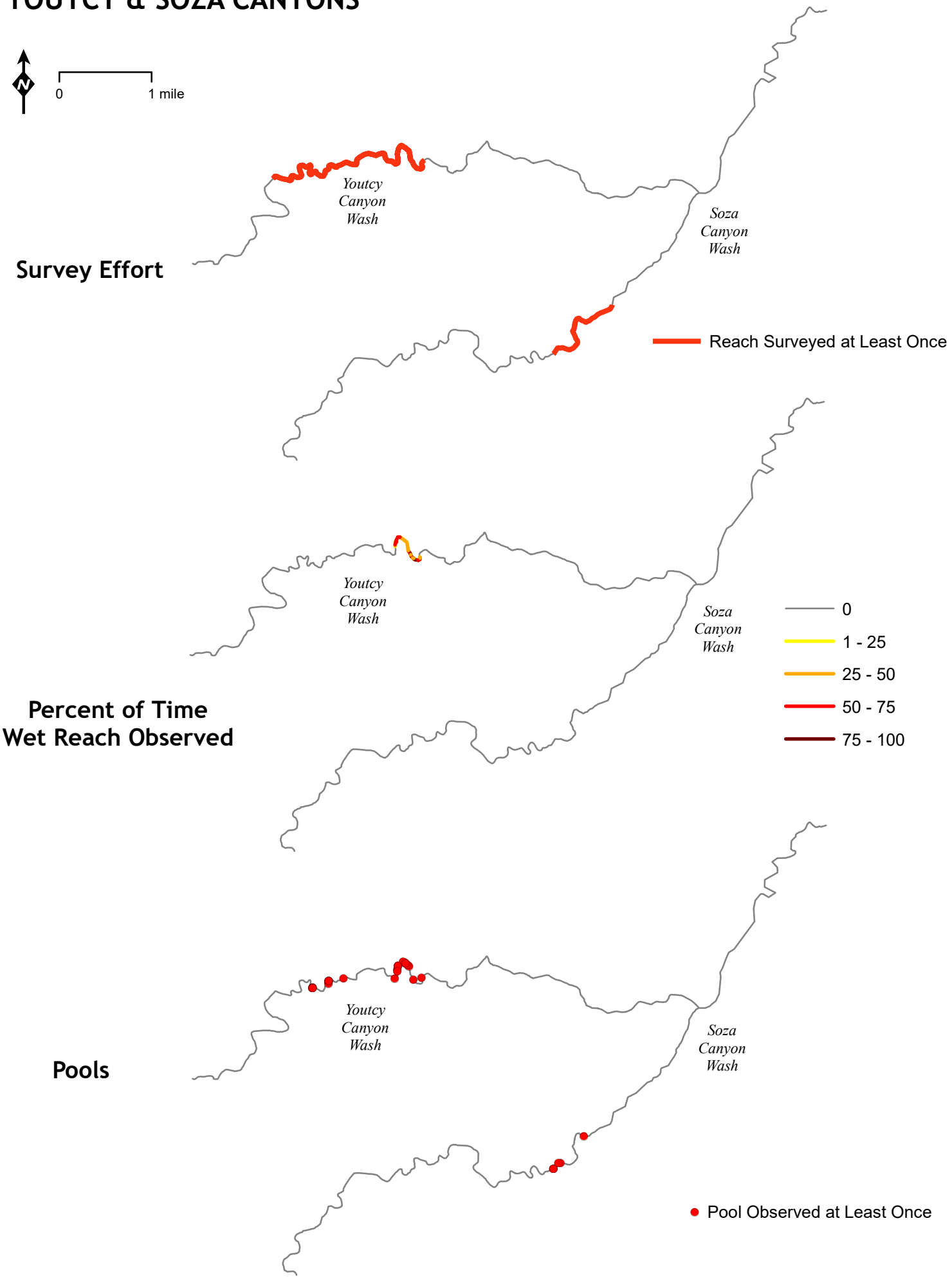


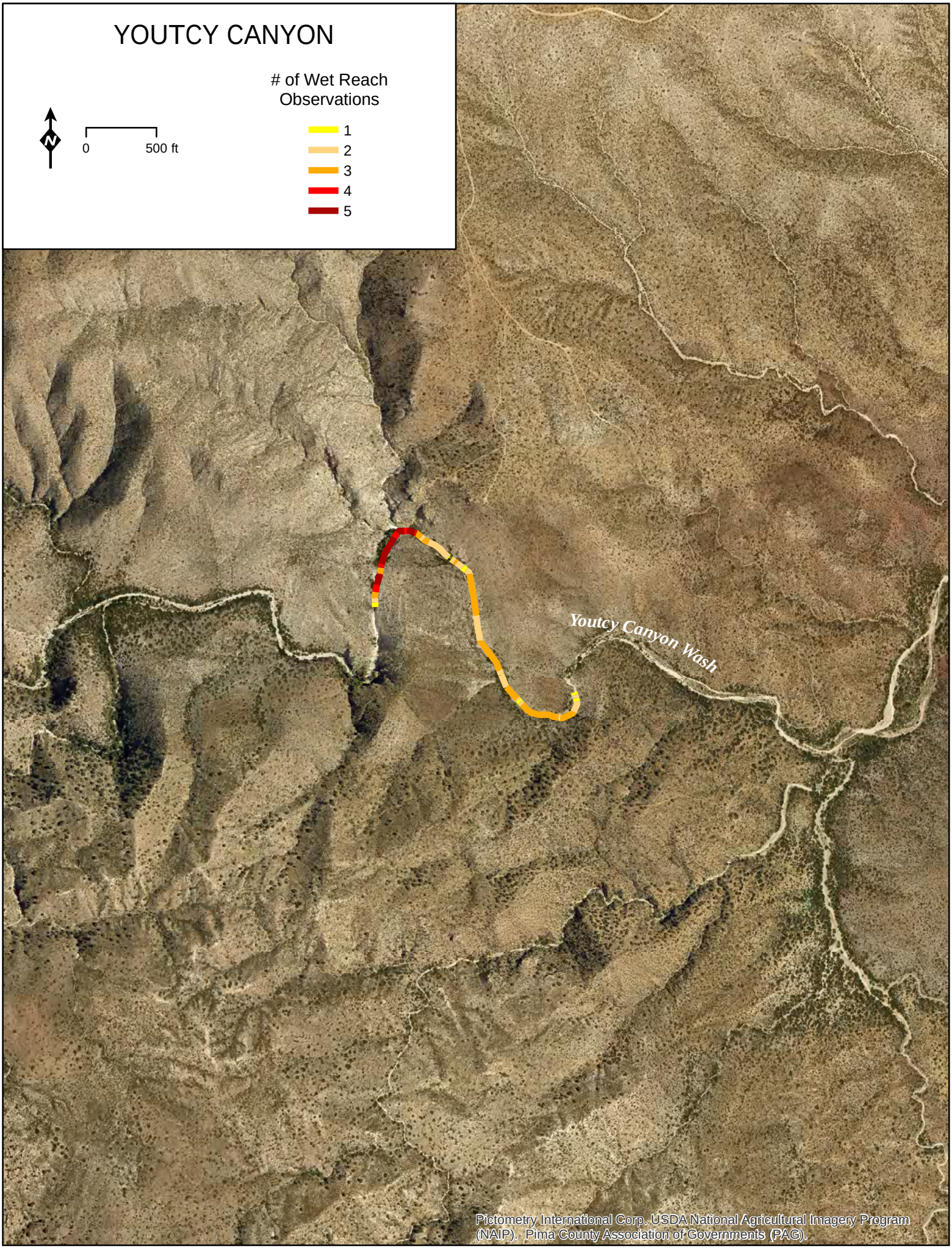





SPARKPLUG TANK CANYON
# of Wet Reach Observations
1
2
3
4
5
0
500 ft
Sparkplug Tank Canyon Wash
Pictometry International Corp. USDA National Agricultural Imagery Program (NAIP). Pima County Association of Governments (PAG).

YOUTCY & SOZA CANYONS




YOUTCY CANYON
# of Wet Reach Observations
1
2
3
4
5
0
500 ft
Youtcy Canyon Wash
Pictometry International Corp. USDA National Agricultural Imagery Program (NAIP). Pima County Association of Governments (PAG).