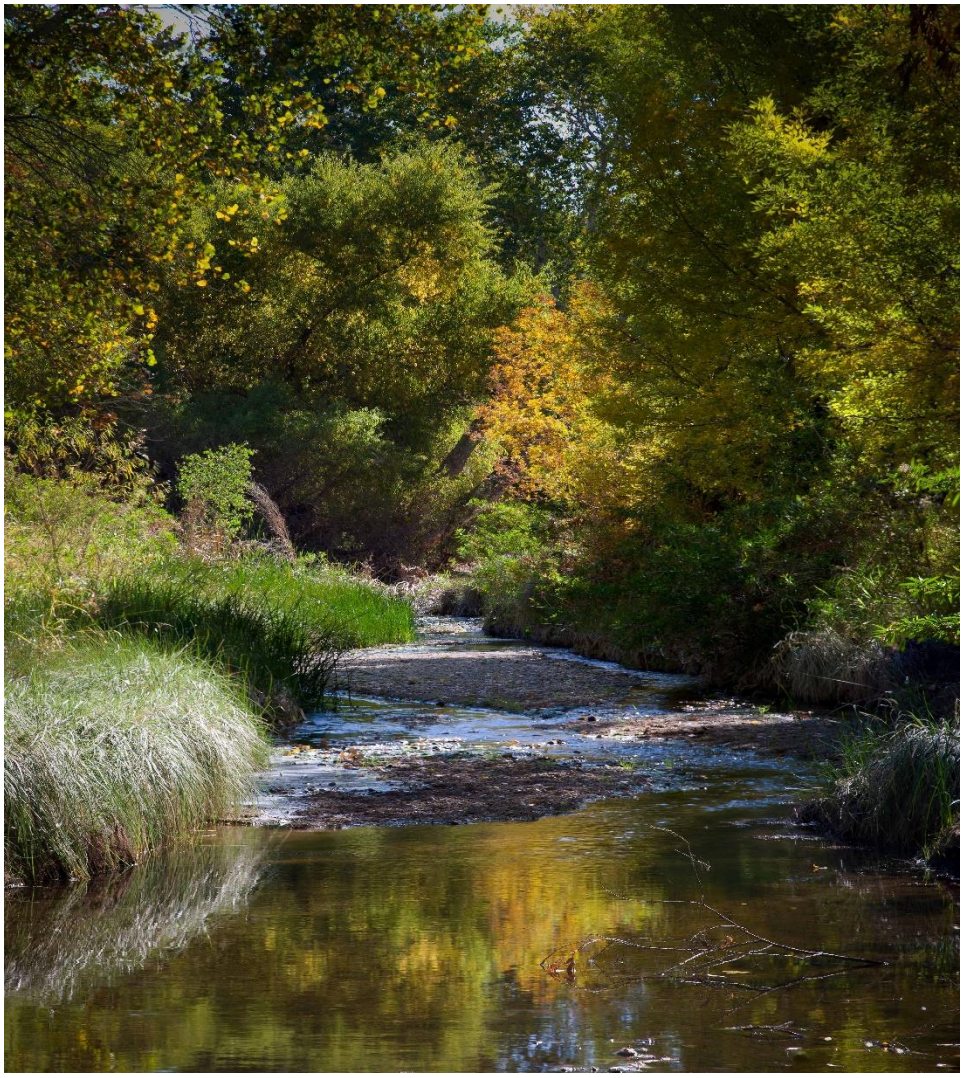
Pima County Ecological Monitoring Program
Springs and Streams Monitoring Protocol

July 2020



PIMA COUNTY
SUSTAINABILITY & CONSERVATION

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Cover photo: Cienega Creek near Three Bridges within the Cienega Creek Natural Preserve

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Contents

Geographic scope and context 2

Methods 2

Monitoring schedule 2

Pre-monsoon wet-dry mapping 3

Spring wet-dry mapping 3

Field survey methodology 6

Data management and analysis 7

Works Cited 10

Appendix A: Monitoring site supplementary information A-1

Appendix B: Wet-dry mapping datasheet B-1

List of Figures

Figure 1. Streams and associated monitoring intervals on Pima County preserve lands. 8

Figure 2. Springs and associated monitoring intervals on Pima County preserve lands. 9

Figure 3. Example of analysis - surface water present in Cienega Creek in June 2017 (shown in red). Area shown includes the Davidson Canyon confluence and Three Bridges. 9

Figure 4. Example of analysis - water permanence in Cienega Creek (shown as percent of surveys when water was present). Color-coded bins in the legend indicate the proportion of survey periods for which a particular stretch had surface water. 9

List of Tables

Table 1. Monitoring schedule for spring and streams on County conservation lands. 7

Abstract

Pima County's wide network of open space lands include a variety of aquatic riparian habitats, from intermittent, but perennial stretches of stream, to small springs and seeps. These aquatic sites, while making up a small proportion of the overall area of the open space lands, have a disproportionately heavy influence on the status and presence of many of the County's Multi-species Conservation Plan's (MSCP) covered species, a number of which are either aquatic or reliant upon aquatic and riparian associated habitats. Pima County's Ecological Monitoring Program includes regular monitoring to track the status and potential management needs of both springs and streams across County lands. This protocol outlines the scope and methods that Pima County will use to monitor its springs and streams. Accurate data describing these resources will play an important role in Pima County's land stewardship and conservation through duration of the MSCP.

Acknowledgements

We thank our colleagues in Pima County Natural Resources, Parks and Recreation and the Regional Flood Control District for assistance with the many seasons of wet-dry mapping data collection that have already occurred, as well as those occurring in the future. Brian Powell, NRPR, deserves especially strong recognition for his many years shepherding monitoring-related inventories and analyses for this and many other elements that are critical to Pima County's ecological stewardship. We also note the heavy influence that his prior reports on aquatic sites on County lands have played in the presentation of this content, and we have incorporated some of his text describing methods into this protocol. We are particularly grateful for the efforts that the Pima Association of Governments has invested in monitoring of Cienega Creek Natural Preserve, and are especially thankful for the quarterly monitoring efforts that PAG staff Melanie Alvarez, Mead Mier, and Ben Hickson organize. We also thank Pima County IT GIS, especially Mike List and Pankaj Jamwal for their ongoing efforts to facilitate data capture, storage, management, as well as for addressing various requests for advice, analyses, and map products. We are grateful to Melanie Alvarez and Mead Mier of PAG, Don Swann of Saguaro National Park, Julia Fonseca and Amanda Webb of Pima County-OSC for critical review that improved this protocol.

Background and Objectives

In arid regions, riparian and aquatic habitats make up a relatively small part of the landscape, yet they hold high species diversity and are important not only for aquatic species, but also for terrestrial species that may depend on riparian systems as important habitats for water, foraging, movement, and shelter. Throughout the development of its flagship Sonoran Desert Conservation Plan (SDCP), Pima County has long recognized the critical role that aquatic habitats play in maintaining healthy ecosystems containing the full spectrum of native plants and animals present in our region and where these habitats occur across the > 250,000 acres of conservation lands that Pima County provides stewardship over (Fonseca et al. 2000; Pima County 2002). The County has, and continues to invest considerably in the acquisition and stewardship of these aquatic and riparian resources where they occur.

Pima County's Multi-species Conservation Plan (MSCP) is the vehicle for which the County remains in compliance with its Section 10 Incidental Take Permit issued by the U.S. Fish and Wildlife Service (USFWS) in 2016 (Pima County 2016). The MSCP covers 44 species of plants and animals (Covered Species), many of which are either obligate aquatic/riparian species or facultative riparian species that rely on aquatic or riparian habitats during some part of their life cycle. The Ecological Monitoring Program, a key part of the MSCP, is tasked with tracking the health of the County's preserve lands and the population status of a variety of the Covered Species that occur on them. One critical monitoring element is the evaluation of the status of streams and springs on County lands. At a minimum, the County has obligated itself to monitoring at least eight springs every two years. Additionally, the County has agreed to monitor perennial stream flow in Cienega Creek Natural Preserve, Buehman Canyon, Davidson Canyon, Youtcy Canyon, and Espiritu Canyon on an annual basis. This monitoring of perennial water resources, or wet-dry mapping, not only provides a means to track the status of these water resources on County lands, but also contributes important information that supports other monitoring elements such as aquatic species (both native and nonnative), as well as provides key information supporting the County's grazing interests under the Range program.

The objective here is to monitor and track the status of important streams, springs, and some un-supplemented stock tanks on County preserve lands.

Since well before Pima County's MSCP was approved by the USFWS and its Section 10 permit issued in 2016, County staff have been monitoring streams, springs, and stock tanks during usually annual wet-dry mapping during June. These efforts have not only resulted in a much better understanding of the status and locations of these resources and the species within them, but have also been synthesized in inventory and monitoring reports (Powell 2011, 2018). Much of the content of this protocol is taken from Powell (2018) and a detailed history of surface water monitoring efforts on County lands may be found there.

In Pima County, June is generally the hottest and driest part of the year, and is often called the foresummer, closely followed by the onsets of the summer monsoons. Estimating surface water extent at this time of year gives insight into what the minimal extent of aquatic habitat is

each year. In this report, we use the term extent to mean physical length, rather than duration of time. Importantly, during the winter rainy season and following summer monsoons, many of these features have substantially more surface water, higher flow volume, and/or greater linear length of wetted flow. Though the majority of the monitoring program's efforts will focus on estimating surface water extent in the hottest and driest part of the year (June), there is also value in collecting data on what the potential length of flow is in perennial stream systems on County lands during spring, particularly after especially wet winters. Information such as this provides for a more complete temporal understanding of a watershed tributary that may be important for better understanding population ecology of some aquatic species, as well as having an important nexus with water rights and mining claims.

Geographic scope and context

Pima County's conservation lands are made up of > 250,000 acres of fee and leased lands (for which the County holds a grazing lease) surrounding the City of Tucson (Figures 1 & 2). Aquatic and riparian habitats on these lands that have permanent or almost-permanent surface water include both supplemented and non-supplemented dirt stock tanks, springs, and stream stretches. These sites occur in both the San Pedro River Watershed (sites on the eastern side of the Santa Catalina and Rincon Mountains) and the Santa Cruz River drainage. See Powell and Fonseca (2019) for a discussion of the value that many of these sites have in the context of native aquatic species covered by the MSCP.

Methods

The primary focusing of this monitoring protocol is to collect data and repeatedly track the extent of surface water at spring and stream sites during the hottest and driest part of the year (i.e., June). This primarily entails collecting data on the 1) physical length of perennial surface water and the distribution of pools in stream features, and 2) the presence and extent of water in spring features. In most cases, monitoring earthen stock tanks is not a priority, but as priorities allow, or as species-specific needs require, water presence and estimated surface extent may also be recorded for these features. Secondarily, there may be triggers that justify discretionary springtime collection of extent of flow in key stream reaches in order to gain a better understanding of flow extent following wet winters to understand the potential maximum aquatic habitat extent of the year.

Monitoring schedule

Pima County's EMP is tasked with tracking the status of a variety of elements, from certain plant and animal species to vegetation and soils (see Appendix Q of the MSCP for a complete list; Pima County 2016). To better balance the realities of limited staff and time resources with the benefit of collecting robust monitoring data, streams and springs on County preserve lands will be monitored on the schedule indicated in Table 1 which was established based on site accessibility and an evaluation of the relative value to MSCP-covered species (at a minimum). Figures 1 and 2 show the distribution of these sites across County preserve lands. Appendix A contains supplementary information, including location and notes, for each monitoring site.

Table 1. Monitoring schedule for spring and streams on County conservation lands.

Site	Annual	Every 2 years	Every 5 years	Opportunistic
Stream Reaches				
Cienega Creek/Davidson Canyon	x			
Buehman/Bullock Canyon	x			
Youtcy Canyon	x			
Espiritu/Soza Canyon	x			
Edgar Canyon	x			
Geesaman Wash				x
Gibb Wash				x
Tanque Verde Creek (downstream – Wentworth Rd.)				x
Agua Verde Creek				x
Springs				
Fundoshi Spring		x		
Agua Caliente Spring		x		
Blacktail Spring		x		
Peck Spring		x		
Turney Spring		x		
Robles Spring			x	
Grapevine Spring			x	
Tennis Spring		x		
Carpenter Spring (Tortolita Mountains)				x
Cliff Spring		x		
Youtcy Canyon Tinajas				x

Pre-monsoon wet-dry mapping

County staff have primarily collected wet-dry mapping data between late May and early July over the many years that this monitoring has occurred. The summer monsoon start date may be variable, occurring between late June and late July. In our area the average start of the monsoon was 5 July (between 1984 to 2009; Crimmins et al. 2011), but during that same time period there were years when it started both substantially earlier (June 17) and later (July 25). The goal here is to complete wet-dry data collection as close as possible to the start of the monsoon, but to finish monitoring all sites BEFORE the first rains start. Safety and logistical concerns also mandate that staff are not walking or driving along some of the necessary back roads and canyon bottoms during or close to large rain events. As such, County staff will strive to complete wet-dry mapping within the first three weeks of June.

Spring wet-dry mapping

There is benefit to having a more complete understanding of the maximal physical extent of surface base flow (i.e., the portion of a stream's flow that is not sustained by precipitation-derived runoff) that may occur in some of the perennial streams on County lands, particularly as it relates to very wet winters (or also very dry winters). Subsequently, this would best be captured in the early spring (March – April), following winters with above average precipitation (or below average precipitation). Monitoring and mapping the extent of flow at these times is a discretionary EMP task that may be complementary to other County activities. The Pima County EMP will collect early spring physical extent of

perennial water opportunistically as conditions may allow and/or in accordance with various needs or priorities that may complement broader management directives. Stream stretches addressed here may include Buehman Canyon, Edgar Canyon, Geesaman Wash, Gibb Wash, Youtcy Canyon, Espiritu Canyon, and Agua Verde Wash.

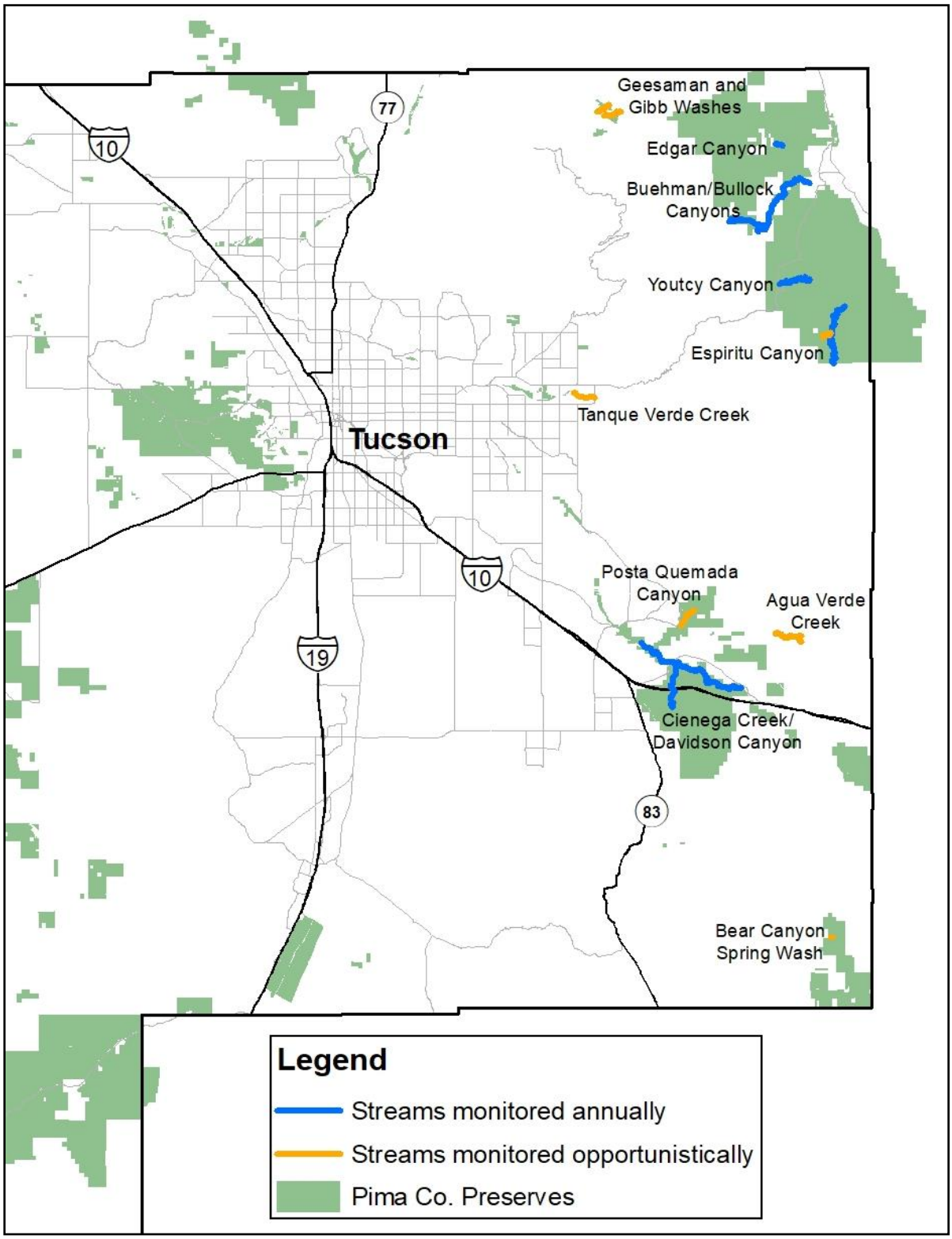

Figure 1. Streams and associated monitoring intervals on Pima County preserve lands.

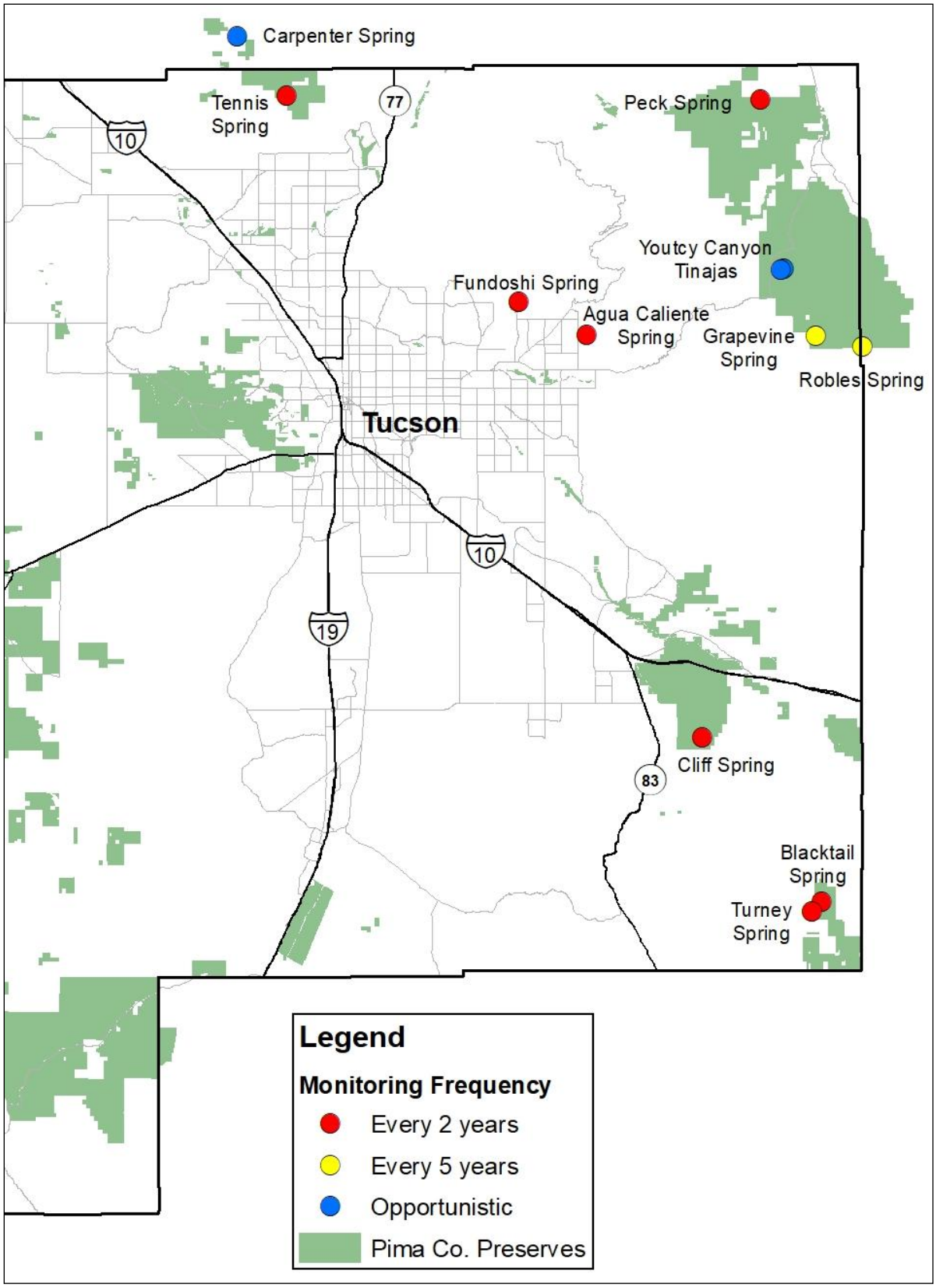

Figure 2. Springs and associated monitoring intervals on Pima County preserve lands.

Field survey methodology

Surveyors record the presence and location of water using hand-held GPS receivers (i.e., Garmin Oregon 450; using datum NAD83) or GPS-enabled field tablets (Panasonic Toughpad FZ-M1). In many cases, surveyors used Toughpads paired with an external GPS receiver (Bad Elf GNSS Surveyor) which led to substantially enhanced economy of battery capacity on the Toughpads. All data collection was made as a single point-based feature. However, surveyors also record a 'track log' in a continually running GPS receiver during a particular survey that can then be exported into a shapefile and archived later. While the Garmin Oregon 450 GPS units (or comparable hand-held GPS units) can give a positional accuracy of 3-5 meters (assuming a clear view of the sky on open terrain), the Bad Elf GPS receivers and the internal GPS receivers on the Panasonic Toughpads are capable of routinely yielding positional accuracies of 1-2 meters or better, given optimal conditions. Data are entered directly into digital datasheets or are collected on a paper form (see Appendix B) and then migrated into a database once back in the office.

For streams, the beginning and ends of every flowing reach were each recorded as a single point. The beginning of the wetted reach was always the upstream end, regardless of which direction the surveyor was walking. Beyond general estimates that may be paired with species observations or qualitative descriptions of a flow segment, depth is not routinely measured. To improve data management and standardization, a point is also recorded for the start and the end of the survey, regardless of whether water is present. Stretches of water that were estimated to be less than 3 meters long were recorded as a pool and marked as a single point (regardless of depth and width), often times with an estimate of dimensions. Any gaps in continuous wetted surface in a stream were treated as a separation between two adjacent stretches of flow, each with an end and beginning point. The Pima Association of Governments (PAG) coordinates wet-dry mapping of Cienega Creek and Davidson Canyon in the Cienega Creek Natural Preserve (CCNP)/Bar V Ranch (e.g., Pima Association of Governments 2017a, 2017b). When processing the data, PAG does not break the flow line if interruptions are < 20 feet long and the soils are wet, under the assumption that the segments were likely connected recently, possibly through diurnal fluctuation in the extent of surface water (e.g., through riparian vegetation transpiration) with higher flows at night. However, they record a GPS point for each break and estimate the length of the break. Similarly, PAG records a single point for any wet feature that is < 20 feet long and estimates its flow length. PAG does not mark any pool that is < 5 feet in diameter or shallower than 4 inches deep unless fish are present (https://www.pagnet.org/documents/water/20FtRuleGuide-2017-01-Draft.pdf). Notes are taken for pools and flowing reaches to indicate if there is evidence of baseflow versus runoff such as clarity or algal presence. PAG gathers average width and maximum depth for each pool.

During opportunistic surveys of earthen cattle tanks surveyors record whether water is present and in some cases width and length of surface water as estimated from GPS track logs. Staff may also use rangefinders (Bushnell Trophy model #202640) to estimate tank dimensions.

PAG routinely takes water quality readings during quarterly wet-dry mapping at CCNP both upstream and downstream of the Davidson Canyon confluence, as well as two sites in Davidson

Canyon (pending water availability). Data collection is based on Arizona Department of Environmental Quality sampling forms. However, Pima County Regional Flood Control District staff estimate flow volume occasionally at these sites during their water sampling efforts. Starting in 2018, EMP staff took at least two water quality measurements (pH, electrical conductivity, total dissolved solids, and water temperature) in most stream stretches using a Hanna Waterproof Tester (HI98129) that is regularly calibrated and cleaned.

During wet-dry mapping surveyors also recorded the location, and often estimates of numbers and life stages, of any MSCP Covered Species, particularly aquatic species such as leopard frogs, longfin dace, Gila topminnow, and Gila chub. Other species of interest, both aquatic and terrestrial, are also often noted and recorded, such as Sonora mud turtles and various raptor species. Any management needs, such as broken fences/trespass grazing, invasive plant observations, or illegal off-highway vehicle use are also noted and given to the appropriate managing department. During PAG's data collection, fish and frogs are recorded as present or absent (indicated to species level if known) for each pool and stream reach. For each pool the average size and different species are recorded.

Taking photographs is not a standardized part of the wet-dry mapping protocol, but is rather used to more generally illustrate the conditions at a particular site, or to capture an observation of a species of interest. The Panasonic toughpads have an integrated digital camera which may be used to link a photograph to a particular point on the digital forms as needed (e.g., to highlight an incidental species observation or to further describe particular aquatic site characteristics). Furthermore, in some cases higher quality images are taken with a DSLR and these images may be uploaded and attached to a point observation from within ArcGIS Collector. PAG has repeat photography points primarily for sites with erosion or drought impact concerns. Several years of past photo records are available. These photos are no longer gathered on a regular schedule.

Data management and analysis

Field data that are recorded using a handheld GPS and paper datasheets are downloaded (the GPS waypoints marking recorded features as well as the surveyors track log) and manually entered into a geodatabase (maintained by Pima County IT GIS) once the surveyor returns to the office, using the ArcGIS Collector app. In cases where data were entered directly into the digital forms on the field tablet, these data are 'synced' with the geodatabase once the tablet has viable wireless connectivity. After data are in the geodatabase, surveyors check the data for any inaccuracies or errors before the data are finalized. Proofed data in the geodatabase are available for County staff and external partners (as relevant) via several mechanisms, including visualization in an Enterprise geodatabase in ArcGIS Portal or sharing of exported shapefiles as necessary.

Here we draw heavily on the methodology already reported in Powell (2018), and much of the below content is from that report. Monitoring data for various streams on County preserve lands have been collected in various ways for many years, and County staff have worked to integrate these data into one database. Montgomery & Associates, in coordination with PAG

collected data on the extent of stream flow in Cienega Creek Natural Preserve in 1975, 1978, 1979, 1982, and 1984-1992. These data are available only in a paper format (M. Alvarez, PAG, personal communication). Wet reaches for Cienega Creek and Davidson Canyon were surveyed by PAG beginning in 1999 and with data provided as shapefiles. Beginning in 2005, PAG started included portions of Davidson Canyon that were upstream of Interstate-10 in quarterly monitoring efforts. PAG's wet reach point features, when processed in the office, were used to clip a consistent stream centerline into flowing and non-flowing reaches. However, over time PAG mapped to different depictions of stream centerlines across survey periods; these data has since been corrected and standardized using a common stream centerline. For example, monitored wet reaches were mapped to 1:24,000 or 1:100,000 scale USGS bluelines, or various versions of the Pima County GIS 'washes' layer during past PAG surveys of Cienega Creek. Data from other monitored streams on County preserve lands were provided by Pima County staff as GPS-collected coordinates for survey start and stop points, wet reach start and stop points, and in-channel point features. It is assumed the GPS-collected data had varying degrees of accuracy. Therefore, there was a need to establish a common depiction of the stream centerlines for comparative measurements over time.

Subsequently, County IT staff transferred all features to a linear referencing system based on the High Resolution National Hydrography Dataset stream centerlines for each respective monitoring stream. A linear referencing data model allows all stream channel features to be stored as table records which in turn reference a *single* GIS layer for stream centerlines. Linear referencing also affords the ability to perform a linear overlay analysis and directly compare the linear extent of surface water present across different monitoring events, as shown below in Figure 3. This method can be then used to create analysis products on an as-needed basis. For example, both automated GIS tools and manual interpretation were used to create linear referencing table measures for stream features for analyses such as for analyzing the degree of water permanence over time within the monitored reaches (Figure 4).

In this work flow, pairs of measures are called events (i.e., a point indicating the start of flow and a point indicating the end of flow). 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, surveys and wet reaches were intersected to yield a flow permanence layer – if a reach was surveyed three times and water was present twice, the permanence value is 66% (Figure 4). All event tables and intersect results are stored in an enterprise geodatabase, which allows for data backups, point-in-time recovery, and multi-user editing. See Powell (2018) for an in depth treatment and reporting of these analyses through the year 2017.

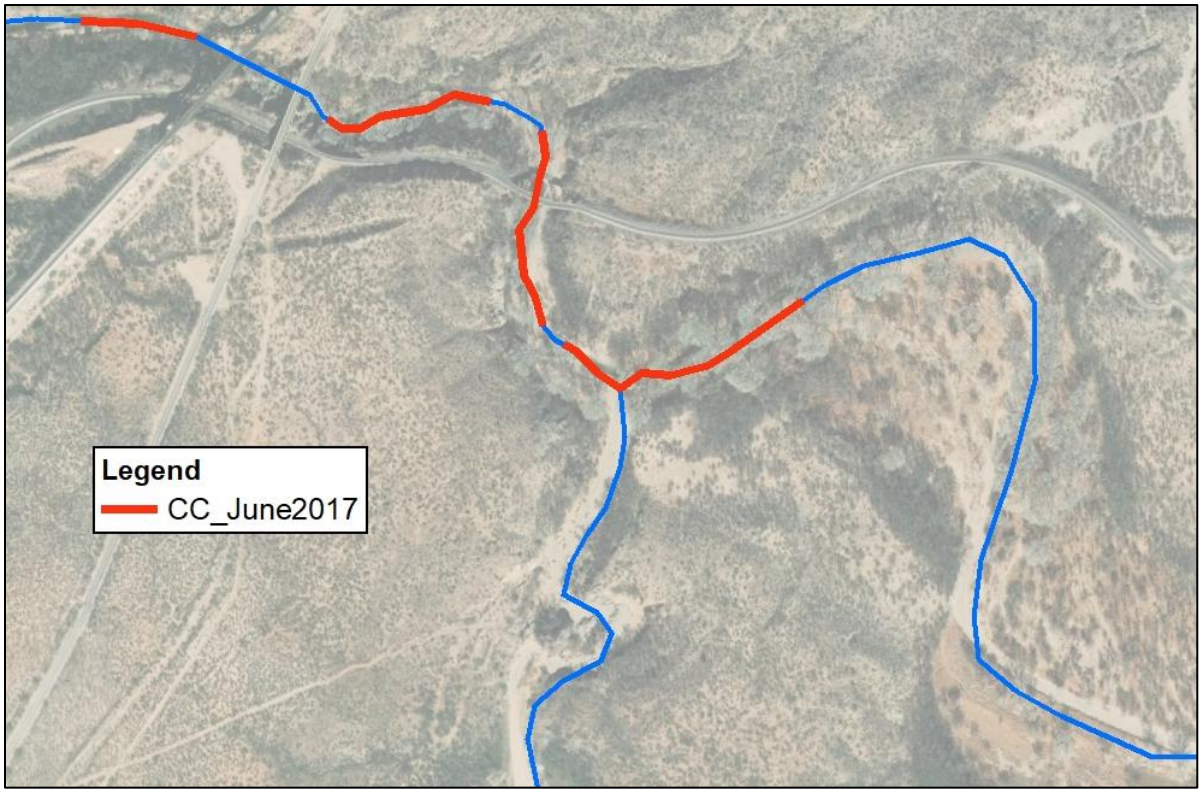

Figure 3. Example of analysis - surface water present in Cienega Creek in June 2017 (shown in red). Area shown includes the Davidson Canyon confluence and Three Bridges.

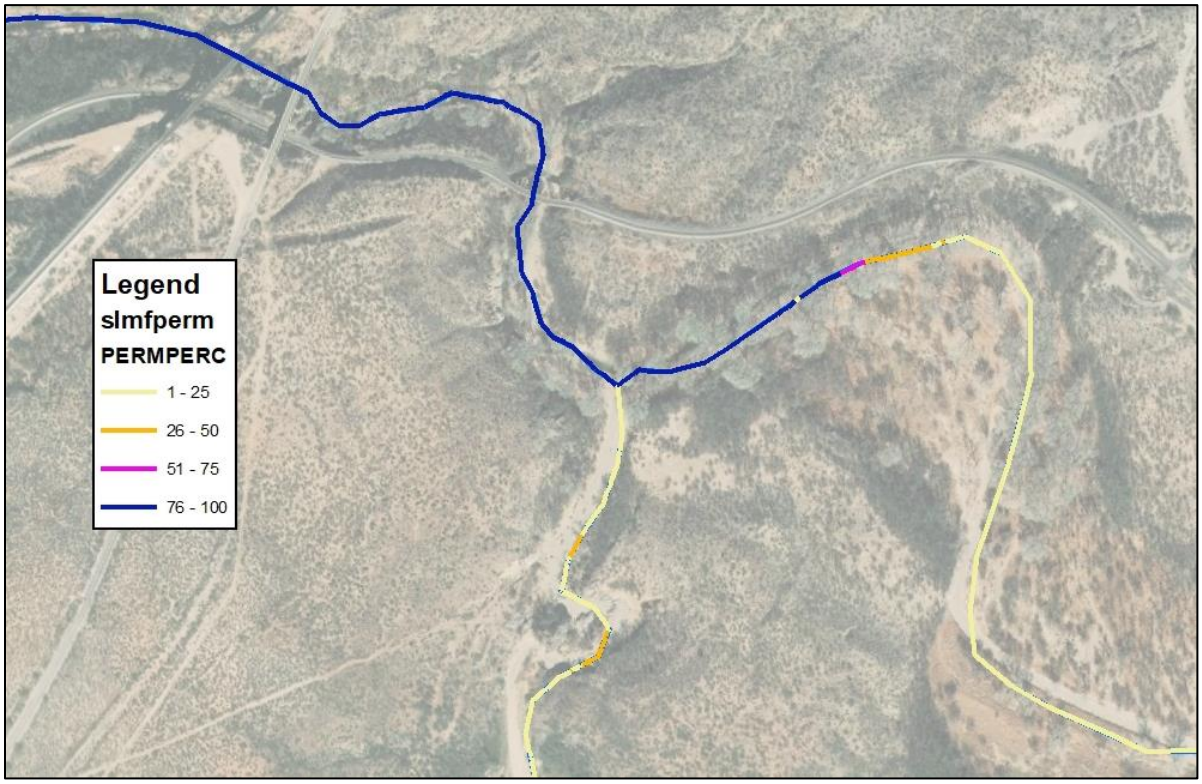

Figure 4. Example of analysis - water permanence in Cienega Creek (shown as percent of surveys when water was present). Color-coded bins in the legend indicate the proportion of survey periods for which a particular stretch had surface water.

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Appendix A: Monitoring site supplementary information

Stream Reaches							
Site	**Frequency**	**Start UTM E**	**Start UTM N**	**End UTM E**	**End UTM N**	**Length (km)**	**Notes**
Cienega Creek	Annual	539756	3540316	530510	3544447	13.16	From Pantano dam to Jungle road crossing.
Davidson Canyon Wash	Annual	533462	3538451	533724	3542487	2.72	Reaches above CC confluence and S of I-10.
Buehman Canyon Wash	Annual	538661	3583396	546081	3586960	12.02	Monitor from FS boundary to bottom of canyon.
Bullock Canyon Wash	Annual	541367	3582447	542172	3583050	1.57	Walk upstream from where Piety Hill Rd. crosses main channel, Buehman Canyon
Youtcy Canyon Wash	Annual	543330	3577644	546108	3578020	4.47	Focus on spring reach in canyon.
Espiritu/Soza Canyon	Annual	548348	3570288	549312	3575559	8.36	Monitor from FS boundary down to above Bar LY, including side canyon. Include Bolt Canyon if time.
Edgar Canyon	Annual	542906	3590592	543615	3590409	0.78	Permanent water upstream of County boundary.
Geesaman Wash	Opportunistic	527134	3593168	528661	3593547	1.83	Park below and hike up and back.
Gibb Wash	Opportunistic	526457	3593502	527577	3594075	1.45	Hike from top to bottom, off of Control Rd.
Tanque Verde Creek (downstream – Wentworth Rd.)	Opportunistic	526270	3567116	524332	3567591	2.12	Be aware of adjacent private property.
Agua Verde Creek	Opportunistic	545365	3544537	545314	3545078	0.65	Be aware of adjacent private property.

Springs				
Site	**Frequency**	**UTM E**	**UTM N**	**Notes**
Fundoshi Spring	2 Years	518963	3574681	Coordinate with RFCD for access.
Agua Caliente Spring	2 Years	525485	3571582	
Blacktail Spring	2 Years	547993	3517158	Check flow below spring box and in Bear Canyon Wash.
Peck Spring	2 Years	542177	3594103	
Turney Spring Complex	2 Years	547168	3516214	Four spring features present.
Robles Spring	5 Years	551951	3570453	Monitor above spring to FS boundary.
Grapevine Spring	5 Years	547456	3571447	Approach road can be exceptionally bad.
Tennis Spring	2 Years	496741	3594437	
Carpenter Spring (Tortolita Mountains)	Opportunistic	492000	3600186	
Cliff Spring	2 Years	536563	3533027	
Youtcy Canyon Tinaja 1	Opportunistic	544361	3577909	
Youtcy Canyon Tinaja 2	Opportunistic	544072	3577786	

Appendix B: Wet-dry mapping datasheet

Pima County Ecological Monitoring Program: **Wet/dry Mapping and Water Availability** Protocol: 2013-1

Location

Property: _____ Site Name/ID: _____

Feature Type (circle one): Stream Reach Stock Tank Spring

Visit

Date: ___/___/___ Observer(s): _____ Visit #: _____

Start time: _____ Stop time: _____ Total search time (minutes): _____

Photograhs taken: Y / N If "yes", file number(s): _____

Survey start: 12R 0 _ _ _ _ _ _, 3 _ _ _ _ _ _ Survey Stop: 12R 0 _ _ _ _ _ _, 3 _ _ _ _ _ _

Notes about features and conditions (including observations of frogs and other riparian species): _____

Datum used (NAD83 preferred): _____

Survey data

Time	Accuracy	UTM Easting	UTM Northing	Water Start/Stop	Notes-include name of feature (if appropriate)
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
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		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	
		12R 0 _ _ _ _ _ _	3 _ _ _ _ _ _	Start Stop Pool	

If found, please call (520) 724-9489

Page ___of___