MEMORANDUM

Date: August 31, 2017

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Fourth Annual *A Living River* Project Report Release – Charting Wetland Health Conditions of the Lower Santa Cruz River 2016 Water Year Report**

Introduction

Data from the Living River Project continues to show improvement is occuring in the Lower Santa Cruz River. The attached 4th Annual Living River Report characterizes river conditions during the second full year after completing the upgrades to Pima County's wastewater treatment facilities in December 2013. The new report documents recent changes in the effluent-dependent Santa Cruz River, including indicators of water quality, aquatic life, water clarity and infiltration during the 2016 water year (October 1, 2015 to September 30, 2016).

The Pima County Regional Wastewater Reclamation Department (RWRD) and the Pima County Regional Flood Control District (RFCD) provided the funding for this report. Funding for some of the data collection came from the remaining U.S. Environmental Protection Agency funds from the Wetland Health grant that initiated the Annual Living River Report series.

Findings

We have documented substantial improvement of the wetland health of the effluent-dependent Santa Cruz River because of higher quality water discharged from Agua Nueva and Tres Rios Wastewater Reclamation Facilities (WRFs). This year's report documents continued improvements in the wetland health as follows:

- Lower ammonia and biochemical oxygen demand, higher dissolved oxygen and similar levels of total dissolved solids as compared to 2013.
- Despite sustained water quality improvement, reduced fines on the bed and improved diversity of macroinvertebrates, the biological index score for macroinvertebrates remains low.
- Citizens reported over 70,000 bird observations along the river encompassing 221 species. Recent additions include Sandhill cranes observed at El Rio Preserve.
- Five fish species are now living in the river with a greater extent of these species downstream.

- RWRD's odor measuring technology shows little to no odors leaving the WRF properties under normal operating conditions.
- Sustained recharge at about 36,600 acre-feet, nearly double the pre-upgrade rate.
- The volume of effluent released in the river in 2016 represented an 8 percent reduction from the volume released in 2013.
- 20 percent of the volume of flow this year originated as stormwater runoff.
- There was increased flow in June. Twenty-two of the 23 miles of the Living River reach had flowing water. Downstream of the Tres Rios WRF at Ina Road, there was full flow extent to Trico Road.

Public Outreach

Our partner, the Sonoran Institute, is currently conducting an online survey to assess community priorities, values and concerns around this reach of the Santa Cruz River. Thus far, the response rate is encouraging and the survey results from the survey will help shape the Santa Cruz River Management Plan. The survey includes a link to a video prepared by Pima County describing the Living River project, RFCD activities along the river and the changes following the WRF upgrades. The survey and video can be viewed at the following web link: www.tiny.cc/scrsurvey.

The Living River Project continued to bring youth to the river for science-based classroom activities and field trips via Pima County's Environmental Education program. For some students, this was the first opportunity they had to experience a flowing river. Over 1,300 children from 18 schools participated in the Living River of Words program this year, resulting in a traveling exhibit of artwork and poetry, which will circulate through Pima County libraries again this year.

The community release of the 4th Annual Living River Report will be held at the Joel Valdez Main Library on September 14, 2017 at 4:00 PM.

CHH/anc

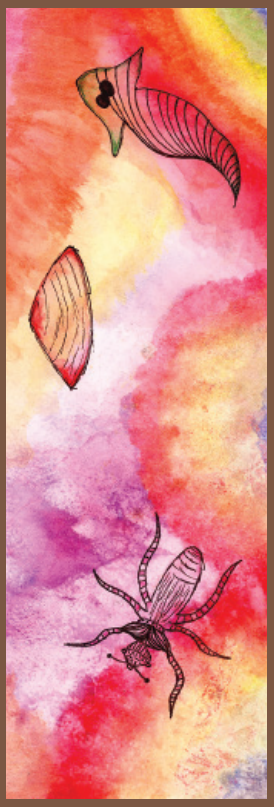
Attachment

c: Carmine DeBonis, Jr., Deputy County Administrator for Public Works
Suzanne Shields, Director, Regional Flood Control District
Jackson Jenkins, Director, Regional Wastewater Reclamation
Chris Cawein, Director, Natural Resources, Parks and Recreation
Linda Mayro, Director, Office of Sustainability and Conservation

a living river

CHARTING WETLAND CONDITIONS OF THE LOWER SANTA CRUZ RIVER

2016 Water Year



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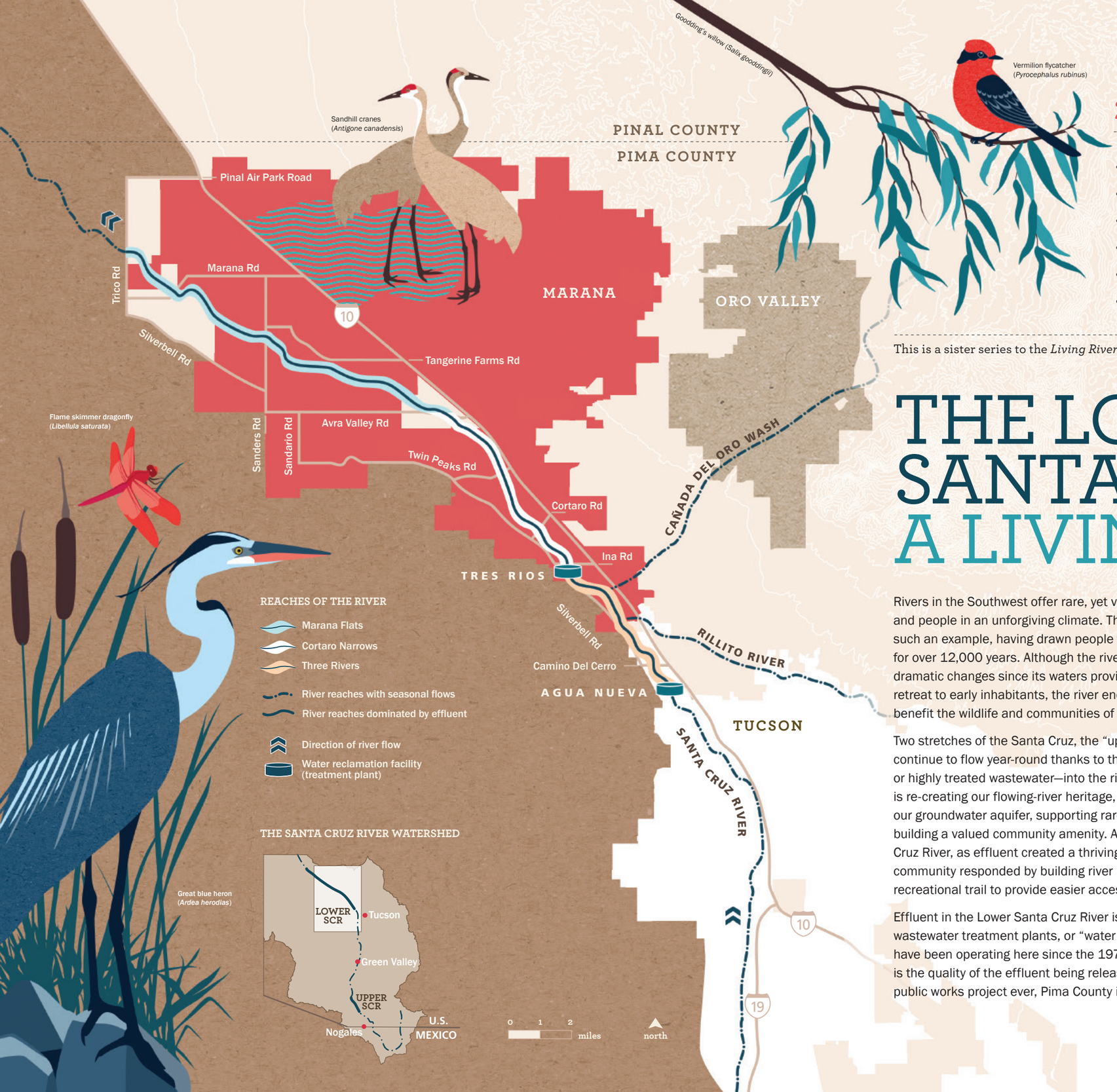


2016 NOTABLE FINDINGS

- Water quality and clarity remained improved
- New fish species appeared
- Sustained increase in river recharge
- Flow extent varies with natural influences and human management
- Wetland plant cover varied with water presence in the river's drying sections
- Very little odor escaped the reclamation facility boundary

This is a sister series to the *Living River* reports completed for the Upper Santa Cruz River (learn more at **www.tiny.cc/uscr**).

THE LOWER SANTA CRUZ RIVER
A LIVING ECOSYSTEM

Rivers in the Southwest offer rare, yet vital, oases for wildlife and people in an unforgiving climate. The Santa Cruz River is such an example, having drawn people to its life-giving waters for over 12,000 years. Although the river has undergone dramatic changes since its waters provided a cool and shady retreat to early inhabitants, the river endures and continues to benefit the wildlife and communities of southern Arizona.

Two stretches of the Santa Cruz, the "upper" and "lower," continue to flow year-round thanks to the release of effluent—or highly treated wastewater—into the river. This use of effluent is re-creating our flowing-river heritage, naturally recharging our groundwater aquifer, supporting rare wildlife habitat, and building a valued community amenity. Along the Lower Santa Cruz River, as effluent created a thriving river ecosystem, the community responded by building river parks and The Loop recreational trail to provide easier access to this river bounty.

Effluent in the Lower Santa Cruz River is not new; two wastewater treatment plants, or "water reclamation facilities," have been operating here since the 1970s. What has changed is the quality of the effluent being released. In its largest public works project ever, Pima County invested more than $600 million to upgrade the facilities. Completed in 2013, this project significantly improved the quality of water released into the river, a key ingredient for a healthier river.

To gauge conditions of this valuable ecosystem and track the impacts of our community investment, Pima County and the Sonoran Institute developed a *Living River* series for the Lower Santa Cruz River. Modeled on the Sonoran Institute's *Living River* report for the Upper Santa Cruz River, this report documents annual change along the Lower Santa Cruz River to gain insight into the river's health. Beginning with baseline monitoring in 2013 (prior to reclamation facility upgrades), the *Living River* series is an assessment of the wetland conditions created and affected by the effluent.

This fourth report examines changes in indicators of river health along a 23-mile stretch of the river during the 2016 water year (October 1, 2015–September 30, 2016). Facility upgrades were completed in December 2013, thus this report captures conditions during the second full water year after project completion.

All *Living River* reports for the Lower Santa Cruz River are available for download at **www.sonoraninstitute.org**.

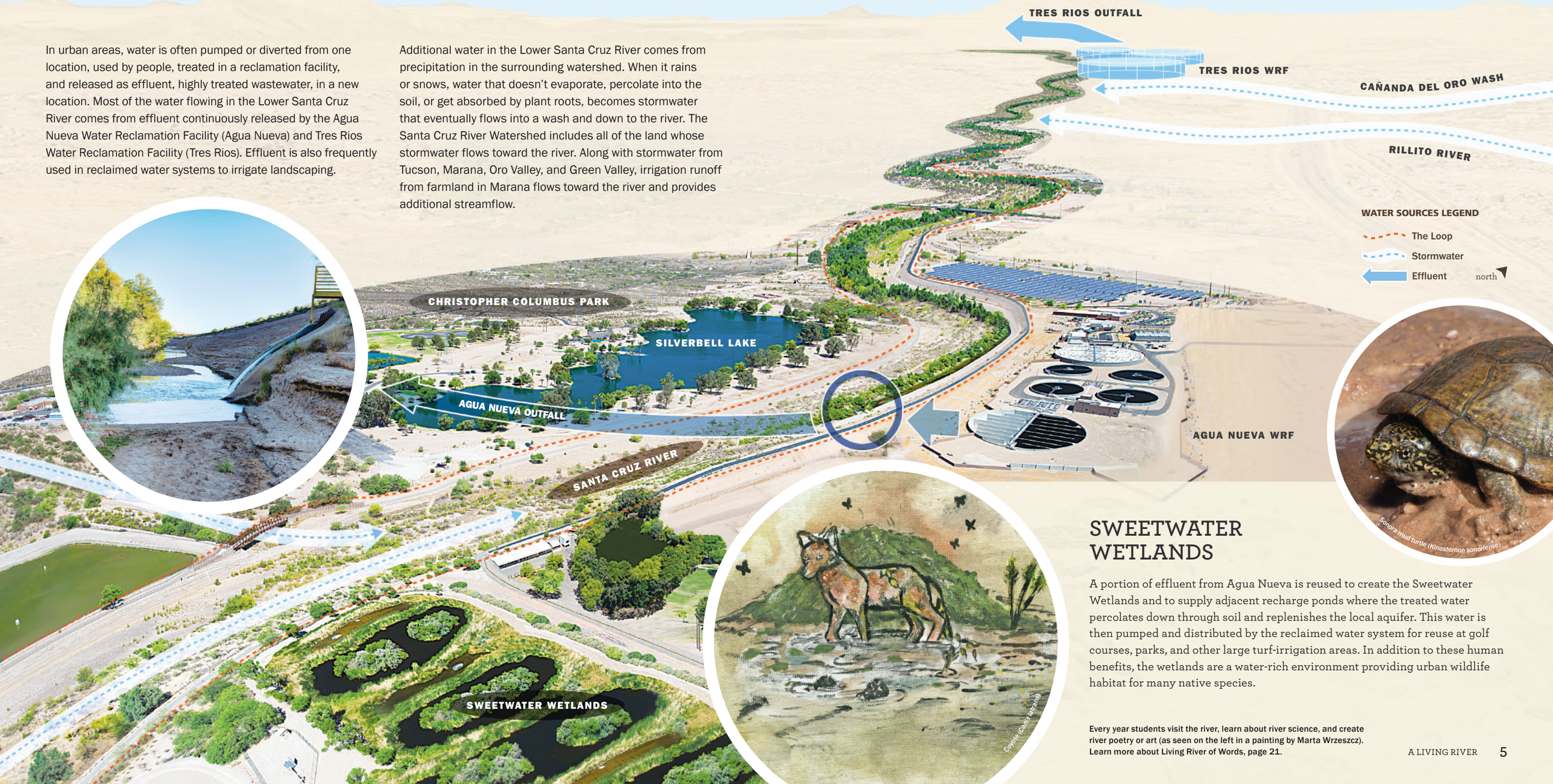
WATER SOURCES

In urban areas, water is often pumped or diverted from one location, used by people, treated in a reclamation facility, and released as effluent, highly treated wastewater, in a new location. Most of the water flowing in the Lower Santa Cruz River comes from effluent continuously released by the Agua Nueva Water Reclamation Facility (Agua Nueva) and Tres Rios Water Reclamation Facility (Tres Rios). Effluent is also frequently used in reclaimed water systems to irrigate landscaping.

Additional water in the Lower Santa Cruz River comes from precipitation in the surrounding watershed. When it rains or snows, water that doesn't evaporate, percolate into the soil, or get absorbed by plant roots, becomes stormwater that eventually flows into a wash and down to the river. The Santa Cruz River Watershed includes all of the land whose stormwater flows toward the river. Along with stormwater from Tucson, Marana, Oro Valley, and Green Valley, irrigation runoff from farmland in Marana flows toward the river and provides additional streamflow.

THE RIBBON OF GREEN

Sections of the Santa Cruz that are dependent entirely on stormwater tend to have vegetation that is adapted to drier conditions. Add effluent to the river and suddenly we see a vivid ribbon of green snaking its way downstream (notice the green start near the Agua Nueva outfall). This green ribbon includes native willows and other wetland plants that need more water. Though these ribbons of green represent a small fraction of the landscape in the desert Southwest, they provide vital habitat for wildlife in the region. They also create a vibrant, cooling corridor for people to enjoy as they visit river parks and travel The Loop recreational path.



SWEETWATER WETLANDS

A portion of effluent from Agua Nueva is reused to create the Sweetwater Wetlands and to supply adjacent recharge ponds where the treated water percolates down through soil and replenishes the local aquifer. This water is then pumped and distributed by the reclaimed water system for reuse at golf courses, parks, and other large turf-irrigation areas. In addition to these human benefits, the wetlands are a water-rich environment providing urban wildlife habitat for many native species.

Every year students visit the river, learn about river science, and create river poetry or art (as seen on the left in a painting by Marta Wrzeszcz). Learn more about Living River of Words, page 21.

ASSESSING CONDITIONS

The *Living River* report evaluates conditions of the Lower Santa Cruz River using indicators (see table below) organized into six categories that represent a breadth of biological, chemical, physical, and social properties of the river. The indicators relate to conditions in the river channel and in the riparian areas, the areas next to and affected by the river. Other characteristics monitored informally and discussed throughout the report include birds, amphibians, reptiles, and recreation.

The purpose of the *Living River* series is to monitor and report on wetland and riparian conditions at various intervals downstream of the effluent discharge points. As effluent flows downstream, it impacts and is impacted by the natural conditions of soils, vegetation, and the surrounding ecosystem. For the purposes of this study, the 23-mile stretch of river is divided into three sections, or reaches: Three Rivers, Cortaro Narrows, and Marana Flats. Reaches were delineated by their differing hydrology, geology, and adjacent land use.

The following pages compare the data collected in the 2016 water year (October 1, 2015–September 30, 2016) to the baseline conditions observed in the 2013 water year. To review data and additional charts from the 2013, 2014, 2015, and 2016 water years, please download a supplementary report from the Sonoran Institute website that is available at **www.tiny.cc/lr16.**

CATEGORY	PURPOSE	INDICATORS
Flow Extent	Water flowing in and out of the system determines available aquatic habitat.	• Miles of flow in June • Number of "dry days" at Trico Road
Water Clarity	Solid particles in the water and on the riverbed can impact habitat and conditions for aquatic life.	• Total suspended solids • Turbidity • Percent fines on riverbed
Water Quality	Specific chemical conditions are necessary to sustain the river's animal and plant communities.	• Total dissolved solids • Ammonia • Dissolved oxygen • Biochemical oxygen demand • Metals
Aquatic Wildlife	Wildlife in the river integrate and reflect conditions of many factors of the surrounding environment.	• Fish • Aquatic invertebrates
Riparian vegetation	Plant communities reflect changes in water quantity and quality.	• Wetland indicator status • Nitrogen affinity score • Riparian tree cover
Social Impacts	Aesthetic factors directly impact people living or recreating along the river.	• Odor at reclamation facilities

MONITORING SITE AT TRICO MARANA ROAD 2013–2016

2013

Before the facility upgrades, the river was flowing to the end of the study area as seen here near Trico Marana Road, May 2013.

2015

Increasingly dry conditions from reductions in flow extent in 2015 caused saltcedar leaves to turn brown and fall near Trico Marana Road, June 2015.

2016

Plant communities vary with presence of water. Saltcedar is "green" again with flowing conditions in the river near Trico Marana Road in June 2016.

Dead willow trees, like the one above left, are a visible reminder of how important water is for life. Increasingly variable flow conditions will challenge plants at this site. Newly sprouted seedlings were observed during the 2016 survey, but time will tell if they become mature trees.

Goodding's willow (left) and saltcedar (right) saplings observed near Trico Marana Road, June 2016.

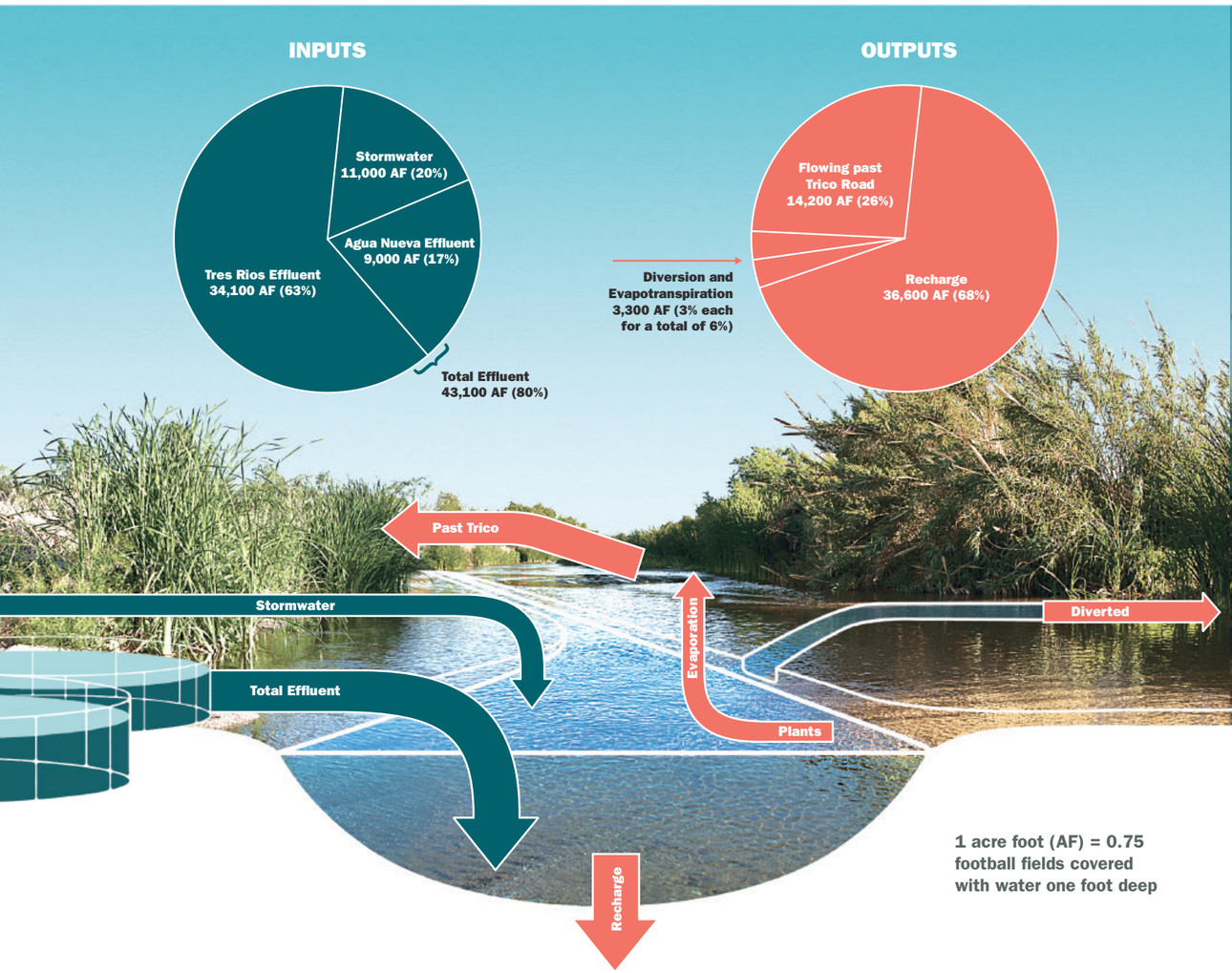
Streamflow, Rainfall, and Water Budget

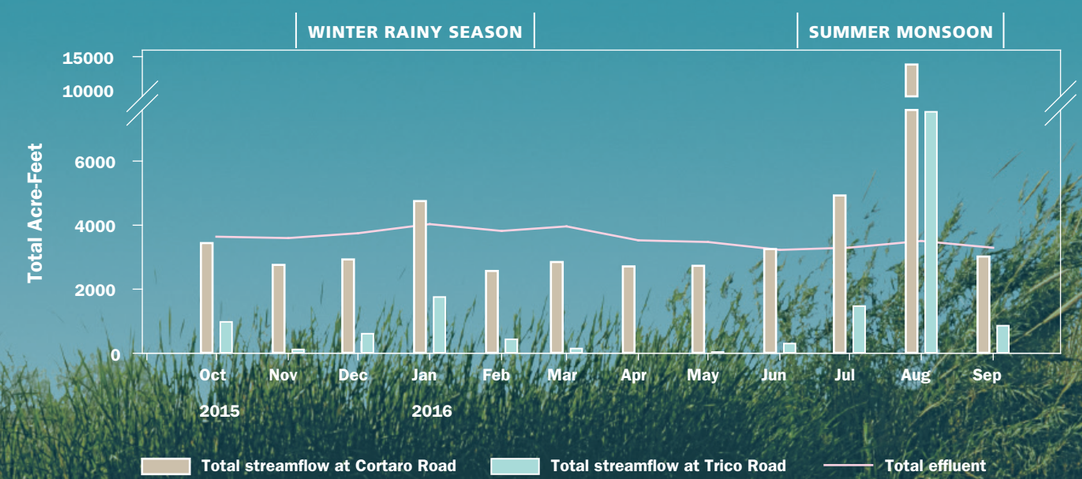
The amount of water flowing in the river provides an important context for the indicator results. Rainfall generates stormwater, contributing to streamflow and flooding. Floods can scour the riverbed, recharge aquifers, disperse seeds, induce seed germination, and clear natural debris.

A water budget for the Lower Santa Cruz River estimates water input and output. Input consists of effluent and stormwater. Output includes water that either flows past Trico Road (see map on page 2), evaporates or is used by wetland vegetation (a process called evapotranspiration), is diverted for agricultural use, or sinks into the riverbed to recharge the local aquifer. Input and output volumes are totaled in acre-feet (AF). An acre-foot is the amount of water needed to cover an acre with water one foot deep. Learn more about streamflow, rainfall, and the water budget, and view data from 2013–2016 at **www.tiny.cc/lr16**.

2016 WATER BUDGET

Total input of water to the Lower Santa Cruz was 54,100 AF and 5% higher than the 2013 baseline. This increase is due to greater stormwater flows, which contributed 20% of the input in 2016 compared to only 8% in 2013. Effluent was still the primary source of water, with a total of 43,100 AF released into the river. This volume represented an 8% reduction from the 47,000 AF released in 2013. Less effluent was released into the river because more was diverted into nearby basins to recharge local aquifers. In terms of output, more water is recharging rather than flowing past Trico Road. The 14,200 AF flowing past Trico Road in 2016 was considerably lower than the 31,000 AF in 2013. This change is likely from the increased rate of infiltration resulting in part from improved water quality which helped reduce the "clogging layer" in the riverbed (see page 14). The fact that 2015 and 2016 had the highest calculations of river recharge in the past four years, with 19,600 AF more recharge in 2016 than in 2013, provides further evidence of a sustained increase in rate of infiltration.





Tucson Airport

Total (inches)	Winter Rains	Summer Monsoon
13.0	2.3	5.7

Streamflow is measured at gage stations at Cortaro Road and Trico Road, which are downstream of the Agua Nueva and Tres Rios reclamation facilities (see map page 2). Data sources for streamflow, rainfall, and water budget include National Weather Service, Pima County Regional Flood Control District, Pima County Regional Wastewater Reclamation Department, Tucson Water, and U.S. Geological Survey.

2016 RAINFALL AND STREAMFLOW

There was more rain in 2016 compared to 2013, and 16% more rain than the 11.2-inch historical average measured at the Tucson International Airport. Extra flow from stormwater was most notable in January, July, and August, when the total volume of streamflow at Cortaro Road was greater than the effluent released into the river upstream. Overall, volume of streamflow at Cortaro Road was generally similar to 2013. However, at Trico Road, streamflow was much lower in 2016 with little recorded flow in March through June, the driest time of year.

SUMMARY OF 2016 CONDITIONS

This report compares indicators in the 2016 water year to 2013 baseline conditions. Data from 2014 and 2015 can be found online in the supplementary report at **www.tiny.cc/lr16**.

As anticipated, water quality improved following the completion of the upgrades to the reclamation facilities. Similar to 2014 and 2015, all measures were better or similar to the 2013 baseline. Most notably, ammonia levels were significantly reduced, improving conditions for fish and aquatic life. Although surveys found no native fish, four fish species were present in the river (a total of five species were found in the river since 2015).

Stretches of the river in Three Rivers and Marana Flats experienced periodic drying. Reduced nutrient levels may have diminished any "clogging layer" in the riverbed, which helped increase infiltration and percolation of river water through the sediment in the riverbed. Water management and diversions also played a role in varying flow extent. Although shorter flow extent may present challenges for wetland plants and aquatic wildlife, increased infiltration of water is a benefit to local aquifers. This is demonstrated by the sustained increase in recharge since the upgrades were completed in 2013 (see water budget).

Sediment and other particles carried in the water decreased, resulting in clear river water on normal non-flooding days. The percentage of the fine materials (silt and clay) covering the riverbed was reduced compared to the 2013 baseline. Fine materials can smother habitat and suppress life on the riverbed if too abundant. Therefore, in addition to improved water quality, the decrease in fine materials may have contributed to improvements in the aquatic invertebrate community.

While pollution-tolerant invertebrates are still present, community diversity improved and the abundance of species sensitive to pollution increased. However, the invertebrate community still reflects impaired river conditions compared to warm-water streams in Arizona that are not dominated by effluent. More time may be needed for the invertebrate community to attain the diversity and abundance found in other natural stream ecosystems.

Release of effluent supports wetland species that are abundant downstream of the reclamation facilities. The river sections that are drying have seen the most change since 2013. Streamside plant communities in these sections vary depending on presence of water at time of survey. These same areas saw a decrease in native willows in 2015, though tree cover was not measured in 2016.

As discussed in the 2013 baseline report, both the extent and intensity of odor emanating from the reclamation facilities has diminished significantly with the upgrade process. An extensive system monitors odor at the facility and along the fenceline. Levels of hydrogen sulfide, the cause of the "rotten egg" odor, were far below the levels required by facility permits.

CATEGORY	2013 CONDITIONS	2016 CONDITIONS
Flow Extent	Water was always flowing through all three reaches.	Flow extent decreased in Three Rivers and Marana Flats and varies with management of water inputs (p. 12).
Water Clarity	High amount of particles in the water column during normal, non-flooding conditions. Materials in the water increased as the river flowed downstream.	Water clarity improved with reduced particles in the water column during normal, non-flooding conditions (p. 13).
Water Quality	High levels of ammonia posed a health risk to aquatic life. Other measures met standards or provided a baseline for comparison in future assessments.	All water quality measures improved or remained similar to 2013. Most important were significant reductions in ammonia, improving conditions for aquatic wildlife (pp. 14–15).
Aquatic Wildlife	No fish in Three Rivers, but Western Mosquitofish present in Cortaro Narrows and Marana Flats. Aquatic invertebrate communities in all three reaches suggest the river is impaired or under environmental stress.	Four fish species found and at least one fish species observed in all three reaches. Aquatic invertebrate communities showed some signs of improvement (pp. 16–17).
Riparian Vegetation	Wetland and nitrogen-tolerant plants increased immediately downstream of the reclamation facilities. With the exception of Marana Flats, riparian trees generally declined as the river flowed downstream.	Effluent supports wetland and nitrogen-tolerant plants as well as mature trees downstream of the reclamation facilities. Plants in drying areas of Three Rivers and Marana Flats vary with presence of water (p. 20).
Social Impacts	Odor data unavailable at press; past efforts to reduce odor impact have resulted in significant reductions in odor levels.	Odor levels far below levels required by facility permits (p. 18).

The fall 2016 fish survey found four non-native fish species in the river.

Captured fish, like this Black Bullhead (*Ameiurus melas*), are placed in a bucket for identification and released.

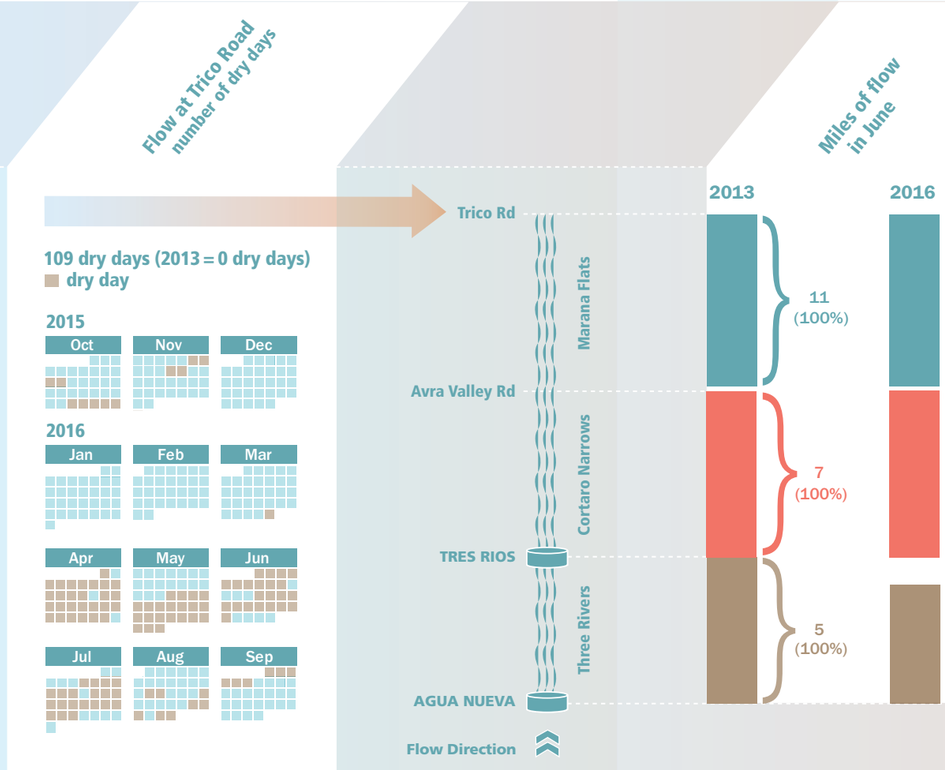
INDICATOR RESULTS

Flow Extent

Measuring flow extent, or the distance the river has visible water flowing, provides a general measure of changes to the river's water budget and the length of available aquatic habitat. Abundant flow extent may suggest high availability of habitat for aquatic life or low infiltration of water into the riverbed. Decreased flow extent could result from low water input or high infiltration of water into the riverbed.

2016 RESULTS
Flowing stretch of river is shorter

Flow extent decreased since 2013. When measured as miles of flow in June, before the summer monsoon, Three Rivers did not flow through the entire reach. Only days before this assessment, flood conditions in Marana Flats broke through a berm diverting river water for irrigation. Otherwise, Marana Flats would likely have had reduced miles of flow as in June of 2015 and 2014. When looking at daily flow at Trico Road, there were 109 days when the river was dry and did not flow to the end of the study area. This is less than the 244 days in 2015 but similar to the 94 days in 2014. Decreased flow extent is primarily due to increased infiltration (see water budget page 8), though natural influences and human management are also factors. Learn more about changes in flow extent and view data from 2013–2016 at **www.tiny.cc/lr16**.



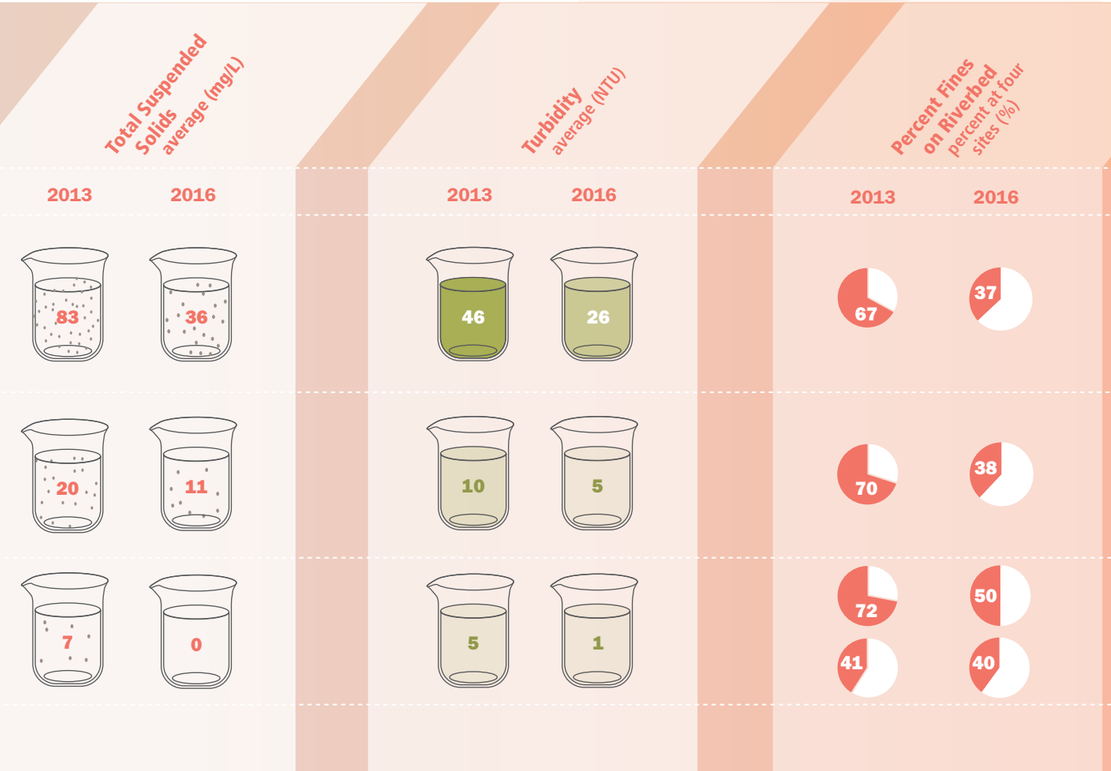
Data source: Pima County Regional Flood Control District and U.S. Geological Survey

Water Clarity

Rivers naturally move sediments and other particles downstream. As these materials are swept away, others are conveyed from upstream, bringing an influx of nutrients, organic matter, and sediments to the river ecosystem. Measuring the concentration of the materials in the water provides an estimate of the suspended particles or "cloudy" conditions in the water. Murky water and the associated fine materials that settle on the riverbed can harm aquatic life and degrade river aesthetics.

2016 RESULTS
Water clarity improved

Water clarity was assessed during normal times when the river was not flooding (murky conditions are normal during storm flows). Overall water clarity has improved since the 2013 baseline prior to the facility upgrades. Suspended particles in the water, as measured by total suspended solids, declined. Turbidity evaluates the ease of seeing through the water, with high scores representing cloudier water. Average turbidity has decreased, indicating improved water clarity. The percent fines that settle out of the water onto the riverbed decreased at all sites in 2016, suggesting improved conditions for aquatic life on the riverbed. Learn more about changes in water clarity and view data from 2013–2016 at **www.tiny.cc/lr16**.



Data source: Pima County Regional Wastewater Reclamation Department, Harris Environmental Group, Inc.

Water Quality

Aquatic ecosystems, such as streams, depend on particular water-quality conditions (chemical, physical, and biological properties) to sustain plant and animal communities. There are many typical measures that help track changes in water quality in the river, including the amounts of total dissolved solids, ammonia, dissolved oxygen, biochemical oxygen demand, and metals.

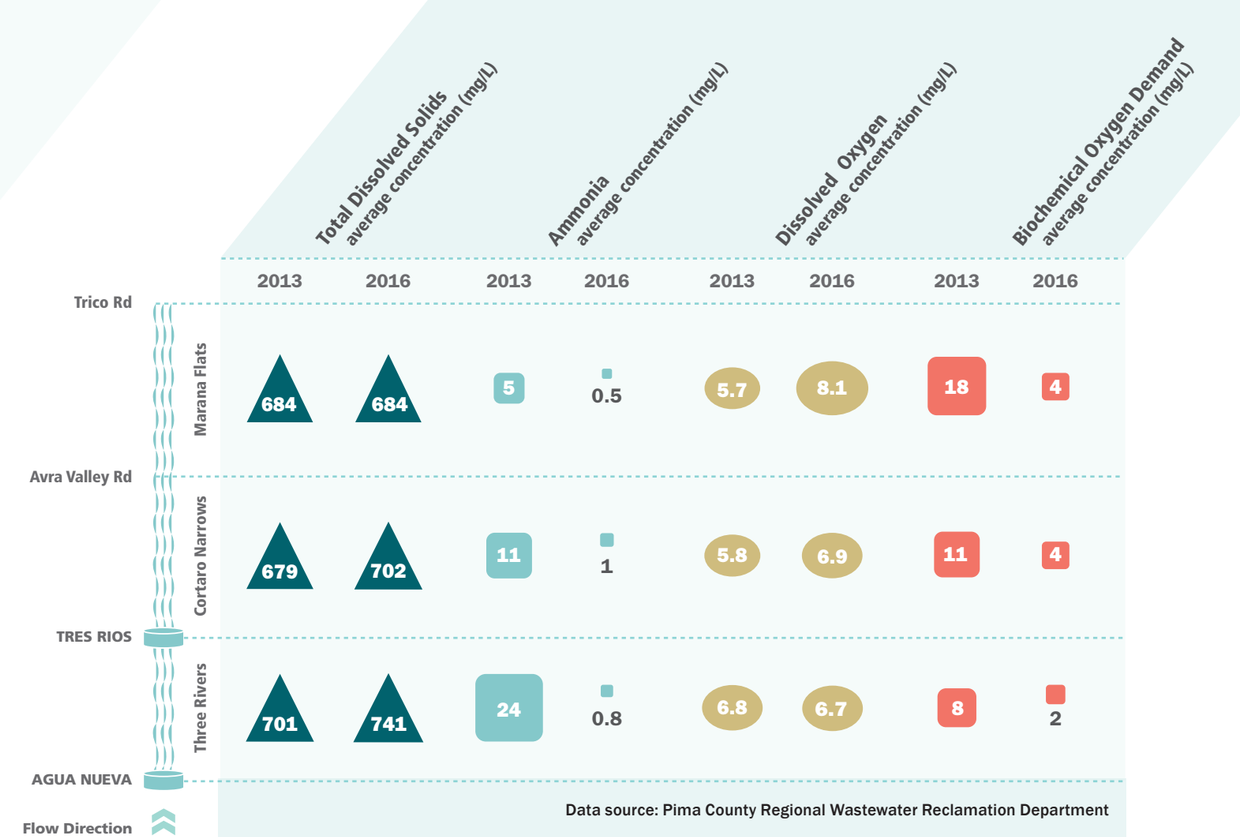
Nitrogen and other nutrients enter the river from air pollution, fertilizer, surface runoff, and release of effluent. While elevated nutrient levels can benefit growth of riparian plants, they can also lead to poor conditions for aquatic wildlife. High nutrient levels can also encourage growth of organisms, such as bacteria and algae, which live in the spaces between the sand and gravel in the streambed. These organisms can explode in number and represent one of the factors that create a "clogging layer" that reduces the ability of water to soak into the riverbed and recharge local aquifers.

Sonora Sucker (*Catostomus insignis*)

Longfin Dace (*Agosia chrysogaster*)

Desert Sucker (*Catostomus clarki*)

Gila Chub (*Gila intermedia*)



Gila Topminnow (*Poeciliopsis occidentalis*)

AMPHIBIANS, REPTILES, AND FISH

Riparian areas are critical habitat for numerous amphibian, reptile, and fish species. The effluent stretch of the Lower Santa Cruz River provides some of the only flowing water habitat for these species in the Tucson area. Historically, the Santa Cruz River was home to a community of amphibians and reptiles commonly found along rivers and desert washes in southeastern Arizona. Though no formal surveys were conducted, Sonora mud turtles have been observed in the river. American bullfrogs and spiny softshell turtles are two non-native species that are present and breeding in the river.

The Santa Cruz River historically supported several native fish species in the Tucson area. These species included Gila Topminnow, Gila Chub, Desert Sucker, Sonora Sucker, Longfin Dace, and a pupfish species that went extinct when the river ceased to flow year-round. Several groups collaboratively survey fish; see results of this annual effort on page 16.

2016 RESULTS

Improved water quality with reduced nitrogen and more dissolved oxygen

The upgraded wastewater treatment process improved the water quality in the river. Ammonia (NH_3) is one form of nitrogen that is toxic to fish at high concentrations and is more common in rivers dominated by effluent. Average concentrations of ammonia significantly declined with the new treatment process. Lower concentration of ammonia and other nutrients is likely a major factor in the reduced clogging layer in the riverbed. Reduced clogging has, in turn, resulted in increased recharge (page 8) and reduced flow extent (page 12).

Fish and other aquatic animals need dissolved oxygen to survive. Levels of dissolved oxygen remained high enough for fish and were highest in Marana Flats. Biochemical oxygen demand estimates the amount of dissolved oxygen used to break down organic matter. If organics are abundant, microorganisms breaking them down use up oxygen in the water and leave little for other aquatic life. Biochemical oxygen demand has declined, suggesting lower organic pollutant levels in the river and more oxygen for aquatic life.

Other measures of water quality remained similar to the 2013 baseline. Measuring total dissolved solids is a common way to test for salts in the water. Total dissolved solids have been higher with the community's rising use of water from the Colorado River. However, the range of observed values remained similar to 2013. Metals in high concentrations can endanger wildlife in aquatic ecosystems. All the samples tested for arsenic, cadmium, chromium, copper, lead, mercury, and zinc were low enough to protect conditions for aquatic wildlife in the river.

Learn more about changes in water quality and view data from 2013–2016 at **www.tiny.cc/lr16**.

Aquatic Wildlife

Water is essential for aquatic wildlife to survive in our arid landscape. With naturally occurring waters becoming increasingly rare throughout the Southwest, release of effluent into the Lower Santa Cruz River provides critical habitat for aquatic wildlife in the Tucson region. Furthermore, wildlife can be good indicators of river health because they integrate and reflect conditions of multiple factors in the surrounding environment, including water quality and availability of habitat.

Data source: Arizona Game and Fish Department, Harris Environmental Group, Inc., Pima County, Sonoran Institute, U.S. Fish and Wildlife Service, University of Arizona

Caddisfly (Trichoptera)

AQUATIC INVERTEBRATES

Caddisflies (adult pictured here) start life in the water and, like mayflies, are sensitive to pollution. Surveys in 2016 found the first caddisfly larvae in the river, providing further evidence of improved water quality.

BIRDS

The Lower Santa Cruz River is an excellent destination for birdwatching. In the 2016 water year, 678 volunteers collected over 70,000 bird observations along the river as part of a citizen-science program managed by Cornell Lab of Ornithology, www.ebird.org. Of these, nearly 10,000 observations were from the newest birding hot spot, the El Rio Preserve, which is home to the wetland area adjacent to the river nicknamed "Lake Marana." Overall, there were 221 unique species observed along the Lower Santa Cruz River, including sandhill cranes observed at El Rio Preserve.

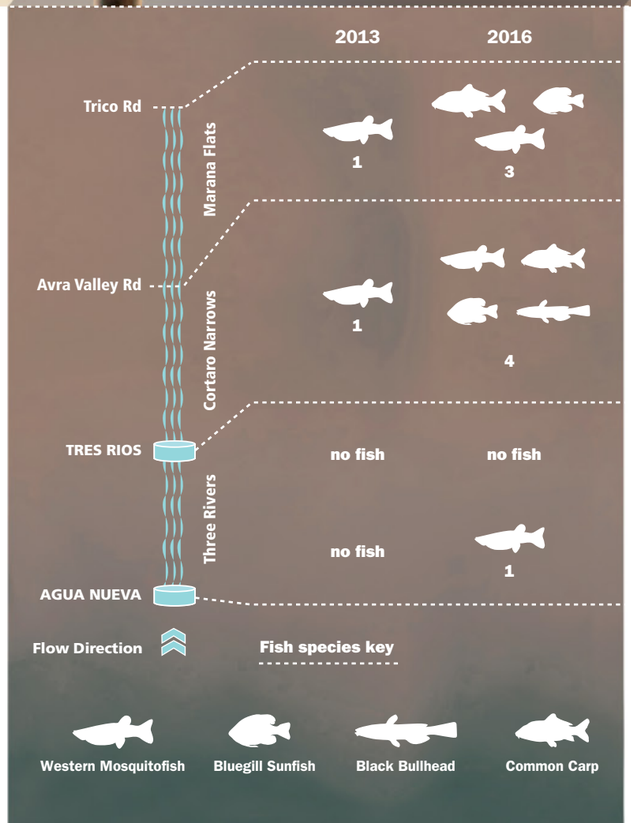
Data source: eBird Basic Dataset. Versions: EBD_relFeb2017. Cornell Lab of Ornithology, Ithaca, New York. Feb 2017

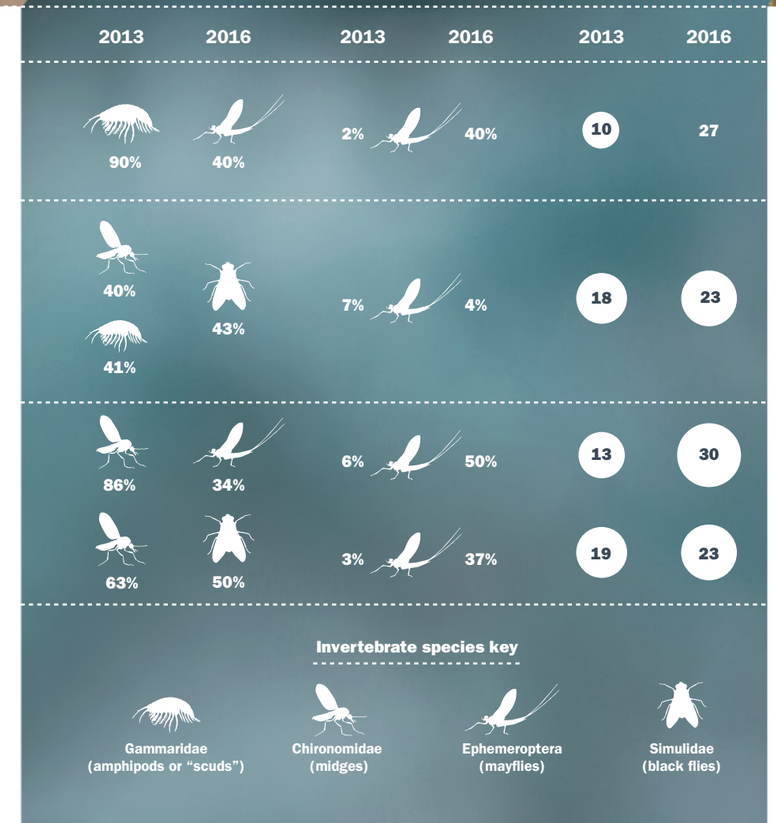
Sandhill cranes (*Antigone canadensis*)

2016 RESULTS

Aquatic wildlife show some improvement

A fall 2016 fish survey was conducted at four locations along the river to detect fish species. Improvements in water quality have allowed fish to thrive. Although there are no native fish species, three additional species were caught in Cortaro Narrows and Marana Flats (a total of five species were found in the river since 2015). Although Western Mosquitofish had expanded in low numbers upstream to Three Rivers in 2014 and 2015, only one individual was observed in 2016. Continued monitoring will determine if Three Rivers provides fish habitat. In time, large floods may bring back native species, since the Longfin Dace and Gila Topminnow are found upstream in Santa Cruz County (see map inset page 2).





A spring 2016 survey of the aquatic invertebrate community was conducted at the same four locations, and there were signs of improvement. The pollution-tolerant midges (Chironomidae) are still present, but are no longer the dominant taxa. Overall, diversity appears higher because the dominant species is now a smaller percentage of the community. If the dominant species is more than 50% of the community, river life is thought to be impaired. There were also increases in the percent of pollution-sensitive mayflies (Ephemeroptera). While this increased diversity is supported by an increase in the biological index scores, the scores remain below 39. Scores below 39 suggest that river life is impaired. Continued monitoring will determine the level of improvements.

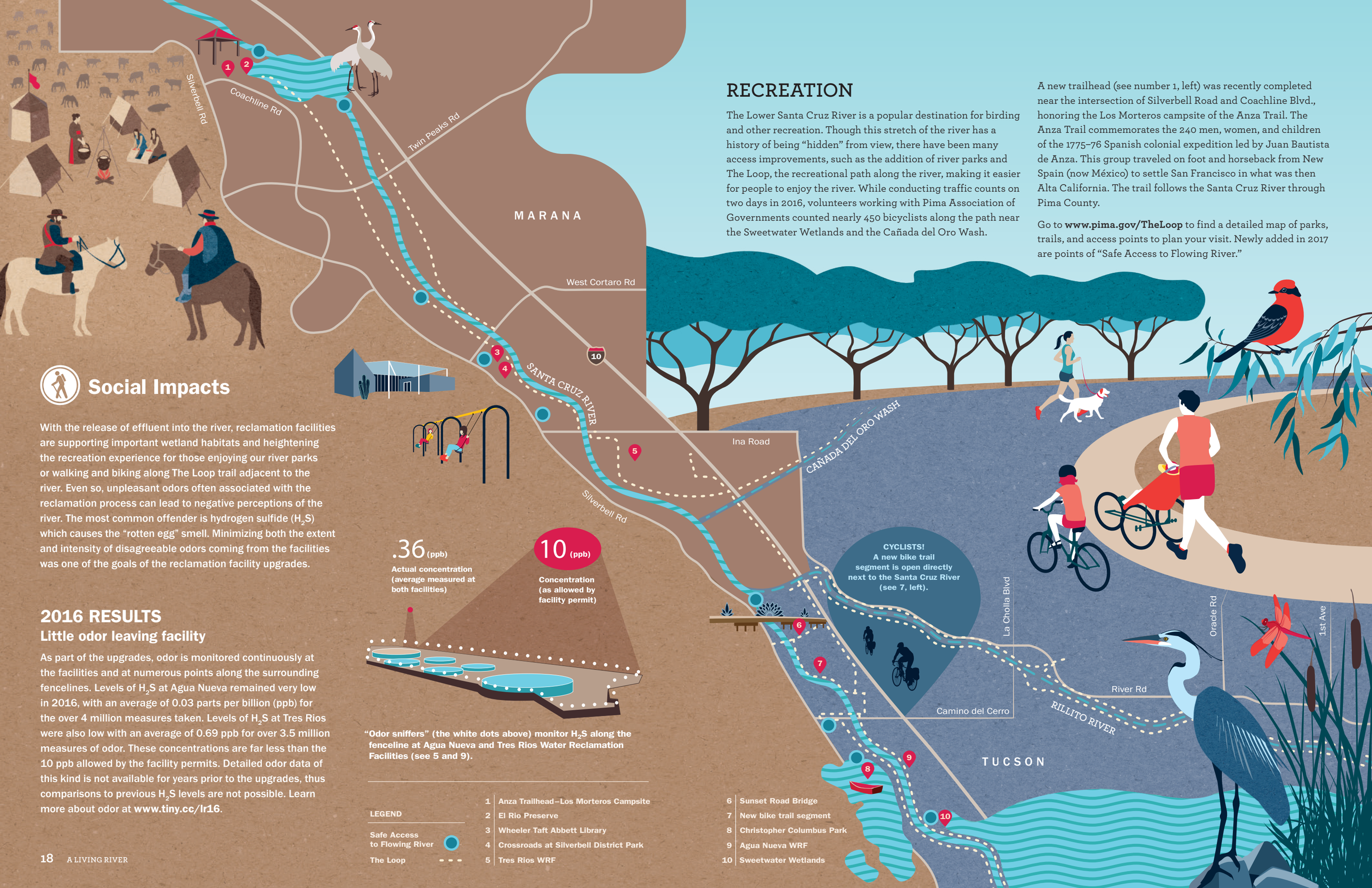
Learn more about aquatic wildlife and view data from 2013–2016 at **www.tiny.cc/lr16**.

RECREATION

The Lower Santa Cruz River is a popular destination for birding and other recreation. Though this stretch of the river has a history of being "hidden" from view, there have been many access improvements, such as the addition of river parks and The Loop, the recreational path along the river, making it easier for people to enjoy the river. While conducting traffic counts on two days in 2016, volunteers working with Pima Association of Governments counted nearly 450 bicyclists along the path near the Sweetwater Wetlands and the Cañada del Oro Wash.

A new trailhead (see number 1, left) was recently completed near the intersection of Silverbell Road and Coachline Blvd., honoring the Los Morteros campsite of the Anza Trail. The Anza Trail commemorates the 240 men, women, and children of the 1775–76 Spanish colonial expedition led by Juan Bautista de Anza. This group traveled on foot and horseback from New Spain (now México) to settle San Francisco in what was then Alta California. The trail follows the Santa Cruz River through Pima County.

Go to **www.pima.gov/TheLoop** to find a detailed map of parks, trails, and access points to plan your visit. Newly added in 2017 are points of "Safe Access to Flowing River."



"Odor sniffers" (the white dots above) monitor H_2S along the fenceline at Agua Nueva and Tres Rios Water Reclamation Facilities (see 5 and 9).

Social Impacts

With the release of effluent into the river, reclamation facilities are supporting important wetland habitats and heightening the recreation experience for those enjoying our river parks or walking and biking along The Loop trail adjacent to the river. Even so, unpleasant odors often associated with the reclamation process can lead to negative perceptions of the river. The most common offender is hydrogen sulfide (H_2S) which causes the "rotten egg" smell. Minimizing both the extent and intensity of disagreeable odors coming from the facilities was one of the goals of the reclamation facility upgrades.

2016 RESULTS

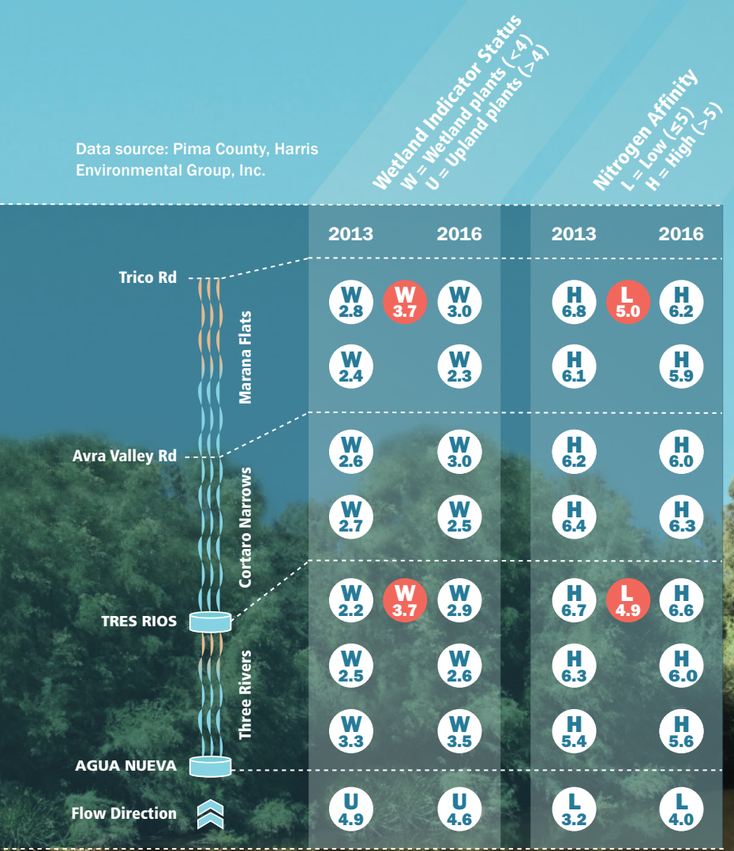
Little odor leaving facility

As part of the upgrades, odor is monitored continuously at the facilities and at numerous points along the surrounding fencelines. Levels of H_2S at Agua Nueva remained very low in 2016, with an average of 0.03 parts per billion (ppb) for the over 4 million measures taken. Levels of H_2S at Tres Rios were also low with an average of 0.69 ppb for over 3.5 million measures of odor. These concentrations are far less than the 10 ppb allowed by the facility permits. Detailed odor data of this kind is not available for years prior to the upgrades, thus comparisons to previous H_2S levels are not possible. Learn more about odor at **www.tiny.cc/lr16**.

Riparian Vegetation

Just as water is essential for aquatic wildlife, many plants grow only in areas with more water, such as wetlands and riparian areas next to rivers and desert washes. Thus, effluent released into the river is also supporting numerous plants that add to the ecosystem diversity along the Lower Santa Cruz River. Although riparian vegetation represents only a small percentage of the land cover in the Santa Cruz River Watershed, it provides important benefits to the region, such as slowing flood flows, increasing groundwater recharge, reducing erosion potential along stream banks, maintaining habitat for wildlife, and providing recreational and spiritual enjoyment.

Data source: Pima County, Harris Environmental Group, Inc.



Variability seen in drying areas. When sites are dry, as in 2015 at two sites, streamside plants shift towards upland plants that grow best in low nitrogen environments.

2016 RESULTS

Effluent supports wetland species

In the spring of 2016, measures of riparian vegetation were taken at seven sites along the river and at one site in a dry area of the river upstream of Agua Nueva. The release of effluent supports wetland species of plants that grow well in high-nitrogen environments. These stream-side plants are most abundant downstream of the reclamation facilities. The changes in vegetation observed since 2013 are at the ends of Three Rivers and Marana Flats, where there have been increasingly variable conditions as noted by changes in flow extent. While there are still wetland plants in these areas, the plant community has varied depending on presence of water at time of survey. In 2015 it appeared that the community was shifting toward upland plants that grow well in drier, low-nitrogen environments, like those found upstream of Agua Nueva. However, in 2016 these sites were wet and shifted back toward more wetland plants that have high nitrogen affinity. Decreased flow extent in these same areas has reduced cover of mature riparian trees. Though trees were not measured in 2016, saplings of Goodding's willow and Tamarix were found. Further monitoring will determine if these saplings will grow to replace the cover of Goodding's willow that notably decreased between 2013 and 2015. Learn more about riparian vegetation and view data from 2013–2015 at **www.tiny.cc/lr16**.

LIVING RIVER OF WORDS YOUTH POETRY AND ART CONTEST

The Living River of Words offers local schools the opportunity to participate in a program that encourages young people to explore how water moves through the landscape as well as the connections that plants, animals, and people have to water.

The *Living River* reports guide the program's science-based classroom activities and field trips to the river. These field trips often represent the first opportunity for many students to experience and visit a flowing river. Students then work with local artists to take what they have learned and create poetry or art entries for an annual contest. The contest is open to all youth who are 5–19 years old, and winning entries are featured in a traveling exhibit.

The 2017 Living River of Words Youth Poetry and Art contest received 1,018 submissions. Included here, and on other pages, are some of the final selections included in the traveling exhibit. Learn more about the program at: **www.pima.gov/nrpr.**

Sunshine shines
on the stream's stones
A rattlesnake's smooth
soft secret leaves
whisper sounds all around.
Mother Earth dreams half open stars.
Between footsteps,
sparkle soft blue hills.
Mountains though grasslands.
Pathway of birds' wings
over the water.

Anelise Moreno, age 8
Agua Caliente Elementary • Ms. Johnson

THE RIVER

The river is a panther
Racing through and catching its prey
The river is a dragonfly
Leaping up and taking off
The river is a treasure box
Holding shiny, sparkly treasures
The river is a stomach
Hungry and gurgling
Rumbling, bubbling and cracking
The river is a mirror
Reflecting on everything around it
The river is a life
For everyone it saves
The river is a hero
Saving everything it feeds

Amaya Preciado, age 9
Ochoa Elementary School • Ms. Selden

Gillian Hammett, age 12 | DeGrazia Elementary • Ms. Mirlocca

ACKNOWLEDGEMENTS

Sonoran Institute and Pima County prepared this report with generous funding from the U.S. Environmental Protection Agency, Pima County Regional Wastewater Reclamation Department, Pima County Regional Flood Control District, and community individuals. We are grateful for the expert guidance from our Living River Technical Committee, and for the support of our project partners, including Arizona Department of Environmental Quality, Arizona State University, Tucson Audubon Society, University of Arizona, and the U.S. Geological Survey.

The Sonoran Institute convened a Living River Technical Committee of ecology, hydrology, and wildlife experts to bring the best available science to bear on the development of the *Living River* health assessments. The Technical Committee provided guidance by selecting and aggregating indicators of river health, identifying reference values or standards for evaluating and tracking changes in river conditions, and reviewing this report. The information presented in this report grew out of discussions involving these experts and represents the product of a collective effort; it does not reflect the opinions or viewpoints of any individual member of the technical team. The viewpoints and opinions expressed in the discussions of the group and captured in this report also do not reflect the opinions or viewpoints of the agencies, institutions, or organizations with whom the technical team members and external reviewers are associated or employed. Any errors or omissions contained herein are solely those of the Sonoran Institute.

Jaime Moreno, age 11 | DeGrazia Elementary • Ms. Mirlocca

THE SONG OF THE RIVER

The song of the river played endlessly
through the night,
As the small insects were chirping away,
and the river was flowing,
the owls hooting,
the fish swimming through the water.
These are the things that make up the song
of the river,
one of the most beautiful sounds in the world.

Alexander S. Frazier, age 11
DeGrazia Elementary • Ms. Mirlocca

RIVER BANK

The birds chirping up in a tree
The green leaves rustling with the wind
The feel of the cool mud below my shoes
The smell of the moisture along the river
Tells me I am home.

Quim Al-Fayed Musa, age 12
DeGrazia Elementary • Ms. Mirlocca

McKenna Whisenant, age 11 | DeGrazia Elementary • Ms. Mirlocca

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We wish to acknowledge additional reviewers who provided valuable knowledge, insight, and assistance:

Daniel Bunting, Harris Environmental Group, Inc.

Jason Ground, Pima County Communications Office

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Design: **Terry Moody**

Printing: **Arizona Lithographers**
07/2017/1700 copies

Image Credits: all front and back cover art this year was created by Living River of Words students. Front left: **Katherine Daily**, age 17, Flowing Wells High School • Ms. Pechuzal; center: detail of painting by **Bianey Franco**, age 15, Tucson High Magnet School • Ms. Jenness; right: **Gabe Marcott**, age 16, Flowing Wells High School • Ms. Pechuzal. **2–3**: illustrations by **Terry Moody**. **4–5** photo montage by **Terry Moody** created with aerial photos by **Brian F. Powell** and **Google Earth**. **4**: outfall at Agua Nueva by **Brian F. Powell**. **5** left: painting of coyote by **Marta Wrzeszcz**, age 11, Basis Tucson North • Ms. Vonier; right: Sonora Mud Turtle by **Todd W. Pierson**. **7**: photos by **Harris Environmental Group, Inc. 8–9**: **Terry Moody**. **11**: top left: **Claire A. Zugmeyer** (Sonoran Institute); bottom left: **Pima County**; bottom right: Bullhead fish by **Claire A. Zugmeyer** (Sonoran Institute); right: **Pima County**. **14–15**: Gila Topminnow by **George Andrejko** (Arizona Game and Fish Department); fish Illustrations by **George Malesky** (Pima County). **16**: caddisfly by **Paul Cooper**. **17**: sandhilll cranes by **Bob Canon**. **18–19**: map illustration by **Terry Moody**. **20**: **Harris Environmental Group, Inc. Back cover student art** left: **Elara Wallenmeyer**, age 14, Tucson High Magnet School • Ms. Jenness; right: **Bianey Franco**, age 15, Tucson High Magnet School • Ms. Jenness

Rylee Dankert, age 7 | Roadrunner Elementary • Ms. Carroll

Estevan Moreno, age 5 | Sewell Elementary • Ms. Dolan

SONORAN INSTITUTE

The Sonoran Institute's mission is to connect people and communities with the natural resources that nourish and sustain them. We work at the nexus of commerce, community, and conservation to help people in the North American West build the communities they want to live in while preserving the values which brought them here. We envision a West where civil dialogue and collaboration are hallmarks of decision making, where people and wildlife live in harmony, and where clean water, air, and energy are assured.

The Sonoran Institute is a nonprofit organization with offices in Tucson and Phoenix, Arizona; and Mexicali, Baja California, Mexico. Visit our website to learn more www.sonoraninstitute.org.

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GET INVOLVED

- Attend the annual Santa Cruz River Research Days to learn about research and conservation efforts that pertain to the natural and cultural resources along the Santa Cruz River. Learn more at www.sonoraninstitute.org.
- Have your child enter the 2018 Living River of Words Youth Poetry and Art Contest. Sign up at www.pima.gov/nrpr.
- Save water, save rivers, and build community by joining Tucson's Conserve2Enhance (C2E) program. Help enhance urban washes that ultimately flow to the Santa Cruz River. Learn more at conserve2enhance.org/Tucson.
- Visit the Santa Cruz! See the river's "headwaters," where effluent is released into the river from Agua Nueva, just north of the Sweetwater Wetlands. From the west entrance, walk a half mile north along The Loop. Visit www.pima.gov/TheLoop for other access points.

PIMA COUNTY

Pima County Regional Flood Control District
www.pima.gov/floodcontrol

Pima County Wastewater Reclamation Department
www.pima.gov/wastewaterreclamation

Pima County Office of Sustainability and Conservation
www.pima.gov/government/sustainability_and_conservation

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