## BOARD OF SUPERVISORS AGENDA ITEM REPORT

**Requested Board Meeting Date:** May 18, 2021

**Title:** Santa Cruz River Heritage Project

**Introduction/Background:**

The City of Tucson has applied for an allocation from the Conservation Effluent Pool (CEP) to support the flowing water and riparian vegetation the Santa Cruz River from the outfall near 29th Street to Congress. The CEP was established in the 2001 Supplemental Agreement between City and County to support riparian restoration projects. City has worked with Regional Flood Control District to identify appropriate vegetation types for this stretch of the river.

**Discussion:**

The City application was first submitted in 2019. After several revisions, the CEP Administrators have deemed the application complete. Per the terms of the Implementing Agreement between City and Council, the Board and Mayor and Council must review and either approve or disapprove the proposal. The proposal will make up to 110 acre-feet per year available to support the water use of vegetation and open water in the bed of the Santa Cruz River. The City will monitor the amount of vegetation and water.

**Conclusion:**

If granted, the amount of evaporation and water use by water and vegetation in the project area will come from the CEP, consistent with the intent of the 2001 Supplemental Agreement and 2011 Implementing Agreement between City and County. If it is not approved, City will have to use effluent they own, which will reduce the amount of recharge credits they can accrue.

**Recommendation:**

Approve the resolution allocating CEP with no retroactive CEP for 2019 or 2020.

**Fiscal Impact:**

None. The City operates this riparian restoration project.

**Board of Supervisor District:**

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☒ 5 ☐ All

Department: Office of Sustainability & Conservation Telephone: 724-6490

Contact: Linda Mayro, Director Telephone: 724-6451

Department Director Signature/Date: Linda Mayro 5/4/2021

Deputy County Administrator Signature/Date: 5/5/2021

County Administrator Signature/Date: C. Rubin-Bacuy 5/5/21

**RESOLUTION NO. 2021-_____**

**PIMA COUNTY RESOLUTION OF THE PIMA COUNTY BOARD OF SUPERVISORS FOR CITY OF TUCSON HERITAGE PROJECT**

The Board of Supervisors of Pima County, Arizona finds:

1. The Sonoran Desert Conservation Plan calls for restoration of the Santa Cruz River.
2. Paseo de las Iglesias Phase 1 provided the first step and is located just upstream of the Heritage Project.
3. The City of Tucson has applied for an allocation from the Conservation Effluent Pool (CEP) to support the flowing water and riparian vegetation the Santa Cruz River from the outfall near 29th Street to Congress.
4. The CEP was established in the 2001 Supplemental Agreement between City and County to support riparian restoration projects.
5. Per the terms of the 2014 Implementing Agreement between City and Council, the Board and Mayor and Council must review and either approve or disapprove the City's proposal.

NOW, THEREFORE, BE IT RESOLVED, that the Board approves the allocation of up to 110 acre-feet of Conservation Effluent Pool annually for the Santa Cruz River Heritage Project beginning calendar year 2021 so long as the City complies with the terms of the Implementing Agreement.

**PASSED AND ADOPTED, this _____day of _____, 2021.**

_____
Chair, Pima County Board of Supervisors

ATTEST:

_____
Clerk of the Board

APPROVED AS TO FORM

_____
Deputy County Attorney

# Conservation Effluent Pool User Application

# for the Santa Cruz River Heritage Project

Date: 03/24/2021

Contact Information

Name of Operator: City of Tucson Phone #: 520-837-2088

Address: 310 W. Alameda St.

P.O. Box 27210 Tucson, AZ 85726

Point of Contact: John Kmiec, Tucson Water Deputy Director

Is this project a: Designated Riparian Project

**Describe the amount of perennial, intermittent, or ephemeral surface or subsurface water already available at the site of the proposed Riparian Project and the amount of water from those sources that the Operator plans to use to support the proposed project.**

The proposed Riparian Project is the Santa Cruz River Heritage Project, which began operations in June 2019.

The Santa Cruz River (SCR) is an ephemeral river that runs north through downtown Tucson. No longer a perennial river, due to decades of intense ground water pumping, the SCR only flows in the Tucson downtown area after heavy rain events, usually during monsoon season (June - September). These heavy rains bring large amounts of water peaking in 2018 just below 6,000 cubic feet per second (Figure 1). Ephemeral flows support some minimal vegetation areas within the Santa Cruz but are insufficient to support riparian habitats.

Tucson Water began discharging Class A reclaimed water from the Tucson Water Reclaimed Water System in June 2019 to support newly established areas of aquatic and riparian habitat in the project area. The maximum flow rate of reclaimed water available is 1,950 gpm.

Figure 2 is an aerial photo of the project area taken prior to commencement of reclaimed water discharge. Figure 3 is an artist's rendering of the project area shortly after commencement of reclaimed water discharge. Figure 4 is an artist's rendering of the project area after 10 years of reclaimed water discharges.

**Describe whether the proposed Riparian Project requires Effluent or Reclaimed Water and the means by which that water resource will be measured and delivered to the project.**

The Riparian Project will require reclaimed water delivered via the existing Tucson Water Reclaimed Water System. Tucson Water is supplementing the SCR flow from 29th St. to Congress St. for a distance of 1.57 miles (Figure 5) with a maximum of 3,150 AF/YR of Class A reclaimed water (maximum flow rate of 1,950 gpm).

The intent of this project is to safely and effectively deliver reclaimed water directly into the SCR through a control valve and metering station that dechlorinates the water prior to its release. Water from the Tucson Water Reclaimed Water System will be measured utilizing a magnetic flow meter at a control valve station prior to discharging to the river. Operation and management of the Riparian Project will be conducted by Tucson Water staff.

**Describe the Operator's 10-year schedule for accepting Conservation Pool Effluent at the proposed Riparian Project.**

Tucson Water is requesting that a maximum of 110 AF/YR of effluent from the Conservation Effluent Pool (CEP) be assigned to cover the evapotranspiration of the Riparian Project.

Year 1

Operations began as of June 24, 2019. From commencement of operations through December 31, 2019 Tucson Water calculated project evapotranspiration usage was 52 AF. This is the volume of CEP Tucson Water requests retroactively for year 1.

Years 2-10

Future requests will be based on annual vegetation surveys and open water evaporation losses calculated using the Cooley Method. Annual CEP requests will be made by January 31st of the following year.

It is expected that the Riparian Project will operate continuously except:

1. If reclaimed water supply is not available during summer peak demand for reclaimed water;
2. When the de minimis discharge location is in use (Cross Cut Road Discharge Facility APP # P-103225);
3. When maintenance is required in the river channel.

**Provide a general description of the proposed Riparian Project, specifying its location, goals, and the type of vegetation or wildlife the project will support. Include the location (pdf map requested) and CEP water demands of any Critical Vegetation or other habitat features as distinct from aquifer recharge or recreational uses of water.**

**Location:**

The Riparian Project will span a 1.57 mile stretch of the SCR from 29th Street/Silverlake Road to Congress St. The outfall location is located approximately ¼ mile north of Silverlake Road along the SCR. The address associated with this parcel location is 1580 South Santa Cruz Lane, Tucson, AZ 85713. The site lies within the NW 1/4 of Section 23, T14S, R13E. The general project location is shown in Figure 5. The treatment facility and outfall location are within a 5-acre parcel owned by Tucson Water that includes undeveloped land, a Tucson Water well site, and underground potable water piping located on the eastern side of the SCR.

**Goals:**

The Riparian Project goals are to provide critical habitat for wildlife and native vegetation, while creating an attractive downtown water feature to enhance quality of life for residents and visitors. This public amenity will also encourage economic development and support cultural and historical preservation while making efficient use of available water resources.

Adding a perennial stream to an otherwise dry riverbed has already created a preservation area that provides a sanctuary for wildlife as shown in Figures 6 and 7. The photos demonstrate a remarkable transformation of the riverbed after just a few months of reclaimed water discharges. This new riparian habitat is visible from the Pima County "Loop" bike path.

**Type of vegetation or wildlife:**

The addition of water in the SCR will facilitate riparian restoration. Although the water itself creates a nexus for riparian restoration, appropriate restoration management is also necessary. Unmanaged growth of certain types of vegetation (e.g. non-native species) in the SCR can result in adverse impacts to the hydraulic capacity of the river, as well as threaten the viability of structures such as bridges that cross the river. Tucson Water has hired the ecology and environmental firm Harris Environmental to survey vegetation, determine a native plant species palette, and create a maintenance plan for long-term vegetation monitoring and control. Additionally, Tucson Water is working with the Pima County Regional Flood Control District (PCRFCD) as well as other stakeholders to assist in providing an environment conducive to riparian restoration throughout the life of the project.

The baseline vegetation survey conducted in June 2018 by Harris Environmental before the Riparian Project started operating showed relatively low plant diversity and high non-native cover. It is anticipated that the water release and follow up re-vegetation efforts will increase plant diversity and native cover which will be documented with annual vegetation surveys as required by the maintenance plan.

Since commencement of the project in June 2019, the area around the project outfall has seen a significant improvement in riparian habitat. In addition, the distribution of a local native seed mix and seed collected from native plants of interest downstream of Pima County's Agua Nueva Water Reclamation Facility has diversified the existing plant cover. Initial seeding was completed between July 2020 through August 2020 along a 1.4 mile stretch from the Riparian Project Outfall in 10-foot swatches on both sides of the channel (wetted banks) and covered about 3.5 acres of seeding. The total ecological area supported by the Riparian Project flow is equal to 34 acres of riparian and aquatic habitat that supports native fish and wildlife (Figure 5).

The 2020 pre-monsoon vegetation survey provided by Harris Environmental is shown in Appendix A. This survey demonstrates the progress made in increasing riparian habitat and plant diversity since the baseline survey was completed. After the 2020 pre-monsoon vegetation survey was completed, PCRFCD performed channel sediment removal within the boundaries of the Riparian Project. The sediment removal project completed by PCRFCD required removal of 85,000 cubic feet of sediment from the SCR between Silverlake Rd. and Cushing Street.

It is estimated that approximately 25% of the vegetation remains following the sediment removal project. Although this stretch of the SCR will be closely managed according to flood control standards, the wildlife and vegetation results are expected to attain comparable results to other similar in-channel projects along the SCR. These two projects are called the Santa Cruz River Managed Underground Storage Facility and the Lower Santa Cruz River Managed Project. At these downstream sites, the release of effluent to the SCR from the Agua Nueva and Tres Rios Water Reclamation Facilities has created an environment that supports mature trees and vegetation, birds, fish, and invertebrates.

Current surveys and studies of the river completed by University of Arizona biologist Michael Bogan show the following findings of wildlife and vegetation in the Riparian Project reach:

- At least 151 unique bird species, including wading birds such as green herons, great egrets, killdeer, and spotted sandpipers
- Amphibians, reptiles, and fish –
    - Checkered garter snake, Sonoran Desert toad, Great Plains toad, and Red-Spotted toad (all native species); American bullfrog (non-native species); and the endangered Gila topminnow
- At least 90 species of aquatic invertebrates–
    - dragonflies and damselflies, caddisflies, mayflies, true flies, snails, and water beetles
- Riparian Vegetation –
    - Cattails, Nutsedges, Duckweed, Speedwell, Mesquite, Palo Verde, Desert Broom, Tamarisk (non-native species)

Tucson Water has established a partnership with Arizona Fish and Wildlife, Arizona Game and Fish, and the University of Arizona to monitor the aquatic wildlife in the channel. Other partners such as the Sonoran Institute and the Audubon Society have high interest in the area and are conducting their own surveys of wildlife and bird species.

Anticipated CEP water demands are discussed in the next section.

**What is the total quantity and annual amount (in acre feet) of Effluent requested to accomplish the Operator's goals in the developing and maintaining the proposed Riparian Project, including any anticipated change that will occur in Effluent demand.**

Tucson Water is requesting up to 110 AF/YR of effluent from the CEP to support the riparian project goals. The amount requested annually will vary due to operational and maintenance constraints and vegetation growth.

At this time, it is uncertain how the project will evolve. Year one was a special case which will be described below. In years 2 – 10 annual vegetation surveys will be performed to monitor vegetation growth; the estimated evapotranspiration rate will change based on type and density of the vegetation. Each year Tucson Water will request a volume of water from the CEP based on evapotranspiration estimates quantified from vegetation transects, open water area, and ariel photography analysis.

A method to quantify evaporation on an annual basis has been established. The vegetation density and open water area are calculated from a georeferenced ariel photograph generated from an annual drone aircraft flyover. The annual image file is uploaded into a geographic information system (GIS) as a layer, which is used to delineated vegetation and open water areas with polygons. The consultant matches the polygons to the referenced pre-monsoon inventory survey, which identified location of vegetation types from mapping transects. Referenced average evapotranspiration rates for each plant class is multiplied by the delineated vegetative area to calculate volume. The open water polygon area is utilized to calculate volume of evaporation using the Cooley Method. Due to a lack of information this method was not used to estimate evapotranspiration for 2019. Instead, 110 AF was prorated over the time the project was operating (172 days) for a total of 52 AF.

Table 1 illustrates the 2020 initial water budget and the associated evapotranspiration rates for the Riparian Project using the method described above. Referenced average evapotranspiration rates utilized for each plant class are footnoted in Table 1. These ET rates are average rates taken from the referenced studies listed in Table 1. and will remain constant.

**Table 1. 2020 Conservation Effluent Pool Water Budget**

| Species | Evaporation Rate (ft/yr) | * Evapotranspiration (ft/yr) | ** Vegetation Area ($ft^2$) | Annual Evaporation (AF/Y) | |
|---|---|---|---|---|---|
| Grass | 0 | 0.98 | 57,434.72 | 1.30 | |
| Trees | 0 | 1.97 | 68,653.93 | 3.10 | |
| Shrubs | 0 | 2.62 | 20,720.63 | 1.25 | |
| Cattails/Wetlands Plants | 0 | 8.61 | 12,698.42 | 2.51 | |
| **Total Phreatophytes** | | **14.19** | **159,507.69** | **8.16** | |
| Open Water | 5.6 - 7.1 | 0 | 139,085 | 18 - 23 | |
| | | Potential Min Annual Evap Rate | | **26.16** | AF/Y |
| | | Potential Max Annual Evap Rate | | **31.16** | AF/Y |

Note: * Evapotranspiration rates based on reference:

United States, Congress, Geological Survey, et al. *Studies of Consumptive Use Of Water by Phreatophytes And Hydrophytes Near Yuma, Arizona* , United States Government Printing Office, 1968.

Williams, David G, and Russell L Scott. *Vegetation-Hydrology Interactions, Dynamics of Riparian Plant Water Use* . Southwest Watershed Research Center, USDA-Agriculture Research Service, 15 Apr. 2009.

** Vegetation area from 2020 post monsoon vegetation survey and post sediment removal plant survey

Please note that in May 2020, PCRFCD performed sediment removal from the reach of the SCR channel where the Riparian Project operates. Based on the 2020 post monsoon survey, Harris Environmental estimated 75% of vegetation was removed during the sediment removal operation.

**Please describe the design and construction schedule the Operator will follow in developing the proposed Riparian Project.**

The intent of this project is to safely and effectively deliver reclaimed water directly into the SCR through a valve control station that dechlorinates the water prior to its release. This water will support the designated Riparian Project and environmental restoration. The area around the outfall is lined with rip rap to reduce the velocity of flow and to encourage growth of cattail. A consultant will monitor and advise on the vegetation of the Riparian Project throughout the life of the project. The project comprises 34 acres of the SCR channel (Figure 5). The most recent vegetation survey report provided by the hired consultant (conducted pre-sediment removal) is provided in Appendix A.

General riparian restoration schedule is as follows:

2018 Post-Monsoon Plant Survey – November 2018

Construction Start - January 2019

River Water Release Dedication – June 24, 2019

2019 Post-Monsoon Plant Survey – November 2019

Seeding and Planting – July 2020 through August 2020

2020 Pre-Monsoon Plant Survey – June through July 2020

2020 Post-Monsoon Plant Survey – October 2020

Stocking of Gila Topminnow – October 26, 2020

January 2021 – 2029 – Submit Annual Report with CEP request

2021 – 2029 Pre-Monsoon Plant Survey – June through July 2021

2021 – 2029 Post-Monsoon Plant Survey – October 2021

2021 – 2029 – Riparian Project annual inspections

Schedule has been dependent on PCRFCD maintenance activities, seasonal rains, and the success of seeding and planting of wetlands plants. The consultant has supported active and passive re-vegetation and distributed 75 lbs. of a customized native seed mix and selected wetland plants from local vendors along the Riparian Project reach. At this time, there are no additional plans to seed or plant but instead to let the natural vegetation growth occur. On October 26, 2020 the Arizona Game and Fish Department and the U.S.

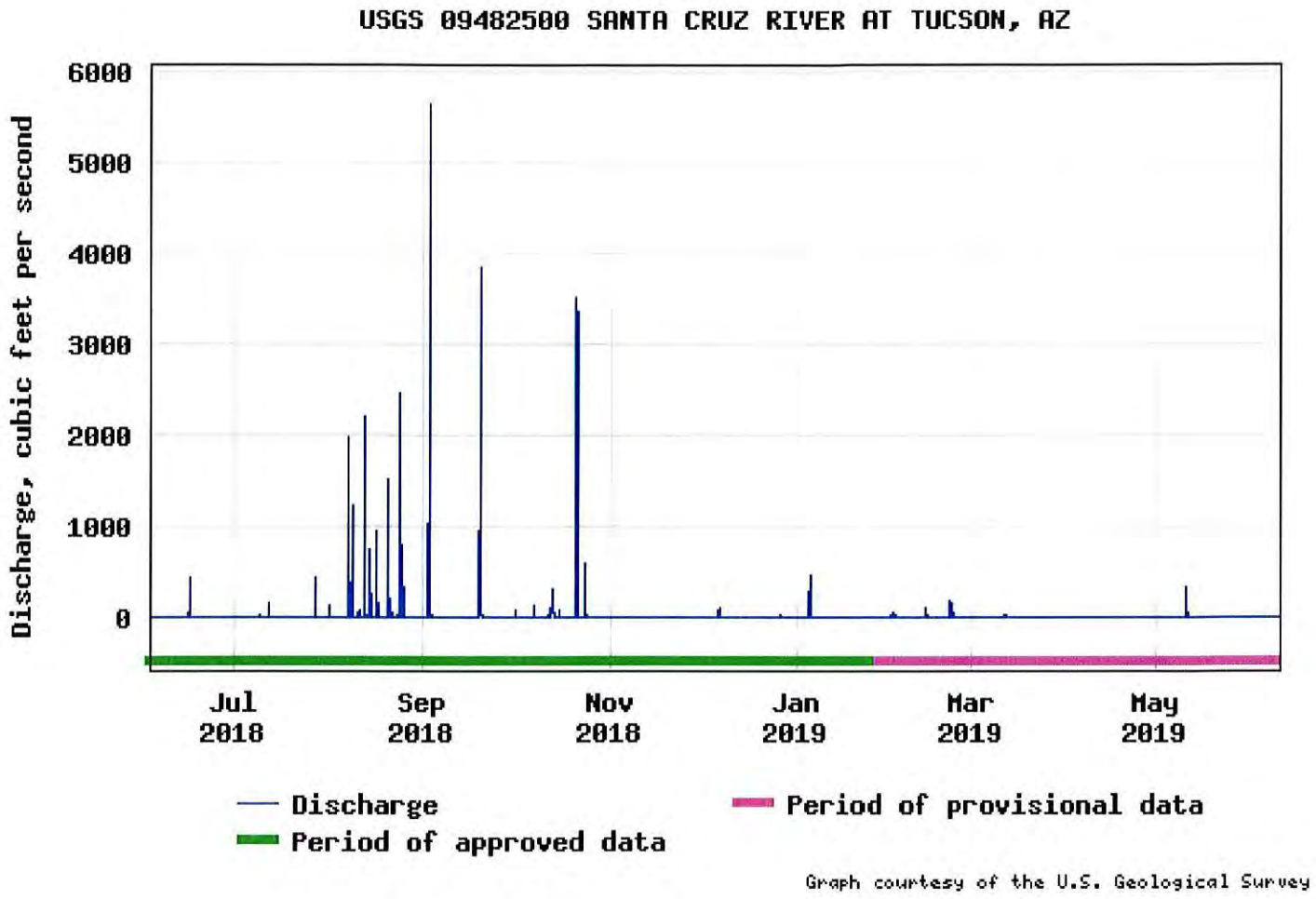
Fish and Wildlife Service released 500 Gila Topminnow into the Riparian Project reach. The flow and open water are crucial elements to maintaining the vegetation and wildlife in the area. The amount of vegetation will be impacted by several factors including natural forces such as floods. Evapotranspiration is requested from the CEP to assist with maintaining the riparian and aquatic habitat along the entire reach of the project.

**Please describe the funding source(s) the Operator will use to develop and maintain the proposed Riparian Project.**

Water fees will provide sufficient financial capability to meet the estimated costs for construction, operation, maintenance, closure, and post closure of the Riparian Project

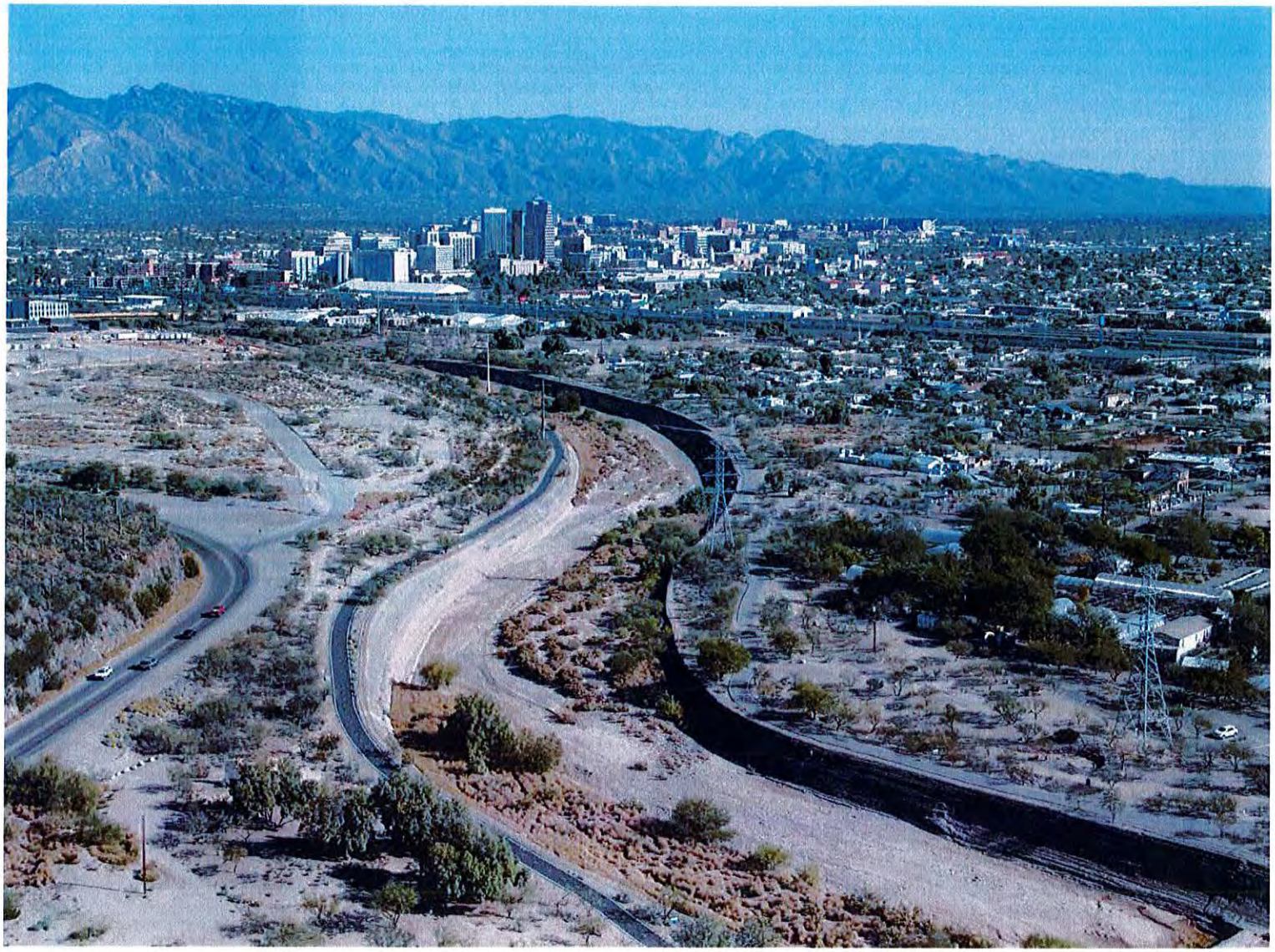
# Figures

# Figure 1


USGS 09482500 SANTA CRUZ RIVER AT TUCSON, AZ
Discharge, cubic feet per second
6000
5000
4000
3000
2000
1000
0
Jul 2018
Sep 2018
Nov 2018
Jan 2019
Mar 2019
May 2019
Discharge
Period of approved data
Period of provisional data
Graph courtesy of the U.S. Geological Survey

# Figure 2

Aerial – Prior to start of Heritage Project

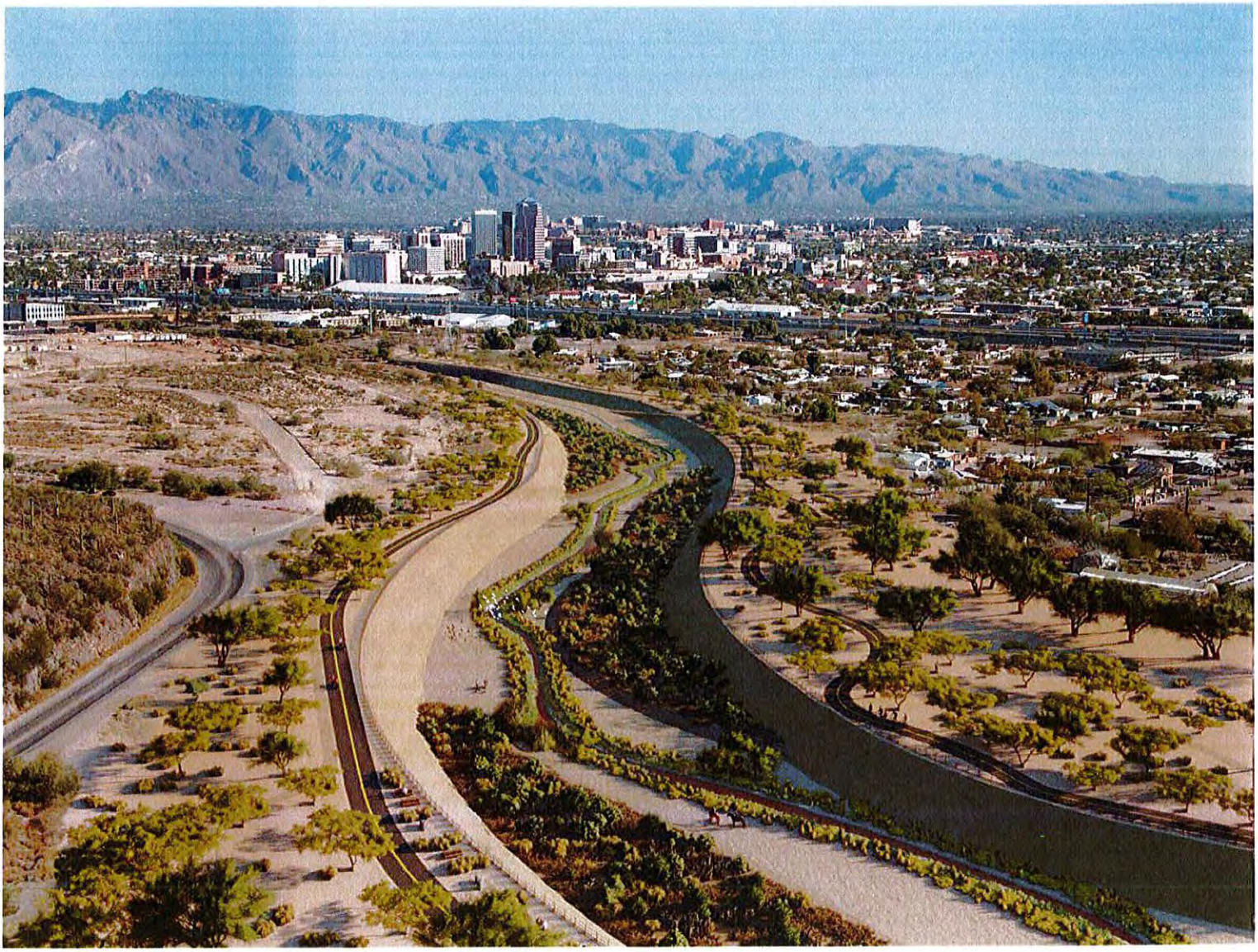


# Figure 3

Current render of Heritage Project

# Figure 4

A Projection – 10 years after start of Heritage Project



# Figure 5 – Riparian Project Area

## Figure 6 - Riparian Outfall June 2020

## Figure 7 - Riparian Outfall October 2020

# Appendix A

# 2020 Pre-Monsoon Vegetation Survey

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## Project Background

Harris Environmental has documented changes in vegetation assemblage and structure within the Heritage Project area (i.e., between 29th St/Silverlake Rd and Cushing St) of the Santa Cruz River (SCR) during pre- and post-monsoon periods since 2018. The primary goal of this work is to provide insight into the vegetation changes that occur within the Heritage Project area, which may be influenced by various conditions such as water flow, flood control measures, re-seeding, and general ecological changes over time. The SCR provides riparian habitat for numerous flora and fauna, and perennial water flow along the Heritage Project area contributes to this important habitat type in the arid desert. Harris Environmental has been involved in ongoing discussions with City of Tucson Water (COT) and Pima County about Heritage Project activities, wildlife salvage, and vegetation management in this area. This report summarizes our findings from the annual pre-monsoon vegetation inventory survey for 2020.

The major abiotic changes that have occurred along the Heritage Project reach since our last report, which discussed the status of vegetation after the monsoon in 2019, are the continued discharge of reclaimed water from the outfall just downstream from the 29th St/Silverlake Rd bridge and the extensive removal of sediment for flood control measures. Water flow was introduced in June 2019, and perennial water has thus been present in the channel for over one year (with periodic interruptions for maintenance and sediment removal). One objective of this survey was to assess whether wetland species have taken hold along the wetted reach. Another was to document the vegetation – primarily woody species and bunch grasses – that were eliminated as a result of sediment removal. We provide here an updated plant inventory, vegetation maps, and a summary of how many individuals (woody vegetation) or patches (grasses) of each plant species were removed, with particular attention to the native versus non-native composition of the remaining assemblage.

## Introduction

A project-wide plant inventory was conducted over several days between 24 June 2020 and 6 July 2020 to produce a list of all plant species identified prior to the onset of monsoon. The final plant list for all surveys conducted (pre- and post-monsoon 2018-2019 and pre-monsoon 2020) is included as Appendix A. The list includes information on plant status (e.g., native, non-native), type (e.g., herb, cactus, shrub, tree), and life history (e.g., annual, perennial). Species that have been present only since flow was reintroduced (post-monsoon 2019) are listed in bold, those that were present in the pre-monsoon survey in 2019 but not 2020 are listed in gray. All other species

are listed in un-bolded black font. We have also included a comparison of the counts of woody plants and patches of certain bunch grasses that were inventoried within the SCR channel (i.e., below the level of the soil cement) during the pre-monsoon period in 2019 and 2020 (Appendix B). This is to demonstrate the approximate quantities of each species that either died during the previous year or were eliminated as a result of sediment removal from flood control measures. Note that percentages are approximations based on occurrences of individuals (for woody species) and patches (for grasses and forbs) rather than total percent cover.

## Methods

Harris Environmental collected vegetation data using a Global Information System (GIS) framework to develop maps of existing vegetation and current conditions along the project reach. A combination of tablets with aerial imagery and Global Positioning System (GPS) units were used in the field to collect data necessary to map vegetation communities. Vegetation maps were created to depict vegetation within the project area (Appendix C). All large, woody tree species present within the project area (i.e., within the main channel and along the overbank) were documented using a digital georeferenced map. Each map depicts all woody species (e.g., trees and shrubs) and cacti present within the Heritage Project area. Large bunchgrasses (e.g., buffelgrass [*Pennisetum ciliare*] and blue panicum [*Panicum antidotale*]) are also depicted, and patches are represented by a single icon. The maps therefore document the rough location and occurrence of these species but do not quantify their density or extent.

## Results

A total of 67 species were identified in the 2020 pre-monsoon inventory survey (compared with 75 in the 2019 pre-monsoon inventory survey), 70% (n = 47) of which were native, down from 73% in 2019 (Appendix A). Of the 20 non-native species observed, eight (8) were woody shrubs or trees (compared with seven (7) in 2019), seven (7) were grasses (compared with eight (8) in 2019) (Appendix A). Four (4) were annual herbaceous species, and one (1), red yucca, was a decorative herbaceous perennial. Athel tamarisk (*Tamarix aphylla*) was the most common non-native tree species, though there were approximately 47% fewer individuals in the channel in 2020 than in 2019 (Appendix B). Extensive monoculture mats of buffelgrass, an invasive bunchgrass, remained common, though the number of patches was reduced by 29% since 2019 (Appendix B).

Overall, approximately 54% of the individual trees, shrubs, and patches of bunch grasses that were present in 2019 remained in the channel in 2020 (e.g., 46% died or were eliminated during

sediment removal) (Appendix B). Of the species reduced by 50% or more, nine (9) were native, and six (6) were non-native. Velvet mesquite (*Prosopis velutina*), a native, non-native athel tamarisk (*Tamarix aphylla*), and Mexican paloverde (*Parkinsonia aculeata*), widely considered naturalized (i.e., an introduced species that has adapted and reproduces successfully in its new environment) were the most abundant tree species within the Heritage Project area in both 2019 and 2020, though their percentages within the channel were reduced by 31%, 53%, and 55%, respectively (Appendix B). Singlewhorl burrobrush (*Hymenoclea monogyra*) was the most common shrub, followed by native desert broom (*Baccharis sarothroides*). However, much of each of these species were eliminated between 2019 and 2020. Less than a quarter (24%) of the singlewhorl burrobrush from 2019 remained in 2020 (Appendix B).

## Discussion

Overall species composition was similar to that documented in the 2019 pre-monsoon inventory survey, though the overall number of species was lower (n = 75 in 2019, n = 67 in 2020) and the percentage of native species was slightly lower (73% in 2019 versus 70% in 2020). Sixteen (16) species were found in the pre-monsoon surveys in 2019 but not in 2020, 12 of which were herbaceous, forbs, or grasses that may have been eliminated during sediment removal. Surveys in 2021 may reveal whether these species will return, though it is not unusual for fluctuations in species composition to occur from year to year. This is particularly true along a waterway, where seasonal flooding, variation in water availability, and environmental stochasticity are high.

Of the eight (8) species that were found in the 2020 pre-monsoon survey that were not present in the 2019 pre-monsoon survey, two (2) had not been documented before (Chinaberry tree [*Melia azedarach*], a non-native tree, and yerba mansa [*Anemopsis californica*], a native forb). Two wetland species that have persisted since the 2019 post-monsoon survey and have thus benefitted from perennial flow are southern cattail (*Typha domingensis*) and watercress (*Nasturtium officinale*). Several non-native grasses that are known to crowd out other species continue to dominate the channel. The number of patches of buffelgrass, a particularly virulent invasive, was only reduced by 29% (Appendix B). The number of patches of Johnson grass (*Sorghum halepense*) dropped from five (5) in 2019 to two (2) in 2020 (Appendix B). These two grass species thrive in disturbed ground and could easily return with more vigor forming larger monocultures than before. This is true for many non-native species, which tend to be colonizers and therefore may become established more quickly than natives after sediment removal and ground disturbance. Continued vegetation surveys will reveal the assemblage and extent of native and non-native species along the Heritage Project area.

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# Appendix A: Santa Cruz River Heritage Project, Pre-monsoon Plant Inventory 2020

***Bolded species** have been present only since the 2019 post-monsoon survey, and gray species were present in the pre-monsoon survey in 2019 but not 2020.

| Family | *Genus species* | Common Name | Status | Type | Form | Pre-mon. 2018 | Post-mon. 2018 | Pre-mon. 2019 | Post-mon. 2019 | Pre-mon. 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Amaranthaceae | *Amaranthus spp.* | pigweed | native | annual | herb | | | | X | |
| Anacardiaceae | *Pistacia chinensis* | Chinese pistache | non-native | perennial | tree | X | X | X | X | X |
| Anacardiaceae | *Rhus lancea* | African sumac | non-native | perennial | tree | X | X | X | | X |
| Apiaceae | *Conium maculatum* | poison hemlock | non-native | biennial | herb | X | X | | | |
| Apocynaceae | *Sarcostemma cynanchoides* | fringed twinevine | native | perennial | herb | | | X | | |
| Asparagaceae | *Agave spp.* | agave | native | perennial | shrub | X | X | X | | X |
| Asparagaceae | *Hesperaloe parviflora* | red yucca | non-native | perennial | herb | | | X | | X |
| Asteraceae | *Ambrosia confertiflora* | weakleaf bur ragweed | native | perennial | forb/herb | X | | X | X | |
| Asteraceae | *Baccharis salicifolia* | seep willow | native | perennial | shrub | X | X | X | | |
| Asteraceae | *Baccharis sarothroides* | desert broom | native | perennial | shrub | X | X | X | X | X |
| Asteraceae | *Baileya multiradiata* | desert marigold | native | perennial | herb | X | X | X | X | X |
| Asteraceae | *Bebbia juncea* | sweetbush | native | perennial | shrub | | | | X | |
| Asteraceae | *Centaurea melitensis* | Maltese starthistle | non-native | annual | herb | | | X | | X |
| Asteraceae | *Conyza canadensis* | Canadian horseweed | native | annual | herb | | | X | X | |
| Asteraceae | *Encelia farinosa* | brittlebush | native | perennial | shrub | X | X | X | X | X |
| Asteraceae | *Helianthus spp.* | sunflower | native | annual | herb | | | X | X | X |
| Asteraceae | *Hymenoclea monogyra* | singlewhorl burrobrush | native | perennial | shrub | X | X | X | X | X |
| Asteraceae | *Isocoma tenuisecta* | burroweed | native | perennial | forb/herb | X | X | X | | X |
| Asteraceae | *Laennecia coulteri* | Coulter's horseweed | native | annual | forb/herb | X | X | X | | X |
| Asteraceae | *Rudbeckia hirta* | black-eyed Susan | native | annual | forb/herb | | | | X | |
| Asteraceae | *Taraxacum officinale* | common dandelion | non-native | annual | forb/herb | | | | X | |
| Asteraceae | *Thymophylla pentachaeta* | fiveneedle prickleyleaf | native | perennial | forb/herb | X | | X | | |
| Asteraceae | *Verbesina encelioides* | golden crownbeard | native | annual | forb/herb | X | | X | X | X |
| Asteraceae | *Xanthium strumarium* | rough cocklebur | native | annual | herb | X | X | X | X | X |
| Bignoniaceae | *Chilopsis linearis* | desert willow | native | perennial | shrub/tree | X | X | X | | X |

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| Family | *Genus species* | Common Name | Status | Type | Form | Pre-mon. 2018 | Post-mon. 2018 | Pre-mon. 2019 | Post-mon. 2019 | Pre-mon. 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Boraginaceae | *Cordia parvifolia* | littleleaf cordia | native | perennial | shrub | | X | | | X |
| Boraginaceae | *Cryptantha spp.* | Cryptantha | native | annual | forb/herb | | | X | | X |
| Boraginaceae | *Phacelia spp.* | scorpionweed | native | annual | forb/herb | | X | | | X |
| Brassicaceae | *Brassica tournefortii* | Sahara mustard | non-native | annual | forb/herb | | | X | | |
| Brassicaceae | *Lepidium spp.* | pepperweed | native | annual | herb | X | X | X | | X |
| Brassicaceae | *Matthiola longipetala* | night-scented stock | non-native | annual | forb/herb | | X | | | |
| **Brassicaceae** | ***Nasturtium officinale*** | **watercress** | **non-native** | **annual** | **herb** | | | | **X** | **X** |
| Brassicaceae | *Sisymbrium irio* | London rocket | non-native | annual | herb | | | X | | X |
| Cactaceae | *Carnegiea gigantea* | Saguaro cactus | native | perennial | cactus | | | X | | X |
| Cactaceae | *Cylindropuntia bigelovii* | teddybear cholla | native | perennial | cactus | | | X | | X |
| Cactaceae | *Cylindropuntia fulgida* | chainfruit/jumping cholla | native | perennial | cactus | X | X | X | | X |
| Cactaceae | *Cylindropuntia spinosior* | walkingstick cactus | native | perennial | cactus | X | X | X | X | X |
| Cactaceae | *Ferocactus spp.* | barrel cactus | native | perennial | cactus | | | | | X |
| Cactaceae | *Ferocactus wislizeni* | fishhook barrel cactus | native | perennial | cactus | X | X | X | X | X |
| Cactaceae | *Opuntia engelmannii* | Engelmann's pricklypear | native | perennial | cactus | X | X | X | X | X |
| Cactaceae | *Opuntia santa-rita* | Santa Rita pricklypear | native | perennial | cactus | X | X | X | | X |
| Cannabaceae | *Cannabis sativa* | hemp | non-native | annual | herb | X | | | | |
| Capparaceae | *Polanisia dodecandra* | redwhisker clammyweed | native | annual | herb | X | | X | | |
| Chenopodiaceae | *Atriplex canescens* | fourwing saltbush | native | perennial | shrub | X | X | X | X | X |
| Chenopodiaceae | *Atriplex elegans* | wheelscale saltbush | native | perennial | herb | X | X | X | X | |
| Chenopodiaceae | *Chenopodium berlandieri* | pitseed goosefoot | native | annual | herb | X | X | X | X | X |
| Chenopodiaceae | *Chenopodium fremontii* | Fremont's goosefoot | native | annual | forb/herb | X | | X | X | |
| Chenopodiaceae | *Salsola tragus* | Russian thistle | non-native | annual | herb | X | X | X | X | X |
| Cyperaceae | *Cyperus spp.* | unknown nutsedge | native | annual | sedge | | X | | | |
| Euphorbiaceae | *Chamaesyce hyssopifolia* | hyssopleaf sandmat | native | perennial | herb | X | | | | |
| Euphorbiaceae | *Chamaesyce micromera* | Sonoran sandmat | native | annual | herb | X | X | | X | |
| Euphorbiaceae | *Chamaesyce spp.* | sandmat | native | annual | herb | X | X | | | |
| Fabaceae | *Acacia constricta* | white-thorn acacia | native | perennial | shrub | X | X | X | X | X |
| Fabaceae | *Acacia greggii* | catclaw acacia | native | perennial | shrub | X | X | X | X | X |

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| Family | *Genus species* | Common Name | Status | Type | Form | Pre-mon. 2018 | Post-mon. 2018 | Pre-mon. 2019 | Post-mon. 2019 | Pre-mon. 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Fabaceae | *Acacia salicina* | willow acacia | non-native | perennial | tree | X | X | | X | |
| Fabaceae | *Astragalus allochrous* | halfmoon milkvetch | native | perennial | forb/herb | | | X | | |
| Fabaceae | *Astragalus spp.* | milkvetch | native | perennial | herb | X | | X | | |
| Fabaceae | *Caesalpinia glauca* | hog potato | native | perennial | forb/herb | | X | | | |
| Fabaceae | *Parkinsonia aculeata* | Mexican paloverde | native | perennial | tree | X | X | X | X | X |
| Fabaceae | *Parkinsonia florida* | blue palo verde | native | perennial | tree | X | X | X | X | X |
| Fabaceae | *Prosopis velutina* | velvet mesquite | native | perennial | tree | X | X | X | X | X |
| Fabaceae | *Prosopsis spp.* | exotic mesquite | non-native | perennial | tree | X | X | X | X | X |
| Fabaceae | *Senna artemisioides ssp. filifolia* | threadleaf senna | non-native | perennial | shrub | | | X | | X |
| Fabaceae | *Senna covesii* | desert senna | native | perennial | herb | X | X | X | X | X |
| Geraniaceae | *Erodium texanum* | Texas stork's bill | native | annual | forb/herb | | X | | | |
| Hydrophyllaceae | *Nama hispidum* | bristly nama | native | annual | forb/herb | X | | X | | |
| Juglandaceae | *Juglans major* | Arizona walnut | native | perennial | tree | | X | X | | |
| Lamiaceae | *Teucrium cubense var. densum* | small coastal germander | native | perennial | forb/herb | X | X | | | |
| Liliaceae | *Dasylirion wheeleri* | common sotol | native | perennial | shrub | X | X | X | | X |
| Liliaceae | *Nolina microcarpa* | beargrass | native | perennial | shrub | X | X | X | | X |
| Loasaceae | *Mentzelia multiflora* | Adonis blazing star | native | perennial | herb | | | X | X | X |
| Malvaceae | *Malva parviflora* | cheeseweed mallow | non-native | annual | forb/herb | | X | | | |
| Malvaceae | *Sphaeralcea ambigua* | desert globemallow | native | perennial | herb | X | X | X | X | X |
| Meliaceae | *Melia azedarach* | Chinaberry tree | non-native | perennial | tree | | | | | X |
| Nyctaginaceae | *Boerhavia coccinea* | scarlet spiderling | native | perennial | forb/herb | X | | | | |
| Nyctaginaceae | *Boerhavia coulteri* | Coulter's spiderling | native | perennial | grass | X | | | | |
| Poaceae | *Aristida purpurea* | purple three-awn | native | perennial | grass | X | X | X | X | X |
| Poaceae | *Bothriochloa ischaemum* | yellow bluestem | non-native | perennial | grass | X | | | | |
| **Poaceae** | ***Bouteloua aristidoides*** | **needle grama** | **native** | **annual** | **grass** | | | | **X** | **X** |
| Poaceae | *Chloris virgata* | feather finger grass | native | annual | grass | | | | X | |
| Poaceae | *Cynodon dactylon* | Bermuda grass | non-native | perennial | grass | X | X | X | X | X |

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| Family | *Genus species* | Common Name | Status | Type | Form | Pre-mon. 2018 | Post-mon. 2018 | Pre-mon. 2019 | Post-mon. 2019 | Pre-mon. 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Poaceae | *Dasyochloa pulchella* | low woollygrass | native | perennial | grass | X | X | X | | X |
| Poaceae | *Digitaria ciliaris* | southern crabgrass | non-native | annual | grass | | X | X | X | |
| Poaceae | *Echinochloa crus-galli* | barnyard grass | non-native | annual | grass | | X | | X | |
| Poaceae | *Eragrostis echinochloidea* | African lovegrass | non-native | perennial | grass | X | X | X | X | X |
| Poaceae | *Eriochloa acuminata* | tapertip cupgrass | native | annual | grass | | X | | | |
| Poaceae | *Panicum antidotale* | blue panicum | non-native | perennial | grass | X | X | X | X | X |
| Poaceae | *Pennisetum ciliare* | buffelgrass | non-native | perennial | grass | X | X | X | X | X |
| Poaceae | *Pennisetum setaceum* | fountain grass | non-native | perennial | grass | | | X | X | X |
| Poaceae | *Schismus barbatus* | Mediterranean grass | non-native | annual | grass | | X | X | X | X |
| Poaceae | *Sorghum halepense* | Johnson grass | non-native | perennial | grass | X | X | X | X | X |
| Polygonaceae | *Eriogonum deflexum* | flatcrown buckwheat | native | annual | forb/herb | | X | X | X | X |
| Polygonaceae | *Eriogonum spp.* | buckwheat | native | annual | herb | X | | | | |
| Rhamnaceae | *Ziziphus obtusifolia* | graythorn | native | perennial | shrub | | | X | | X |
| Salicaceae | *Populus fremontii* | Fremont cottonwood | native | perennial | tree | | | X | | |
| Sapindaceae | *Sapindus saponaria* | western soapberry | native | perennial | shrub/tree | X | X | X | | |
| Saururaceae | *Anemopsis californica* | yerba mansa | native | perennial | forb/herb | | | | | X |
| Scrophulariaceae | *Veronica anagallis-aquatica* | water speedwell | native | perennial | herb | | | | X | |
| Solanaceae | *Datura wrightii* | sacred datura | native | perennial | herb | X | X | X | X | X |
| Solanaceae | *Nicotiana glauca* | tree tabacco | non-native | perennial | shrub/tree | X | X | X | X | X |
| Solanaceae | *Nicotiana obtusifolia* | desert tobacco | native | perennial | subshrub | X | X | X | X | X |
| Solanaceae | *Solanum elaeagnifolium* | silverleaf nightshade | native | perennial | herb | X | X | X | X | X |
| Tamaricaceae | *Tamarix aphylla* | athel tamarisk | non-native | perennial | tree | X | X | X | X | X |
| Tamaricaceae | *Tamarix ramosissima* | saltcedar | non-native | perennial | tree | X | X | X | X | X |
| **Typhaceae** | ***Typha domingensis*** | **southern cattail** | **native** | **perennial** | **herb** | | | | **X** | **X** |
| Viscaceae | *Phoradendron californicum* | desert mistletoe | native | perennial | shrub | | | X | X | X |
| Zygophyllaceae | *Larrea tridentata* | creosotebush | native | perennial | shrub | X | X | X | X | X |

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## Appendix B: Counts of woody species and patches of bunch grasses below the soil cement in the Santa Cruz River Heritage Project Area

### Pre-Monsoon survey 2020

* Note that these are counts of occurrences of individuals or patches of each species, not total cover. Native species are highlighted in gray.

| Common Name | Status | Number of Individuals/ Patches Present in 2019 | Number of Individuals/ Patches Present in 2020 | Number of Individuals/ Patches Gone | Percent Individuals/ Patches Remaining in 2020 |
|---|---|---|---|---|---|
| African sumac | non-native | 2 | 0 | 2 | 0% |
| fourwing saltbush | native | 2 | 0 | 2 | 0% |
| Fremont cottonwood | native | 2 | 0 | 2 | 0% |
| honey mesquite | native | 1 | 0 | 1 | 0% |
| seep willow | native | 2 | 0 | 2 | 0% |
| willow acacia | non-native | 1 | 0 | 1 | 0% |
| singlewhorl burrobrush | native | 86 | 21 | 65 | 24% |
| blue panicum | non-native | 4 | 1 | 3 | 25% |
| creosotebush | native | 3 | 1 | 2 | 33% |
| exotic mesquite | non-native | 3 | 1 | 2 | 33% |
| Johnson grass | non-native | 5 | 2 | 3 | 40% |
| desert broom | native | 35 | 15 | 20 | 43% |
| Mexican paloverde | native | 65 | 29 | 36 | 45% |
| athel tamarisk | non-native | 34 | 16 | 18 | 47% |
| whitethorn acacia | native | 2 | 1 | 1 | 50% |
| velvet mesquite | native | 49 | 34 | 15 | 69% |
| buffelgrass | non-native | 24 | 17 | 7 | 71% |
| saltcedar | non-native | 4 | 3 | 1 | 75% |
| blue paloverde | native | 12 | 10 | 2 | 83% |
| catclaw acacia | native | 7 | 6 | 1 | 86% |
| desert willow | native | 2 | 2 | 0 | 100% |
| prickly pear cactus | native | 1 | 1 | 0 | 100% |
| **Total Individuals/ Patches** | | **347** | **160** | **187** | **54%** |

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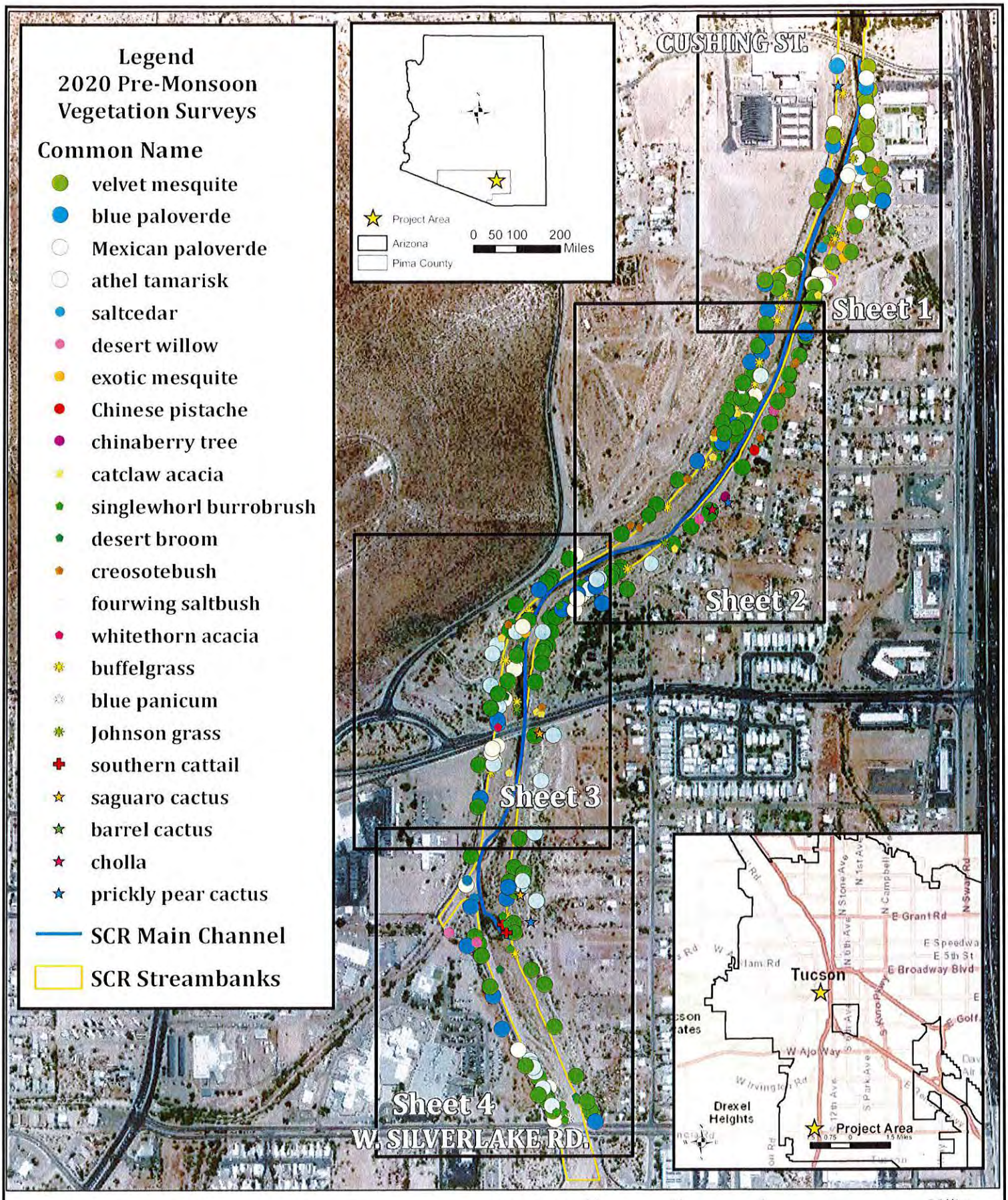
# Appendix C: *Maps of Vegetation within Heritage Project Reach Pre-monsoon Plant Inventory 2020

***Includes maps of vegetation removed since the 2019 pre-monsoon survey**

Begins on next page




# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Extent

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Map Produced by A. La Porte
Harris Environmental, 2020
UTM, WGS 84
Basemap: ESRI 2020


# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 1

0.05 0.025 0 0.05 Miles

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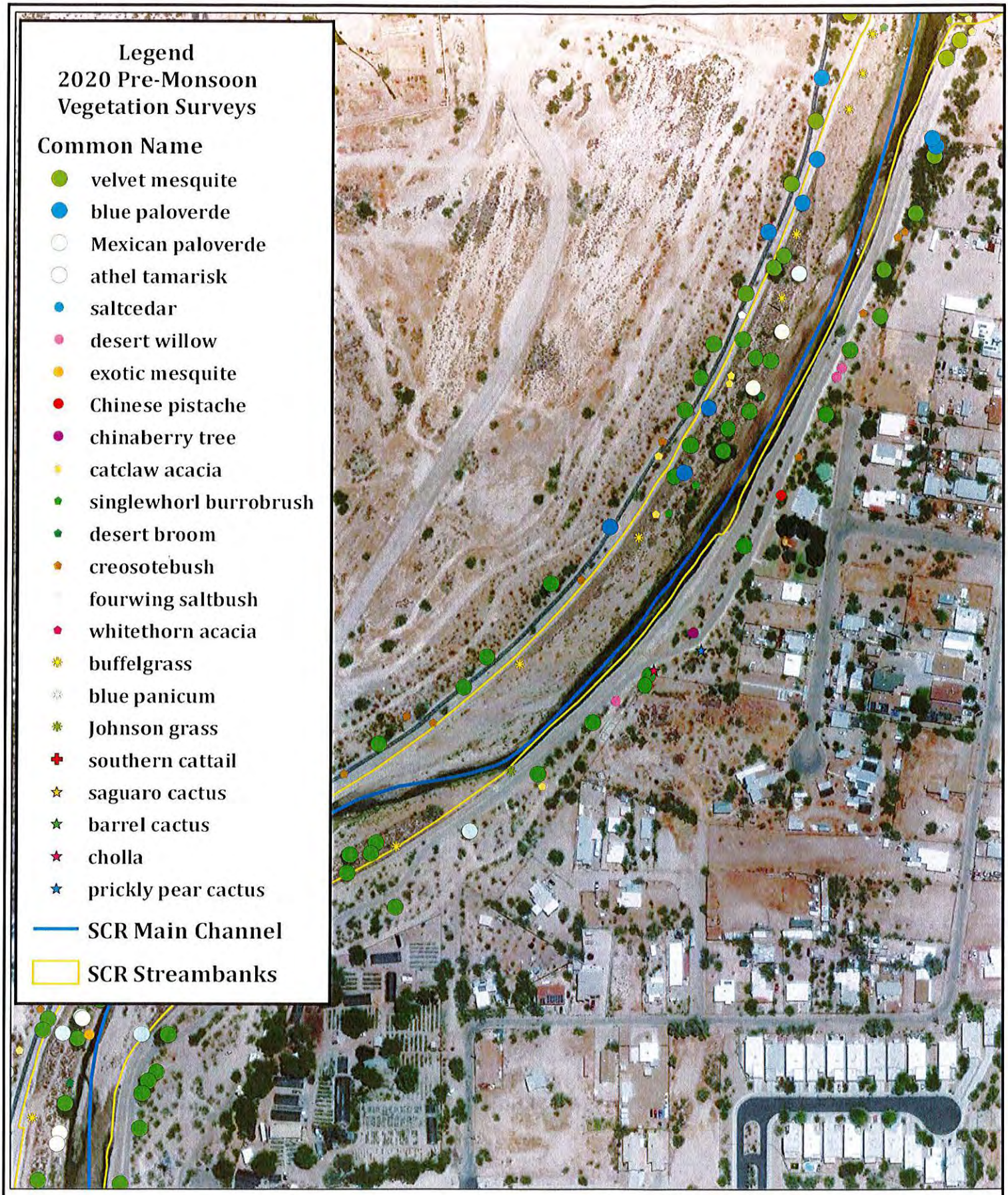
UTM, WGS 84
Basemap: ESRI, 2020




# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 2

0.065 0.0325 0 0.065 Miles

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UTM, WGS 84
Basemaps ESRI, 2020


# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 3

0.055 0.0275 0 0.055 Miles

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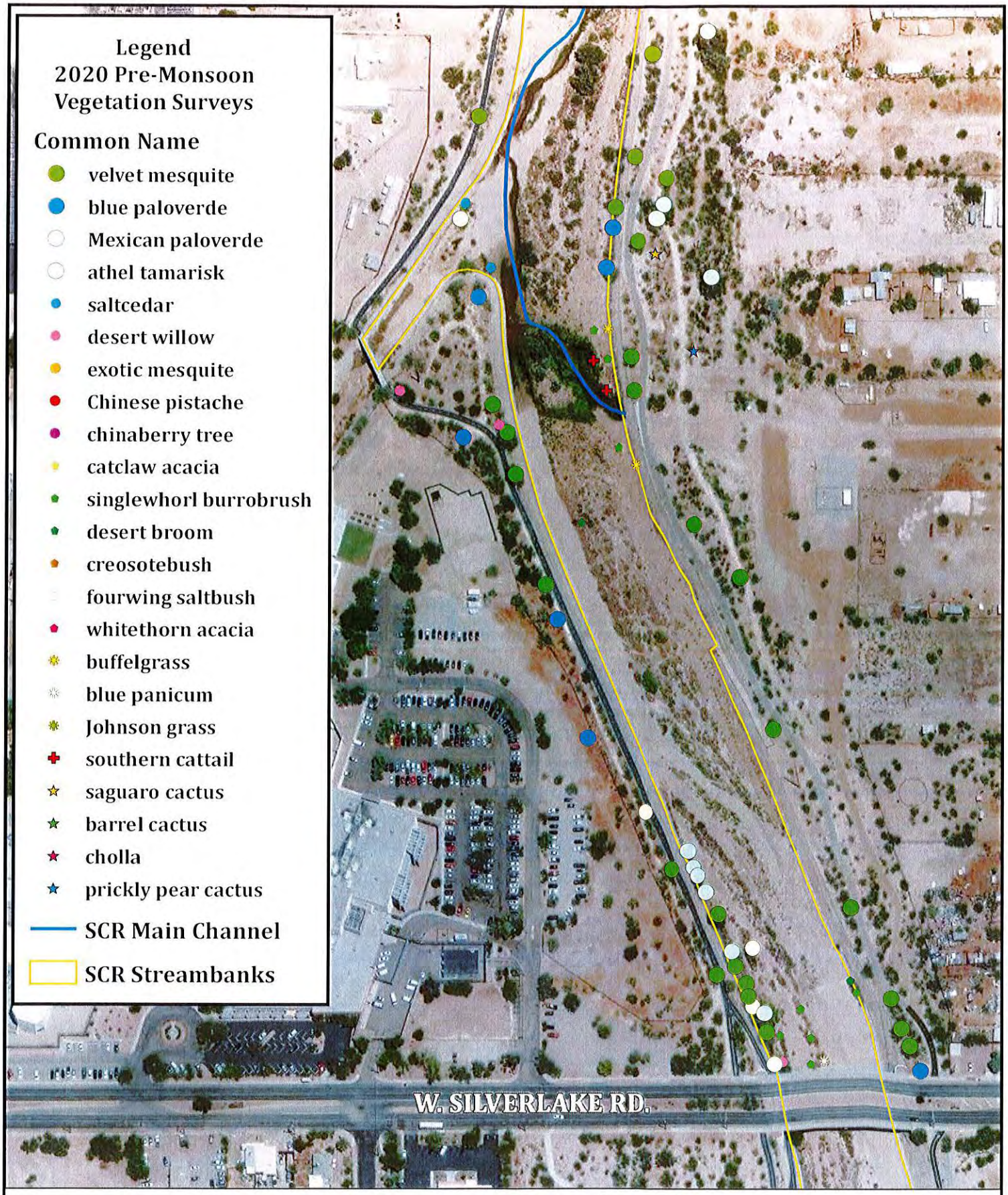
UTM, WGS 84
Basemap: ESRI, 2020




# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 4

0.055 0.0275 0 0.055 Miles

W E

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Map Produced By A. La Porte
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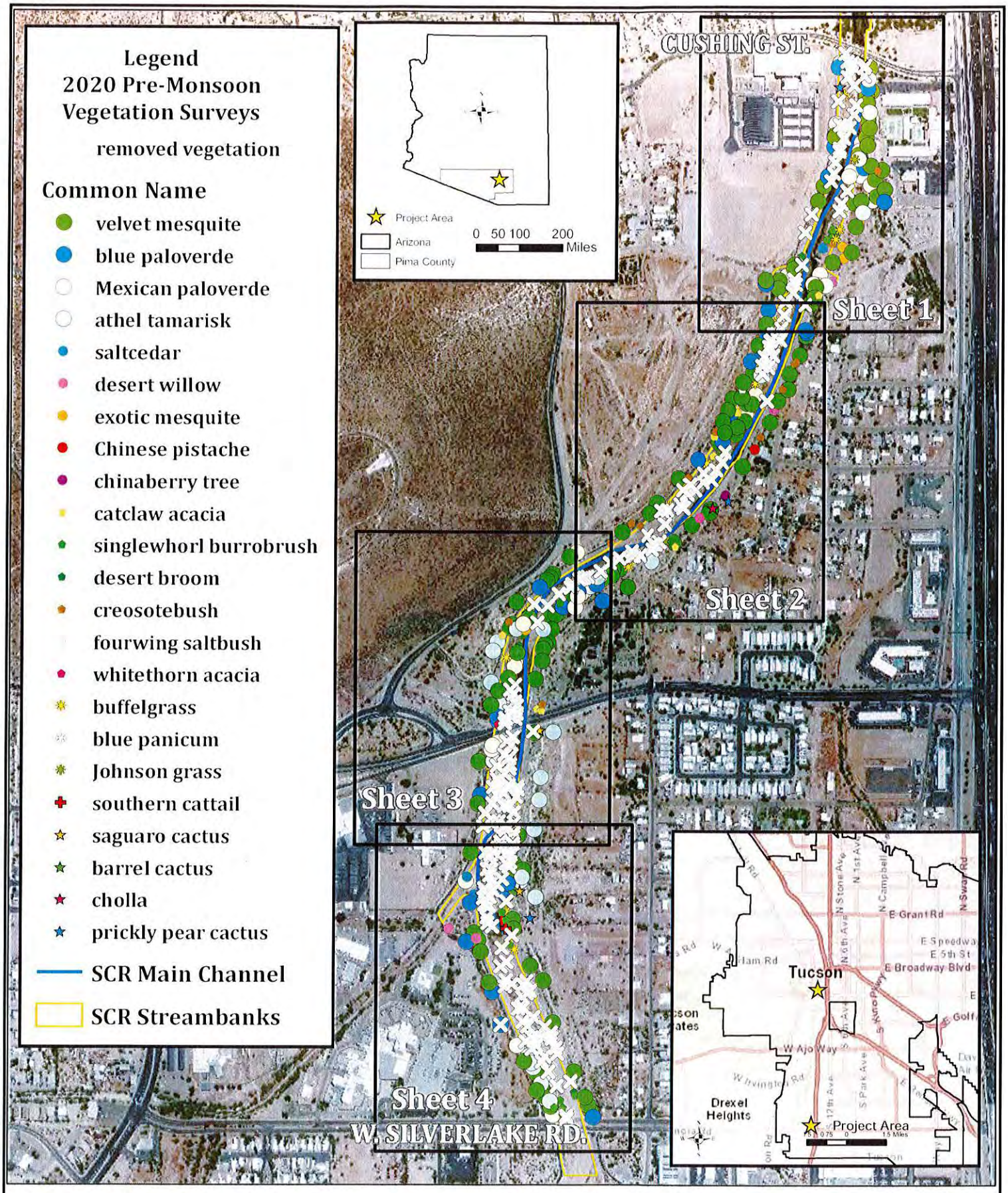
UTM, WGS 84
Basemap: ESRI, 2020




# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project Extent

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Map Produced by A. La Porte
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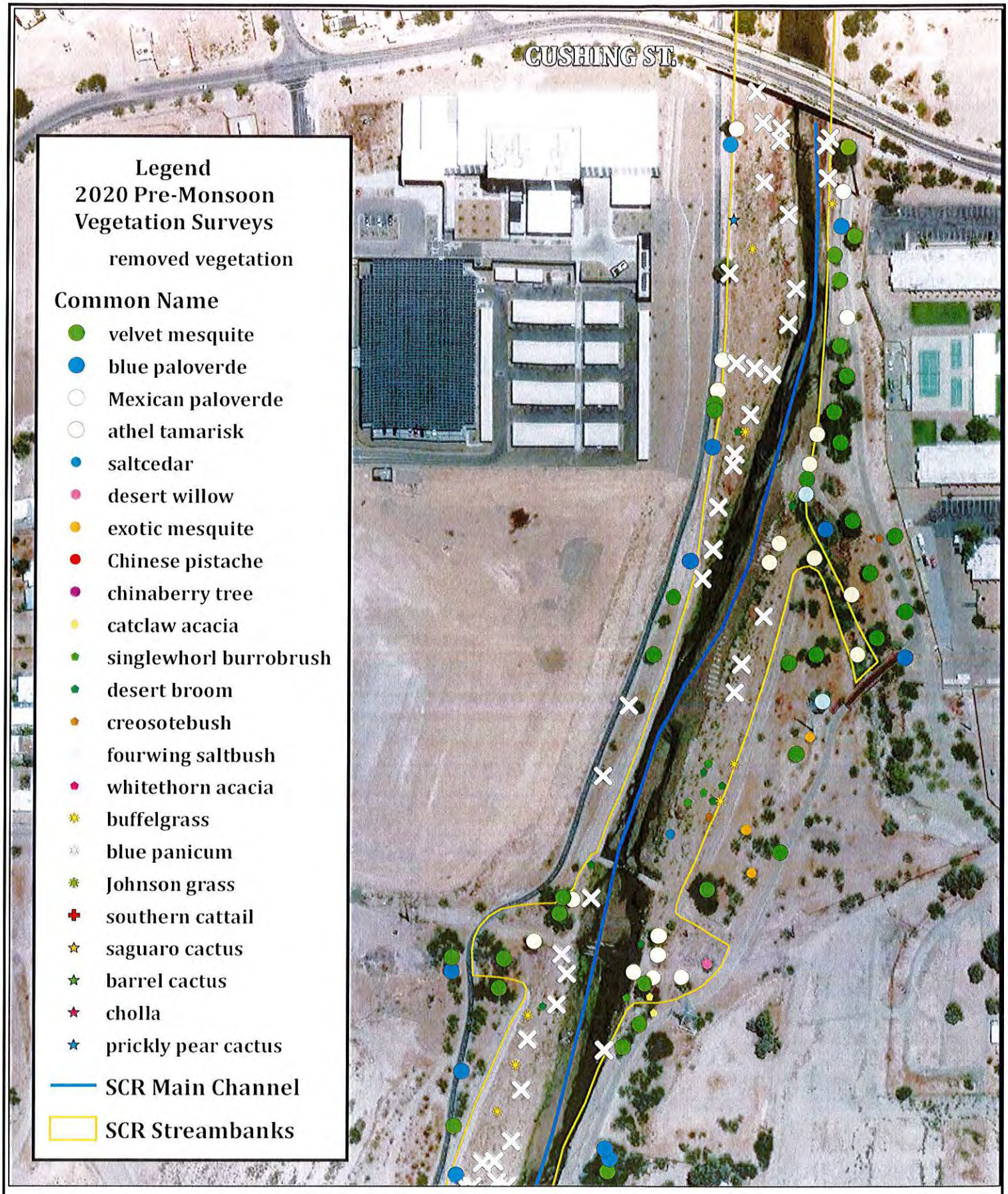
UTM, WGS 84
Basemap: ESRI 2020




# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 1

0.05 0.025 0 0.05 Miles

W E

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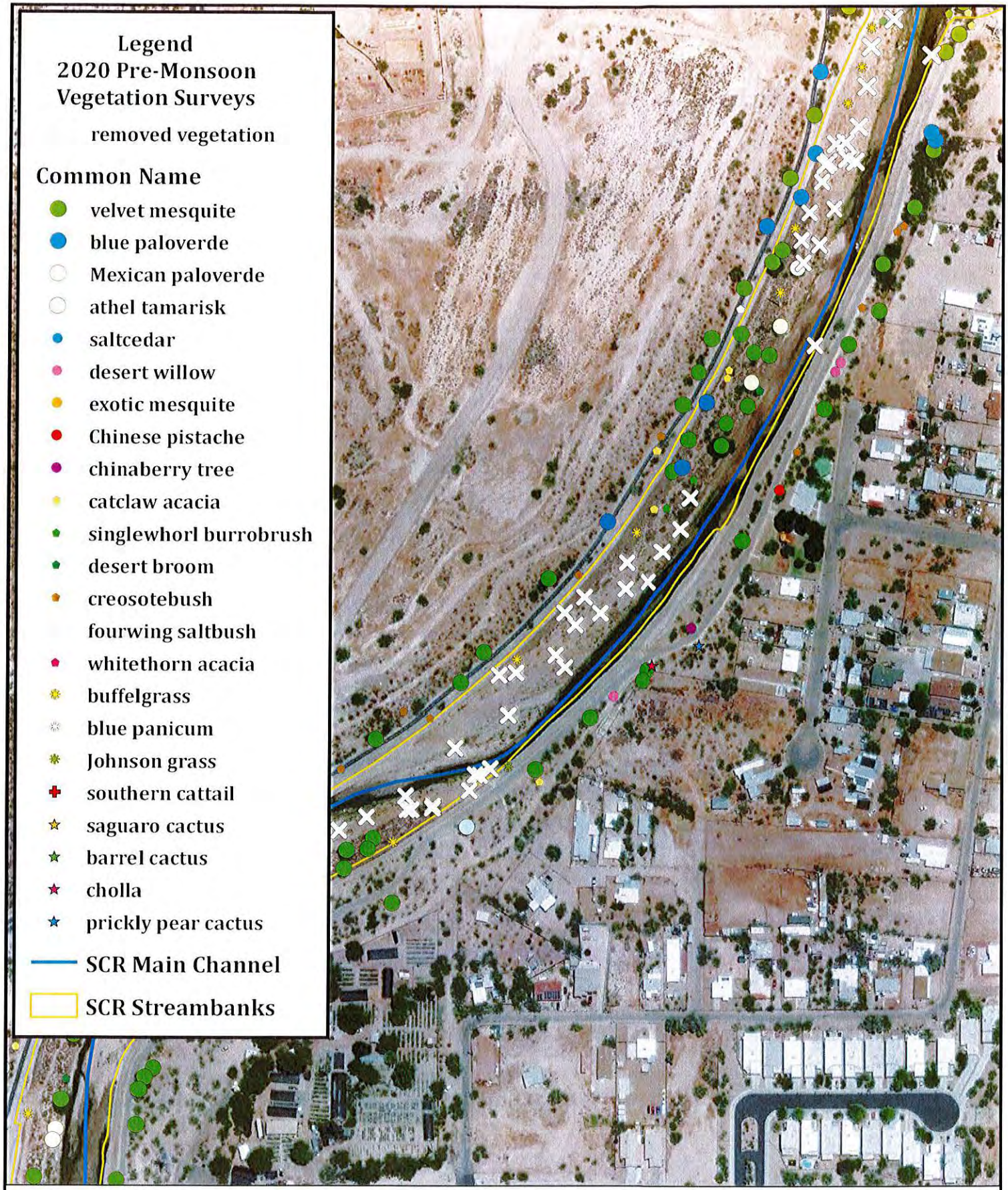
UTM, WGS 84
Basemap: ESRI, 2020




# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 2

0.065 0.0325 0 0.065 Miles

W E

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Basemap: ESRI, 2020


# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 3

0.055 0.0275 0 0.055 Miles

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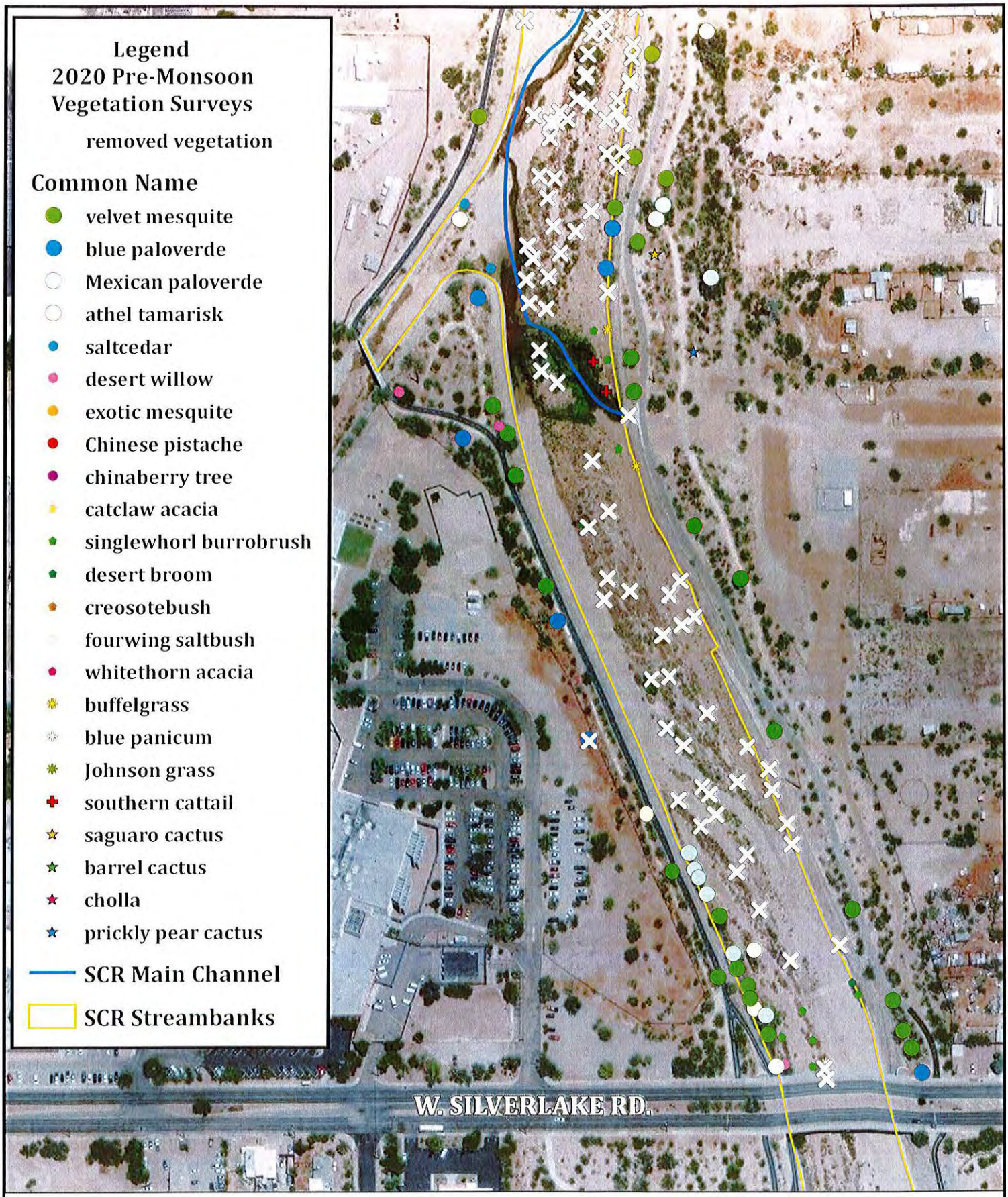


# Vegetation Mapping, Pre-monsoon 2020
# Santa Cruz River Heritage Project
# Sheet 4

0.055 0.0275 0 0.055 Miles

W E

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UTM, WGS 84
Basemap: ESRI, 2020