Annual Report of the

Prado Basin Habitat Sustainability Committee

Water Year 2019

June 3, 2020

Prepared for:

Inland Empire Utilities Agency
&
Chino Basin Watermaster

Prepared by:

Wildermuth Environmental, Inc.

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Acronyms, Abbreviations, and Initialisms

ACOE	US Army Corps of Engineers
af	acre-feet
afy	acre-feet per year
AMP	Adaptive Management Plan for the PBHSP
Annual Report	Annual Report of the Prado Basin Habitat Sustainability Committee
BLM	Bureau of Land Management
CAL FIRE	California Department of Forestry and Fire Protection
CBMWD	Chino Basin Municipal Water District
CBWM	Chino Basin Watermaster
CCWF	Chino Creek Well Field
CDA	Chino Basin Desalter Authority
CDFM	Cumulative Departure from the Mean
CEQA	California Environmental Quality Act
Chino Basin	Chino Groundwater Basin
CIMIS	California Irrigation Management Information System
DBH	Diameter at Breast Height
FD	Fusarium Dieback
ft-bgs	feet below ground surface
FRAP	Fire and Resource Assessment Program
GIS	Geographic Information System
GMP	Groundwater Monitoring Program
HCMP	Hydraulic Control Monitoring Program
IEUA	Inland Empire Utilities Agency
LEDAPS	Landsat Ecosystem Disturbance Adaptive Processing System
mgl	milligrams per liter
mi^2	square miles

Acronyms, Abbreviations, and Initialisms (cont'd)

MWD	Metropolitan Water District of Southern California
NDVI	Normalized Difference Vegetation Index
NASA	National Aeronautics and Space Administration
NEXRAD	Next Generation Radar
NPS	National Park Service
OBMP	Optimum Basin Management Program
OC-59	The OCWD's imported water turnout tributary to Prado Basin
OCWD	Orange County Water District
Parties	Parties to the Chino Basin Judgment
PBHSC	Prado Basin Habitat Sustainability Committee
PBHSP	Prado Basin Habitat Sustainability Program
POTWs	Publicly Owned Treatment Works
Prado Basin	Prado Basin Management Zone
PSHB	Polyphagous Shot Hole Borer - *Euwallacea fornicates*
QA/QC	Quality Assurance and Quality Control
RHMP	Riparian Habitat Monitoring Program
SAWA	Santa Ana Watershed Association
SARCUP	Santa Ana River Conjunctive Use Program
SCL	Scan Line Detector
SEIR	Subsequent Environmental Impact Report
SWMP	Surface-Water Monitoring Program
TDS	Total Dissolved Solids
USBR	United States Bureau of Reclamation
UCSB	University of California Santa Barbara
USGS	United States Geological Survey
USDA	United State Department of Agriculture

Acronyms, Abbreviations, and Initialisms (cont'd)

USFWS	United States Fish and Wildlife Service
VOCs	Volatile Organic Compounds
Watermaster	Chino Basin Watermaster
WEI	Wildermuth Environmental Inc.
WRCRWA	Western Riverside County Regional Wastewater Authority
WY	Water Year

Section 1 – Background and Objectives

This *Annual Report of the Prado Basin Habitat Sustainability Committee for Water Year 2019* (Annual Report) was prepared on behalf of the Prado Basin Habitat Sustainability Committee (PBHSC), convened by the Inland Empire Utilities Agency (IEUA) and the Chino Basin Watermaster (Watermaster) pursuant to the mitigation monitoring and reporting requirements of the Peace II Subsequent Environmental Impact Report (SEIR) (Tom Dodson, 2010).

This introductory section provides background on the general hydrologic setting of the Prado Basin; the Chino Basin Judgment; the Optimum Basin Management Program (OBMP), its Programmatic EIR, and the Peace Agreement; the Peace II Agreement and its Subsequent EIR; and the formation of the PBHSC and the development of the adaptive management plan (AMP) for the Prado Basin Habitat Sustainability Program (PBHSP).

1.1 Prado Basin

The Prado Basin is the flood control area behind Prado Dam, which was constructed in 1941 as the major flood-control facility within the Santa Ana River Watershed. The US Army Corps of Engineers (ACOE) regulates releases of water from Prado Dam for both purposes of flood control and groundwater recharge in Orange County. Releases of water temporarily held in storage in the Prado Basin for groundwater recharge in Orange County is coordinated with the Orange County Water District (OCWD). Figure 1-1 shows the location of the Prado Basin in the southern portion of the Chino Groundwater Basin (Chino Basin). The Prado Basin boundary shown on Figure 1-1 is the Prado Basin Management Zone boundary as defined in the Santa Ana Region Basin Plan (Regional Board, 2016), which approximately follows the 566 feet above mean sea level (ft-amsl) elevation contour behind Prado Dam.

Approximately 4,300 acres of riparian habitat have developed within the Prado Basin, creating the largest riparian habitat in Southern California. Portions of the riparian habitat have been designated as critical habitat to several endangered or threatened species. Figure 1-2 shows the locations of the critical habitat, as defined by the US Fish and Wildlife Service (USFWS). Most of the riparian habitat in Prado Basin is designated as critical habitat for one or multiple species, including the Santa Ana Sucker, the Southwestern Willow Flycatcher, and Least Bell's Vireo.

The Santa Ana River (SAR) flows through the Prado Basin from east to west. The tributaries of the SAR that flow into the Prado Basin include San Antonio/Chino, Cucamonga/Mill, and Temescal Creeks. The major components of flow within the SAR and its tributaries are: runoff from precipitation, discharge of tertiary-treated effluent from wastewater treatment plants, rising groundwater, discharge of untreated imported water from the OC-59 turnout conveyed through the Prado Basin for groundwater recharge in Orange County, and dry-weather runoff.[1]

[1] Dry-weather runoff consists of excess irrigation runoff, purging of wells, dewatering discharges, etc.

The Prado Basin is a hydrologically complex region of the lower Chino Basin. Groundwater in the Chino Basin generally flows from the forebay regions in the north towards the Prado Basin in the south. Depth to groundwater is relatively shallow in the Prado Basin area, and the SAR and its tributaries are unlined across the Prado Basin, which allows for groundwater/surface-water interaction. Groundwater outflows in the Prado Basin occur via evapotranspiration by riparian vegetation and rising-groundwater discharge to the SAR and its tributaries.

To the north of the Prado Basin, the Chino Basin Desalter Authority (CDA) owns and operates a municipal well field. Figure 1-1 shows the locations of existing CDA wells. The well field pumps groundwater with high concentrations of total dissolved solids (TDS), nitrate, and volatile organic compounds (VOCs). The CDA treats the groundwater at two regional facilities using reverse osmosis, ion exchange, and blending to produce a potable water supply for the region. VOCs are currently treated through blending, and new treatment processes are being added to increase their removal. CDA operations are fundamental to achieving many of the management goals outlined in the OBMP and both Peace Agreements, which are discussed below.

1.2 Chino Basin Judgment, OBMP, and Peace Agreement

A 1978 Judgment entered in the Superior Court of the State of California for the County of San Bernardino (Chino Basin Municipal Water District vs. City of Chino et al.) established pumping and storage rights in the Chino Basin. The Judgment established the Chino Basin Watermaster to oversee the implementation of the Judgment and provided Watermaster with the discretionary authority to develop an OBMP to maximize the beneficial use of the Chino Basin. The OBMP was developed by Watermaster and the parties to the Judgment (Parties) in the late 1990s (WEI, 1999). The OBMP maps a strategy to enhance the yield of the Chino Basin and provide reliable high-quality water supplies for the development expected to occur in the region. The goals of the OBMP are: to enhance basin water supplies, to protect and enhance water quality, to enhance the management of the Basin, and to equitably finance the OBMP.

In 2000, the Parties executed the Peace Agreement (Watermaster, 2000), which documented their intent to implement the OBMP. The Peace Agreement included an OBMP Implementation Plan, which outlined the time frames for implementing tasks and projects in accordance with the Peace Agreement and the OBMP. The OBMP Implementation Plan is a comprehensive, long-range water-management plan for the Chino Basin and includes: the use of recycled water for direct reuse and artificial recharge, the capture of increased quantities of high-quality storm-water runoff, the recharge of imported water when TDS concentrations are low, the desalting of poor-quality groundwater in impaired areas of the basin, the support of regulatory efforts to improve water quality in the basin, subsidence management, storage management, and the implementation of management activities to reduce the discharge of high-TDS/high-nitrate groundwater to the SAR, thus ensuring the protection of downstream beneficial uses in Orange County.

The Chino Basin Municipal Water District (CBMWD) was the plaintiff in the legal action that resulted in the Judgment. The CBMWD was formed in 1950 to supply supplemental, imported water purchased from the Metropolitan Water District of Southern California (MWD) to the Chino Basin. On July 1, 1998, the CBMWD changed its name to the IEUA and expanded its role to become the regional supplier of recycled water for most of the Chino Basin. For OBMP implementation, the IEUA has served as the lead agency for compliance with the California Environmental Quality Act (CEQA). A Program Environmental Impact Report for the OBMP (SCH#2000041047) was certified by the IEUA in July 2000 (Tom Dodson, 2000).

1.3 The Peace II Agreement and its Subsequent EIR

To further implement the goals and objectives of the OBMP, the Parties executed the Peace II Agreement in 2007, which modified the OBMP Implementation Plan (Watermaster, 2007). The two main activities of the Peace II Agreement are: (i) increasing the controlled overdraft of the Chino Basin, as defined in the Judgment,[2] by 400,000 acre-feet (af) through 2030 (re-operation), and (ii) refining the planned expansion facilities of the Chino Basin Desalter program from about 30,000 to 40,000 acre-feet per year (afy) of groundwater production. Re-operation is allocated specifically to offset the production of the Chino Basin Desalters. Both re-operation and desalter expansion contribute to the attainment of "hydraulic control" of groundwater outflow from the Chino Basin to the SAR. The attainment and maintenance of hydraulic control is a requirement of Watermaster and the IEUA, as defined in the Water Quality Control Plan for the Santa Ana River Basin (California Regional Water Quality Control Board, Santa Ana Region, 2008). Hydraulic control ensures that the water management activities in the Chino Basin will not impair the beneficial uses designated for SAR water quality downstream of Prado Dam.

The expansion of the Chino Basin Desalters, described in the Peace II Agreement, was accomplished, in part, by the construction and operation of the Chino Creek Well Field (CCWF) in the southwest portion of Chino Basin (see Figure 1-3). During Peace II Agreement planning, the estimated capacity of the CCWF was about 5,000 to 7,700 afy (WEI, 2007). The CCWF wells were constructed in 2011-2012, and their actual capacity is about 1,500 afy.

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[2] The Judgment established 200,000 AF of controlled overdraft over the period of 1978 to 2017. Re-operation increases the controlled overdraft to 600,000 acre-ft through 2030.

In 2010, the IEUA certified the Peace II SEIR (Tom Dodson, 2010) to evaluate the environmental impacts that could result from implementing the Peace II Agreement. One of the potential impacts evaluated was the possible lowering of groundwater levels (drawdown) in the Prado Basin area, which could impact riparian vegetation that is dependent upon shallow groundwater. Watermaster performed modeling studies to predict the extent and magnitude of the drawdown associated with the implementation of the Peace II Agreement, using the planned capacity of 7,700 afy of the CCWF (WEI, 2007). Figure 1-3 (modified from Figure 4.4-10 from the Peace II SEIR) shows the model-predicted drawdown in the Prado Basin area for the period of 2005 to 2030. The drawdown throughout most of the Prado Basin area was predicted to be less than five feet by 2030.

Although the available modeling work indicated that implementing the Peace II Agreement would not cause significant adverse effects on Prado Basin riparian habitat, a contingency measure to address the potential for drawdown of groundwater levels and its impact on riparian vegetation was included in the Peace II SEIR as Mitigation Measure 4.4-3 (Biological Resources/Land Use & Planning section of the Mitigation Monitoring and Reporting Program).

Mitigation Measure 4.4-3 was developed to ensure that the riparian habitat will not incur unforeseeable significant adverse effects from the Peace II implementation and to contribute to the long-term sustainability of the riparian habitat. Mitigation Measure 4.4-3 calls for:

1. Watermaster, the IEUA, the OCWD, and other stakeholders that choose to participate to jointly fund the development of an adaptive management program to monitor the extent and quality of the Prado Basin riparian habitat and investigate and identify essential factors to its long-term sustainability.

2. Watermaster and the IEUA to convene the PBHSC, comprised of representatives from all interested parties to implement the adaptive management program.

3. The PBHSC to prepare annual reports pursuant the adaptive management program. Annual reports are to include recommendations for ongoing monitoring and any adaptive management actions required to mitigate any measured or prospective loss of riparian habitat resulting from Peace II activities.

1.4 Adaptive Management Plan for the PBHSP

Pursuant to Mitigation Measure 4.4-3 in the SEIR, Watermaster and the IEUA convened four meetings of the PBHSC, starting in late-2012, to develop the adaptive management plan for the PBHSP and facilitate its implementation. Watermaster and the IEUA adopted the final *2016 Adaptive Management Plan for the Prado Basin Habitat Sustainability Program* (AMP) in August 2016 (WEI, 2016).

The AMP was designed to answer the following questions to satisfy the monitoring and mitigation requirements of the Peace II SEIR:

1. *What are the factors that potentially can affect the extent and quality of the riparian habitat?*

2. *What is a consistent, quantifiable definition of "riparian habitat quality," including metrics and measurement criteria?*
3. *What has been the historical extent and quality of the riparian habitat in the Prado Basin?*
4. *How has the extent and quality of the riparian habitat changed during implementation of Peace II?*
5. *How have groundwater levels and quality, surface-water discharge, weather, and climate changed over time? What were the causes of the changes? And, did those changes result in an adverse impact to riparian habitat in the Prado Basin?*
6. *Are there other factors besides groundwater levels, surface-water discharge, weather, and climate that affect riparian habitat in the Prado Basin? What are those factors? And, did they (or do they) result in an adverse impact to riparian habitat in the Prado Basin?*
7. *Are the factors that result in an adverse impact to riparian habitat in the Prado Basin related to Peace II implementation?*
8. *Are there areas of prospective loss of riparian habitat that may be attributable to the Peace II Agreement?*
9. *What are the potential mitigation actions that can be implemented if Peace II implementation results in an adverse impact to the riparian habitat?*

The AMP outlines a process for monitoring, modeling, and annual reporting to answer and address the questions listed above. Appendix A to the AMP is the initial monitoring program: *2016 Monitoring Program for the Prado Basin Habitat Sustainability Program*. Annual reports are intended to document: monitoring and modeling activities, the analysis and interpretation of the monitoring and modeling results, and recommendations for changes to the PBHSP, which may include monitoring, modeling, and/or mitigation, if deemed necessary. Any future mitigation measures that are deemed necessary will be developed jointly by Watermaster and the IEUA.

1.5 Annual Report Organization

This Annual Report for water year (WY) 2019 is the fourth annual report of the PBHSC. It documents the collection, analysis, and interpretations of the data and information generated by the PSHSP through September 30, 2019 and is organized into the following sections:

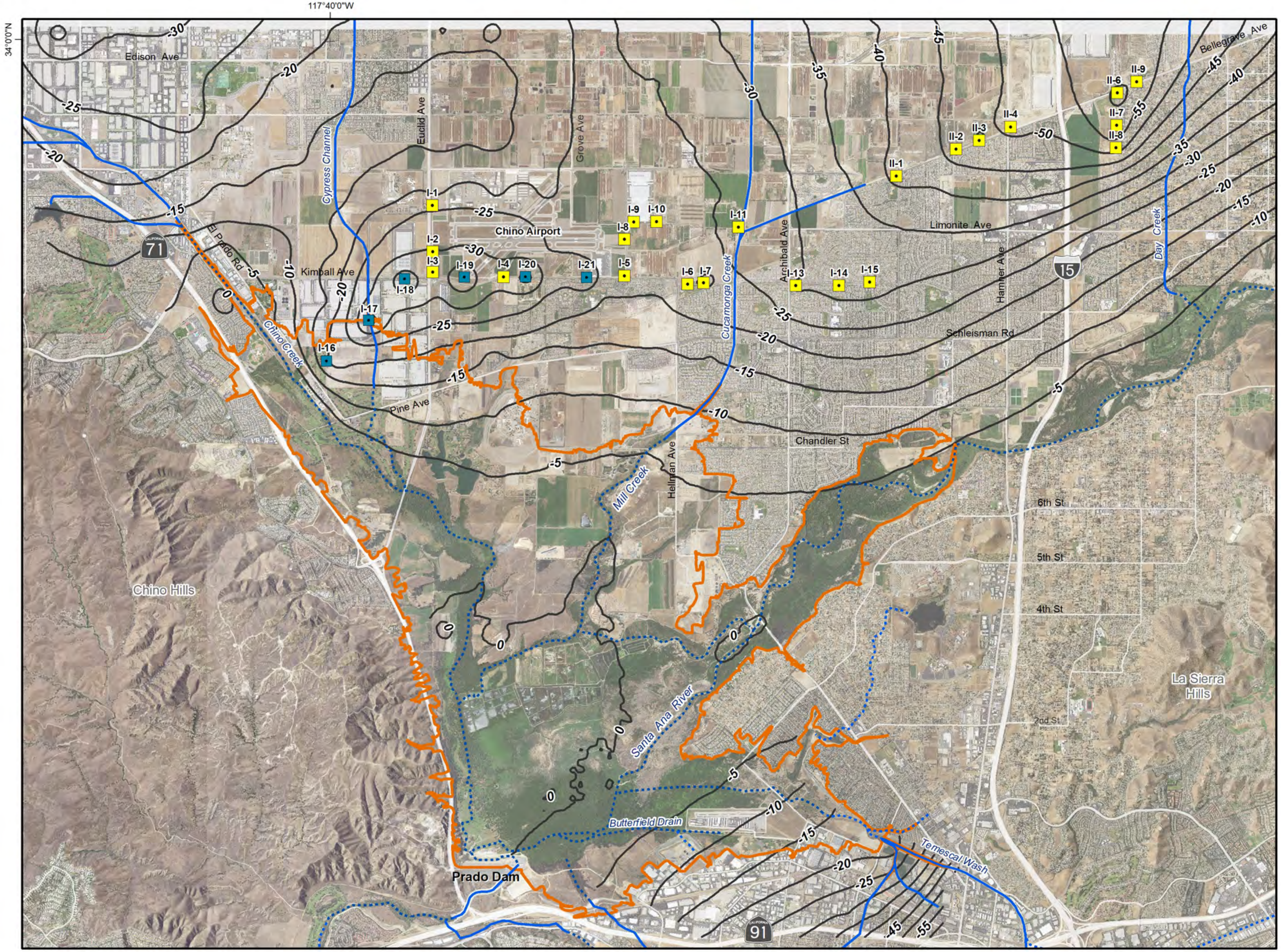
Section 1 – Introduction. This section describes the background and objectives of the PBHSP and the Annual Report.

Section 2 – Monitoring, Data Collection, and Methods. This section describes the collection of historical information and recent monitoring data and describes the groundwater-modeling activities performed during WY 2019 for the PBHSP.

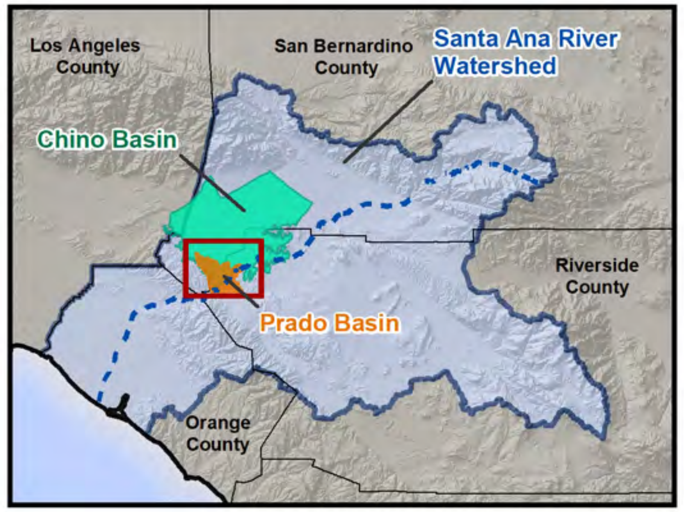
Section 3 – Results and Interpretations. This section describes the results and interpretations that were derived from the information, data, and groundwater-modeling.

Section 4 – Conclusions and Recommendations. This section summarizes the main conclusions derived from the PBHSP through the prior water year and describes the recommended activities for the subsequent fiscal year as a proposed scope-of-work, schedule, and budget.

Section 5 – References. This section lists the publications cited in the report.



Aerial Photo: USDA, 2016. Mosaic of photos from June 2, 2016 to June14, 2016



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: VMW
Date: 4/9/2020
File: Figure 1-3_PeaceII Model

0 1 2 Miles
0 1 2 3 Kilometers

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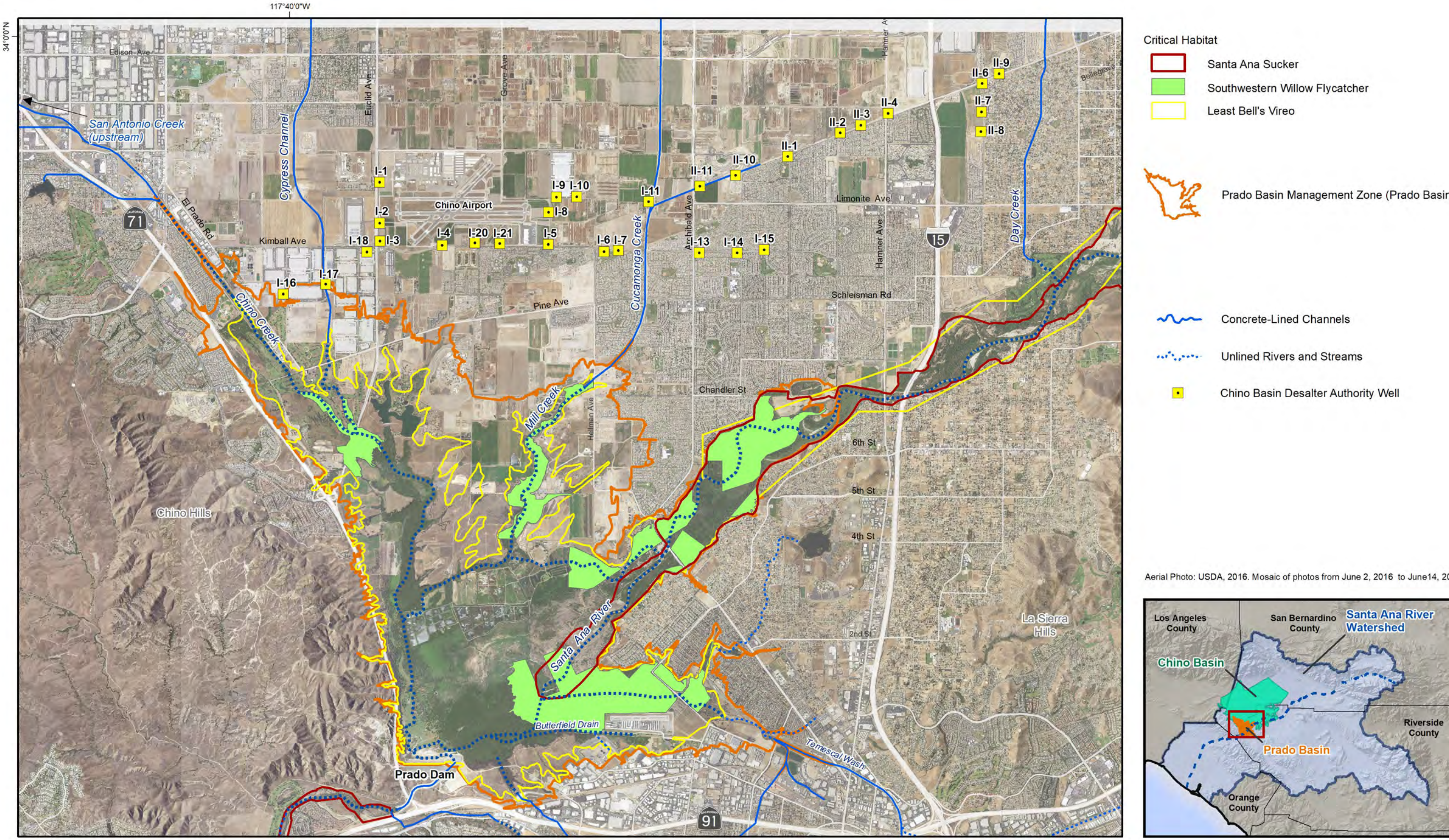
Projected Change in Groundwater-Levels

FY 2005 to 2030 -- Peace II Alternative

Figure 1-3



Prepared by:

Wildermuth Environmental, Inc.

Author: VMW
Date: 4/20/2020
File: Figure 1-2

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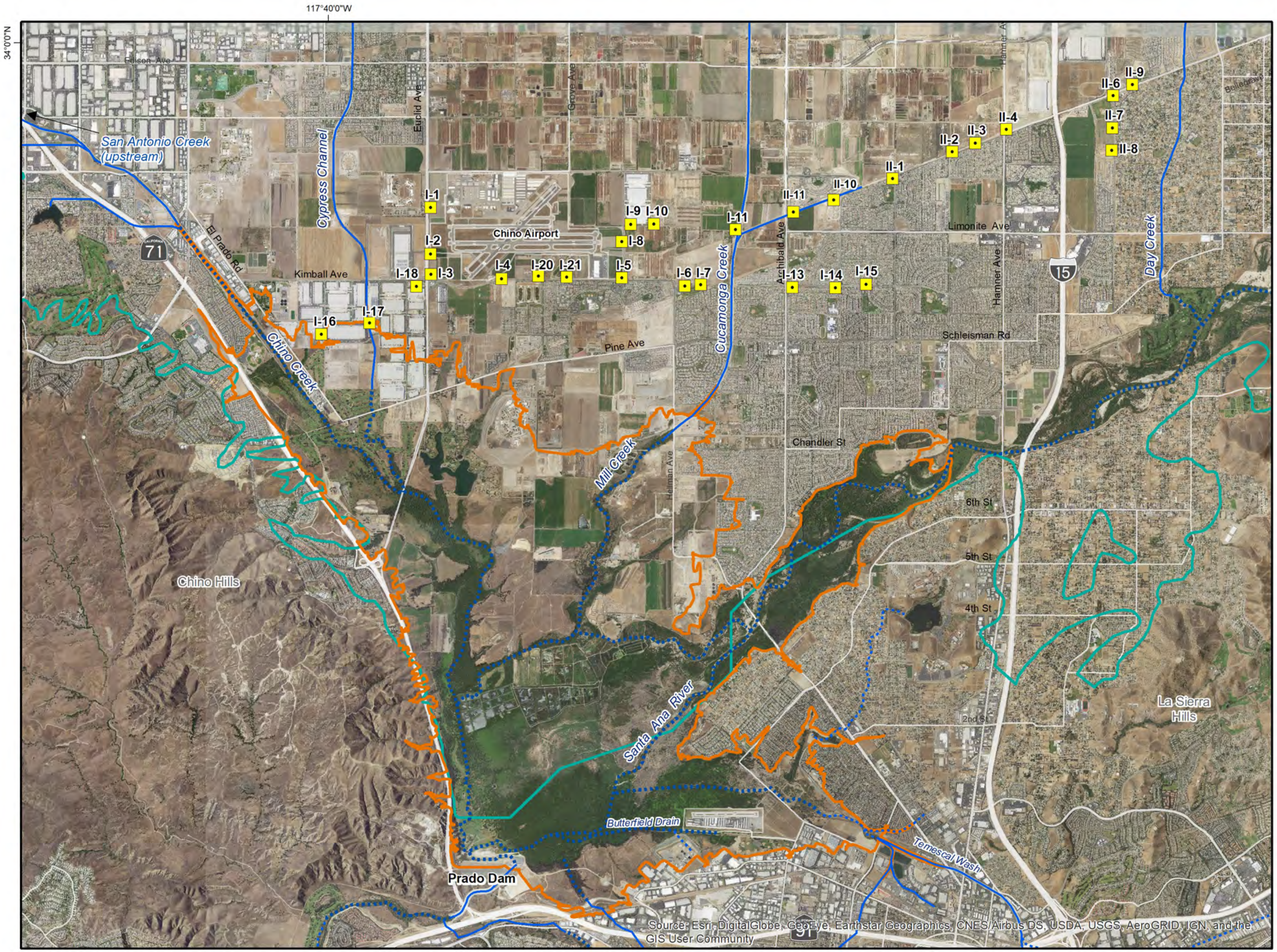
Critical Habitat for Endangered or Threatened Species in the Prado Basin Area

Figure 1-2



Prado Basin Management Zone (Prado Basin) - as defined in the Santa Ana Region Basin Plan (Regional Board, 2016) which approximately follows the 566 feet above mean sea level elevation contour in the flood control area behind Prado Dam.

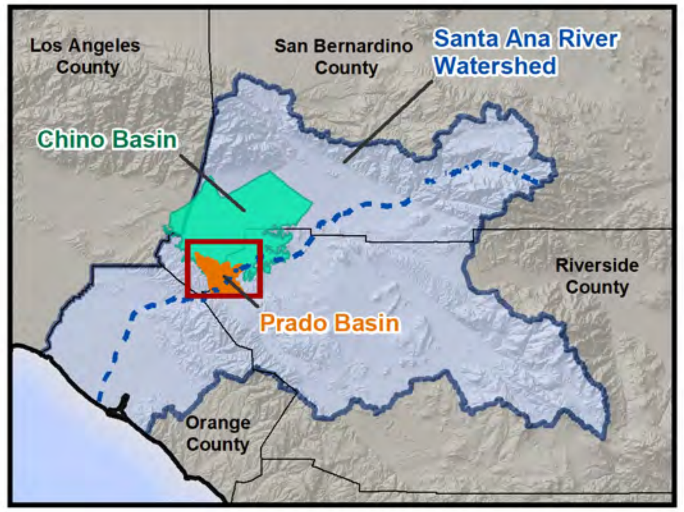
Hydrologic Boundary of the Chino Groundwater Basin (Chino Basin)

Concrete-Lined Channels

Unlined Rivers and Streams

Chino Basin Desalter Authority Well

Aerial Photo: USDA, 2016. Mosaic of photos from June 2, 2016 to June14, 2016



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: VMW
Date: 4/8/2020
File: Figure 1-1

0 1 2 Miles

0 1 2 3 Kilometers

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Prado Basin Area

Figure 1-1

Section 2 – Monitoring, Data Collection, and Methods

The PBHSP was designed, in part, to answer Question 1 from the AMP:

1. *What are the factors that potentially can affect the extent and quality of the riparian habitat?*

The main hydrologic factors that can potentially affect the extent and quality of the riparian habitat in the Prado Basin include, but are not limited to, groundwater levels, surface-water discharge, weather events, and long-term climate. As such, the PBHSP includes integrated monitoring and analysis programs for riparian habitat, groundwater, surface water, climate, and other potential factors (e.g. wildfire, pests, etc.).

Since the implementation of the AMP in WY 2016, data collection efforts included the compilation of historical data through present. The period of data available for each data type varies, but all span both pre- and post-Peace II implementation. Data collection efforts for historical data were described in the first two annual reports for WY 2016 and WY 2017. Data collection efforts for subsequent water years have focused on recent water year monitoring data. All data collected and compiled for this effort were uploaded to Watermaster's centralized relational database, HydroDaVE^{SM}, and used in the analyses.

This section describes the collection of recent monitoring data and the groundwater-modeling activities performed for the PBHSP during WY 2019.

2.1 Riparian Habitat Monitoring

The objective of the Riparian Habitat Monitoring Program (RHMP) is to collect data to help answer questions 2, 3, and 4 from the AMP:

2. *What is a consistent quantifiable definition of "riparian habitat quality," including metrics and measurement criteria?*
3. *What has been the historical extent and quality of the riparian habitat in the Prado Basin?*
4. *How has the extent and quality of the riparian habitat changed during the implementation of Peace II?*

To answer these questions, the RHMP includes time series data and information on the extent and quality of riparian habitat in the Prado Basin over a historical period, including both pre- and post-Peace II implementation.

Figure 2-1 displays the features of the RHMP. Two types of monitoring and assessment are performed: regional and site-specific. Regional monitoring and assessment is appropriate because the main potential stress associated with Peace II activities is the regional drawdown of groundwater levels. The intent of site-specific monitoring and assessment is to verify and complement the results of regional monitoring.

2.1.1 Regional Monitoring of Riparian Habitat

Regional monitoring and assessment of the riparian habitat is performed by mapping the extent and quality of riparian habitat over time using: (i) multi-spectral remote-sensing data and (ii) air photos.

2.1.1.1 Multi-Spectral Remote Sensing Data

The Normalized Difference Vegetation Index (NDVI), derived from remote sensing measurements by Landsat Program satellites, is used to assess the extent and quality of the riparian vegetation in the Prado Basin over a long-term historical period. NDVI is a commonly used numerical indicator of vegetation health that can be calculated from satellite remote-sensing measurements (Ke et al., 2015; Xue, J. and Su, B., 2017). NDVI is calculated from visible and near-infrared radiation reflected by vegetation, is an index of greenness correlated with photosynthesis, and can be used to assess spatial and temporal changes in the distribution and productivity of vegetation (Pettorelli, 2013). Appendix A provides background information on NDVI, explains why NDVI was chosen as an analytical tool for the PBHSP, discusses its advantages and limitations, and describes how NDVI estimates were used for the PBHSP.

For the current reporting period, NDVI estimates were collected from the USGS using the Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA) On Demand Interface[3] (USGS, 2017b) over the period November 2018 through October 2019 to span the entire growing-season period (March-October 2019). To obtain complete spatial coverage of the Prado Basin area, NDVI estimates were requested for all Landsat scenes for Path 040, Rows 036 and 037 from the Landsat 7 and Landsat 8 satellites. The NDVI were processed and uploaded to Watermaster's centralized relational database, HydroDaVE^{SM}, which includes tools to manage, review, and extract NDVI estimates. The frequency of NDVI estimates from the Landsat 7 and 8 satellites is about every eight days. However, not all NDVI estimates are useable due to disturbances that can be caused by cloud cover, unfavorable atmospheric conditions, or satellite equipment malfunction. NDVI estimates were reviewed for these disturbances and excluded from analysis if they were determined erroneous. Appendix A describes the how the NDVI estimates were collected, reviewed, and assembled for the PBHSP.

[3] https://espa.cr.usgs.gov/login?next=https%3A%2F%2Fespa.cr.usgs.gov%2F

2.1.1.4 Collection and Analysis of Air Photos

Georeferenced air photos are used to visually characterize the spatial extent and quality of the riparian habitat in the Prado Basin. The air photos also serve as an independent check on interpretations of NDVI, which involves visual comparison of the extent and density of the riparian habitat, as shown in the air photos, to the NDVI maps. For ongoing monitoring, a high-resolution (3-inch pixel) image of the visible spectrum for the entire Prado Basin is acquired at the approximate peak of each growing season, typically in July.

For the current reporting period, the acquisition of the 2019 air photo included a custom flight that was performed by Digital Mapping Inc. on July 4 and 5, 2019. The cost to acquire the 2019 air photo was shared with the OCWD. This was the third annual high-resolution air photo acquired for the PBHSP.

2.1.2 Site-Specific Monitoring of Riparian Habitat

The objective of the site-specific monitoring of riparian habitat is to collect data that can be used to ground-truth the interpretations derived from the regional monitoring and assessment of the riparian habitat (Pettorelli, 2013). Prior to the implementation of the AMP, site-specific monitoring performed in the Prado Basin included vegetation surveys performed by the USBR in 2007 and 2013 (USBR, 2008b; 2015). Since the implementation of the AMP, the USBR conducted vegetation surveys for the PBHSP in 2016 and 2019. The USBR vegetation surveys performed for the PBHSP in 2016 and 2019 consist of 37 sites in the Prado Basin: 24 previously established USBR sites during the 2007 and 2013 sampling and 14 new sites established in 2016 that are primarily located near the PBHSP monitoring wells.

During this reporting period, the USBR conducted vegetation surveys in September 2019. Details of the 2019 USBR surveys are described in the USBR's 2019 Prado Basin Vegetation Survey – September 2019 vegetation survey report (USBR, 2020) and in Section 3.1.3.

The OCWD performs site-specific monitoring in the southern portion of Prado Basin to monitor for effects of the operation of Prado Dam on riparian habitat. OCWD site-specific monitoring includes: seasonal monitoring at nine canopy photo stations located along the edge of Prado Basin, seasonal monitoring at 10 understory photo stations within different surface elevations of the inundation zone behind the dam, 40 stacked-cube monitoring sites monitored in the spring and summer throughout different surface elevation ranges of the inundation zone, and 40 stacked-cube monitoring sites in Least Bell's Vireo nesting and territory locations in the riparian habitat. The most recent OCWD results performed during this reporting period are described in the *Prado Basin Water Conservation and Habitat Assessment 2018-2019* report (OCWD, 2020).

Figure 2-1 shows the locations of the USBR vegetation surveys and the OCWD photo and stacked-cube monitoring sites.

2.2 Factors that Potentially Affect the Riparian Habitat

The main factors that can potentially affect riparian habitat in Prado Basin include, but are not limited to: groundwater levels, surface-water discharge, weather/climate, wildfires, and pests.

This section describes the methods employed to collect and analyze information on these factors to help answer questions 5, 6, and 7 from the AMP:

5. *How have groundwater levels and quality, surface-water discharge, weather, and climate changed over time? What were the causes of the changes? And, did those changes result in an adverse impact to riparian habitat in the Prado Basin?*

6. *Are there other factors besides groundwater levels, surface-water discharge, weather, and climate that affect riparian habitat in the Prado Basin? What are those factors? And, did they (or do they) result in an adverse impact to riparian habitat in the Prado Basin?*

7. *Are the factors that result in an adverse impact to riparian habitat in the Prado Basin related to Peace II implementation?*

2.2.1 Groundwater Monitoring Program

A primary result of implementation of the Peace II Agreement is the lowering of groundwater levels (drawdown) in the southern portion of Chino Basin. Hence, drawdown is a factor that is potentially related to Peace II implementation and could adversely impact riparian habitat.

The Groundwater Monitoring Program (GMP) includes the collection of three types of data: groundwater production, groundwater level, and groundwater quality. Watermaster has been implementing a groundwater monitoring program across the entire Chino Basin to support various basin management initiatives and activities, and all data within Watermaster's centralized relational database are available to the GMP.

Watermaster's groundwater monitoring network was expanded in 2015 specifically for the PBHSP with the construction of 16 new monitoring wells at nine sites located along the fringes of the riparian habitat and between the riparian habitat and the CDA well field. These wells, along with two existing monitoring wells, HCMP-5/1 and RP2-MW3, are specifically monitored for the PBHSP and are called the "PBHSP monitoring wells."

Figure 2-2 shows the extent of the study area for which the GMP data are compiled and used for the PBHSP. The area covers the Prado Basin and the upgradient areas to the north that encompass the CDA well field. Figure 2-2 also shows the wells in the study area where groundwater data were available in WY 2019.

2.2.1.1 Groundwater Production

Groundwater production influences groundwater levels and groundwater-flow patterns. Groundwater-production data are analyzed together with groundwater-level data to characterize the influence of groundwater production on groundwater levels. Groundwater-production data are also used as an input to the Chino Basin groundwater-flow model to evaluate past and future conditions in the Chino Basin, which, for the PBHSP, supports the analysis of prospective losses of riparian habitat (see Section 2.3).

Watermaster collects quarterly groundwater-production data for all active production wells within the Chino Basin. The data are checked for quality assurance and quality control (QA/QC) and uploaded to Watermaster's centralized relational database. The active production wells within the study area include CDA wells and privately owned wells used for agricultural, dairy, or domestic purposes.

During WY 2019, Watermaster collected groundwater-production data at about 100 wells in the GMP study area.

2.2.1.2 Groundwater Level

Monitoring groundwater levels in the Prado Basin is a key component of the PBHSP, as the potential for declining groundwater levels related to Peace II implementation could be a factor that adversely impacts riparian habitat. Groundwater-level data are analyzed together with production data to characterize how groundwater levels have changed over time in the GMP study area and to explore the relationship(s) to any observed changes that occurred in the extent and quality of the riparian habitat. Groundwater-level and production data are also used as input to the Chino Basin groundwater flow model to evaluate past and future conditions in the Chino Basin, which, for the PBHSP, supports the analysis of prospective losses of riparian habitat (see Section 2.3).

Watermaster collects groundwater-level data at various frequencies at wells in the GMP study area to support various groundwater-management initiatives. The data are checked for QA/QC and uploaded to Watermaster's centralized relational database.

During WY 2019, Watermaster collected groundwater-level data from 241 wells in the study area (see Figure 2-2). At 121 of these wells, water levels were measured by well owners at varying frequencies and provided to Watermaster. The remaining 120 wells are CDA wells, dedicated monitoring wells, or private wells that are monitored by Watermaster using manual methods once per month or with pressure transducers that record water levels once every 15 minutes. Groundwater-levels at the 18 PBHSP monitoring wells have been measured with pressure transducers since May 2015.

2.2.1.3 Groundwater Quality

Water-quality data can be used to understand the various potential sources of shallow groundwater in the Prado Basin. Groundwater-quality data are compared to surface-water-quality data to characterize groundwater/surface-water interactions in the Prado Basin and assess the importance of those interactions to the extent and quality of the riparian habitat.

Watermaster collects groundwater-quality data from wells in the GMP study area to support various groundwater-management initiatives. These data are checked for QA/QC and uploaded to Watermaster's centralized relational database.

During WY 2019, groundwater-quality data were collected from 60 wells in the study area (see Figure 2-2). Of these wells, 124 were sampled by the well owners at varying frequencies. The remaining 36 wells are dedicated monitoring wells or private wells sampled by Watermaster either quarterly, annually, or triennially (every three years).

Watermaster has performed groundwater-quality monitoring at the PBHSP monitoring wells since they were constructed in 2015, and the monitoring program has been tailored to discern the groundwater/surface-water interactions important to the sustainability of the riparian habitat. During WY 2019, Watermaster sampled four of the 18 PBHSP monitoring wells quarterly as part of a pilot monitoring program that was initiated in July 2018. The pilot program is designed to enhance the understanding of groundwater/surface-water interactions in this area. Probes were installed in the four monitoring wells to measure and record EC, temperature, and water levels at a 15-minute frequency. Samples of groundwater were analyzed quarterly for EC, temperature, and the parameters listed in Table 2-1. The same monitoring methods and protocols were performed at nearby surface-water sites in Chino Creek for comparison with the groundwater data. Watermaster conducted the quarterly download of the transducers and collection of the samples at the four PBHSP monitoring wells in December 2018, March 2019, June 2019, and September 2019.

2.2.2 Surface-Water Monitoring Program

Surface-water discharge in the Prado Basin is another factor that can influence the extent and quality of riparian habitat and can influence groundwater levels. Surface-water discharge data are evaluated for the PBHSP to characterize historical and current trends in the discharge of the SAR and its tributaries in the Prado Basin and to explore the relationship(s) to any observed changes that occurred in the extent and quality of the riparian habitat. Surface-water discharge data are also used as input to the Chino Basin groundwater-flow model to evaluate past and future conditions in the Chino Basin, which for the PBHSP, supports the analysis of prospective losses of riparian habitat (see Section 2.3). Surface-water quality is compared to groundwater-quality data to characterize groundwater/surface-water interactions in the Prado Basin and the importance of those interactions to the extent and quality of the riparian habitat.

The surface-water monitoring program for the PBHSP involves collecting existing, publicly available, surface-water discharge and quality data from sites within or tributary to the Prado Basin. Figure 2-3 shows the location of the surface-water monitoring sites used in the PBHSP. These sites include discharge locations for publicly owned treatment works (POTWs), USGS stream gaging stations, Watermaster and IEUA Maximum-Benefit Monitoring Program surface-water-quality monitoring sites, ACOE's storage levels and inflow to Prado Dam, and the OCWD's discharge of untreated imported water from the OC-59 turnout tributary to Prado Basin. All surface-water discharge and quality data were collected for WY 2019, checked for QA/QC, and uploaded to Watermaster's relational database.

As noted in Section 2.2.1.3 above, a pilot monitoring program was initiated July 2018 at two locations along Chino Creek near monitoring wells PB-7 and PB-8 to help characterize groundwater/surface-water interactions. Probes were installed in Chino Creek adjacent to PB-7 and PB-8 to measure and record EC, temperature, and stage at a 15-minute frequency. Surface-water samples were collected and analyzed quarterly for EC, temperature, and the parameters listed in Table 2-1. Watermaster conducted the quarterly download of the transducers and collection of the samples at the surface water sites in December 2018, March 2019, June 2019, and September 2019.

2.2.3 Climatic Monitoring Program

Climatic data are used to characterize how the climate has changed over time in the study area and to explore the relationship(s) to any observed changes that occurred in the extent and quality of the riparian habitat. Climatic data are also used for the Chino Basin groundwater-flow model to evaluate past and future conditions in the Chino Basin, which for the PBHSP, supports the analysis of prospective losses of riparian habitat (see Section 2.3).

The climatic monitoring program for the PBHSP involves collecting existing, publicly available precipitation and temperature data in the vicinity of the Prado Basin. Figure 2-3 shows the location of the stations where data are available and collected for the PBHSP. These sites include monitoring stations for the California Irrigation Management Information System (CIMIS) for temperature data, spatially gridded climate datasets from Next-Generation Radar (NEXRAD), and the PRISM Climate Group for regional precipitation and temperature data. The Chino Basin boundary was used to extract the spatially gridded data for precipitation, and the Prado Basin boundary was used to extract the spatially gridded data for maximum and minimum temperature. Climatic data are collected annually and uploaded to Watermaster's relational database.

2.2.4 Other Factors That Can Affect Riparian Habitat

The AMP recognizes that there are potential factors other than groundwater, surface water, and climate that can affect riparian habitat in the Prado Basin. These factors include, but are not limited to: wildfire, disease, pests, and invasive species. To the extent necessary, data and information on these factors are collected and analyzed to explore for relationships to changes in the extent and quality of the riparian habitat.

In WY 2016, during the analysis for the first Annual Report, two specific factors were identified as potential impacts to the Prado Basin riparian habitat: wildfires and an invasive pest known as the Polyphagous Shot-Hole Borer (*Euwallacea fornicates*; PSHB hereafter). In WY 2018, the removal of the non-native invasive weed *Arundo donax* (arundo) was identified as a factor to impact riparian habitat in the Prado Basin. The following describes the information that was collected for these three factors and how they are used to explore for relationships to changes that have occurred in the extent and quality of riparian habitat.

2.2.4.1 Wildfires

Wildfires occur periodically in the Prado Basin and can reduce the extent and quality of riparian habitat. For the PBHSP, the occurrence and locations of wildfires are used to help understand and explain the trends observed in the extent and quality of the riparian vegetation.

To map the extent of any wildfires that have occurred in the study area, fire-perimeter data were collected from the Fire and Resource Assessment Program (FRAP) of the California Department of Forestry and Fire Protection (CAL FIRE).[4]

For the current reporting period, wildfire data were obtained from the FRAP database for the Prado Basin region for calendar year 2018.[5]

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[4] http://frap.fire.ca.gov/projects/fire_data/fire_perimeters_index

[5] Data for the previous year is available each year in April.

2.2.4.2 Polyphagous Shot-Hole Borer (PSHB)

The PSHB is a beetle that burrows into trees, introducing a fungus (*Fusarium euwallacea*) into the tree bark that spreads the disease Fusarium Dieback (FD).[6,7] FD destroys the food and water conducting systems of the tree, eventually causing stress and tree mortality. The PSHB was first discovered in Southern California in 2003 and has been recorded to have caused branch die-back and tree mortality for various tree specimens throughout the Southern California region (USDA, 2013). The PSHB is an identified pest within the Prado Basin and has the potential to negatively impact riparian habitat vegetation (USBR, 2016; Palenscar, K., personal communication, 2016; McPherson, D., personal communication, 2016).

OCWD biologists in the Prado Basin have been working with the University of California at Riverside, the USFWS, and the Santa Ana Watershed Association (SAWA) to actively monitor the occurrence and impact of PSHB within Prado Basin riparian habitat (Zembal, R., personal communication, 2017). To date, no reports have been prepared by these agencies.

Information on PSHB occurrence in the Prado Basin has been obtained from the University of California, Department of Agriculture and Natural Resources' online PSHB/FD Distribution Map,[8] USBR vegetation surveys of riparian habitat in the Prado Basin, and from the OCWD's PSHB trap deployment and monitoring. For the PBHSP, the occurrences of the PSHB in the Prado Basin are used to help understand and explain the trends observed in the extent and quality of the riparian vegetation. For the current reporting period, PSHB data were collected during the 2019 USBR vegetation surveys in Prado Basin for the PBHSP.

2.2.4.3 Arundo Removal

Non-native arundo is prominent throughout riparian habitat in the Prado Basin. Arundo consumes significantly more water than native plants, can out-compete native vegetation, and is flammable in nature increasing the risk of wildfire. There are several SAR watershed stakeholders that remove arundo in the riparian habitat to restore native habitat to aid in the recovery of the threated and endangered species, such as the Least Bell's Vireo and Santa Ana Sucker. For the PBHSP, the occurrence and locations of habitat restoration activities that include the removal of arundo can help understand and explain trends in the extent and quality of the riparian habitat. The OCWD and Santa Ana Watershed Association (SAWA) in coordination with others, are the main entities in the watershed that implement habitat restoration programs that include removing Arundo.

In WY 2019, information on arundo removal and management activities that have occurred recently in the Prado Basin were obtained to track these programs and explore if there is a connection between these activities and trends observed in the extent and quality of riparian habitat. This effort involved coordinating with the OCWD and SAWA to obtain information on the location and timing of these programs.

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[6] http://ucanr.edu/sites/pshb/

[7] http://cisr.ucr.edu/polyphagous_shot_hole_borer.html

[8] http://ucanr.edu/sites/pshb/Map/

2.3 Prospective Loss of Riparian Habitat

Monitoring and mitigation requirement 4.4-3 in the Peace II SEIR calls for annual reporting for the PBHSP:

> *Annual reports will be prepared and will include recommendations for ongoing monitoring and any adaptive management actions required to mitigate any measured loss or* ***prospective loss*** *of riparian habitat that may be attributable to the Peace II Agreement (emphasis added).*

The meaning of "prospective loss" in this context is "future potential loss" of riparian habitat. Predictive modeling of groundwater levels can be used to answer question 8 from the AMP:

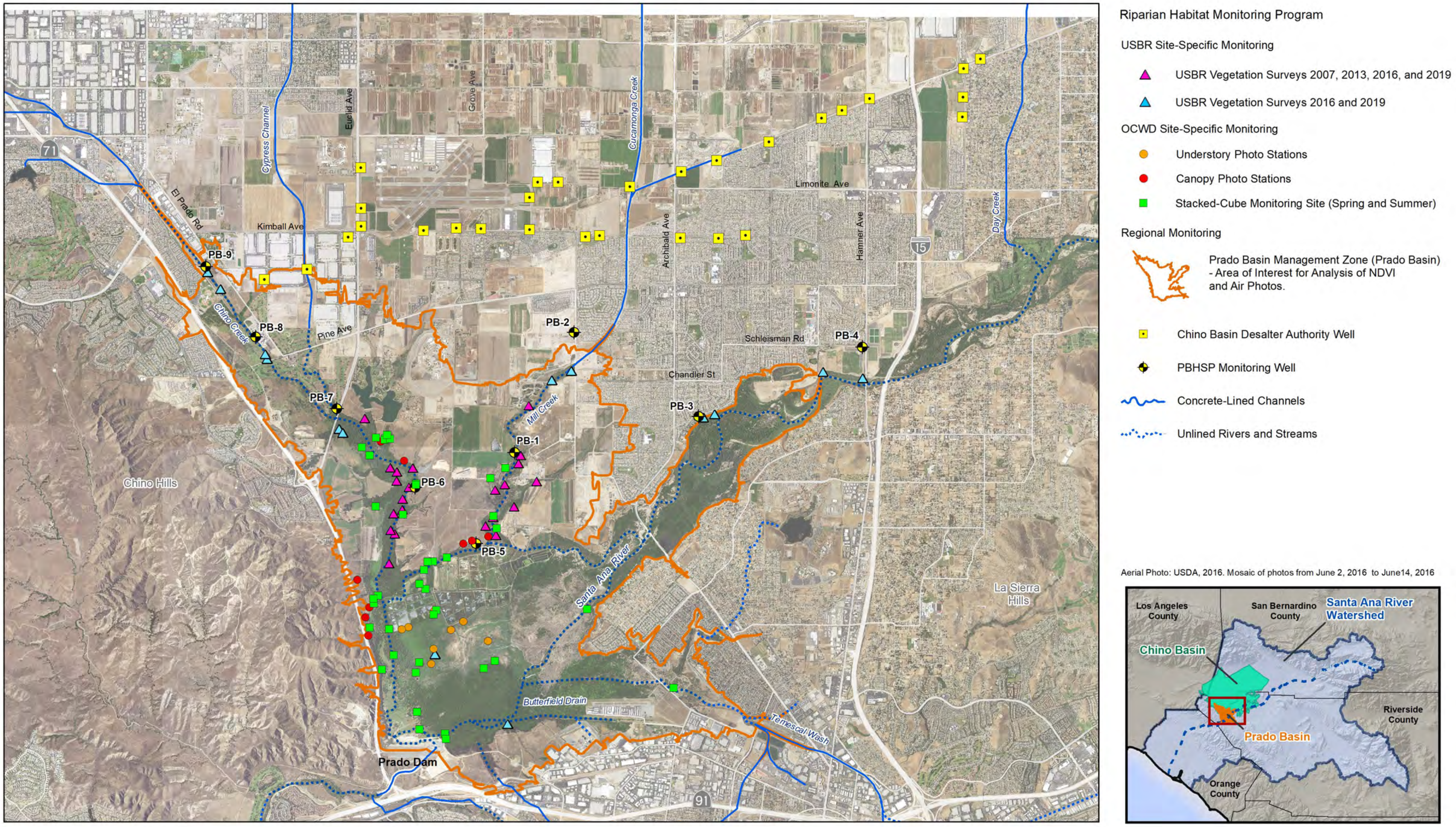
8. *Are there areas of prospective loss of riparian habitat that may be attributable to the Peace II Agreement?*

Watermaster's most recent groundwater-modeling results can be used to evaluate forecasted groundwater-level changes within the Prado Basin under current and projected future conditions in the Basin, including, but not limited to, plans for pumping, storm-water recharge, and supplemental water recharge. To perform this evaluation, the predictive model results are mapped and analyzed to identify areas (if any) where groundwater levels are projected to decline to depths that may negatively impact riparian habitat in the Prado Basin.

For this Annual Report, Watermaster's most recent groundwater model projections were used to characterize future groundwater-level conditions in the PBHSP study area. This model projection was the simulation of planning scenario 2020 SYR1 for the 2020 recalculation of Safe Yield using the updated Chino Basin groundwater-flow model (WEI, 2020).

Table 2-1
Parameter List for the Groundwater and Surface Water Quality Monitoring Program

Chemical Parameter	Method Detection Limit	Method
Alkalinity in CaCO3 units	2 mg/L	SM2320B
Ammonia Nitrogen	0.05 mg/L	EPA 350.1
Bicarbonate as HCO3 *Calculated*	2 mg/L	SM2320B
Calcium Total ICAP	1 mg/L	EPA 200.7
Carbonate as CO3 *Calculated*	2 mg/L	SM2320B
Chloride	1 mg/L	EPA 300.0
Hydroxide as OH *Calculated*	2 mg/L	SM2320B
Magnesium Total ICAP	0.1 mg/L	EPA 200.7
Nitrate as Nitrogen by IC	0.1 mg/L	EPA 300.0
Nitrate as NO3 *Calculated*	0.44 mg/L	EPA 300.0
Nitrite as Nitrogen by IC	0.05 mg/L	EPA 300.0
Nitrate plus Nitrite as Nitrogen *Calculated*	0.1 mg/L	EPA 300.0
PH (H3=past HT not compliant)	0.1 Units	SM4500-HB
Potassium Total ICAP	1 mg/L	EPA 200.7
Silica	0.5 mg/L	EPA 200.7
Sodium Total ICAP	1 mg/L	EPA 200.7
Specific Conductance, 25 C	2 umho/cm	SM2510B
Sulfate	0.5 mg/L	EPA 300.0
Total Dissolved Solids (TDS)	10 mg/L	E160.1/SM2540C
Total Hardness as CaCO3 by ICP *Calculated*	3 mg/L	SM 2340B
Total Organic Carbon	0.3 mg/L	SM5310C/E415.3
Turbidity	0.05 NTU	EPA 180.1



Prepared by:

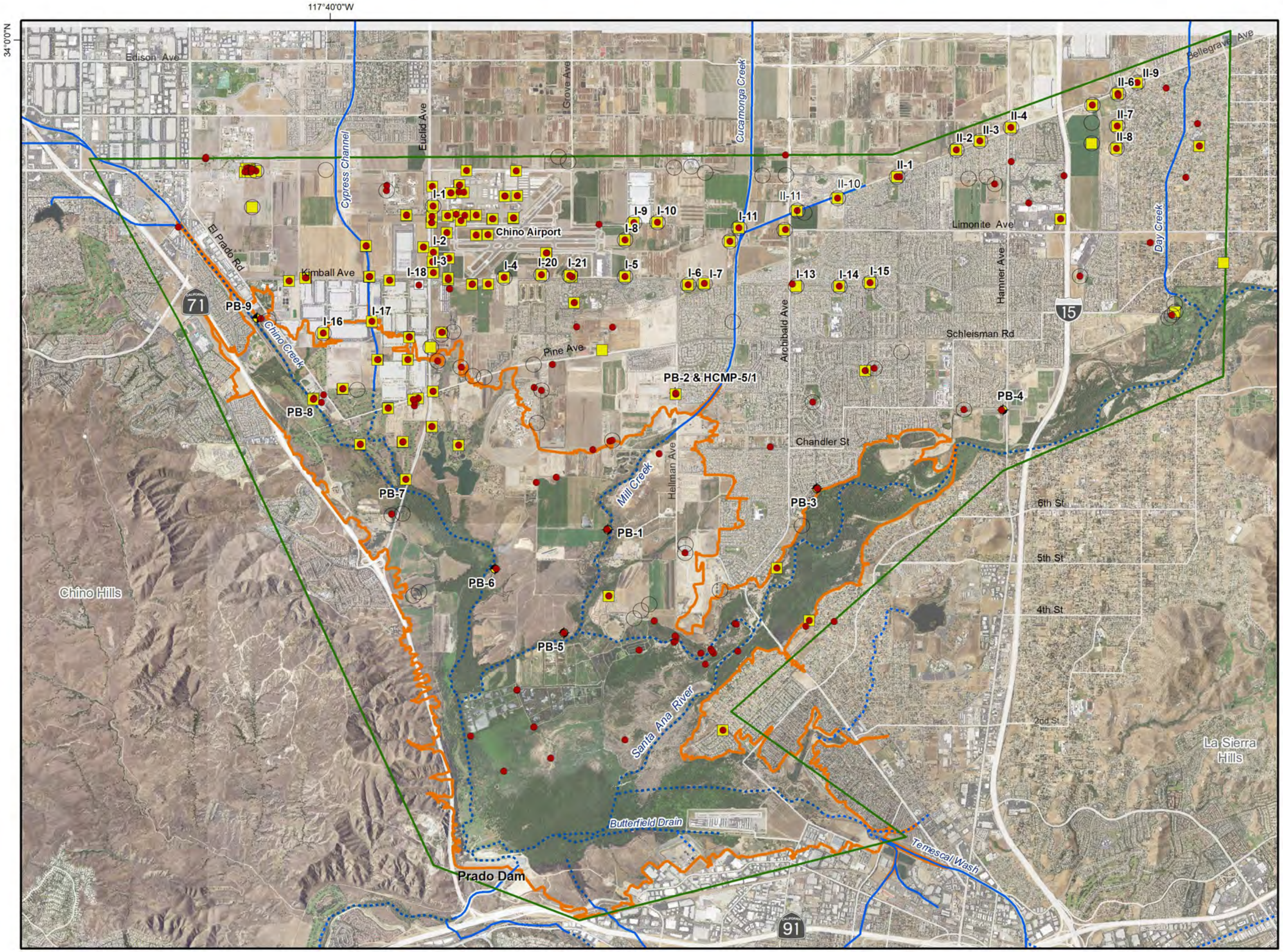
WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: VMW
Date: 4/20/2020
File: Figure 2-1 Veg Monitoring

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Riparian Habitat Monitoring Program

Figure 2-1



Wells with Groundwater Data - Water Year 2019

- Wells with Production Data
- Wells with Water Level Data
- Wells with Water Quality Data

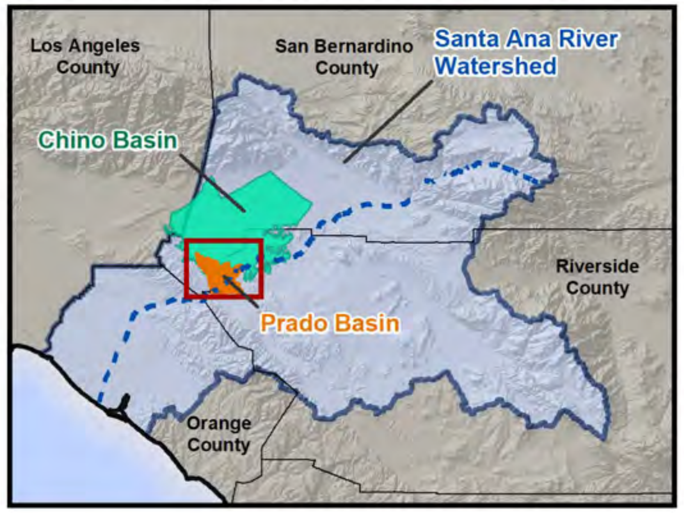
Wells Labeld on the Map:

Chino Basin Desalter Authority Well - Labled with **"I-" or "II"** -

PBHSP Monitoring Well - Labled with **"PB-"** -

- Groundwater Monitoring Program (GMP) Study Area
- Concrete-Lined Channels
- Unlined Rivers and Streams
- Prado Basin Management Zone (Prado Basin)

Aerial Photo: USDA, 2016. Mosaic of photos from June 2, 2016 to June14, 2016



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: VMW
Date: 4/20/2020
File: Figure 2-2_Groundwater Monitoring Program

0 1 2 *Miles*
0 1 2 3 *Kilometers*

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Prado Basin Habitat Sustainability Committee

Groundwater Monitoring Program

Figure 2-2

3.1 Trends in Riparian Habitat Extent and Quality

This section describes the analysis and interpretation of the monitoring data and groundwater-modeling results for the PBHSP. Analyzed data span various historical periods, based on data availability, and include both pre- and post-Peace II implementation (2007).

More specifically, this section describes the trends in the extent and quality of the riparian habitat, describes the trends in factors that can impact the riparian habitat, and evaluates potential cause-and-effect relationships—particularly any cause-and-effect relationships that may be associated with Peace II implementation. The factors that could have potentially impacted the extent and quality of the riparian habitat, including changes in groundwater levels, surface-water discharge, climate, and other factors, such as pests, wildfires, and habitat management activities. Declining groundwater levels is the primary factor that is potentially related to Peace II implementation and could adversely impact the riparian habitat.

This section also includes a review of Watermaster's most recent predictive Chino Basin groundwater modeling results to identify areas of potential future drawdown that could impact the riparian habitat.

3.1.1 Extent of the Riparian Habitat

Figure 3-1a is a times series of historical air photos for 1960, 1977, 1985, 1999, 2006, and 2016 that were analyzed in the first Annual Report (WEI, 2017). This figure illustrates changes in the extent and vegetated density of riparian habitat in the Prado Basin from 1960 to 2016. From the 1930s to about 1960, large areas of the Prado Basin were managed to minimize the growth of riparian vegetation and its associated consumptive use of water in an effort to maximize flow in the SAR (Woodside, G., personal communication, 2017). In general, from 1960 to 1999, the mapped extent of the riparian habitat increased from about 1.8 to 6.7 square miles (mi^2), and its vegetated density increased. Since 1999, the extent and vegetated density of the riparian habitat has remained relatively constant.

Figure 3-1b compares air photos that were acquired for the PBHSP in July 2018 and July 2019. Both of these air photos are high resolution (3-inches pixels), which allows for a side-by-side visual comparison of riparian vegetation extent and quality from 2018 to 2019.

Figure 3-1c compares the 2019 air photo and the mapped extent of the riparian habitat to the NDVI estimates for the Prado Basin area on a date that corresponds to the maximum of the spatial average of NDVI during the growing season for 2019.[9] Four main observations and interpretations are derived from this figure:

[9] The growing season for the Prado Basin riparian vegetation is from March through October (Merkel, 2007; USBR, 2008). The maximum NDVI for the 2019 growing season occurred on July 10, 2019.

1. Generally, the following ranges in NDVI during the growing season correspond to these land cover types:

NDVI	Land Cover During Growing Season
< 0	Water
0 - 0.2	Non-vegetated surfaces, such as urbanized land cover and barren land
0.3 - 1.0	Vegetated land cover: higher NDVI values indicate greater photosynthetic activity

2. Prado Basin riparian vegetation areas have NDVI estimates of about 0.3 to 0.9 during the growing season. Active agricultural lands in the Prado Basin region can also have NDVI values of a similar range during the growing season.
3. The NDVI estimates support the delineation of the extent of the riparian habitat as drawn from the air photos.
4. The consistency of NDVI values to land cover observed in the air photo indicates that the processing of NDVI estimates for this study were performed accurately, which supports subsequent analyses and interpretations.

3.1.2 Quality of the Riparian Habitat

As discussed and referenced in Section 2, NDVI is an indicator of the photosynthetic activity of vegetation and therefore can be used to interpret the health or "quality" of the riparian vegetation. In this section, NDVI is spatially and temporally analyzed in maps and time-series charts for defined areas throughout Prado Basin to characterize changes in the quality of riparian habitat over the period 1984 to 2019.

3.1.2.1 Spatial Analysis of NDVI

Figure 3-2 compares maps of NDVI side by side for the entire Prado Basin area for 2018 and 2019 on the dates that correspond to the maximum growing-season NDVI as a spatial average across the entire extent of the riparian vegetation in the Prado Basin. Figure 3-3 is a map of change in NDVI from 2018 to 2019 that was prepared by subtracting the 2018 NDVI map from the 2019 NDVI map in Figure 3-2. These figures identify areas that may have experienced a recent change in the quality of riparian habitat.

Visual inspection of Figure 3-2 and Figure 3-3 shows notable areas of NDVI increase located along portions of Chino Creek, Mill Creek, and the southwest reach of the SAR below the OCWD wetlands. Inspection of the air photos in Figure 3-1b corroborates the increases NDVI for these areas, showing increased green land cover in these same areas from 2018 to 2019.

These areas showing notable increases in spatial NDVI are similar areas where there were notable declines in NDVI identified during WY 2018 and reported on in the Annual Report (WEI, 2019). NDVI trends will be further analyzed along with factors that can impact riparian habitat in Sections 3.2 through 3.6 of this report.

3.1.2.2 Temporal Analysis of NDVI

NDVI pixels[10] within defined areas throughout the Prado Basin were spatially averaged and temporally analyzed in time-series charts. The defined areas include large and small areas within Prado Basin and are shown in Figure 3-4. The large areas include the entire extent of the riparian habitat in 2018 (6.8 mi^2 - 19,520 NDVI pixels), the extent of the riparian habitat along the upper portion of Chino Creek (0.74 mi^2 – 2,134 NDVI pixels), the extent of the riparian habitat along Mill Creek (0.26 mi^2 - 759 NDVI pixels), and a rectangular region in the lower portion of the Prado Basin (0.23 mi^2 - 677 NDVI pixels). The small areas are located along the northern reaches of the Prado Basin riparian habitat near the PBHSP monitoring wells (all areas are 3,600 square meters—four NDVI pixels).

Figures 3-5 through 3-9k are time-series charts of the NDVI for each of the defined areas. These figures are used to characterize long- and short-term changes in NDVI in specific areas, which provide context for interpreting the trends and changes in NDVI that have been occurring during Peace II implementation, and indicate changes in the quality of riparian habitat. Each figure shows three datasets that illustrate trends in the NDVI estimates:

1. **Spatial Average NDVI** (green dots). Spatial Average NDVI are the spatial average of the NDVI pixels within the defined area. These data characterize the seasonal and long-term trends in NDVI for each defined area. The NDVI exhibit an oscillatory pattern caused by seasonal changes in the riparian habitat. The NDVI time-series are typical for a deciduous forest, where NDVI values are higher in the growing season from March through October and lower in the dormant season from November through February when plants and trees shed their leaves.
2. **Average Growing-Season NDVI** (black squares and black curve). The Average Growing-Season NDVI is the annual average of the Spatial Average NDVI for each growing season from March through October. This curve shows the annual changes and long-term trends in the NDVI for the growing-season. This metric is used to analyze year-to-year changes and long-term trends in NDVI.
3. **Maximum Growing-Season NDVI** (red squares and red curve). The Maximum Growing-Season NDVI is the annual maximum of the Spatial Average NDVI for each growing season from March through October. Maximum Growing-Season NDVI typically occurs during summer months. This curve shows the annual changes and long-term trends in the maximum NDVI.

NDVI maps or air photos are included on the time-series charts for spatial reference and as a visual check on the interpretations derived from the time-series charts. These air photos are for 2006, 2017, 2018, and 2019—showing a time just prior to Peace II implementation (2006) and for the last three years.

[10] Each NDVI pixel is 30 x 30 meters.

To statistically characterize long-term trends in NDVI, the Mann-Kendall statistical trend test (Mann-Kendall test) was performed on the Average Growing-Season NDVI for all defined areas over the following three periods:

- 1984 to 2019: the entire period of record
- 1984 to 2006: period prior to Peace II Agreement implementation
- 2007 to 2019: period subsequent to Peace II Agreement implementation

The Mann-Kendall test utilizes a ranking formula to statistically analyze if there is an increasing trend, decreasing trend, or no trend in the NDVI time-series. Appendix B describes the Mann-Kendall test methods and results. The final Mann-Kendall test results for the Average Growing-Season NDVI are shown on each time-series chart and are summarized in Table 3-1.

The previous WY 2018 Annual Report focused on the recent one-year (2017-2018) and three-year (2015-2018) decreases in NDVI at most of the defined areas in the Prado Basin. During WY 2019, the NDVI increased in all defined areas. To help characterize the meaningfulness of these recent one-year changes in the NDVI for each defined area, Table 3-2 compares the one-year change in the Average Growing-Season NDVI from 2018 to 2019 to changes and variability in Average Growing-Season NDVI over the historical period of 1984 to 2018.

3.1.2.2.1 Temporal Analysis of NDVI in Prado Basin

Figure 3-5 is a time-series chart from 1984 to 2019 of the spatial average of all 19,520 NDVI pixels that are within the maximum delineated extent of the riparian habitat in the Prado Basin.[11] The intent of the time series is to characterize the trend and changes in NDVI for the Prado Basin as a whole, which is used as a basis of comparison to the trends and changes in the NDVI for each of the smaller defined areas shown in subsequent figures. Figure 3-5 also includes NDVI maps from 2006, 2017, 2018, and 2019 to visually compare the spatial NDVI to the NDVI time-series.

Figure 3-5 and Table 3-2 show that the Average Growing-Season NDVI varies from year-to-year by no more than 0.07 with no apparent long-term trends. The Mann-Kendall test result on the Average Growing-Season NDVI indicates "no trend" over the 1984 to 2019 period, "no trend" over the 1984 to 2006 period, and "no trend" over the 2007 to 2019 period.

From 2018 to 2019, the Average Growing-Season NDVI increased by 0.03, following the previous three-year decline in the Average Growing-Season NDVI of -0.06 from 2015-2018. This recent one-year increase in Average Growing-Season NDVI is within the historical range of NDVI variability. This time-series analysis of NDVI suggests that the riparian habitat in Prado Basin, analyzed as a whole, did not experience statistically significant declines in NDVI

[11] The extent of the riparian habitat in the Prado Basin has been relatively stable since 1999. The maximum extent of the riparian habitat is verified by the 2017, 2018, and 2019 high-resolution air photos.

during the historical period of record from 1984 to 2019 nor has not during the post-Peace II Agreement period from 2007 to 2019.

3.1.2.2.2 Temporal Analysis of NDVI within Large Areas along Chino Creek, Mill Creek and in Lower Prado Basin

Figures 3-6 through 3-8 are time-series charts from 1984-2019 of the spatial average for all NDVI pixels within large areas of riparian habitat located along the reaches of Chino Creek, along the reaches of Mill Creek, and in the lower Prado Basin. These charts characterize trends and changes in NDVI for these large areas of the riparian habitat in the Prado Basin and provide a basis for comparison to the NDVI trends and changes for each of the smaller defined areas. These figures include a series of air photos for spatial reference and as a visual check on the interpretations derived from the NDVI time-series charts. The air photos are for 2006, 2017, 2018, and 2019—showing a time just prior to the Peace II implementation period (2006) and the last three years.

Chino Creek

Figure 3-6 is an NDVI time-series chart for 1984-2019 of the spatial average of all 2,134 NDVI pixels along the northern reach of Chino Creek in the Prado Basin. This reach of Chino Creek is susceptible to impacts from declining groundwater levels potentially associated with Peace II implementation.

Figure 3-6 and Table 3-2 show that, over the period of record, the Average Growing-Season NDVI varies from year-to-year by no more than 0.06 with no long-term declining trends. The Mann-Kendall test result on the Average Growing-Season NDVI indicates an "increasing trend" over the 1984 to 2019 period, an "increasing trend" over the 1984 to 2006 period, and "no trend" over the 2007 to 2019 period.

From 2018 to 2019, the Average Growing-Season NDVI increased by 0.10, following the previous three-year decline in the Average Growing-Season NDVI of -0.09 from 2015 to 2018. The recent one-year increase in Average Growing-Season NDVI of 0.10 during 2018-2019 is the maximum one-year change in NDVI over the period of record. Visual inspection of the 2019 air photo shows green areas throughout the reach of Chino Creek that were brown in the 2018 air photo.

Mill Creek

Figure 3-7 is a NDVI time-series chart for 1984-2019 of the spatial average of all 759 NDVI pixels along the northern reach of Mill Creek in the Prado Basin. This reach of Mill Creek is susceptible to impacts from declining groundwater levels potentially associated with Peace II implementation.

Figure 3-7 and Table 3-2 show that, over the period of record, the Average Growing-Season NDVI varies from year-to-year by no more than 0.10. The Mann-Kendall test result on the Average Growing-Season NDVI indicates "no trend" over the 1984 to 2019 period, "no trend" over the 1984 to 2006 period, and "no trend" over the 2007 to 2019 period.

From 2018 to 2019, the Average Growing-Season NDVI increased by 0.11, following the previous three-year decline of -0.12 from 2015 to 2018 and one-year decline of -0.11 from 2017 to 2018. The recent one-year increase in Average Growing-Season NDVI of 0.11 from 2018 to 2019 is equivalent to the previous one-year decrease and is the maximum one-year change in NDVI over the historical period of record. Visual inspection of the 2019 air photo shows a noticeable increase in green areas along Mill Creek that were brown in the 2018 air photo.

Lower Prado

Figure 3-8 is an NDVI time-series chart for 1984-2019 of the spatial average of all 677 NDVI pixels within a rectangular area in the southern portion of the Prado Basin (Lower Prado). The riparian habitat in this area of the Prado Basin is not expected to be impacted by the drawdown associated with Peace II implementation, based on groundwater-modeling projections. Hence, this chart can be used as a basis of comparison to trends in NDVI for each of the smaller defined areas located further to the north along Chino Creek, Mill Creek, and the SAR.

Figure 3-8 shows that, over the period of record, the Average Growing-Season NDVI varies from year-to-year by no more than 0.10 with no long-term declining trends. The Mann-Kendall test results on the Average Growing-Season NDVI indicates an "increasing trend" over the 1984 to 2019 period, "no trend" over the 1984 to 2006 period, and an "increasing trend" over the 2007 to 2019 period.

From 2018 to 2019, the Average Growing-Season NDVI increased by 0.03 following the previous three-year decline of -0.02 from 2015 to 2018 and one-year decline of -0.01 from 2017 to 2018. This recent increase in Average Growing-Season NDVI is within the historical range of NDVI variability for the same time spans. This time-series analysis of NDVI suggests that the riparian habitat in Lower Prado did not experience significant declines in NDVI during the historical period of record from 1984 to 2019.

3.1.2.2.3 Temporal Analysis of NDVI within Small Areas along Chino Creek, Mill Creek, and the Santa Ana River

Figures 3-9a through 3-9k are time-series charts of the spatial average of four NDVI pixels for small defined areas located along Chino Creek, Mill Creek, and the SAR near the PBHSP monitoring wells from 1984 to 2019. The purpose of these charts is to characterize long-term trends and short-term changes in NDVI for smaller areas primarily located along the northern stream reaches of the Prado Basin riparian habitat—areas that are most susceptible to potential impacts from declining groundwater levels associated with Peace II implementation. The areas are located near a PBHSP monitoring well to facilitate the comparison of changes in groundwater levels versus changes in the riparian habitat.

The time-series charts on these figures provide context for interpreting recent trends and changes in NDVI that have been occurred since Peace II implementation. Each figure includes a series of air photos for spatial reference and as a visual check on the interpretations derived from the NDVI time-series charts. The air photos are for 2006, 2017, 2018, and 2019—showing a time just prior to the Peace II implementation period (2006) and for the last three years.

***Chino Creek* (Figures 3-9a to 3-9d)**. Four areas were analyzed along Chino Creek: CC-1, CC-2, CC-3, and CC-4 (see Figure 3-4 for locations). These are vegetated areas in the Prado Basin located along Chino Creek just southwest of the CDA well field.

These figures and Table 3-2 show that, over the period of record, the Average Growing-Season NDVI varies from year-to-year by up to 0.14 with no long-term declining trends. For all four areas, the Mann-Kendall test result on the Average Growing-Season NDVI indicates an "increasing trend" over the 1984 to 2019 period, "no trend" or "increasing trend" over the 1984 to 2006 period, and "no trend" or 'increasing trend' over the 2007 to 2019 period.

For all four areas, the Average Growing-Season NDVI increased from 2018 to 2019, following a three-year decline from 2015 to 2018. For three of the four areas, the recent one-year increases in the Average Growing-Season NDVI are within their historical ranges of one-year NDVI variability. For CC-2, the recent one-year NDVI increase is the maximum one-year change in the Average Growing-Season NDVI over the period of record. Visual inspection of the 2019 air photo shows a noticeable increase in green areas along Chino Creek that were brown in the 2018 air photo.

Mill Creek **(Figures 3-9e to 3-9h).** Four areas were analyzed along Mill Creek: MC-1, MC-2, MC-3, and MC-4 (see Figure 3-4 for locations). These are vegetated areas in the Prado Basin located along Mill Creek just southwest of the CDA well field.

These figures and Table 3-2 show that, over the period of record, the Average Growing-Season NDVI varies year-to-year by up to 0.18. For all four areas, the Mann-Kendall test result on the Average Growing-Season NDVI indicates an "increasing trend" or "no trend" for the 1984 to 2019 period, "no trend" or "decreasing trend" for the 1984 to 2006 period, and "no trend' for the 2007 to 2019 period.

For all four areas, the Average Growing-Season NDVI increased from 2018 to 2019, following a three-year decline from 2015 to 2018. For each area, the recent one-year increase in Average Growing-Season NDVI is within the historical range of one-year NDVI variability. Visual inspection of the 2019 air photo shows a noticeable increase in green areas along Mill Creek that were brown in the 2018 air photo.

Santa Ana River **(Figures 3-9i to 3-9k).** Three areas were analyzed along the floodplain of the SAR: SAR-1, SAR-2, and SAR-3 (see Figure 3-4 for locations). These are vegetated areas in the Prado Basin located along the SAR south of the CDA well field.

These figures show that over the period of record the Average Growing-Season NDVI varies by up to 0.21 from year-to-year. For all three areas, the Mann-Kendall test result on the Average Growing-Season NDVI indicates an "increasing trend" for the 1984 to 2019 period and "no trend" or "increasing trend" for the 1984 to 2006 period. The Mann-Kendall test results on the Average Growing-Season NDVI for the 2007 to 2019 period indicate a "decreasing trend" for SAR-1, "no trend" for SAR-2, and an "increasing trend" for SAR-3.

For all three areas, the Average Growing-Season NDVI increased from 2018 to 2019. For two of the areas, the increase was following a three-year decline from 2015 to 2018. For the SAR-1 area, the recent three-year decline in the Average Growing-Season NDVI from 2015-2018 was -0.36, which exceeded the magnitude of any historical three-year change in Average Growing-Season NDVI. Visual inspection of the air photos shows large distinct areas of browning of the vegetation at SAR-1 in 2017 but a slight increase in the greenness in 2018 and 2019. The causes of these changes are discussed later in this section.

3.1.3 Analysis of Vegetation Surveys

Vegetation surveys are performed for the PBHSP once every three years. The most recent vegetation survey was performed in 2019 by the USBR which was a continuation of the surveys performed in 2007, 2013, and 2016. Preliminary findings and results from the 2019 vegetation survey were published in the draft report in March 2020 (USBR, 2020). The draft report and results are currently being reviewed and analyzed for their meaningfulness, and a final report will be completed by June 2020.

Table 3-3 summarizes some of the measured parameters for all areas surveyed in 2007, 2013, 2016, and 2019. The measurements of percent canopy cover from the USBR vegetation surveys are the most appropriate measured data for ground-truthing the NDVI. Percent canopy cover is a measurement of the percentage of the ground surface area that is directly covered by the vertical projections of tree crowns (USDA, 1999). Although there is no direct quantitative relationship between percent canopy cover and NDVI, percent canopy cover is a metric of the areal density of the vegetation that is reflecting visible and near-infrared light and therefore can be used for comparison with the NDVI analysis. Where and when available, the percent canopy cover at surveyed areas near the areas of NDVI analysis in Figures 3-9a through 3-9k are charted with the NDVI time-series data. Where percent canopy cover measurements are available for more than one year, they typically show stable or increasing trends, consistent with the increasing trends in NDVI since 2007. Table 3-3a shows that overall the percent canopy cover for all surveyed areas each year has increased: the average percentages of canopy cover at all areas surveyed in 2007, 2013, 2016, and 2019 were 75%, 76%, 86%, and 82%, respectively.

The USBR vegetation surveys in 2016 and 2019 noticed the presence of the invasive pest—the PSHB. Overall the presence of the PSHB decreased in 2019 at all of the sites where it was noted in 2016, and some of the sites no longer indicated the presence of the PSHB in 2019 where noted in 2016. The vegetation surveys provide a measurement of the change in riparian habitat health from 2016 to 2019 for those survey locations impacted by the PSHB. This is discussed in further detail in Section 3.6.2.

3.1.4 Summary

The extent of the riparian habitat in the Prado Basin has been delineated from air photos and maps of NDVI. The extent increased from about 1.85 mi^2 in 1960 to about 6.7 mi^2 by 1999 and has remained relatively constant since.

The quality of riparian habitat has been characterized through the analysis of air photos and maps and time-series charts of NDVI for large and small areas located throughout the Prado Basin. The analyses indicate an increase in the greenness of the riparian vegetation across most of the Prado Basin from 2018 to 2019. At most areas, this increase in greenness followed a three-year decrease in NDVI from 2015 to 2018. Inspection of the air photos corroborates the observation of increased greenness throughout the Prado Basin from 2018 to 2019.

The remainder of Section 3 describes the factors that can affect the riparian habitat, how these factors have changed over time, and how the changes in these factors may explain the changes that are being observed in the riparian habitat described above.

3.2 Groundwater and Its Relationship to Riparian Habitat

Peace II Agreement implementation was projected to change groundwater pumping patterns and reduce artificial recharge through 2030, both of which would change groundwater levels in the Chino Basin. These groundwater level changes, caused by Peace II Agreement implementation and other unrelated water management activities,[12] have the potential to impact the extent and quality of Prado Basin riparian habitat.

This section characterizes the history of groundwater pumping and changes in groundwater-levels in the GMP study area and compares this history to the trends in the extent and quality of the riparian habitat described in Section 3.1.

3.2.1 Groundwater Pumping

Table 3-4 lists the groundwater pumping estimates for the GMP study area for WY 1961 to 2019.[13] Figure 3-10 is a map and illustrates the spatial distribution of groundwater pumping from wells within the GMP study area for WY 2019, the extent of the riparian habitat, and the mix of agricultural and urban overlying land uses in 2019. This figure includes a bar chart of the annual groundwater pumping in the GMP study area (from Table 3-4). Specifically, Figure 3-10 shows the groundwater pumping history of the GMP study area:

- From 1961 to 1990, groundwater pumping in this area averaged about 45,900 afy. Pumping mainly occurred at private domestic and agricultural wells distributed throughout the area.
- From 1991 to 1999, groundwater pumping in this area steadily declined, primarily due to conversions of agricultural to land urban uses. By WY 1999, groundwater pumping in this area was estimated to be about 23,600 afy—about 49 percent less than average annual pumping from 1961-1990.
- From 2000 to 2019, CDA pumping commenced and increased to replace the declining agricultural groundwater pumping—as envisioned in the OBMP/Peace Agreement and Peace II Agreement. By WY 2019, total groundwater pumping from the area was about 37,400 afy— an increase of about 85 percent from 1999.

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[12] Other water management activities unrelated to Peace II Agreement implementation include changes in wastewater discharge to the SAR due to conservation, recycling, and drought response; increases in storm water diverted and recharged; increases in recycled water recharge; management of groundwater in storage; and the implementation of the Dry-Year Yield Program with the Metropolitan Water District of Southern California.

[13] Production for years prior to WY 2001 were estimated in the calibration of the 2013 Chino Basin groundwater model (WEI, 2015). Production estimates for WY 2001 and thereafter are based on metered production data and water-duty estimates compiled by Watermaster.

3.2.2 Groundwater Levels

Figures 3-11a and 3-11b are groundwater-elevation contour maps of the GMP study area for the shallow aquifer system in September 2016 (first Annual Report condition) and September 2019 (current condition).[14] The contours were drawn based on measured groundwater elevations at wells. These contours were used to create rasterized surfaces of groundwater elevation for September 2016 and September 2019. The raster for September 2016 was subtracted from the raster for September 2019 to create a raster of change in groundwater elevation from 2016 to 2019 (Figure 3-12). As, Figure 3-12 shows, from 2016 to 2019, groundwater levels changed by up to +/- five feet across the GMP study area.

Figure 3-13 is a map of depth-to-groundwater in September 2019. It was created by subtracting a one-meter horizontal resolution digital elevation model of the ground surface (Associated Engineers, 2007) from the raster of groundwater elevation for September 2019. An outline of the Prado Basin riparian habitat's maximum extent[15] is superimposed on the 2019 depth-to-groundwater raster. With few exceptions,[16] the riparian habitat overlies areas where the depth-to-groundwater is less than 15 feet below the ground surface.

3.2.3 Groundwater Levels Compared to NDVI

Figures 3-14a through 3-14c are time-series charts that compare long-term trends in groundwater pumping and groundwater elevations to the trends in the quality of the riparian vegetation as indicated by the NDVI for three areas in the Prado Basin: Chino Creek, Mill Creek, and the SAR. The period of analysis for these charts is 1984 to 2019—the period of NDVI availability. The upper chart in these figures compares changes in groundwater levels for each respective area to long-term trends in groundwater pumping within the study area. Groundwater-elevation estimates for the period of 1984 to 2013 were extracted from Watermaster's most recent calibration of its groundwater-flow model at the monitoring well locations (WEI, 2020). The more recent groundwater-elevation data shown on these charts were measured at monitoring wells constructed by Watermaster and the IEUA to support the Hydraulic Control Monitoring Program (HCMP) (beginning in 2005) and the PBHSP (beginning in 2015). Where the measured and model-estimated groundwater elevations overlap in time, the model-estimated elevations mimic the seasonal fluctuations and longer-term trends of the measured elevations and are typically no more than 10 feet different. This supports the use of these model-estimated groundwater elevations in this analysis.

The lower chart in Figures 3-14a through 3-14c displays the time series of the Average Growing-Season NDVI for the defined areas, discussed in Section 3.1, along Chino Creek, Mill Creek,

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[14] Historical groundwater-elevation data for the Prado Basin are scarce due to a lack of wells and/or monitoring. As such, the discussion and interpretation of measured groundwater elevations focuses on the GMP's period of record.

[15] Verified with 2019 air photo.

[16] Exceptions include: the upstream reach of Temescal Wash in the Prado Basin and some limited areas west of the southern reach of Chino Creek.

and the SAR. For reference, the Mann-Kendall test results for trends in the Average Growing-Season NDVI for 1984-2018, 1984-2006, and 2007-2019 are shown in the legend.

The NDVI observations and interpretations below focus on recent trends in Average Growing-Season NDVI (Section 3.1) and whether observed groundwater level trends may be contributing to recent NDVI changes.

Chino Creek (Figure 3-14a). Over the period of record shown on the chart, groundwater levels appear to have changed only slightly in response to long-term changes in groundwater pumping—typically by less than +/- five feet. Groundwater levels have remained relatively stable in this area, despite the decline in groundwater pumping from 1990-2000 and the subsequent increase in CDA pumping after 2000.

The groundwater levels measured at the PBHSP monitoring wells along Chino Creek show that there is no long-term increasing or decreasing trend in groundwater levels along Chino Creek and that groundwater levels fluctuate seasonally, in some cases by more than 15 feet, under the seasonal stresses of pumping and recharge. During the winter months of WY 2017 and 2019, groundwater levels at the PBHSP monitoring wells increased to their highest recorded levels, likely in response to the recharge of stormwater discharge in unlined creeks and the associated surface-water reservoir that ponds behind Prado Dam. Over the last year, from September 2018 to September 2019, groundwater levels increased by about a foot along the northern and southern portions of Chino Creek (PB-9/1, and PB-6/1), and increased by about two feet along the central portion of Chino Creek (PB-8, RP3-MW3, and PB-7/1).

From 2018 to 2019, the Average Growing-Season NDVI increased at all five areas along Chino Creek, following a three-year decline. These recent NDVI increases are within the historical range of one-year variability in NDVI for some of the areas; however, for the large Chino Creek area and smaller CC-2 area, these one-year increases are the maximum change observed in NDVI for these areas over the long term (see Table 3-2). Visual inspection of the 2019 air photo reveals more green in areas along Chino Creek that were brown in the 2018 air photo (see Section 3.1). Groundwater levels have remained relatively stable and within the historical range of short- and long-term variability; as such, they are not likely the cause of the recent NDVI increases and greening in riparian habitat along Chino Creek.

Mill Creek*. *(Figure 3-14b). Over the period of record shown on the chart, groundwater levels appear to respond to the long-term changes in groundwater pumping—typically by up to +/- 10 feet. These responses were greatest along the northern portion of Mill Creek near the MC-1 area (at the HCMP-5 and PB-2 wells) where groundwater levels increased by about 10 feet in response to a decline in pumping from 1990 to 2000 and declined by a similar amount after the CDA pumping began in 2000. Downstream from the MC-1 area, groundwater levels along Mill Creek have remained relatively stable over the period of record.

The groundwater levels measured at the PBHSP monitoring wells along Mill Creek show that there is no long-term increasing or decreasing trend in groundwater levels along Mill Creek and that groundwater levels fluctuate seasonally, in some cases by more than 10 feet, under the seasonal stresses of pumping and recharge. During the winter months in WY 2017 and WY

2019, groundwater levels at most of the PBHSP monitoring wells increased to their highest recorded levels, likely in response to the recharge of stormwater discharge in unlined creeks and the associated surface-water reservoir that ponds behind Prado Dam. Over this past year, from September 2018 to September 2019, groundwater levels at the monitoring wells along Mill Creek decreased by about 1.5 feet along the northern portion (PB-2 and HCMP-5/1), remained stable along the central portion (PB-1), and increased about 1.5 feet along the southern portion (PB-5/1).

From 2018 to 2019, the Average Growing-Season NDVI increased at all five areas along Mill Creek, following a three-year decline. These recent NDVI increases are within the one-year variability in NDVI in these areas except for the large Mill Creek area, which shows the maximum change observed in NDVI for this area (see Table 3-2). Analysis of the 2019 air photo reveals more green in areas along Mill Creek that were brown in the 2018 air photo (see Section 3.1). Groundwater levels have remained relatively stable and within the historical range of short- and long-term variability; as such, they are not likely the cause of the recent NDVI increases and greening in riparian habitat along Mill Creek.

Santa Ana River (***Figure 3-14c***). Over the period of record shown on the chart, groundwater levels appear to respond to changes in groundwater pumping—typically by less than +/- 10 feet. These responses are greatest along the northern portion of the SAR near the SAR-1 area (PB-4 well) where groundwater levels increased by about 10 feet in response to a decline in pumping from 1990-2000 and declined by a similar amount after CDA pumping began in 2000. Downstream from the SAR-1 area, groundwater levels along the SAR have remained relatively stable over the period of record.

The groundwater levels measured at the PBHSP monitoring wells along the SAR show that groundwater levels fluctuate seasonally by up to three feet under the seasonal stresses of pumping and recharge, and there is no long-term increasing or decreasing trend in groundwater levels. During this past year, from September 2018 to September 2019, groundwater levels at the monitoring wells along the SAR decreased by about 0.5 to two feet.

From 2018 to 2019, the Average Growing-Season NDVI increased at all four areas along the SAR, following a three-year decline. These recent NDVI increases are within the one-year variability in NDVI at these areas (see Table 3-2). Visual inspection of the 2019 air photo reveals more green in areas along the SAR that were brown in the 2018 air photo (see Section 3.1). For SAR-1, the 2019 air photo shows an increase in greenness from the 2017 and 2018 air photos, which both show distinct areas of browning of the vegetation that coincided with the sharp decreases in the Average Growing-Season NDVI. Factors other than groundwater were determined responsible for this sharp decrease in NDVI at SAR-1 and will be discussed later in this report (Section 3.6). Changes in groundwater levels were not likely the cause of the recent one-year NDVI increases and greening in the riparian habitat along the SAR because groundwater levels declined over the past year and remain within their historical range of short- and long-term variability.

3.2.4 Summary

The following observations and interpretations were derived from the analysis of groundwater pumping, groundwater levels, and NDVI:

- From 1961 to 1990, groundwater pumping from private domestic and agricultural wells in the study area averaged about 45,900 afy. From 1991 to 1999, groundwater pumping steadily declined to about 23,600 afy primarily due to conversions from agricultural to urban land uses. In 2000, CDA pumping commenced to replace the declining agricultural production. In WY 2019, total groundwater pumping in the study area was about 34,500 afy.

- Depth to groundwater in the Prado Basin area is relatively shallow—typically less than 15 feet below ground surface where riparian habitat exists. The shallow groundwater contributes to rising groundwater discharge to the SAR and its tributaries and evapotranspiration by the riparian vegetation in the Prado Basin.

- During WY 2019, groundwater levels across the study area fluctuated, in some cases by up to 15 feet, under the seasonal stresses of pumping and recharge. During the winter months of WY 2019, groundwater levels at some of the PBHSP monitoring wells increased to their highest recorded levels, likely in response to the recharge of stormwater discharge in unlined creeks and the surface-water reservoir that ponds behind Prado Dam.

- Since groundwater level measurements commenced at the PBHSP monitoring wells in 2015, there has been no observed increasing or decreasing trend in groundwater levels along the reaches of Chino Creek, Mill, Creek, and SAR. From September 2016 to September 2019, groundwater levels across the study area remained relatively stable (+/- 5 feet).

- In Section 3.1, the analysis of air photos and maps and time-series charts of NDVI for areas of Prado Basin indicated an increase in the greenness of the riparian vegetation throughout the Prado Basin over the 2018-2019 period. Groundwater levels have remained relatively stable and within their historical range of short- and long-term variability; as such, they are not the likely cause of recent NDVI increases and greening of the riparian habitat.

3.3 Analysis of Groundwater/Surface Water Interactions

One of the objectives of the PBHSP is to identify factors that contribute to the long-term sustainability of Prado Basin riparian habitat. The depth to groundwater analysis shown in Figure 3-13 indicates that the riparian vegetation exists in areas of shallow groundwater, where groundwater levels are typically 15 feet below ground surface (ft-bgs) or less, and that the riparian vegetation is likely dependent, at least in part, upon the shallow groundwater.

The previous Annual Reports for WY 2017 and WY 2018 (Section 3.3) included a comprehensive analysis to understand the sources of the shallow groundwater in the Prado

Basin and the groundwater/surface-water interactions that may be important to the long-term sustainability of the riparian habitat (WEI, 2018; 2019). The analysis included using surface-water discharge and quality, groundwater quality, groundwater levels, and groundwater modeling as multiple lines of evidence to analyze the groundwater/surface water interactions at the nine PBHSP well locations—along the fringes of the riparian habitat and adjacent to Chino Creek, Mill Creek, and the SAR. In general, the analysis concluded that the SAR and northern portion of Mill Creek are losing reaches, characterized by streambed recharge. Most other areas along Chino and Mill Creeks are gaining reaches, characterized by groundwater discharge. That said, at most locations in the Prado Basin, there appear to be multiple and transient sources that feed the shallow groundwater, and the groundwater/surface-water interactions are complex. Additional monitoring is needed to better characterize the sources of shallow groundwater and groundwater/surface-water interactions. This additional monitoring began in 2018 as a pilot program, which included:

- High-frequency water-quality monitoring at two PBHSP monitoring well sites along Chino Creek: PB-7 and PB-8 (two wells at each site). Each monitoring well was equipped with probes to measure and record EC, temperature, and water levels at a 15-minute frequency. The wells were visited quarterly to download data from the probes, measure water levels, and collect grab samples for laboratory analyses of TDS and general mineral chemistry to validate and support the high-frequency data.

- High-frequency water-quality monitoring at two surface-water sites along Chino Creek adjacent to the monitoring well sites. Each site was equipped with a probe to measure and record EC and temperature at a 15-minute frequency. The surface-water sites were visited quarterly to download data from the probes and collect grab samples for laboratory analyses of TDS and general mineral chemistry to validate and support the high-frequency data.

The probes were installed at the groundwater and surface-water sites in July 2018; in late-2018, the surface-water probes were lost during large storm events. The surface-water probes were reinstalled in September 2019 using a more secure configuration.

The high-frequency data collected for the pilot monitoring program thus far is limited, and there has not been an extended period of time when the surface and groundwater data were collected simultaneously. The data from the pilot program shows promise, but more time and data are needed to make interpretations.

3.4 Climate and Its Relationship to the Riparian Habitat

Precipitation and temperature are climatic factors that can affect the extent and quality of riparian habitat. Precipitation can provide a source of water for consumptive use by the riparian vegetation via the direct infiltration of precipitation and runoff, which increases soil moisture that can be directly used by the vegetation, or by maintaining groundwater levels underlying the vegetation for its subsequent use. Temperatures affect the rate of plant growth and productivity. Both factors are unrelated to the implementation of the Peace II Agreement.

This section characterizes the time series of precipitation and temperature in the Prado Basin area and compares that time series to trends in the quality of the riparian habitat, as indicated by NDVI, to help determine if these factors have influenced the riparian habitat in the Prado Basin.

3.4.1 Precipitation

Figure 3-16 is a time-series chart that shows annual precipitation estimates within the Chino Basin for WY 1896 to 2019. These estimates were computed as a spatial average across the Chino Basin using rasterized data from the PRISM Climatic Group (an 800-meter by 800-meter grid). The long-term average annual precipitation in the Chino Basin is 16.36 inches per year (in/yr). The chart includes a cumulative departure from mean (CDFM) precipitation curve, which characterizes the occurrence and magnitude of wet and dry periods: positive sloping segments (trending upward to the right) indicate wet periods, and negative sloping segments (trending downward to the right) indicate dry periods.

Review of the CDFM precipitation curve indicates that the Chino Basin experienced several prolonged wet and dry periods from WY 1896 to 2019. Typically, dry periods are longer in duration than wet periods. The longest dry period occurred between 1946 through 1977 (32 years). The current dry period is a 21-year period, starting in WY 1999, and includes the Peace/Peace II Agreement period (2001 through 2019). Over the 123-year record, about 39 percent of the years had precipitation greater than the average, and 61 percent had below average precipitation. In the 19-year period since the Peace Agreement was implemented, 32 percent of the years had precipitation greater than the average, and 68 percent had below average precipitation. During the last five years (WY 2015 through WY 2019) of the current 21-year dry period (WY 1999 through WY 2019), average precipitation was 12.76 in/yr—about 22 percent less than the long-term annual average. Precipitation in WY 2019 was 22.24 inches, which is six inches above the long-term average and the wettest year since WY 2011.

3.4.2 Temperature

Maximum and minimum temperatures during the growing season are the temperature metrics used in this analysis because plant growth and development are dependent upon the temperatures surrounding the plant (Hatfield and Prueger, 2015). Maximum temperatures during the growing season directly influence photosynthesis, evapotranspiration, and breaking of the dormancy of vegetation (Pettorelli, 2015). Minimum temperatures affect nighttime plant respiration rates and can potentially have an effect on plant growth that occurs during the day (Hatfiled et. al, 2011). Hence, both temperature metrics can influence NDVI. All species of plants have a range of maximum and minimum temperatures necessary for growth (Hatfield and Prueger, 2015). Climate change is more likely to increase minimum temperatures while maximum temperatures are affected more by local conditions (Knowles et al., 2006; Alfaro et al., 2006).

Figure 3-17 is a time-series chart that shows the average maximum and minimum Prado Basin temperatures for the growing-season months of March through October from 1896 to 2019 (growing-season maximum and minimum temperatures). These temperature estimates were computed as a spatial average across the Prado Basin using rasterized data from the PRISM Climatic Group (an 800-meter by 800-meter grid) of monthly maximum and minimum temperature estimates. This chart also shows the five-year moving average of the growing-season maximum and minimum temperatures for the Prado Basin. The five-year moving average is a smoothing technique used to reveal trends over time.

This chart also shows a complete record of atmospheric carbon dioxide (CO2) concentrations assembled from multiple sources:

- Values prior to 1959 were estimated from an analysis of the Law Dome DE08 and DE08-2 ice cores in Antarctica. (Acquired from the Carbon Dioxide Information Analysis Center, http://cdiac.ornl.gov/trends/co2/lawdome.html. Accessed on June 6, 2017).
- Values after 1959 are from measured CO2 concentration data at the Mauna Loa Observatory in Hawaii. (Acquired from the National Oceanic and Atmospheric Association's Earth Systems Research Laboratory, https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html. Accessed on June 5, 2017).

The time history of atmospheric CO2 concentrations shows a slight increasing trend from about 290 parts per million (ppm) in the late 1890s to about 310 ppm in 1950. After 1950, the CO2 concentration shows an amplified increasing trend and exceeds 400 ppm by 2015.

From 1896 to 2019, the growing-season maximum temperature fluctuates between 80° F to 86° F and does not appear to have a prominent long-term increasing or decreasing trend. From 1896 to 2019, the growing-season minimum temperature fluctuates between 49° F to 59° F and has an increasing trend starting in 1950 of about five degrees Fahrenheit through 2019. This increasing trend in the growing-season minimum temperature beginning 1950 appears to correlate with the increase in atmospheric CO2 concentrations. The five-year moving averages of both the growing-season minimum and maximum temperatures display an increasing trend over the recent six years (2013-2018) in the Prado Basin and, in 2018, had the highest calculated values over the entire period of record. In 2019, the growing-season minimum and maximum temperatures and the five-year moving averages all decreased slightly from the previous year.

3.4.3 Climate Compared to NDVI

Figures 3-18a through 3-18c are time-series charts that compare long-term trends in precipitation and temperature to trends in the quality of the riparian vegetation, as indicated by NDVI, for three areas in the Prado Basin: Chino Creek, Mill Creek, and the SAR. The period of analysis is 1984-2019—the period of NDVI availability. The upper chart on the figures displays the time series of annual precipitation in Chino Basin, the CDFM precipitation curve, and the five-year moving average for the growing-season maximum and minimum temperatures in the Prado Basin. The lower chart displays the time series of the Average Growing-Season NDVI for the defined areas discussed in Section 3.1 along Chino Creek, Mill Creek, and the SAR. For reference, the Mann-Kendall test results for trends in the Average Growing-Season NDVI for 1984-2018, 1984-2006, and 2007-2019 are shown in the legend.

The observations and interpretations below are focused on recent increases in Average Growing-Season NDVI during WY 2019 described in Section 3.1 and whether observed trends in temperature and precipitation may be contributing to recent increases in NDVI.

Chino Creek (Figure 3-18a). From 2018 to 2019, Average Growing-Season NDVI increased at all five areas along Chino Creek, following a three-year decline (2015-2018). For the large Chino Creek area and smaller CC-2 area, these one-year increases are the maximum changes observed in NDVI for these areas over the period of record (see Table 3-2). These recent increases in NDVI occurred during a year of above-average precipitation and slightly lower minimum and maximum temperatures in the Prado Basin. These observations indicate that the cooler, wetter conditions in WY 2019 are a contributing cause of the observed increases in NDVI along Chino Creek.

Mill Creek (Figure 3-18b). From 2018 to 2019, the Average Growing-Season NDVI increased at all five areas along Mill Creek, following a three-year decline. For the large Mill Creek area, this is the maximum change observed in NDVI over the period of record (see Table 3-2). These recent increases in NDVI occurred during a year of above-average precipitation and slightly lower minimum and maximum temperatures in the Prado Basin. These observations indicate that the cooler, wetter conditions in WY 2019 are a contributing cause of the observed increases in NDVI along Mill Creek.

Santa Ana River (Figure 3-18c). From 2018 to 2019, the Average Growing-Season NDVI increased at all four areas along the SAR, following a three-year decline. These recent increases in NDVI occurred during a year of above-average precipitation and slightly lower minimum and maximum temperatures in the Prado Basin. These observations indicate that the cooler, wetter conditions in WY 2019 are a contributing cause of the observed increases in NDVI along the SAR.

3.5 Stream Discharge and Its Relationship to the Riparian Habitat

Stream discharge in the SAR and its tributaries that flow through the Prado Basin is a factor that can affect the extent and quality of Prado Basin riparian habitat Basin. Stream discharge can recharge the groundwater system along losing stream reaches and supply water through the groundwater system to riparian vegetation. Stream discharge is also important to fauna living within the stream system. Flooding events and flood-control/water-conservation operations at Prado Dam can scour and inundate areas of the riparian habitat and potentially cause adverse impacts.

This section characterizes the time series of stream discharge within the Prado Basin and compares that time series to trends in the extent and quality of the riparian habitat, as indicated by NDVI, to help determine whether changes in stream discharge have influenced the riparian habitat in the Prado Basin.

3.5.1 Stream Discharge

There are three primary components of stream discharge in the SAR and its tributaries: storm discharge, non-tributary discharge, and base-flow discharge. Storm discharge is rainfall runoff. Non-tributary discharge typically originates from outside the watershed, such as imported water discharged from the OC-59 turnout on San Antonio Creek. Base-flow discharge, as used herein and by the Santa Ana River Watermaster, includes tertiary-treated wastewater discharge from POTWs (Publicly-Owned Treatment Works), rising groundwater, and dry-weather runoff.

Figure 3-19 includes time-series charts that summarize important annual discharges within the upper SAR watershed that are tributary to Prado Dam from water years 1971 to 2019 (SARWM, 2020). The upper chart on Figure 3-19 characterizes the annual outflow from the Prado Basin as total measured SAR discharge at USGS gage *SAR at below Prado Dam*. The upper chart also shows the base-flow component of total measured discharge as estimated by the Santa Ana River Watermaster. This chart shows that base-flow discharge declined from about 154,000 afy in 2005 to an average of about 76,000 afy over the period 2012-2019. The decline in base-flow discharge is primarily related to declines in POTW effluent discharges that are tributary to Prado Basin. In WY 2019, both total and base-flow discharge at below Prado Dam increased to their highest values since 2011:

- *Total Discharge at below Prado Dam in WY 2019*. Total discharge in WY 2019 was about 252,000 af, which is about 137,070 afy greater than the average total discharge over the previous seven years (2012 to 2018), and about 169,400 afy greater than total discharge in WY 2018.
- *Base-Flow Discharge at below Prado Dam in WY 2019*. Base-flow discharge was about 98,000afy, which is about 25,300 afy greater than the average base-flow discharge over the previous seven years (2012 to 2018), and about 32,600 afy greater than base-flow discharge in WY 2018.

The lower chart on Figure 3-19 shows that the combined POTW discharges that are tributary, at least in part, to Prado Dam. The POTW discharges declined from about 192,000 afy in 2005 to an average of about 95,000 afy for the last eight years (2012-2019). This decrease is mostly attributed to decreases in effluent discharge from the IEUA and POTWs that discharge to Temescal Creek. The post-2005 decrease in POTW effluent discharge was caused by increased recycled-water reuse, decreased water use due to the economic recession that began in 2008, and the implementation of emergency water-conservation measures during the recent drought since 2012. In WY 2019, POTW discharge was about 107,000 afy, which is about 11,100 afy greater than the average POTW discharge over the previous seven years, and about 21,400 afy greater than POTW discharge in WY 2018.

3.5.2 Stream Discharge Compared to NDVI

Figures 3-20a through 3-20c are time-series charts that compare long-term trends in stream discharge to trends in the quality of the riparian vegetation, as indicated by NDVI, for three areas in Prado Basin: Chino Creek, Mill Creek, and the SAR. The period of analysis for these charts is 1984-2019—the period of NDVI availability. The upper chart on the figures displays the annual volumes of measured discharge to each stream during the growing season (March-October), including: measurements at USGS gaging stations located upstream of the Prado Basin and POTW discharges.[17] The lower chart displays the time series of the Average Growing-Season NDVI for defined areas, as discussed in Section 3.1, along Chino Creek, Mill Creek, and the SAR. For reference, the Mann-Kendall test results for trends in the Average Growing-Season NDVI for 1984-2018, 1984-2006, and 2007-2019 are shown in the legend.

The observations and interpretations below are focused on the recent (2019) increases in Average Growing-Season NDVI, as described in Section 3.1, and whether observed trends in surface-water discharge may be contributing to recent increases in NDVI.

Chino Creek (Figure 3-20a). Chino Creek is a concrete-lined, flood-control channel that transitions into an unlined stream channel at the Prado Basin boundary and flows south to merge with Mill Creek and the SAR behind Prado Dam (see Figure 2-3). The upper chart on Figure 3-20a shows discharge to Chino Creek during the growing season, including: measured discharge at USGS gage *Chino Creek at Schaefer* and the POTW discharges downstream of the USGS gage, including discharges from the IEUA Carbon Canyon, RP-2, RP-5, and RP-1 plants. Measured discharge at *Chino Creek at Schaefer* includes storm-water and dry-weather runoff in the concrete-lined channel upstream of the IEUA discharge locations and imported water discharge from the OC-59 turnout. Discharges not characterized in this figure are storm-water runoff, dry-weather runoff, and rising-groundwater discharge downstream of the *Chino Creek at Schaefer* gage. From 1984 to 2019, discharge in Chino Creek during the growing-season progressively increased through 1999 and then decreased. The decreasing trend in growing-season discharge since about 1999 was caused by dry climatic conditions, water conservation in response to drought, and decreases in effluent discharge from IEUA plants. During the recent seven-year period, from 2012 to 2018, growing-season discharge in Chino Creek averaged about 7,700 afy. In 2019, growing-season discharge was about 8,900 af, which is about 1,100 afy greater than the average growing-season discharge over the last seven years, and about 7,700 afy greater than growing-season discharge in 2018. This increase growing-season discharge in Chino Creek during 2019 is attributed to increases in the storm-water/dry-weather runoff and POTW discharges.

From 2018 to 2019, Average Growing-Season NDVI increased at all five areas along Chino Creek, following a three-year decline. For the large Chino Creek area and smaller CC-2 area, these one-year increases are the maximum changes observed in NDVI for these areas over the period of record (see Table 3-2). These recent increases in NDVI occurred during a year of above-average growing-season discharge in Chino Creek. This observation indicates that the increasing stream discharge in 2019 is a contributing cause of the recent increases in NDVI along Chino Creek.

[17] These charts do not describe other hydrologic processes that affect surface-water discharge within the Prado Basin, including evaporation, evapotranspiration, the infiltration of water along unlined stream segments, and rising groundwater discharge.

Mill Creek (Figure 3-20b). Cucamonga Creek is a concrete-lined flood-control channel and transitions into an unlined stream channel at the Prado Basin boundary, and at that point, its name changes to Mill Creek (see Figure 2-3). The upper chart on Figure 3-20b shows discharge to Mill Creek during the growing season, including: POTW effluent discharge from the IEUA RP-1 plant to Cucamonga Creek and measured discharge downstream at USGS gage *Cucamonga Creek near Mira Loma* (less the RP-1 discharge). The measured discharge at *Cucamonga Creek near Mira Loma* (less the RP-1 discharge) is representative of storm-water and dry-weather runoff in Cucamonga Creek upstream of this gaging station during the growing season. Discharges not characterized on this figure are storm-water runoff, dry-weather runoff, and rising-groundwater discharge downstream of the *Cucamonga Creek near Mira Loma* gage. From 1984 to 2019, growing-season discharge in Mill Creek progressively increased through 2004 and then decreased. The decreasing trend in growing-season discharge since about 2004 was caused by dry climatic conditions, water conservation in response to drought conditions after 2012, and the decrease in effluent discharge from the IEUA RP-1 plant. During the recent seven-year period from 2012 to 2018, growing-season discharge averaged about 7,100 afy. In 2019, the growing-season discharge was about 14,100 af, which is about 7,000 afy greater than the average growing-season discharge over the last seven years, and about 5,100 afy greater than growing-season discharge in 2018.

From 2018 to 2019, Average Growing-Season NDVI increased at all five areas along Mill Creek, following a three-year decline. For the large Mill Creek area, this is the maximum change observed in NDVI over the period of record see (Table 3-2). These recent increases in NDVI occurred during a year of above-average growing-season discharge in Mill Creek. This observation indicates that the increasing stream discharge in 2019 is a contributing cause of the recent increases in NDVI along Mill Creek.

Santa Ana River (Figure 3-20c). The SAR is an unlined stream channel from the Riverside Narrows to Prado Dam—its entire reach across the Chino Basin (see Figure 2-3). The upper chart on Figure 3-20c shows the annual growing-season discharge at the USGS gage *Santa Ana River at MWD Crossing* (Riverside Narrows) and the annual growing-season discharges to the SAR downstream of the Riverside Narrows, including POTW effluent from the City of Riverside's Regional Water Quality Control Plant and the Western Riverside County Regional Wastewater Authority (WRCRWA) plant that is conveyed in an unlined channel (along with a portion of SAR discharge) to the OCWD Wetlands. The measured discharge at the *Santa Ana River at MWD Crossing* gage represents storm-water runoff and base-flow discharge in the SAR upstream of the gaging station at the Riverside Narrows. The base-flow discharge includes POTW discharge from the RIX and Rialto treatment plants, dry-weather runoff, and rising groundwater. Discharges not characterized on this figure are storm-water runoff, dry-weather runoff, and rising-groundwater discharge downstream of the *Santa Ana River at MWD Crossing* gage.

From 1984 to 2011, growing-season discharge in the SAR averaged about 78,100 afy with episodic increases in storm-water discharge during wet years. During the recent seven-year period, from 2012 to 2018, growing-season discharge in the SAR gradually declined and averaged about 47,000 afy. The decreasing trend in growing-season discharge was caused by dry climatic conditions, water conservation in response to drought, and decreasing base flow at the Riverside Narrows. In 2019, the growing-season discharge in the SAR was about 52,000 af, which is about 5,600 afy greater than the average growing-season discharge during 2012 to 2018, and about 12,800 afy greater than growing-season discharge in 2018.

From 2018 to 2019, the Average Growing-Season NDVI increased at all four areas along the SAR, following a three-year decline. These recent increases in NDVI occurred during a year of above-average growing-season discharge in the SAR. This observation indicates that the increasing stream discharge in 2019 is a contributing cause of the recent increases in NDVI along the SAR.

3.6 Other Factors and Their Relationships to Riparian Habitat

Other factors that can affect the extent and quality of riparian habitat in the Prado Basin analyzed in this Annual Report include wildfire, pests, and arundo management. These factors are unrelated to Peace II Agreement implementation.

This section characterizes what is known about these factors and compares them to trends in the extent and quality of the riparian habitat to determine their impacts, as characterized by the NDVI.

3.6.1 Wildfire

Available wildfire perimeter data from the FRAP database[18] were compiled within the Prado Basin extent for the period of 1950-2018.[19] The FRAP database shows that wildfires occurred in the Prado Basin in 1985, 1989, 2007, 2015, and 2018. Figure 3-21 shows the spatial extent of these wildfires, mapped over the 2019 air photo. The most recent wildfire was along the southern reach of Chino Creek in 2018. Portions of the 2018 wildfire area are still identifiable in the air photo by small areas of brownish land cover that lack vegetation.

Figures 3-22a through 3-22c are time-series charts that explore the relationship between other factors that can impact riparian vegetation and NDVI for three reaches in the Prado Basin: Chino Creek, Mill Creek, and the SAR. The figures show the Average Growing-Season NDVI for the 14 defined areas of riparian habitat discussed in Section 3.1 and shown in Figures 3-6 through 3-8 and 3-9a through 3-9k. Wildfire occurrences, annotated by date, are shown on the charts if their extent intersects with the extent of the defined area of NDVI analysis.

The recent 2018 wildfire burned the southern portion of Chino Creek. The Chino Creek area, which includes the northern portion of the 2018 wildfire, showed a decrease in the Average Growing-Season NDVI of about 0.05 following the wildfire. There are other notable declines in the Average Growing-Season NDVI for some of the defined areas impacted by the 2007 and

[18] http://frap.fire.ca.gov/index (Website for California Department of Forestry and Fire Protection's Fire and Resource Assessment Program).

[19] Data is updated in late April for the previous year; 2019 data were not available for this annual report.

1985 wildfires, suggesting negative effects of these wildfires on the riparian habitat. Following the 2007 wildfire, which burned portions of Chino and Mill Creeks, the Average Growing-Season NDVI at MC-2 decreased by about 0.08; and following the 1985 wildfire that burned portions of SAR floodplain, the Average Growing-Season NDVI at SAR-1 and SAR-2 decreased slightly by about 0.02 and 0.01, respectively.

3.6.2 Polyphagous Shot Hole Borer

PSHB, from the group known as ambrosia beetles, is a relatively new pest in Southern California. PSHB burrows into trees and introduces fungi that assists in establishing colonies. Infection caused by the fungi can cause a dark stain surrounding the entry holes, discolored bark, leaf discoloration and wilting, and die off of entire branches or trees.

In spring 2016, OCWD biologists observed die off of riparian trees in patches throughout the Prado Basin, especially arroyo and black willows, and confirmed that the cause was from PSHB (ACOE and OCWD, 2017; OCWD 2020). Although PSHB arrived prior to 2016, this was the first notable die off in the Prado Basin. Since 2016, OCWD biologists have noted that the presence of PSHB is widespread throughout the Prado Basin and has reduced tree canopy cover, but tree mortality has remained confined to small local patches (Zembal, R., personal communication, 2018). OCWD biologists observed that the affected trees that had not died were showing signs of severe infestation, exhibiting branch failure, significant staining, and crown sprouting after the upper branches had died back. (ACOE and OCWD, 2017). In infected trees, crown sprouting allows some of the trees to persist, but the PSHB have been observed to attack the recently emerged limbs once they grow to two to three inches in diameter, causing the sprouting to be temporary. The die back and crown sprouting has resulted in a reduction of canopy in many areas (OCWD, 2020). Canopy loss in heavily infested areas may allow faster-growing invasive non-native species to colonize and out-compete native trees and shrubs in the understory (OCWD, 2020).

In 2016 and 2017, OCWD biologists in the Prado Basin worked with the University of California, Riverside, the USFWS, and SAWA to actively monitor the occurrence and impact of PSHB within Prado Basin riparian habitat. These agencies conducted studies on how to potentially protect certain areas of the Prado Basin from PSHB using attractants and deterrents; however, there were too many trees to effectively protect the entire forest (Zembal, R., personal communication, 2018). Traps were placed throughout the lower portion of Prado Basin and along the SAR by the OCWD and SAWA. The total number of PBHB beetles trapped at each location between August 2016 and April 2017 ranged from seven to 2,092.

Figure 3-21 shows the locations where the presence of PSHB has been documented within the Prado Basin from 2016 to 2019 by: University of California, Department of Agriculture Natural Resources;[20] PSHB traps deployed by the OCWD and SAWA between August 2016 and April 2017; and the USBR vegetation surveys performed in 2016 and 2019.

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[20] http://ucanr.maps.arcgis.com/apps/Viewer/index.html?appid=3446e311c5bd434eabae98937f085c80

During the 2016 USBR vegetation surveys, the presence of the PSHB was identified at 30 of the 37 survey sites. At these sites, all of the trees identified with the presence of PSHB were noted as "stressed," except one which was noted as "dead." The 2016 USBR surveys were the first site-specific surveys that documented the presence and abundance of PSHB for the PBHSP.

During the 2019 USBR vegetation surveys, the presence of the PSHB was identified at only seven of the 30 sites that were originally identified with PSHB presence in 2016—a 61 percent decrease. In 2019, the presence was only noted at sites along Chino and Mill Creeks; no presence was noted at sites along the SAR. The percentage of trees with the noted presence of the PSHB decreased from 28 to three percent at sites along Chino Creek; and decreased from 57 to nine percent at sites along Mill Creek. OCWD biologists have suggested that the wet year of 2019 may have allowed the riparian trees to better resist PSHB burrowing and fungal disease impacts (USBR, 2020).

For the 30 sites in Prado Basin where the presence of the PSHB was noted in 2016, the table below summarizes the changes in tree stress, tree mortality, and percent canopy cover from 2016 to 2019.

Summary of PSHB Impact on Trees in Prado Basin
2016 to 2019

Reach	Observation/Measurement	2016	2019	Change *2016-2019*
Chino Creek	% of Trees not Stressed	4%	39%	35%
	% of Trees Stressed	88%	45%	-43%
	% of Trees Dead	9%	15%	6%
	Average % Canopy Cover	92%	82%	-10%
Mill Creek	% of Trees not Stressed	3%	30%	27%
	% of Trees Stressed	70%	41%	-29%
	% of Trees Dead	24%	28%	4%
	Average % Canopy Cover	77%	75%	-2%
SAR	% of Trees not Stressed	33%	53%	20%
	% of Trees Dead	10%	15%	5%
	% of Trees Stressed	56%	31%	-25%
	Average % Canopy Cover	85%	93%	8%

As the table indicates, the reduced presence of the PSHB has reduced tree stress across the Prado Basin; however, the PSHB had an adverse impact from 2016 to 2019, as evidenced by the increased percentage of dead trees and some reductions in percent canopy cover.

Figures 3-22a through 3-22c are time-series charts that explore the relationship between PSHB occurrence and NDVI for three reaches in Prado Basin: Chino Creek, Mill Creek, and the SAR. These figures show the Average Growing-Season NDVI for the 14 defined areas of riparian habitat discussed in Section 3.1 and shown in Figures 3-6 through 3-8 and 3-9a through 3-9k. For each defined area, the percentage of infected trees relative to the total of all trees within each nearby survey site are plotted on the charts. All but one of the defined areas shown in Figures 3-22a through 3-22c are near survey sites where PSHB was noted in 2016. At all of these sites, the percentage of trees impacted decreased from 2016 to 2019, and the Average Growing-Season NDVI in the nearby defined areas increased from 2018 to 2019. These observations indicate that the reduced presence of the PSHB in 2019 is a contributing cause of the observed increases in NDVI along Chino Creek, Mill Creek, and the SAR.

3.6.3 Arundo Removal

The OCWD and SAWA[21] are the main entities that implement habitat restoration programs, including the removal and management of arundo in the SAR watershed for the promotion of native habitat for endangered or threatened species. The OCWD and SAWA sometimes work collaboratively with each other on these programs and with other stakeholders in the watershed, such as the USFWS, California Department of Fish and Wildlife (CDFW), ACOE, Regional Board, Counties of Riverside and San Bernardino, and several cities. There are many ongoing programs throughout the Prado Basin for the management and maintenance of riparian habitat, which include arundo management. SAWA publishes an annual report on the status of all habitat restoration projects they are involved with in the watershed (SAWA, 2018). Figure 3-21 shows the locations of known areas where habitat restoration activities have occurred recently in the Prado Basin, including the management and removal of arundo. The current known habitat restoration activities in 2019 include the area of the 2015 wildfire in the lower Prado area, where the OCWD is controlling the regrowth of arundo following the fire, and various patches along the SAR and lower Prado Basin area, where SAWA is leading efforts to remove arundo. These areas and activities are not inclusive of all activities currently occurring in the Prado Basin but are the known locations identified for the PBHSP where there are current arundo management activities and notable impacts to vegetation in the PBHSP.

In WY 2018, there were two areas identified with notable impacts to the riparian vegetation that resulted from habitat restoration activities. These areas include:

- The area along the SAR west of Hamner Avenue that includes the SAR-1 area
- The area of the 2015 wildfire southeast of the OCWD wetlands

The WY 2018 Annual Report (WEI, 2019) describes these areas of arundo removal and management projects and notable decreases in NDVI and observed changes by air photo.

Figures 3-22a through 3-22c are time-series charts that explore the relationship between arundo management and removal programs and NDVI for three reaches in Prado Basin: Chino Creek, Mill Creek, and the SAR. These figures show the Average Growing-Season NDVI for the 14 defined areas of riparian habitat discussed in Section 3.1 and shown in Figures 3-6 through 3-8 and 3-9a through 3-9k. Arundo management and removal occurrences, annotated by date, are shown on the charts if the arundo extent intersects with the extent of the defined area of NDVI analysis. The SAR-1 area shows an increase in the Average Growing-Season NDVI from 2018 to 2019, following a significant decrease in the NDVI for the previous three years, which coincided with an arundo removal program.

[21] SAWA is a non-profit agency with a five-member board, consisting of one member from the OCWD and the remaining from four resource conservation districts (RCDs) in the watershed, including the Riverside-Corona RCD, Temecula-Elsinore-Anza RCD, San Jacinto RCD, and Inland Empire RCD.

3.7 Analysis of Prospective Loss of Riparian Habitat

The meaning of "prospective loss" of riparian habitat in this context is the "future potential loss" of riparian habitat. Watermaster's recent predictive modeling results[22] were used to identify areas of prospective loss of riparian habitat that may be attributable to the Peace II Agreement by projecting future groundwater level conditions in the Prado Basin area through 2030. To perform this evaluation, the predictive model results were mapped and charted to identify areas, if any, where groundwater levels are projected to decline to depths that may negatively impact riparian habitat in the Prado Basin.

Figure 3-23 is a map that shows the model-predicted change in groundwater levels in the Prado Basin area over the period of 2018-2030. The map shows that groundwater levels are predicted to remain steady across most of the Prado Basin area through 2030. The stability in groundwater levels is explained in part by projected declines in groundwater production from private wells in the area, the IEUA's delivery of treated recycled water to this area for direct uses (such as outdoor irrigation), and the fact that most of the CDA production will occur to the north and northeast. Figure 3-23 shows that the most likely area where groundwater levels are projected to decline by 2030 is the northern portion of Mill Creek and the SAR.

Figure 3-24 is a time-series chart of model-predicted groundwater levels at the PBHSP monitoring wells for the period of 2018 to 2030. These wells are strategically located adjacent to the riparian habitat south of the CDA well field to best understand the potential impacts of Peace II implementation on groundwater levels and riparian habitat. The chart shows:

- Groundwater levels are projected to fluctuate seasonally at the PBHSP monitoring wells by about one to two feet.
- Groundwater levels are projected to remain stable at most of the PBHSP monitoring wells through the duration of the Peace II Agreement (through 2030) with no significant periods of increasing or decreasing groundwater levels.
- Some of the PBHSP monitoring wells are projected to experience declines in groundwater levels of about one to three feet by 2030: PB-2 along northern portion Mill Creek (~three feet of decline) and PB-3 and PB-4 along the northern portion of the SAR (~one foot of decline).

With regard to prospective loss of riparian habitat:

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[22] The predicted groundwater level changes through 2030 were made with the 2020 Chino Basin Groundwater Model for Scenario 2020 SYR1. The results of this model scenario were used to recalculate the 2020 Safe Yield of the Chino Basin (WEI, 2020). Scenario SYR1 is based on the water demands and water supply plans provided by the Watermaster parties, planning hydrology that incorporates climate change impacts on precipitation and ET_0, and assumptions regarding cultural conditions and future replenishment.

- Across most of the Prado Basin where riparian habitat exists, there are no projected declines in groundwater levels through 2030 that indicate a threat for prospective loss of riparian habitat.

- There are two areas within the Prado Basin where groundwater levels are projected to decline by 2030—the northernmost reaches of Mill Creek and the SAR. Figure 3-13 shows the current depth-to-groundwater (Fall 2019) across the Prado Basin. Where the riparian vegetation is growing along the northernmost reaches of Mill Creek, the maximum depth to water is about 10 ft-bgs. The model-projected maximum decline in groundwater levels from 2018-2030 is about three feet in this area, which equates to a maximum depth to groundwater of about 13 ft-bgs. Where the riparian vegetation is growing along the northernmost reaches of the SAR, the maximum depth to water is about seven ft-bgs. The model-projected maximum decline in groundwater levels from 2017-2030 is about one foot in this area, which equates to a maximum depth to groundwater of about eight ft-bgs. Figure 3-13 shows that riparian vegetation in the Prado Basin grows in areas where depth-to-groundwater is up to 15 feet-bgs. Hence, the projected declines in groundwater levels along Mill Creek and the SAR are minor, and it is unlikely that they will result in adverse impacts to Prado Basin riparian habitat.

- The projected changes in groundwater levels in the Prado Basin study area are predicated on the Chino Basin parties pumping groundwater and conducting recharge operations consistent with their planning assumptions, incorporated in the model scenario.

Table 3-1
Mann-Kendall Test Results of the Average-Growing Season NDVI Trends for Defined Areas in the Prado Basin

Defined Area	Figure Number	Mann Kendal Test Result[1]		
		Period of Record 1984 - 2019	Prior to Peace II 1984 - 2006	Post Peace II 2007 - 2019
2019 Rip Veg Extent	3-5	No Trend	No Trend	No Trend
Chino Creek Area	3-6	Increasing	Increasing	No Trend
Mill Creek Area	3-7	No Trend	Decreasing	No Trend
Lower Prado	3-8	Increasing	No Trend	Increasing
CC-1	3-9a	Increasing	Increasing	No Trend
CC-2	3-9b	Increasing	Increasing	No Trend
CC-3	3-9c	Increasing	No Trend	Increasing
CC-4	3-9d	Increasing	No Trend	No Trend
MC-1	3-9e	Increasing	No Trend	No Trend
MC-2	3-9f	No Trend	Decreasing	No Trend
MC-3	3-9g	No Trend	No Trend	No Trend
MC-4	3-9h	Increasing	Increasing	No Trend
SAR-1	3-9i	Increasing	Increasing	Decreasing
SAR-2	3-9j	Increasing	Increasing	No Trend
SAR-3	3-9k	Increasing	No Trend	Increasing

[1] See Appendix B for a description of the Mann-Kendall statistcal trend test and results

Table 3-2
Characterization of Variability in the Average-Growing Season NDVI for Defined Areas in the Prado Basin

Defined Area	Figure Number	Historical NDVI Statistics 1984 - 2018		One-Year Change in NDVI from 2018-2019 [1]
		Average Annual Change in NDVI (Absolute Value)	Maximum One-Year Change in NDVI (Absolute Value)	
Riparian Vegetation Extent	3-5	0.02	0.07	0.03
Chino Creek Area	3-6	0.03	0.06	**0.10**
Mill Creek Area	3-7	0.04	0.11	**0.11**
Lower Prado	3-8	0.03	0.10	0.03
CC-1	3-9a	0.03	0.09	0.05
CC-2	3-9b	0.02	0.07	**0.08**
CC-3	3-9c	0.03	0.14	0.03
CC-4	3-9d	0.04	0.12	0.01
MC-1	3-9e	0.03	0.10	0.02
MC-2	3-9f	0.04	0.18	0.11
MC-3	3-9g	0.04	0.12	0.08
MC-4	3-9h	0.03	0.11	0.09
SAR-1	3-9i	0.05	0.21	0.11
SAR-2	3-9j	0.03	0.11	0.01
SAR-3	3-9k	0.03	0.11	0.04

Notes:

1- **Bold values** indicate the recent one year change is the maximum one-year change in NDVI over the period of record

Table 3-3
Summary of USBR Vegetation Surveys in 2007, 2013, 2016, and 2019 in the Prado Basin - Canopy Cover, Tree Condition, and Occurrence of Polyphagous Shot-Hole Borer

Site	Canopy Cover (%)[1]					Tree Condition (% trees surveyed per plot)[2]															Polyphagous Shot-Hole Borer[3]				
						Not Stressed (Live)					Stressed					Dead									
	2007	2013	2016	2019	Change Through 2019	2007	2013	2016	2019	Change Through 2019	2007	2013	2016	2019	Change Through 2019	2007	2013	2016	2019	Change Through 2019	Present in 2016	% of Trees in 2016	Present in 2019	% of Trees in 2019	% Change in 2019
Chino Creek Sites																									
Chino 3	59%	NM	NM	NM	-	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--
Chino 3B	NM	97%	96%	96%	--	NM	100%	0%	33%	-67%	NM	0%	100%	44%	44%	NM	0%	0%	22%	22%	no	0%	no	0%	0%
Chino 4	80%	94%	98%	84%	4%	NM	100%	7%	55%	-45%	NM	0%	80%	40%	40%	NM	0%	13%	5%	5%	no	0%	no	0%	0%
Chino 9	92%	96%	95%	96%	4%	NM	100%	0%	23%	-77%	NM	0%	100%	59%	59%	NM	0%	0%	18%	18%	no	0%	no	0%	0%
Chino 11	94%	96%	96%	98%	4%	NM	100%	50%	69%	-31%	NM	0%	42%	0%	0%	NM	0%	8%	31%	31%	no	0%	no	0%	0%
Chino 16	46%	61%	81%	52%	7%	NM	NM	27%	50%	23%	NM	NM	64%	50%	-14%	NM	NM	9%	0%	--	no	0%	no	0%	0%
Chino 18	38%	87%	90%	77%	39%	NM	100%	7%	15%	-85%	NM	0%	67%	69%	69%	NM	0%	27%	15%	15%	yes	40%	no	0%	-40%
Chino 21	98%	94%	88%	17%	-81%	NM	100%	0%	73%	-27%	NM	0%	100%	0%	0%	NM	0%	0%	27%	27%	yes	17%	no	0%	-17%
Chino 24	93%	93%	98%	94%	1%	NM	100%	6%	32%	-68%	NM	0%	94%	56%	56%	NM	0%	0%	12%	12%	yes	6%	no	0%	-6%
Chino 30	79%	88%	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--
Chino 30B	NM	NM	89%	74%	-15%	NM		0%	20%	20%	NM	NM	89%	50%	-39%	NM	NM	11%	30%	19%	yes	100%	no	0%	-100%
Chino 31	82%	93%	97%	91%	9%	NM	100%	7%	4%	-96%	NM	0%	93%	72%	72%	NM	0%	0%	24%	24%	yes	7%	no	0%	-7%
Chino 34	96%	97%	89%	75%	-21%	NM	100%	0%	33%	-67%	NM	0%	67%	33%	33%	NM	0%	33%	33%	33%	no	0%	no	0%	0%
Chino 78	95%	98%	87%	98%	3%	NM	100%	0%	45%	-55%	NM	0%	80%	55%	55%	NM	0%	20%	0%	0%	yes	80%	no	0%	-80%
Chino 81	92%	0%	NM	NM	-	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--
Chino 85	89%	0%	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--
Chino X3	NM	NM	93%	94%	1%	NM	NM	25%	83%	58%	NM	NM	75%	17%	-58%	NM	NM	0%	0%	0%	no	0%	no	0%	0%
Chino X4	NM	NM	92%	94%	2%	NM	NM	0%	43%	43%	NM	NM	100%	14%	-86%	NM	NM	0%	43%	43%	yes	100%	yes	71%	-29%
Chino X5	NM	NM	96%	95%	-1%	NM	NM	75%	89%	14%	NM	NM	25%	11%	-14%	NM	NM	0%	0%	0%	yes	25%	no	0%	-25%
Chino X6	NM	NM	98%	99%	1%	NM	NM	87%	47%	-40%	NM	NM	13%	47%	34%	NM	NM	0%	7%	7%	yes	13%	no	0%	-13%
Chino X7	NM	NM	88%	66%	-22%	NM	NM	0%	43%	43%	NM	NM	70%	43%	-27%	NM	NM	30%	14%	-16%	yes	70%	no	0%	-70%
Chino X8	NM	NM	85%	99%	14%	NM	NM	0%	71%	71%	NM	NM	62%	24%	-38%	NM	NM	38%	6%	-32%	yes	46%	yes	6%	-40%
Average	**81%**	**78%**	**92%**	**83%**	**-3%**	**-**	**100%**	**16%**	**46%**	**-21%**	**-**	**0%**	**73%**	**38%**	**10%**	**-**	**0%**	**11%**	**16%**	**12%**	**yes**	**28%**	**no**	**4%**	**-24%**
Mill Creek Sites																									
Mill 1	40%	0%	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--
Mill 3	8%	13%	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--
Mill 4	38%	6%	0%	0%	-38%	NM	0%	0%	100%	100%	NM	63%	50%	0%	-63%	NM	37%	50%	0%	-37%	yes	50%	no	0%	-50%
Mill 8	66%	88%	82%	79%	13%	NM	33%	33%	0%	-33%	NM	67%	0%	50%	-17%	NM	0%	67%	50%	50%	yes	33%	no	0%	-33%
Mill 11	75%	80%	NM	NM	--	NM	90%	NM	NM	--	NM	0%	NM	NM	--	NM	10%	NM	NM	--	NM	NM	NM	0%	--
Mill 18	62%	68%	78%	90%	28%	NM	100%	38%	10%	-90%	NM	0%	38%	80%	80%	NM	0%	25%	10%	10%	yes	38%	no	0%	-38%
Mill 22	89%	93%	96%	93%	4%	NM	86%	0%	43%	-43%	NM	0%	79%	43%	43%	NM	14%	21%	14%	0%	yes	64%	no	0%	-64%
Mill 30	63%	63%	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	NM	--	NM	NM	NM	0%	--
Mill 35	81%	95%	NM	NM	--	NM	100%	NM	NM	--	NM	0%	NM	NM	--	NM	0%	NM	NM	--	NM	NM	NM	0%	--
Mill 39	94%	87%	96%	96%	2%	NM	92%	0%	13%	-79%	NM	0%	67%	63%	63%	NM	8%	33%	25%	17%	yes	44%	yes	38%	-6%
Mill 60	76%	90%	83%	51%	6%	NM	86%	0%	0%	-86%	NM	0%	93%	69%	69%	NM	14%	7%	31%	17%	yes	29%	no	0%	-29%
Mill 62	66%	96%	96%	63%	30%	NM	100%	0%	6%	-94%	NM	0%	94%	25%	25%	NM	0%	6%	69%	69%	yes	94%	yes	25%	-69%
Mill 63	70%	97%	78%	43%	8%	NM	100%	0%	15%	-85%	NM	0%	68%	23%	23%	NM	0%	32%	62%	62%	yes	41%	yes	23%	-18%
Mill 67	75%	95%	NM	NM	--	NM	100%	NM	NM	--	NM	0%	NM	NM	--	NM	0%	NM	NM	--	NM	NM	NM	0%	--
Mill 69	92%	84%	75%	98%	6%	NM	90%	0%	67%	-23%	NM	0%	64%	0%	0%	NM	10%	36%	33%	23%	yes	64%	yes	22%	-42%
Mill 82	92%	96%	56%	91%	-1%	NM	100%	0%	69%	-31%	NM	0%	75%	15%	15%	NM	0%	25%	15%	15%	yes	25%	yes	8%	-17%
Mill 101	90%	94%	83%	88%	-2%	NM	96%	0%	26%	-70%	NM	0%	87%	48%	48%	NM	4%	13%	26%	22%	yes	83%	no	0%	-83%
Mill X9	NM	NM	94%	94%	0%	NM	NM	70%	42%	-28%	NM	NM	30%	58%	28%	NM	NM	0%	0%	0%	yes	10%	no	0%	-10%
Mill X10	NM	NM	89%	95%	6%	NM	NM	0%	70%	70%	NM	NM	50%	30%	-20%	NM	NM	50%	0%	-50%	yes	50%	no	0%	-50%
Average	**69%**	**73%**	**77%**	**75%**	**5%**	**-**	**84%**	**11%**	**35%**	**-38%**	**-**	**9%**	**61%**	**39%**	**23%**	**-**	**7%**	**28%**	**26%**	**15%**	**yes**	**48%**	**no**	**7%**	**-39%**
Santa Ana River Sites																									
SAR X1	NM	NM	58%	86%	28%	NM	NM	76%	75%	-1%	NM	NM	5%	13%	8%	NM	NM	19%	13%	-6%	yes	3%	no	0%	-3%
SAR X2	NM	NM	93%	79%	-14%	NM	NM	11%	60%	49%	NM	NM	89%	30%	-59%	NM	NM	0%	10%	10%	yes	17%	no	0%	-17%
SAR X11	NM	NM	88%	94%	6%	NM	NM	27%	44%	17%	NM	NM	64%	11%	-53%	NM	NM	9%	44%	35%	yes	82%	no	0%	-82%
SAR X12	NM	NM	96%	100%	4%	NM	NM	9%	44%	35%	NM	NM	91%	44%	-47%	NM	NM	0%	13%	13%	yes	91%	no	0%	-91%
SAR X13	NM	NM	87%	100%	13%	NM	NM	0%	17%	17%	NM	NM	67%	67%	0%	NM	NM	33%	17%	-16%	yes	67%	no	0%	-67%
SAR X14	NM	NM	88%	97%	10%	NM	NM	0%	75%	75%	NM	NM	100%	25%	-75%	NM	NM	0%	0%	0%	yes	100%	no	0%	-100%
Average	**-**	**-**	**85%**	**93%**	**8%**	**-**	**-**	**21%**	**53%**	**32%**	**-**	**-**	**69%**	**32%**	**-38%**	**-**	**-**	**10%**	**16%**	**6%**	**yes**	**60%**	**no**	**0%**	**-60%**
Average all Sites	**75%**	**76%**	**86%**	**82%**	**8%**	**-**	**91%**	**15%**	**43%**	**-19%**	**-**	**5%**	**68%**	**37%**	**7%**	**-**	**4%**	**17%**	**19%**	**12%**	**yes**	**40%**	**no**	**5%**	**-35%**

Notes:

NM - Not Measured

1- Canopy cover is a measurement of the percentage of a ground area directly covered by vertical projections of tree crowns. In the field, canopy cover is measured using a spherical densiometer standing five meters from the center of the plot in the four cardinal directions (north, south, east, west). Canopy Cover percent herein is the average of the four measurements.

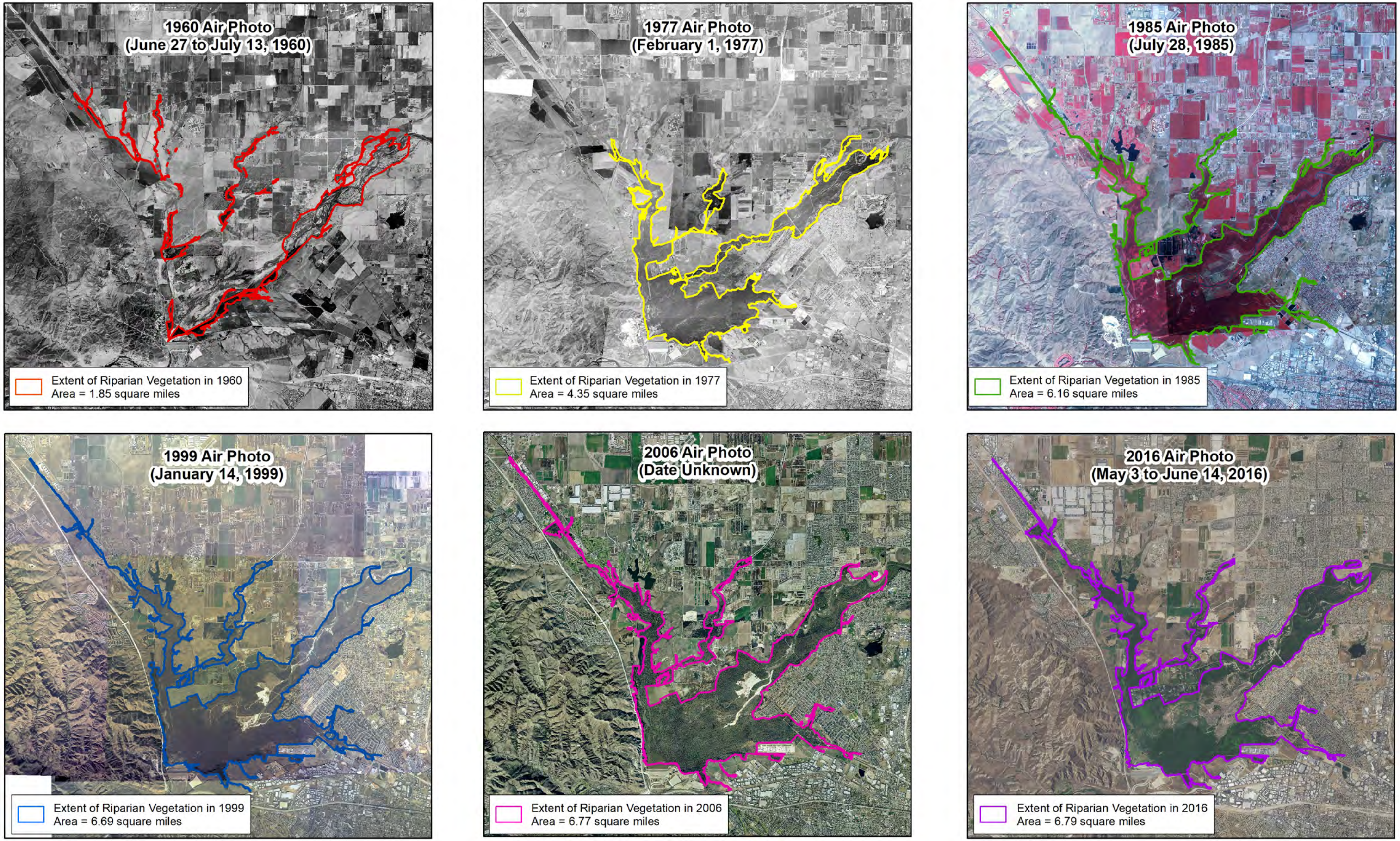
2- Tree condition is a qualitative measurement of the health of the tree. Trees were assessed and classified as "live," "stressed," or "dead". The percentage of each classification per plot is shown here.

3- In 2016 and 2019 trees were assessed for the presence of polyphagous shot-hole borers (PSHB). If a tree showed signs of the beetle it was noted. The percent of trees in each plot that showed signs of beetle infestation was then calculated.

Table 3-4
Annual Groundwater Pumping in the Groundwater Monitoring Program Study Area

Water Year	Non-CDA Pumping (afy) [1]	CDA Pumping (afy)	Total Pumping (afy) [1]
1961	48,577	0	48,577
1962	43,811	0	43,811
1963	43,293	0	43,293
1964	45,170	0	45,170
1965	43,294	0	43,294
1966	46,891	0	46,891
1967	42,709	0	42,709
1968	47,180	0	47,180
1969	37,754	0	37,754
1970	45,849	0	45,849
1971	45,492	0	45,492
1972	47,541	0	47,541
1973	38,427	0	38,427
1974	47,014	0	47,014
1975	44,606	0	44,606
1976	44,847	0	44,847
1977	45,710	0	45,710
1978	46,881	0	46,881
1979	48,829	0	48,829
1980	46,402	0	46,402
1981	53,326	0	53,326
1982	41,719	0	41,719
1983	42,200	0	42,200
1984	52,877	0	52,877
1985	46,876	0	46,876
1986	54,501	0	54,501
1987	46,875	0	46,875
1988	46,277	0	46,277
1989	46,835	0	46,835
1990	45,732	0	45,732
1991	42,266	0	42,266
1992	44,617	0	44,617
1993	43,186	0	43,186
1994	37,390	0	37,390
1995	32,604	0	32,604
1996	35,200	0	35,200
1997	33,340	0	33,340
1998	22,366	0	22,366
1999	23,632	0	23,632
2000	24,299	523	24,822
2001	21,249	9,470	30,719
2002	20,271	10,173	30,445
2003	18,600	10,322	28,922
2004	18,606	10,480	29,086
2005	13,695	10,595	24,290
2006	14,261	19,819	34,079
2007	12,988	28,529	41,517
2008	12,293	30,116	42,409
2009	11,694	28,456	40,150
2010	10,452	28,964	39,416
2011	10,460	28,941	39,401
2012	11,193	28,230	39,423
2013	11,433	27,380	38,813
2014	9,059	29,626	38,685
2015	6,985	29,877	36,862
2016	5,900	28,249	34,148
2017	5,899	28,351	34,250
2018	7,504	29,191	36,695
2019	5,348	32,004	37,352
Average: 1961-1990	45,917	0	45,917
Average: 1991-1999	34,956	0	34,956
Average: 2000-2019	12,609	22,465	35,074

1- Prior to water year 2001 production is estimated with the calibrated 2013 Chino Basin groundwater model (WEI, 2015).



Prepared by:
WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 2/4/2020
File: Figure 3-1a_2019_AirPhotos_VegExtent

0 1 2 Miles
0 1 2 3 Kilometers

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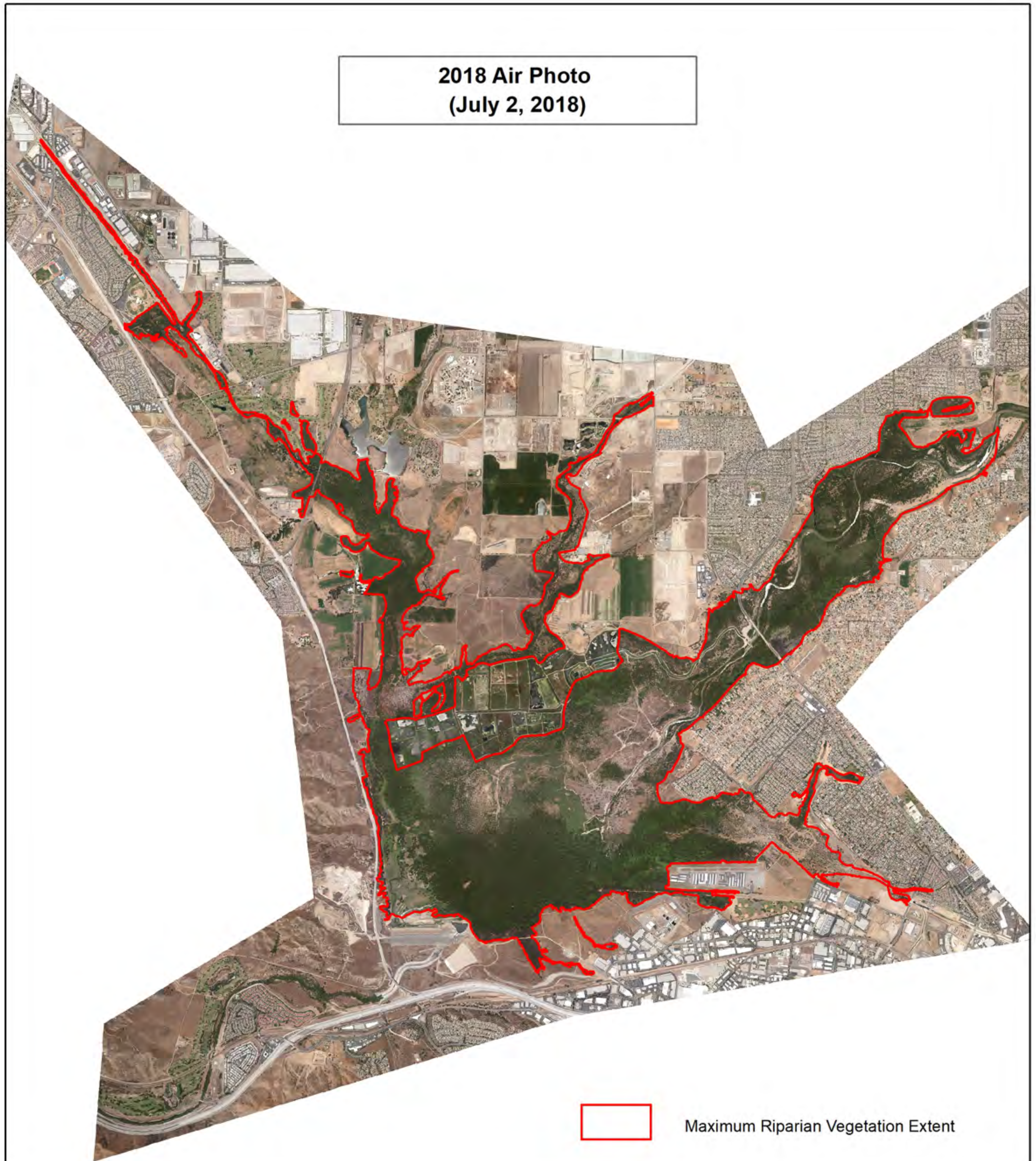
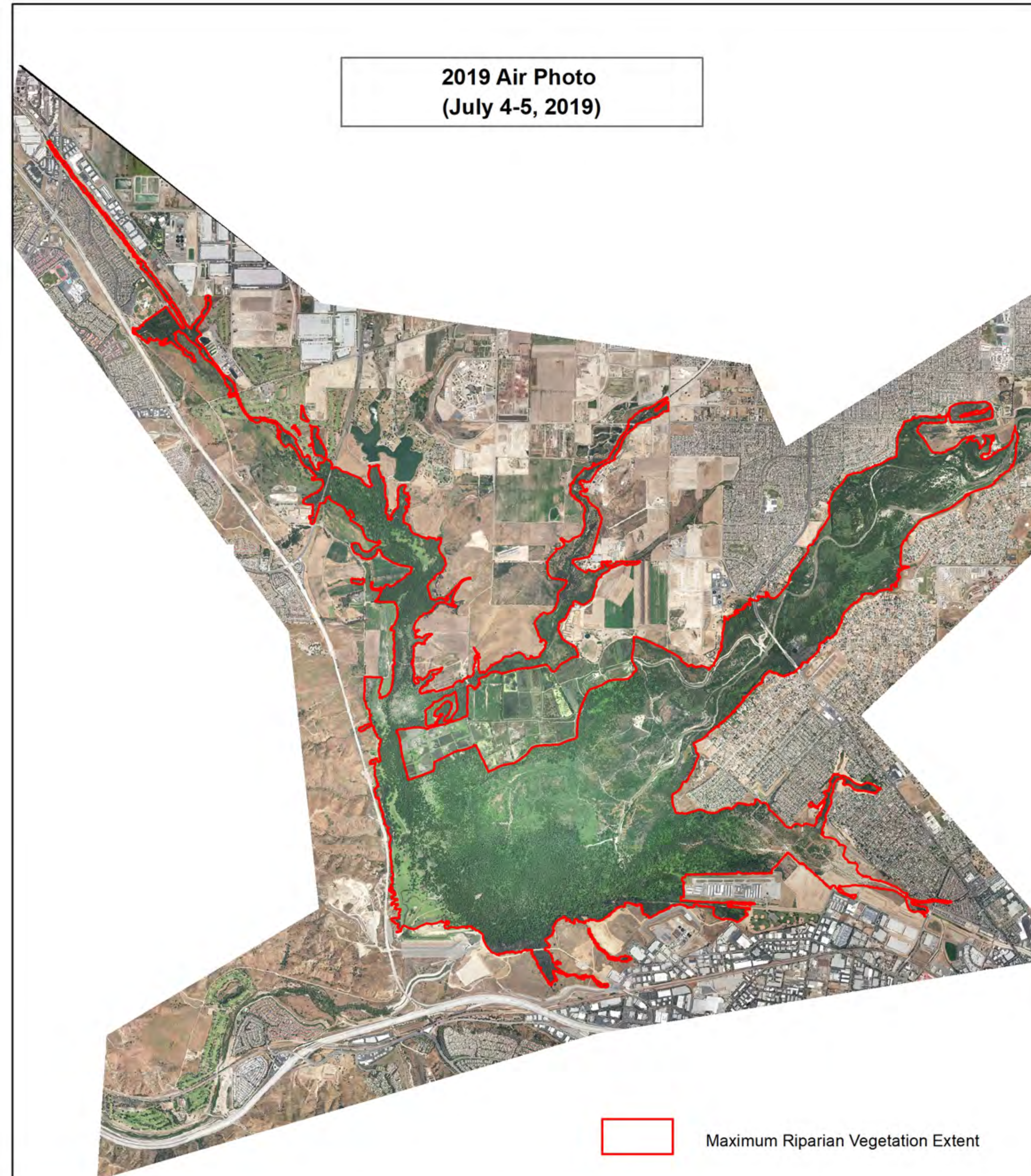
Historical Air Photos and Extent of Riparian Vegetation
1960 to 2016

Figure 3-1a





Prepared by:
WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 4/7/2020
File: Figure 3-1b_2018 and 2019 Air Photos

0 1 2 Miles
0 1 2 3 Kilometers

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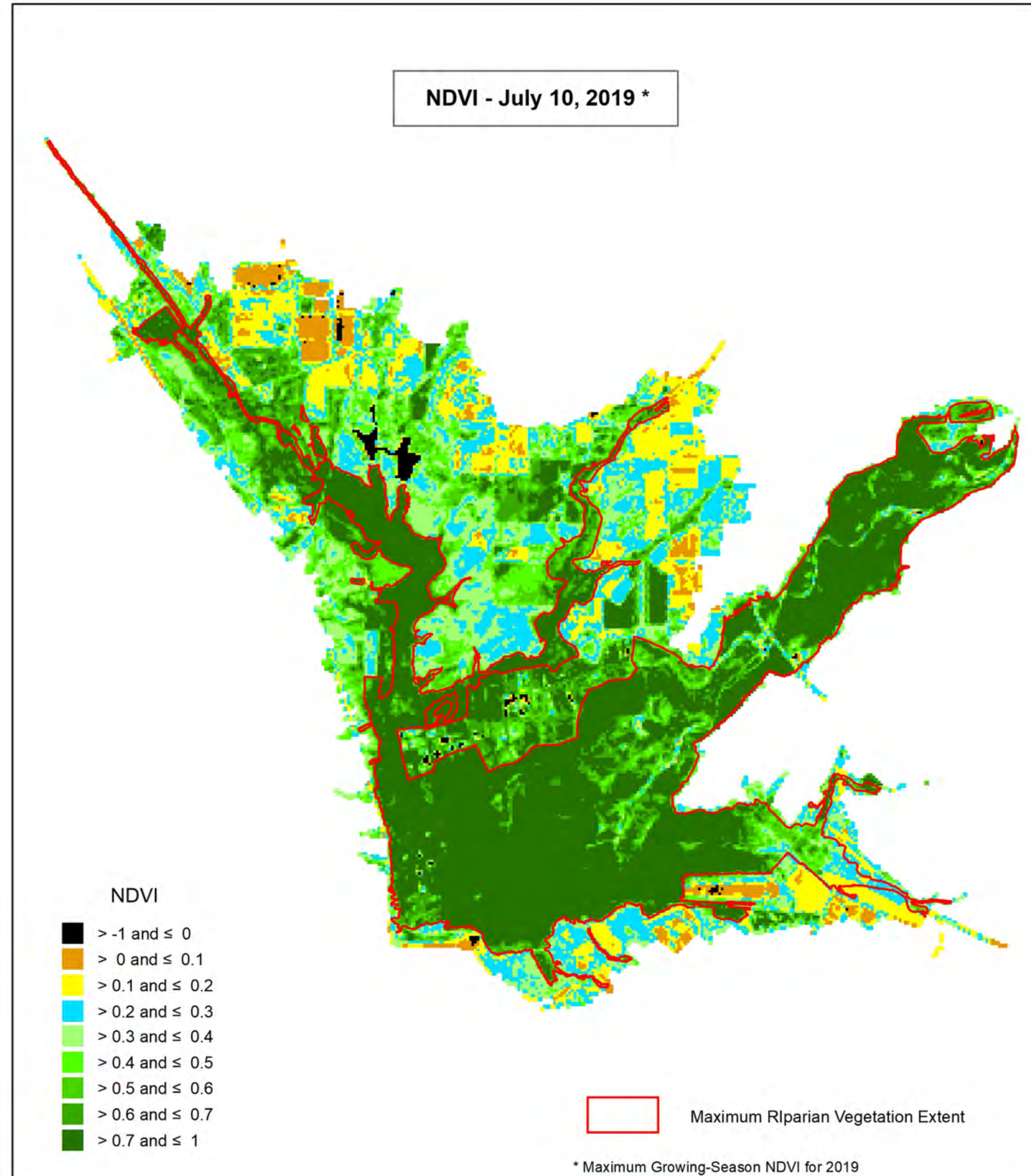
Air Photos and Extent of the Riparian Vegetation
2018 and 2019

Figure 3-1b



Prepared by:

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Author: RT
Date: 3/13/2020
File: Figure 3-1c_2019_Prado_AirP_NDVI

0 1 2 Miles
0 1 2 3 Kilometers

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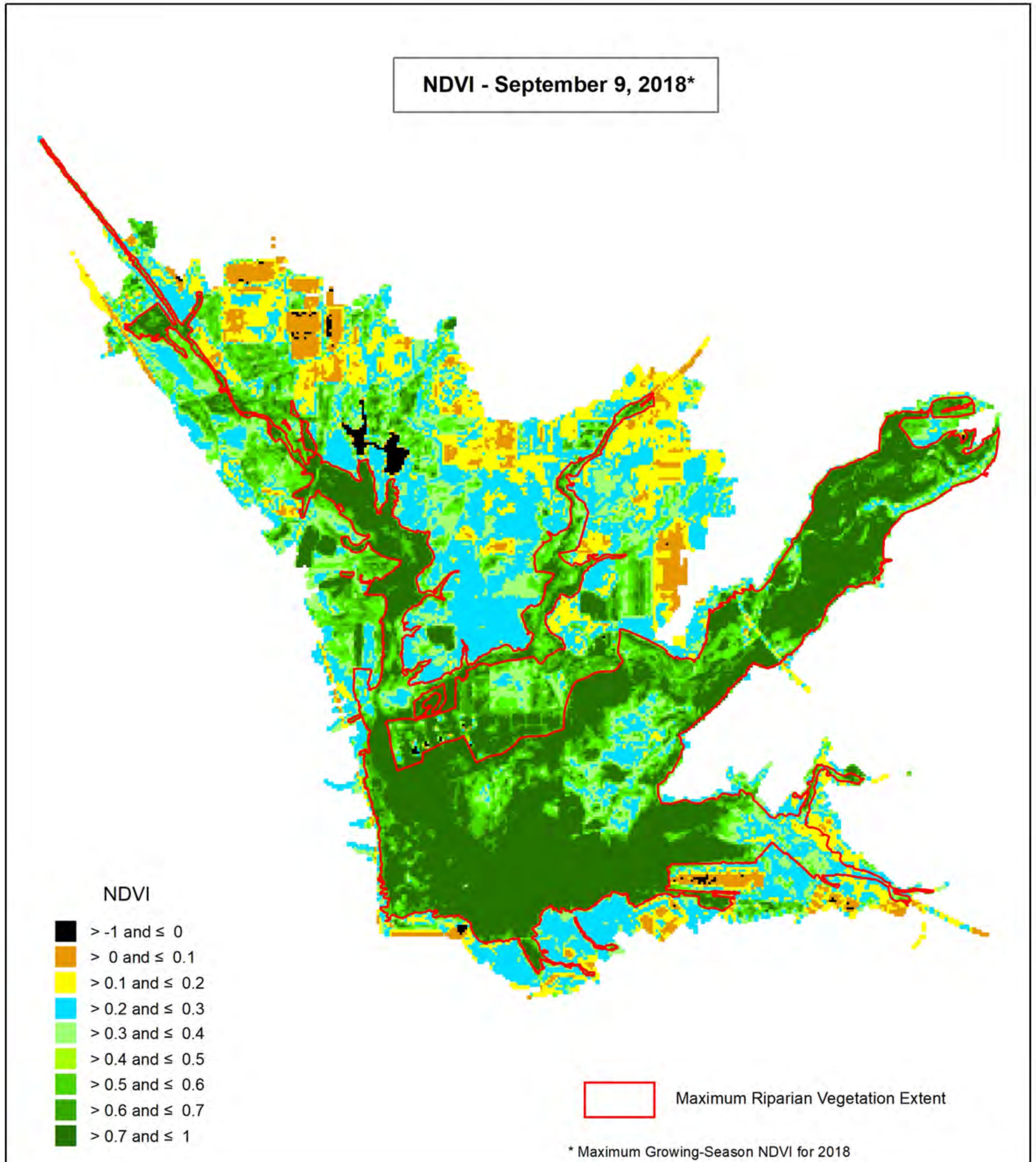
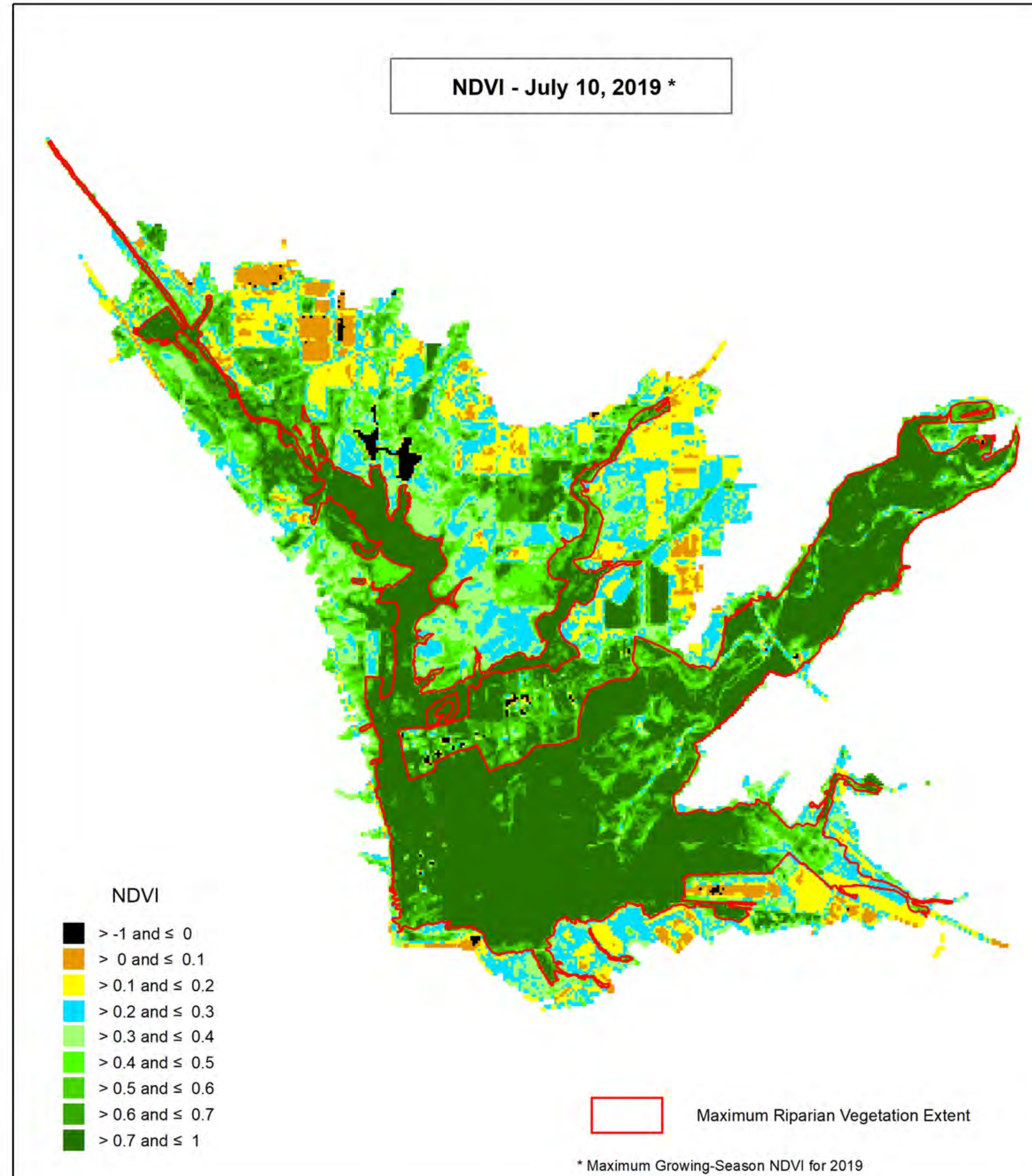
2019 Air Photo and Spatial NDVI for the Prado Basin Area

Figure 3-1c





Prepared by:
WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 2/4/2020
File: Figure 3-2_2018_2019_NDVI

0 1 2 Miles
0 1 2 3 Kilometers

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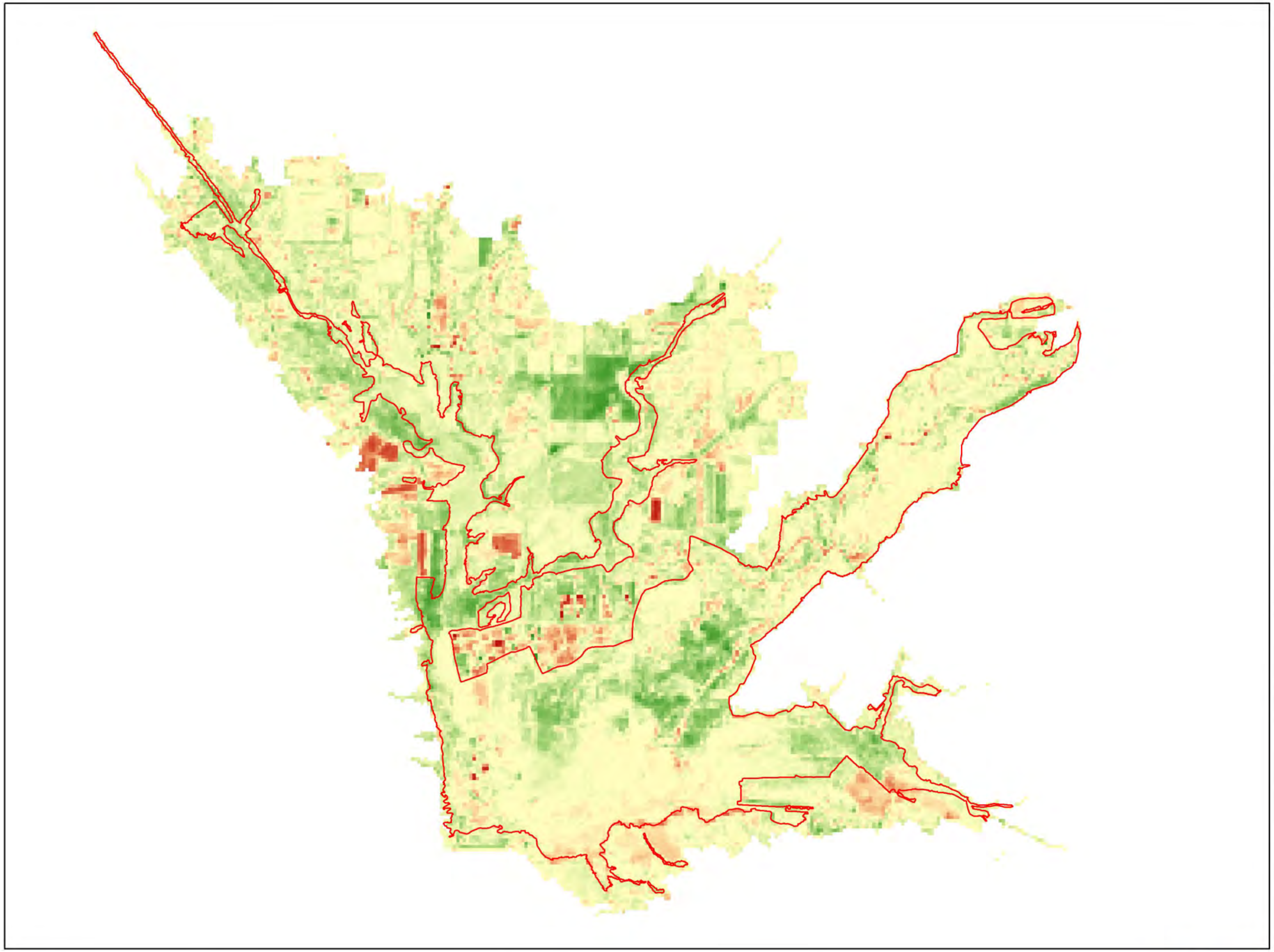
Prado Basin Habitat Sustainability Committee

Spatial NDVI of the Prado Basin
2018 and 2019

Figure 3-2

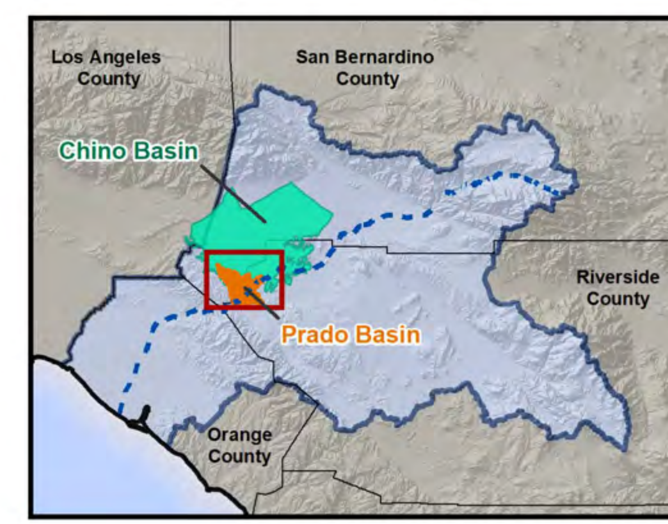


Change in Maximum Growing-Season NDVI Values from 2018 to 2019

0.7 Increase

-0.7 Decrease

Maximum Riparian Vegetation Extent in Prado Basin



Prepared by:

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Author: RT
Date: 4/20/2020
File: Figure 3-3_new_NDVI Change Map_2018_2019

0 1 2 Miles

0 1 2 3 Kilometers

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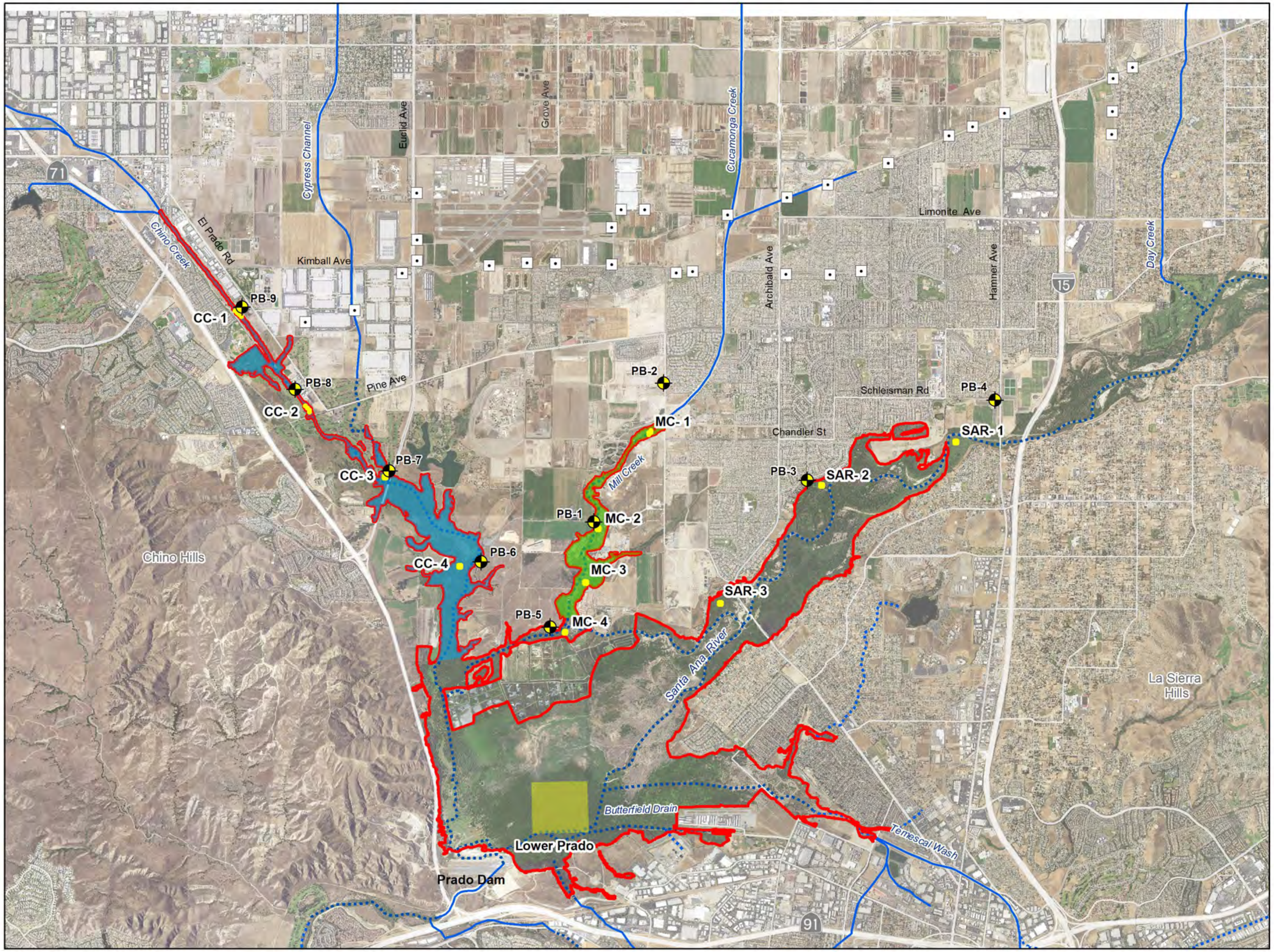
Spatial Change in NDVI for the Prado Basin
2018 and 2019

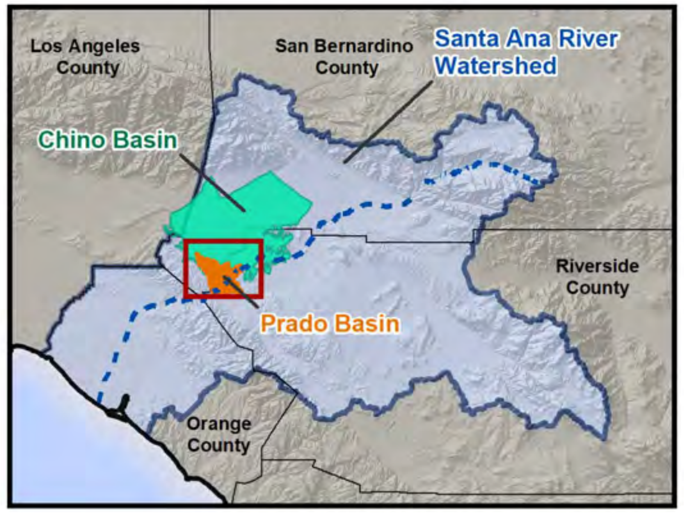
Figure 3-3



Defined Areas Analyzed for NDVI Temporally in Time-Series Charts

- 6.8 square-mile area (19,520 pixels) Riparian Vegetation Extent (Figure 3-5)
- 0.74 square-mile area (2,134 NDVI pixels) in Chino Creek (Figure 3-6)
- 0.26 square-mile area (759 NDVI pixels) in Mill Creek (Figure 3-7)
- 0.23 square-mile area (677 NDVI pixels) in Lower Prado (Figure 3-8)
- 3,600 square-meter area (four NDVI pixels) (Figures 3-9a through 3-9k)
- PBHSP Monitoring Well Site
- Chino Basin Desalter Authority Well
- Concrete-Lined Channels
- Unlined Rivers and Streams

Aerial Photo: USDA, 2016. Mosaic of photos from June 2, 2016 to June14, 2016



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Author: RT
Date: 4/9/2020
File: Figure 3-4 Veg Monitoring_NDVI_Sites

0 1 2 Miles
0 1 2 3 Kilometers

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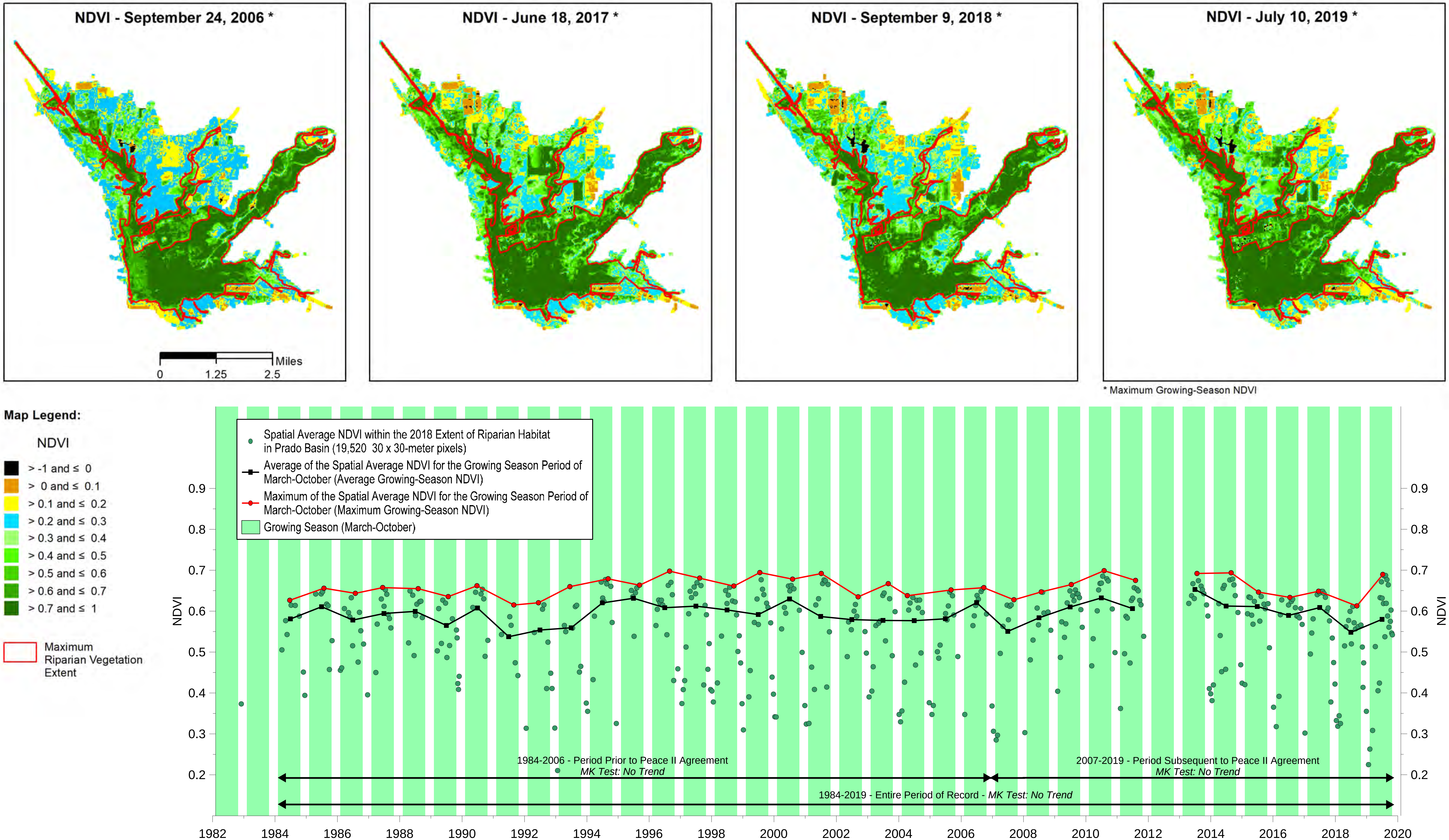
Areas for Analysis of NDVI Time Series

Figure 3-4



Prepared by:

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Wildermuth Environmental, Inc.

Author: RT
Date: 20200310
Filename: 18-19_NDVI_Prado Regional.grf

MK Test = Mann-Kendall Test Result

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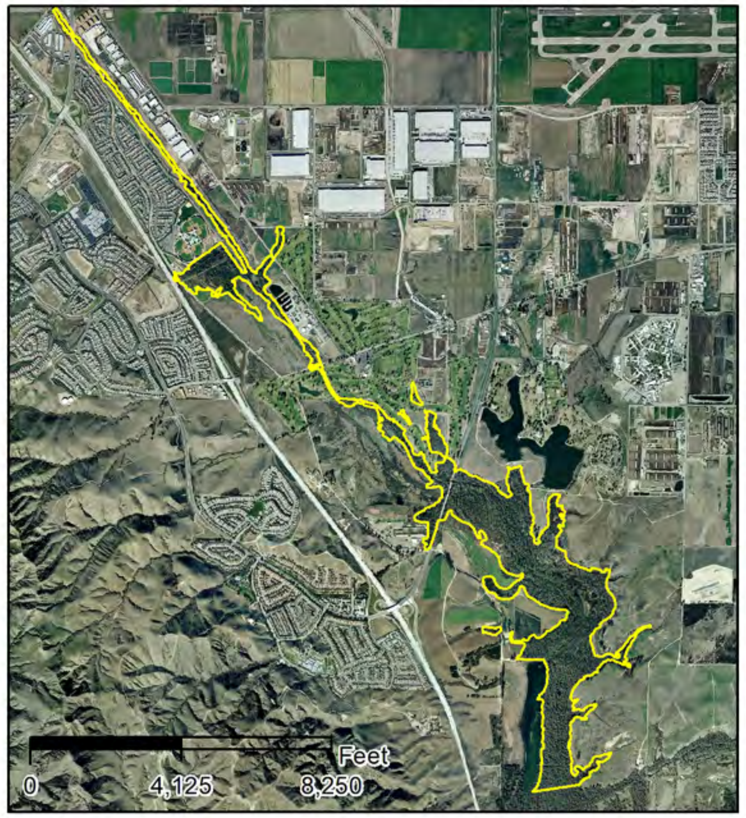
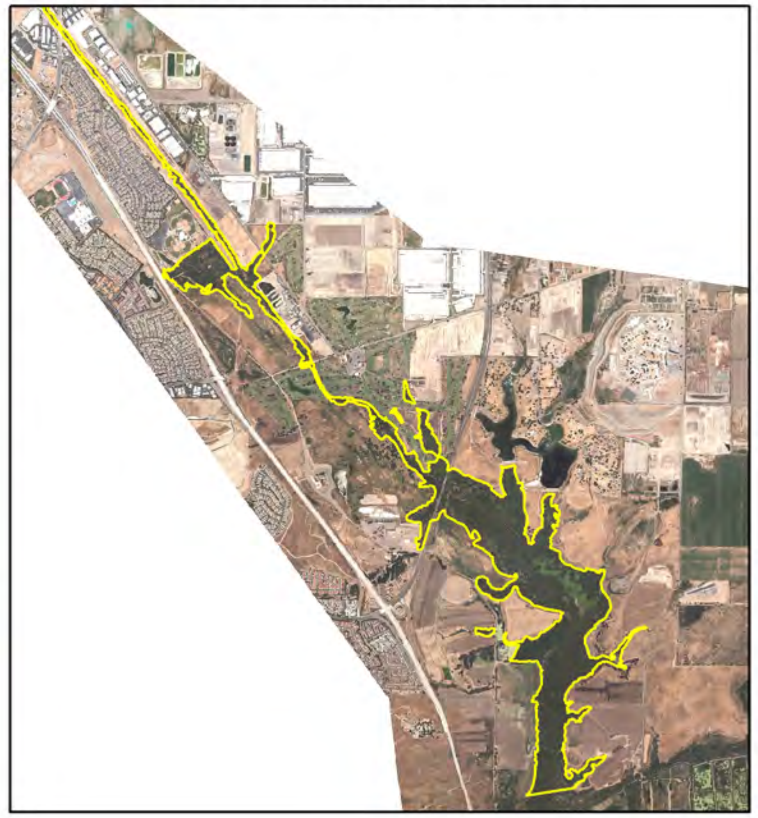
Time Series of NDVI for the 2019 Riparian Vegetaion Extent - *1984 to 2019*

Figure 3-5

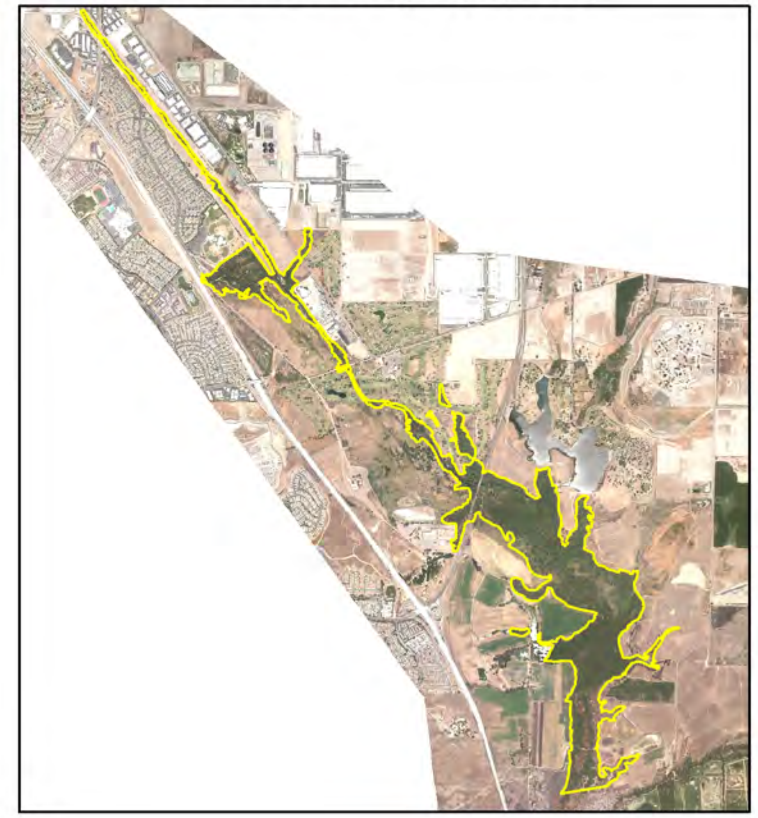
2006 Air Photo (Date Unknown)



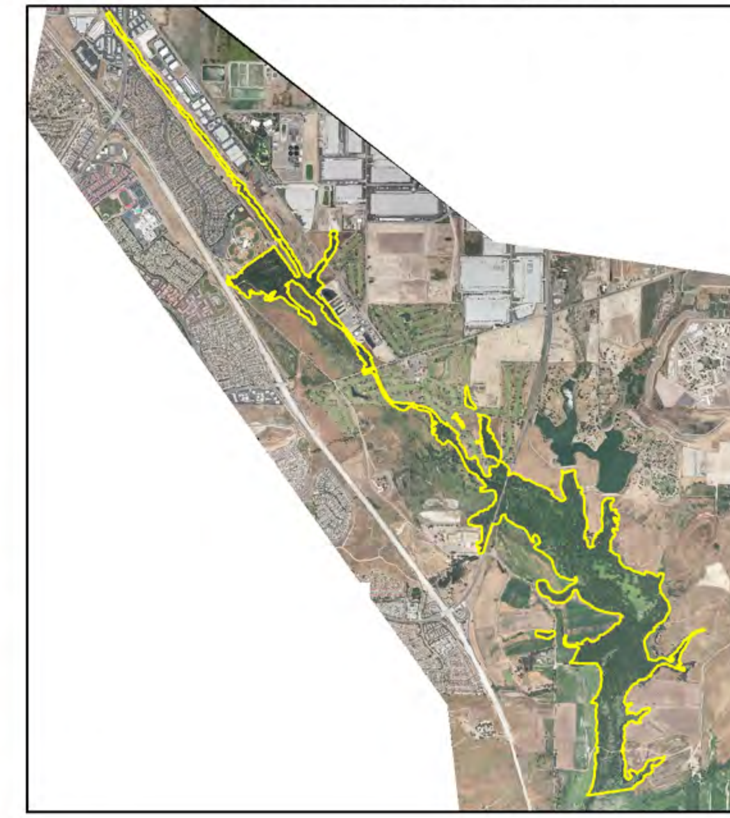
2017 Air Photo (July 3, 2017)



2018 Air Photo (July 2, 2018)

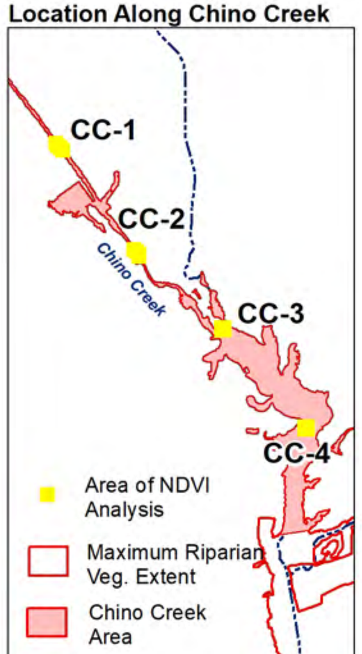


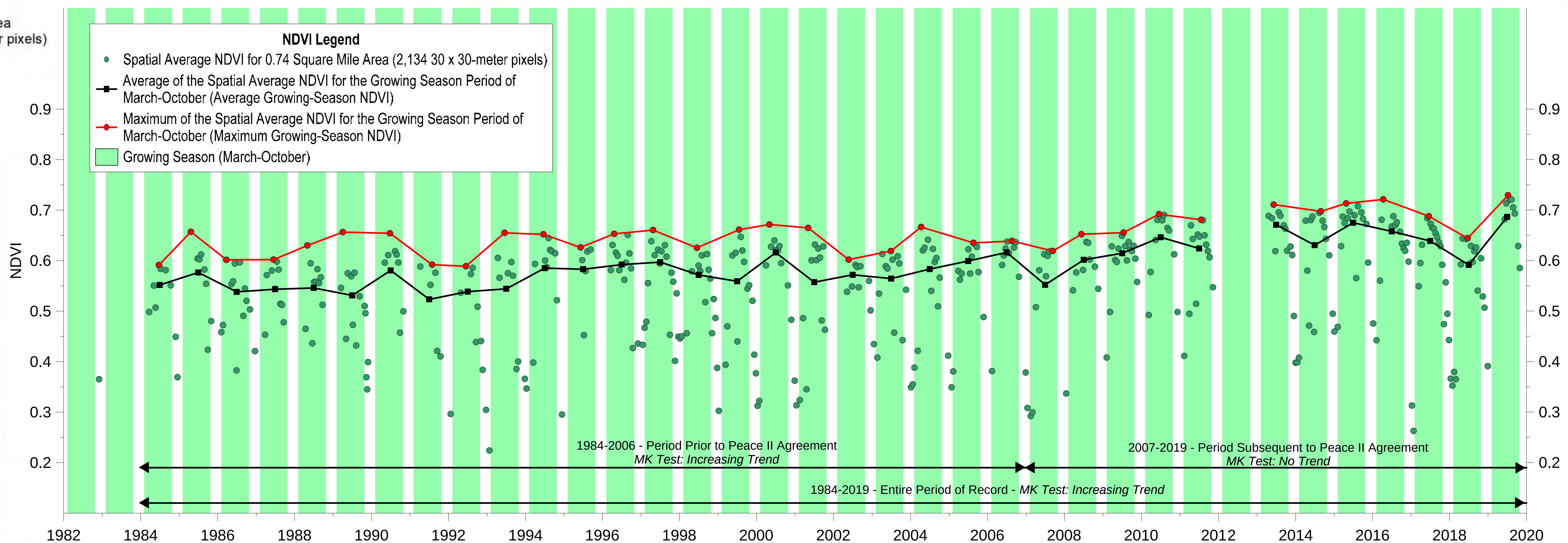
2019 Air Photo (July 4-5, 2019)



0.74 Square Mile Area
(2,134 30 x 30-meter pixels)

Location Along Chino Creek





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Author: RT
Date: 20200310
Filename: 18-19_NDVI_CC Area.grf

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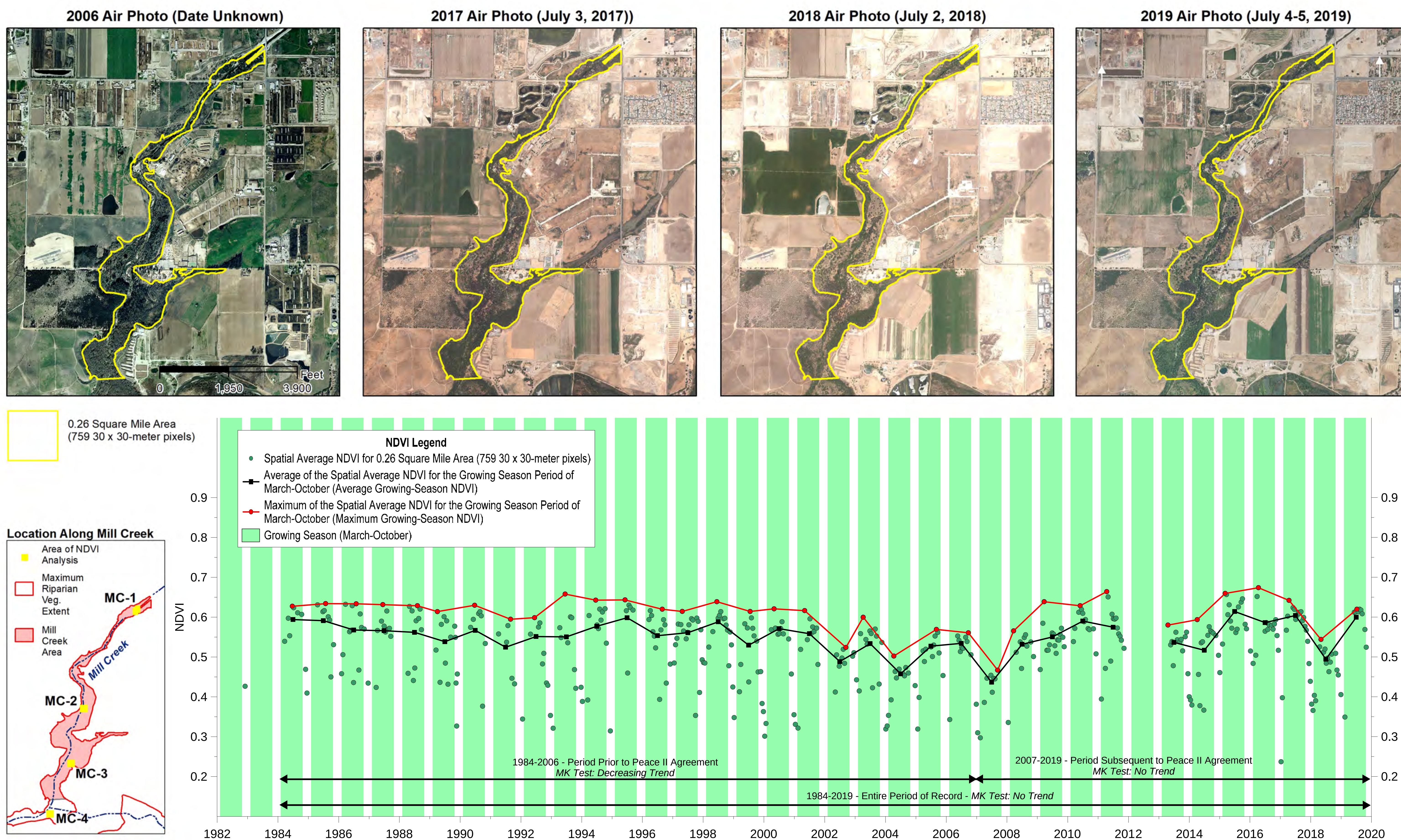
Time Series of NDVI and Air Photos
Along Chino Creek Area for 1984 to 2019

Figure 3-6



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Author: RT
Date: 20200310
Filename: 18-19_NDVI_Lower Prado.grf

MK Test = Mann-Kandall Test Result

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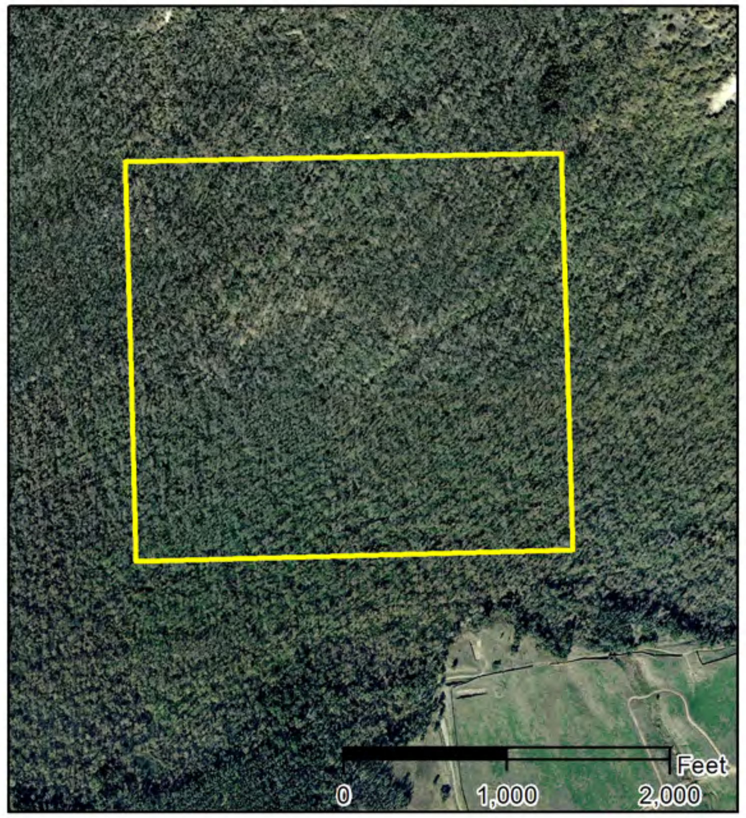
Time Series of NDVI and Air Photos
along Mill Creek Area for 1984 to 2019

Figure 3-7

2006 Air Photo (Date Unknown)



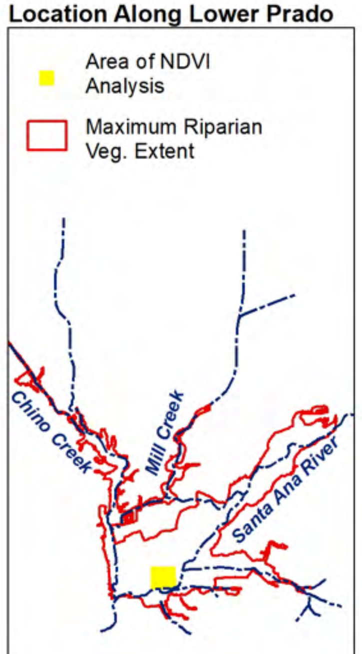
2017 Air Photo (July 3, 2017)

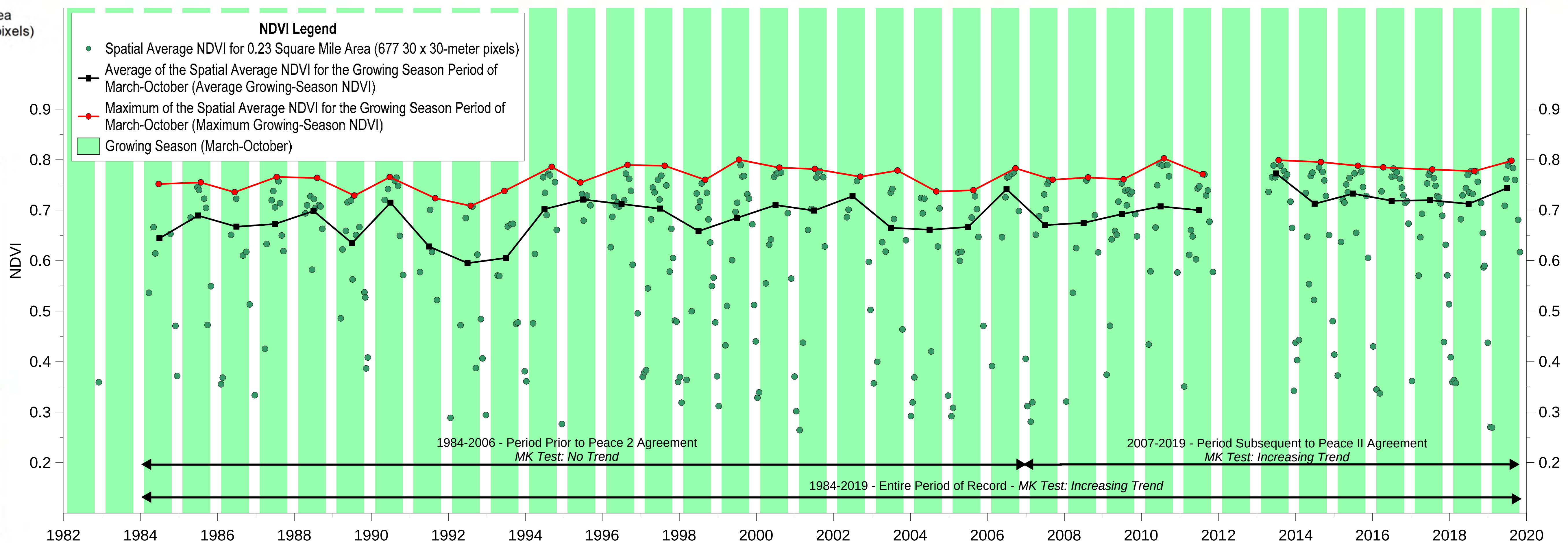
2018 Air Photo (July 2, 2018)

2019 Air Photo (July 4-5, 2019)

0.23 Square-Mile Area
(677 30 x 30 meter pixels)

Location Along Lower Prado





Prepared by:
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Author: RT
Date: 20200310
Filename: 18-19_NDVI_Lower Prado.grf

MK Test = Mann-Kandall Test Result

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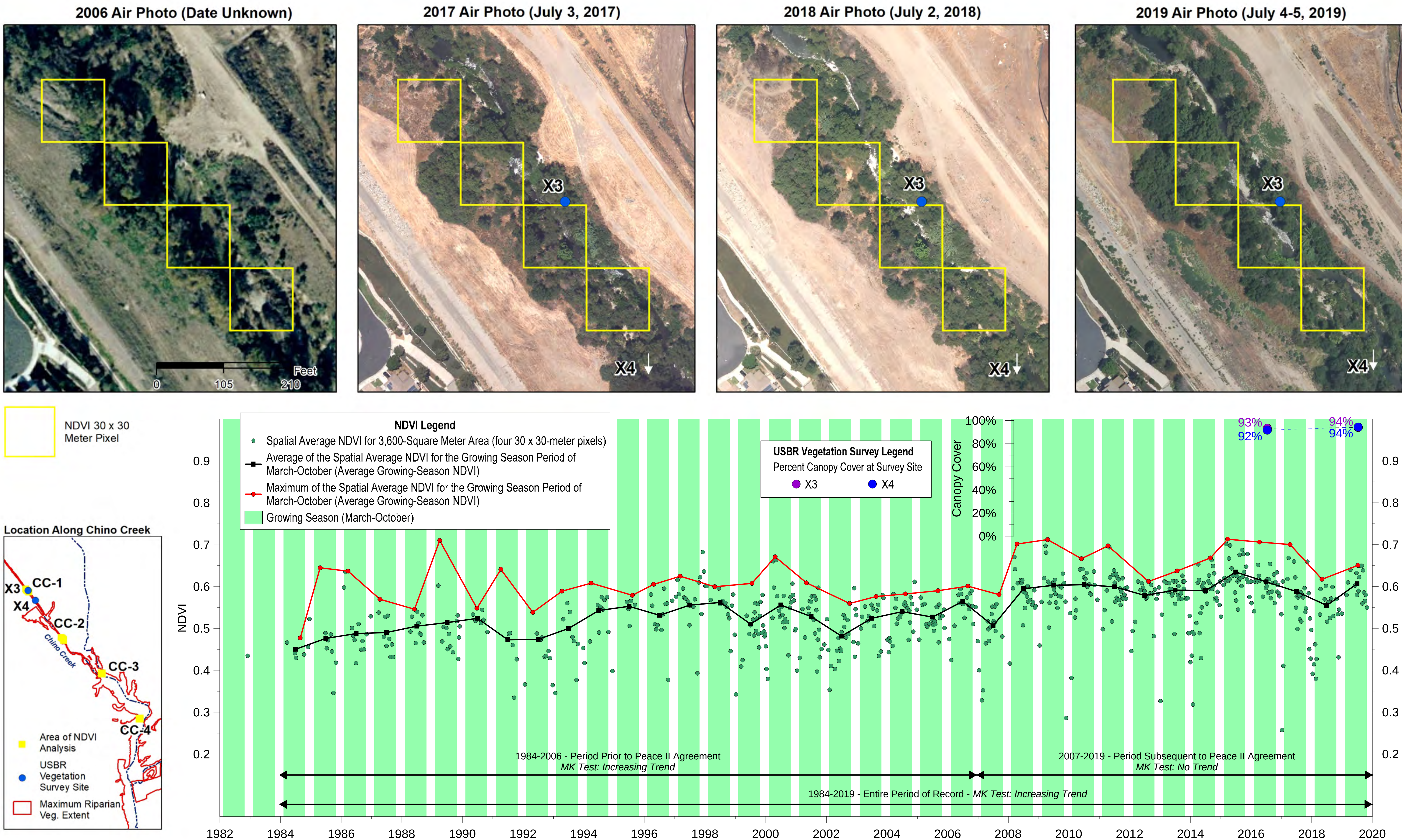
Time Series of NDVI and Air Photos
Lower Prado Area for 1984 to 2019

Figure 3-8



Prepared by:

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Author: RT
Date: 20200113
Filename: 18-19_NDVI_CC-1.grf

MK Test = Mann-Kandall Test Result

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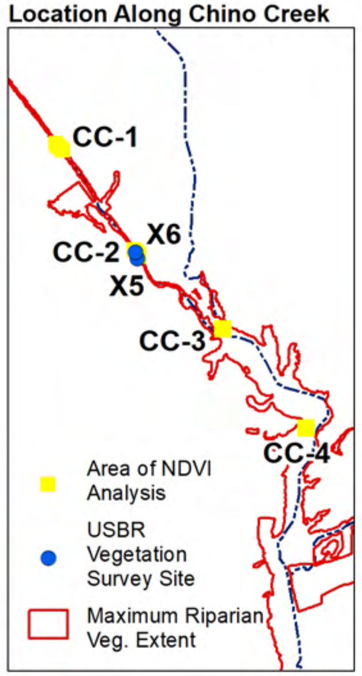
Prado Basin Habitat Sustainability Committee

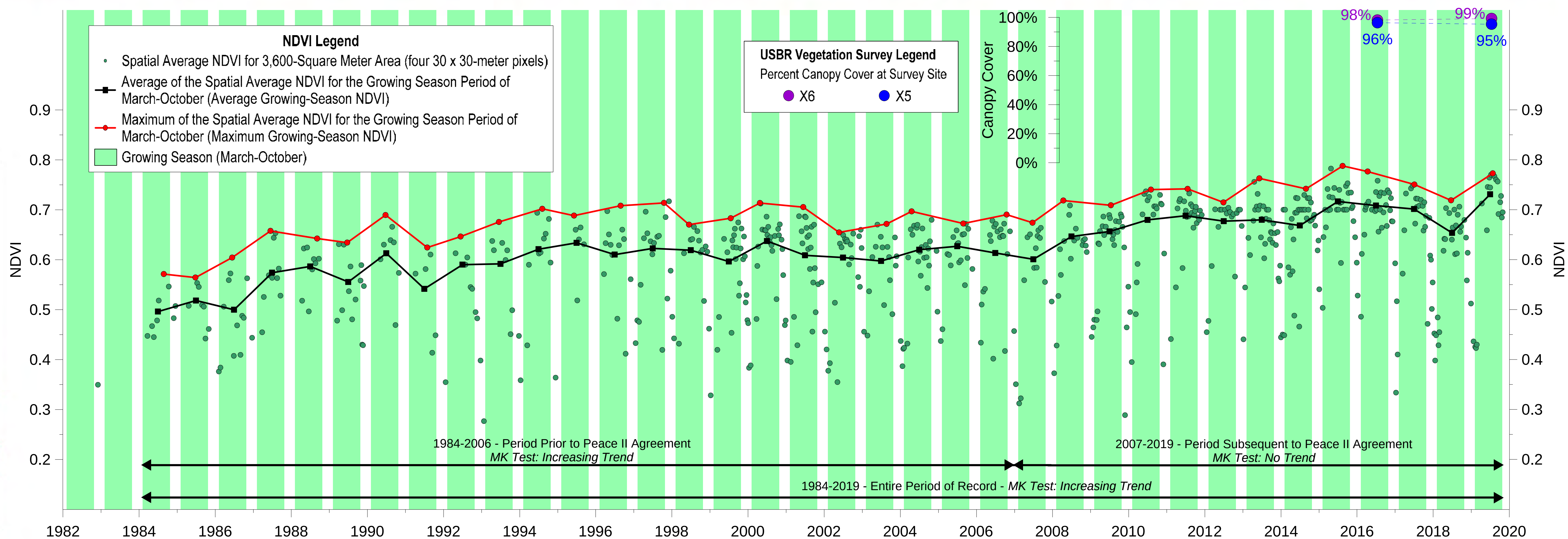
Time Series of NDVI and Air Photos
CC-1 Area for 1984 to 2019

Figure 3-9a

NDVI 30 x 30 Meter Pixel

Location Along Chino Creek





Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 20200310
Filename: 18-19_NDVI_CC-2_Airphoto.grf

MK Test = Mann-Kendall Test Result

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Time Series of NDVI and Air Photos
CC-2 Area for 1984 to 2019

Figure 3-9b

2006 Air Photo (Date Unknown)

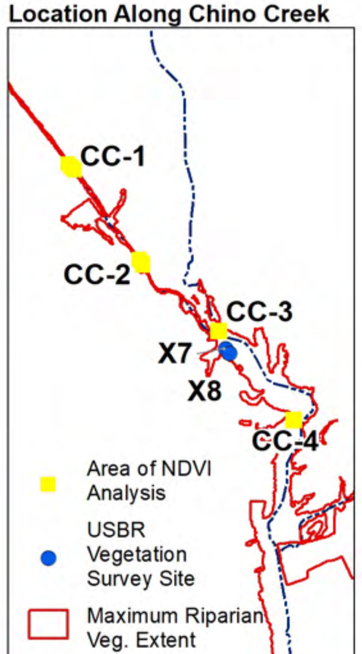
2017 Air Photo (July 3, 2017)

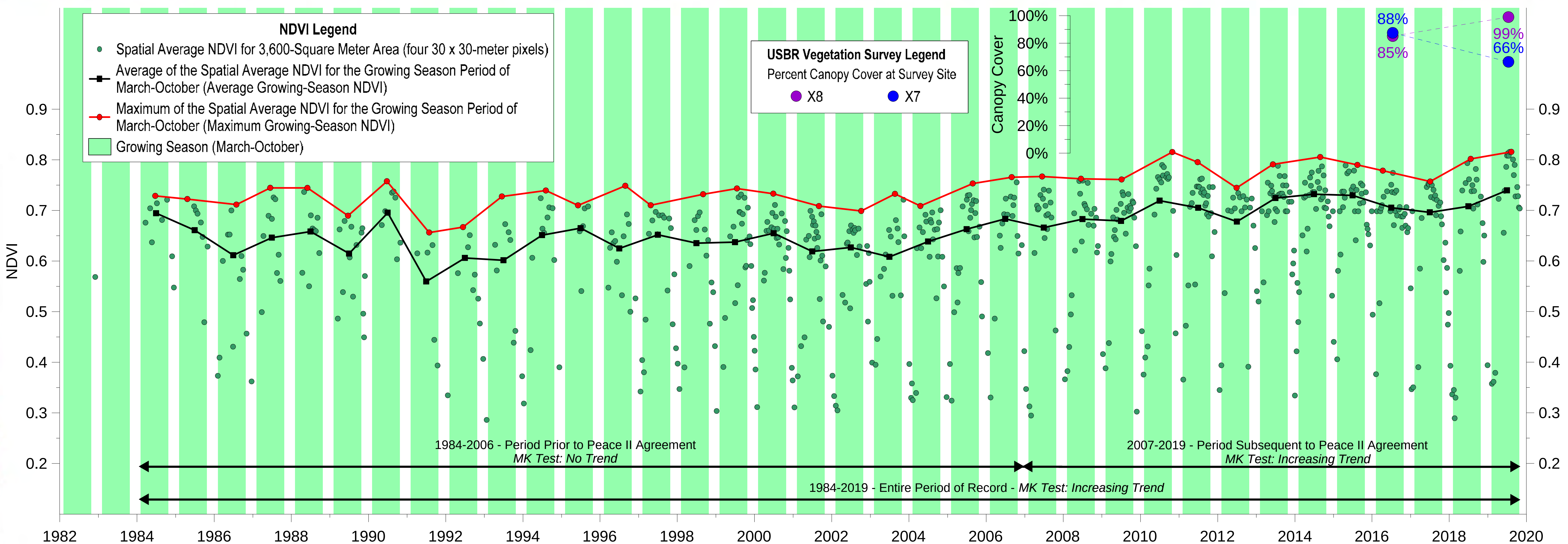
2018 Air Photo (July 2, 2018)

2019 Air Photo (July 4-5, 2019)

NDVI 30 x 30 Meter Pixel

Location Along Chino Creek





Prepared by:

WEI
Wildermuth Environmental, Inc.

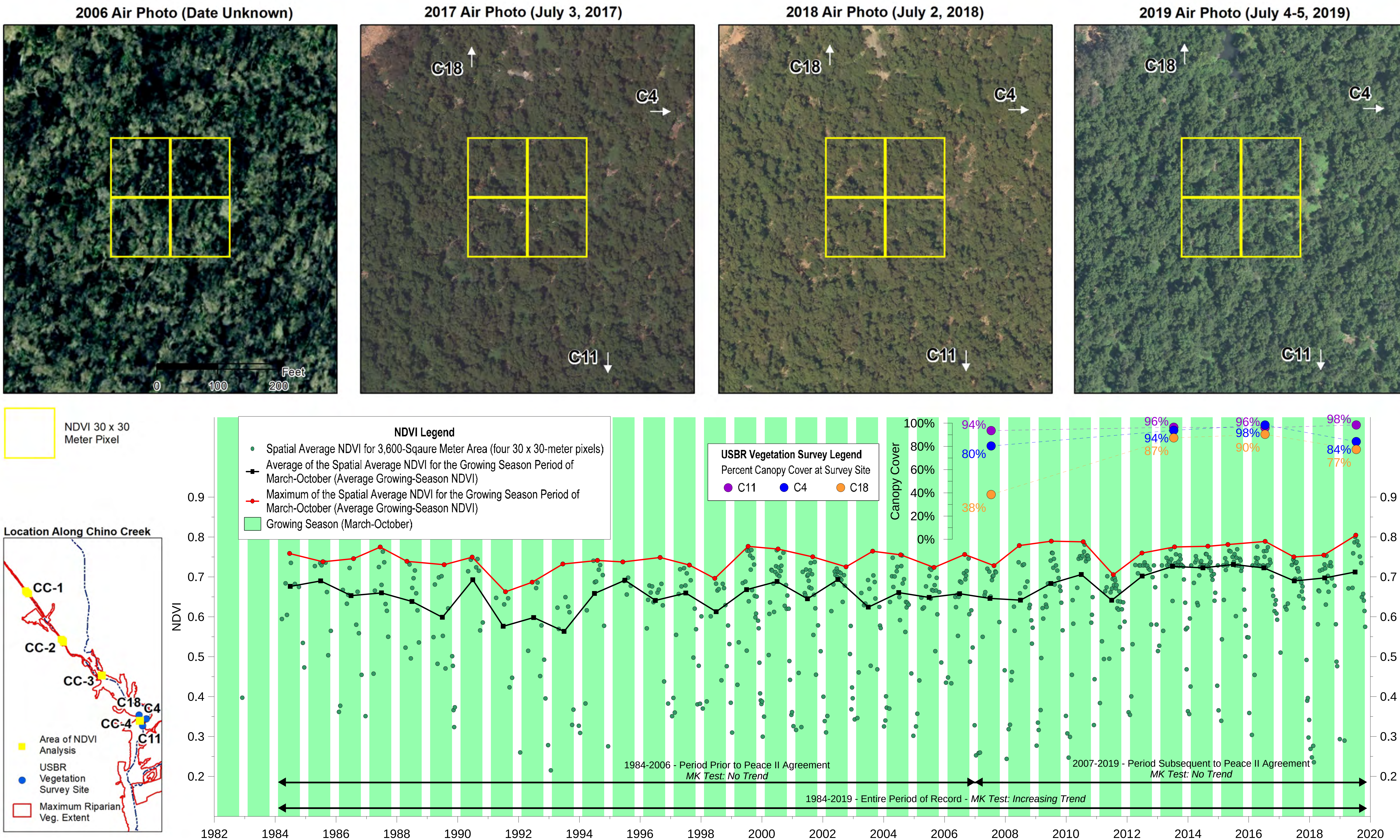
Author: RT
Date: 20200310
Filename: 18-19_NDVI_CC-3.grf

MK Test = Mann-Kendall Test Result

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Time Series of NDVI and Air Photos
CC-3 Area for 1984 to 2019

Figure 3-9c



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 20200313
Filename: 18-19_NDVI_CC-4.grf

MK Test = Mann-Kendall Test Result

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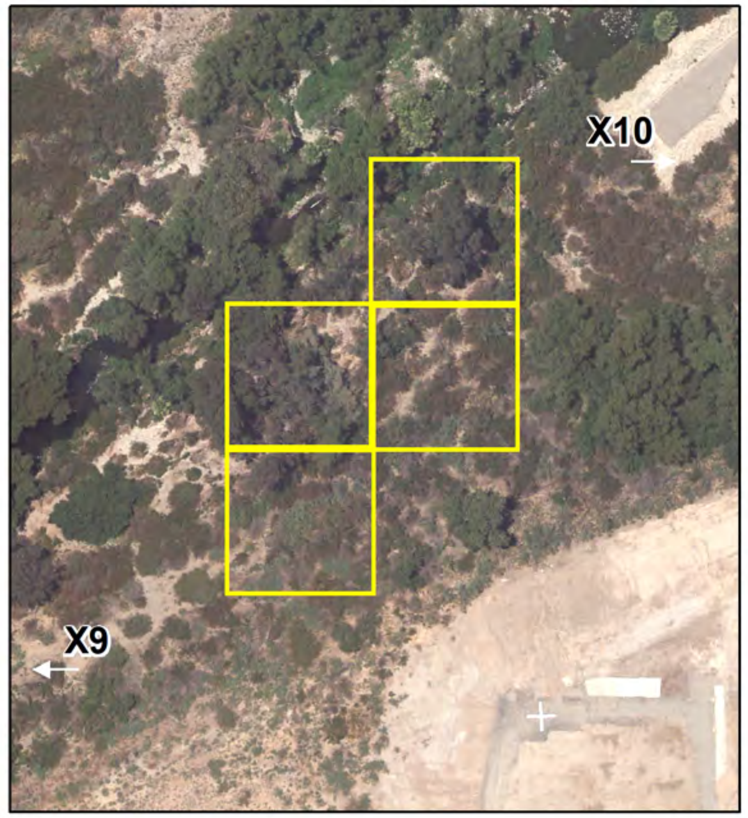
Prado Basin Habitat Sustainability Committee

Time Series of NDVI and Air Photos
CC-4 Area for 1984 to 2019

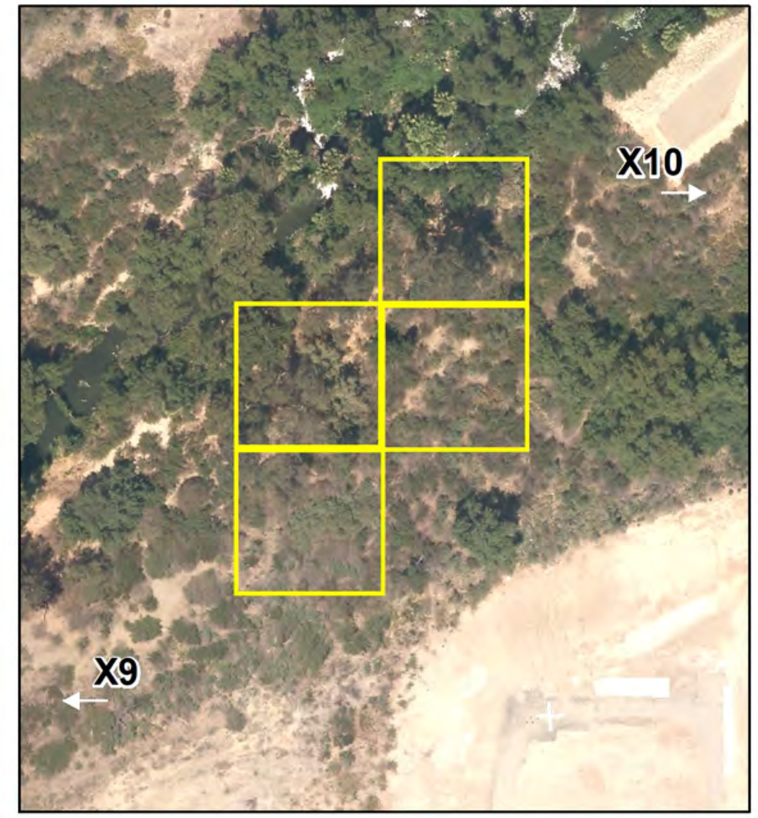
Figure 3-9d

2006 Air Photo (Date Unknown)

2017 Air Photo (July 3, 2017)



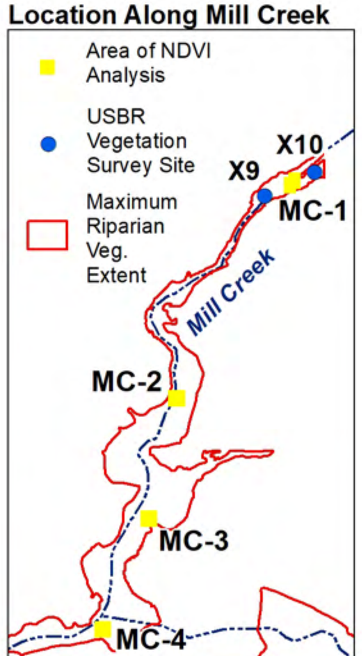
2018 Air Photo (July 2, 2018)

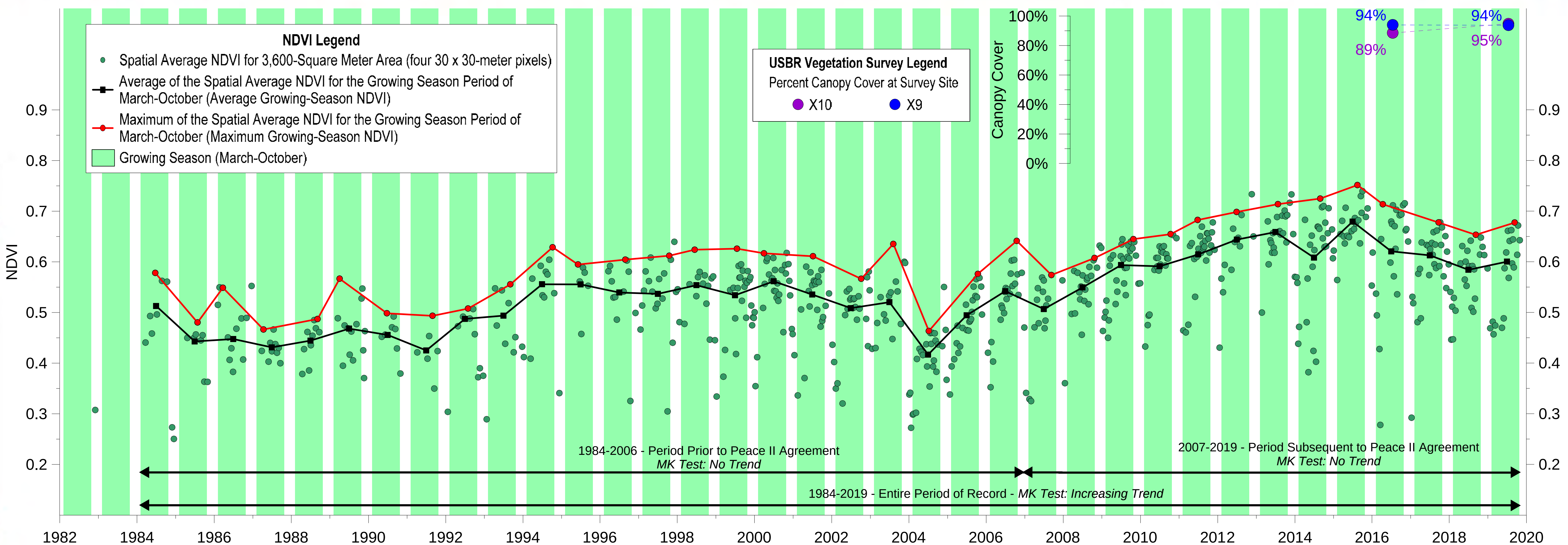


2019 Air Photo (July 4-5, 2019)

NDVI 30 x 30 Meter Pixel

Location Along Mill Creek





Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 20200310
Filename: 18-19_NDVI_MC-1.grf

MK Test = Mann-Kendall Test Result

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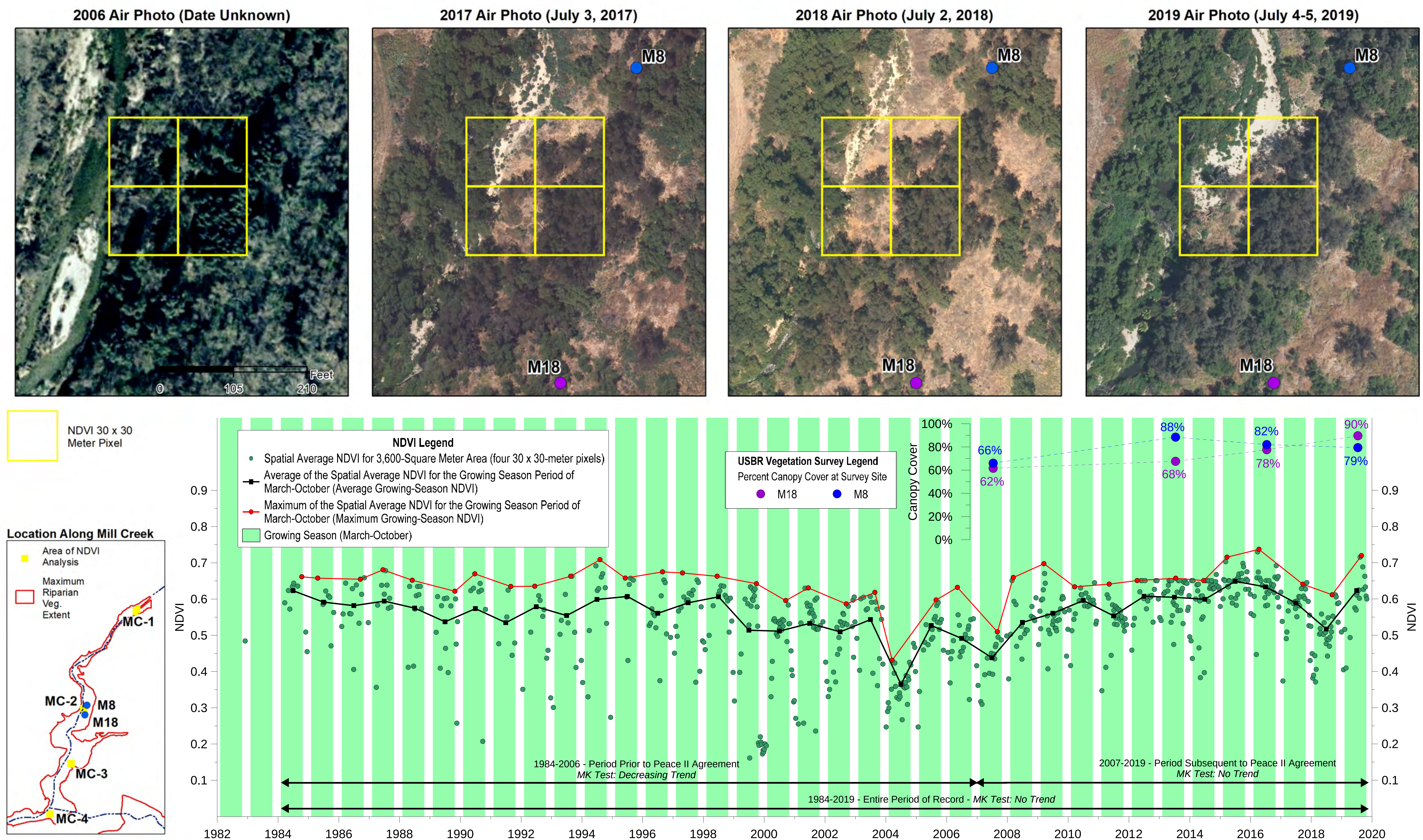
Prado Basin Habitat Sustainability Committee

Time Series of NDVI and Air Photos
MC-1 Area for 1984-2019

Figure 3-9e



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 20200113
Filename: 18-19_NDVI_MC-2.grf

MK Test = Mann-Kendall Test Result

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Prado Basin Habitat Sustainability Committee

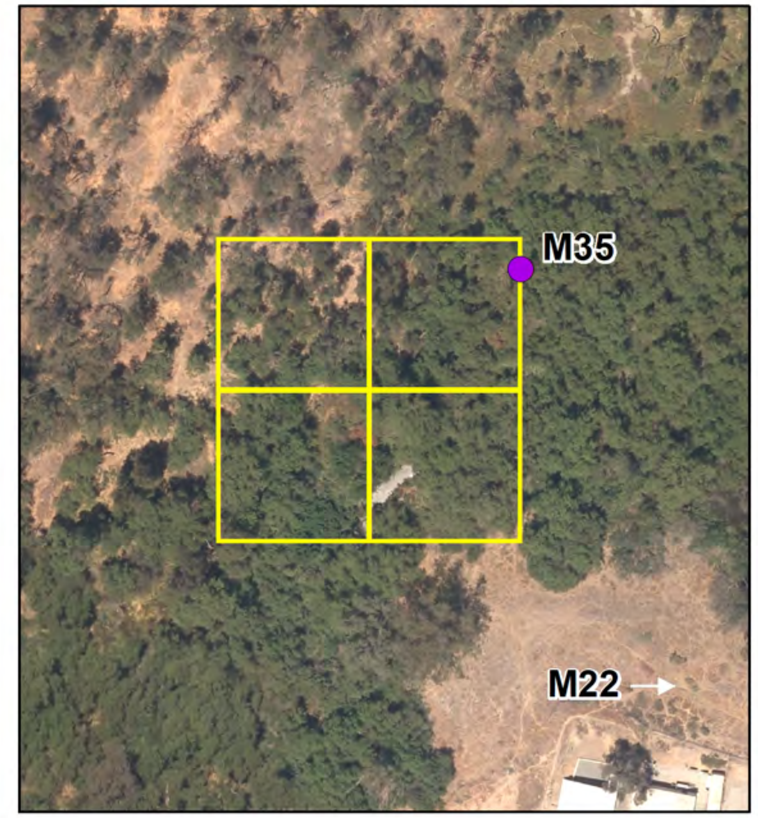
Time Series of NDVI and Air Photos
MC-2 Area for 1984 to 2019

Figure 3-9f

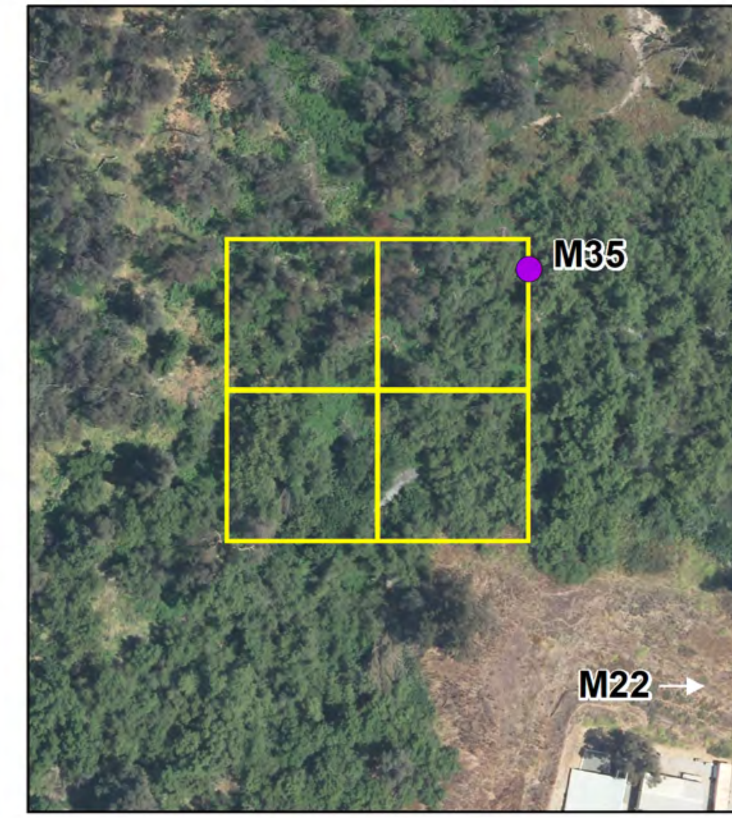
2006 Air Photo (Date Unknown)

2017 Air Photo (July 3, 2017)

2018 Air Photo (July 2,2018)

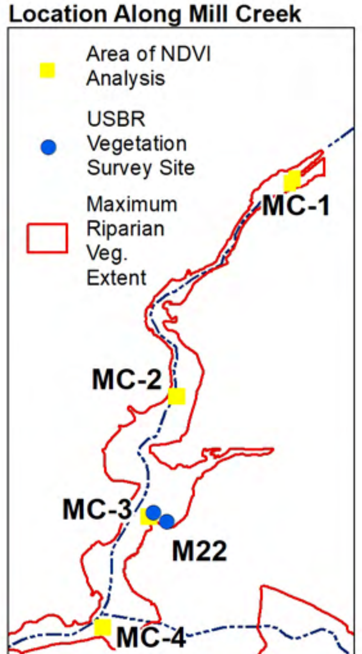


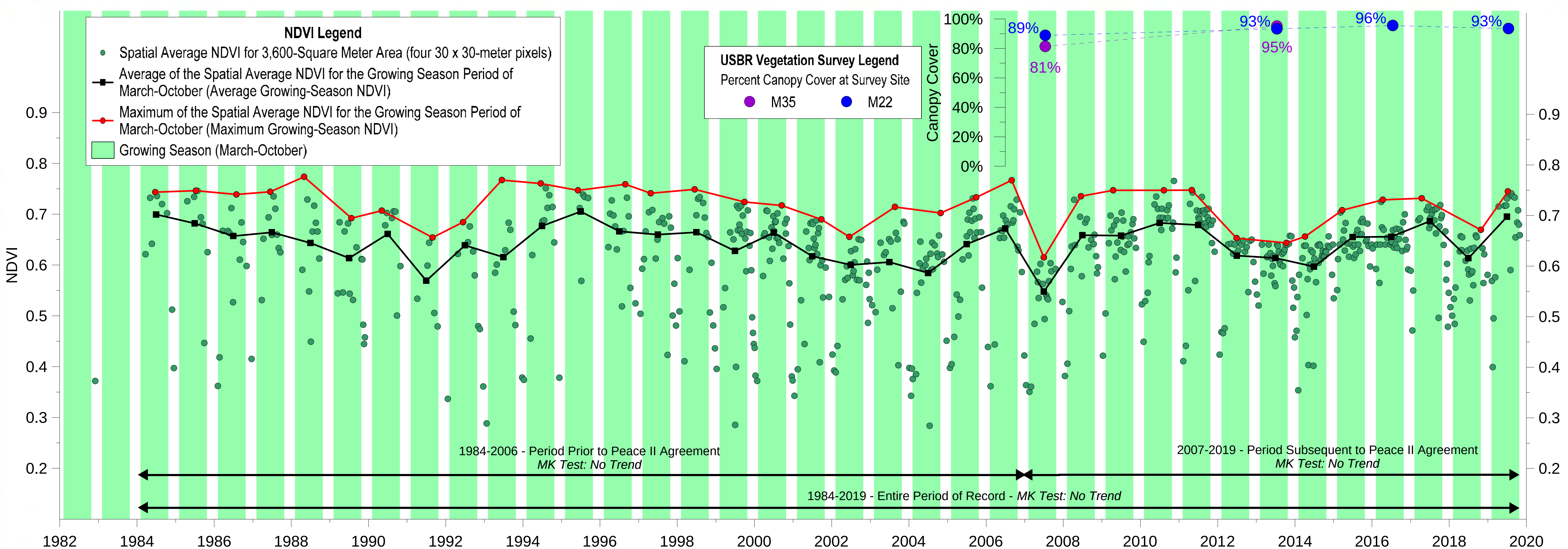
2019 Air Photo (July 4-5, 2019)



NDVI 30 x 30 Meter Pixel

Location Along Mill Creek





Prepared by:

WEI
Wildermuth Environmental, Inc.

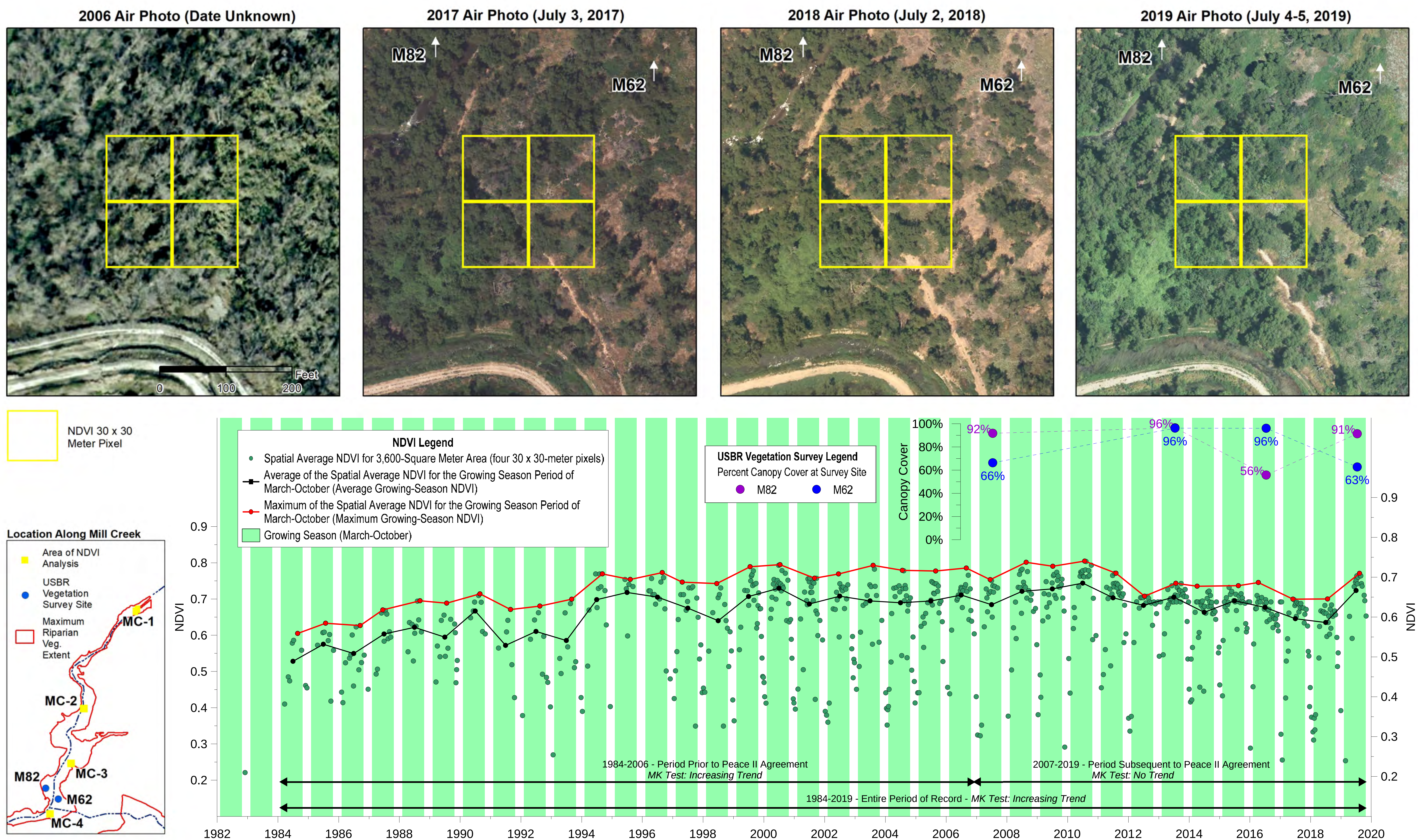
Author: RT
Date: 20200310
Filename: 18-19_NDVI_MC-3.grf

MK Test = Mann-Kendall Test Result

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Time Series of NDVI and Air Photos
MC-3 Area for 1984 to 2019

Figure 3-9g



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 20200310
Filename: 18-19_NDVI_MC-4_AirPhoto.grf

MK Test = Mann-Kendall Test Result

2019 Annual Report
Prado Basin Habitat Sustainability Committee

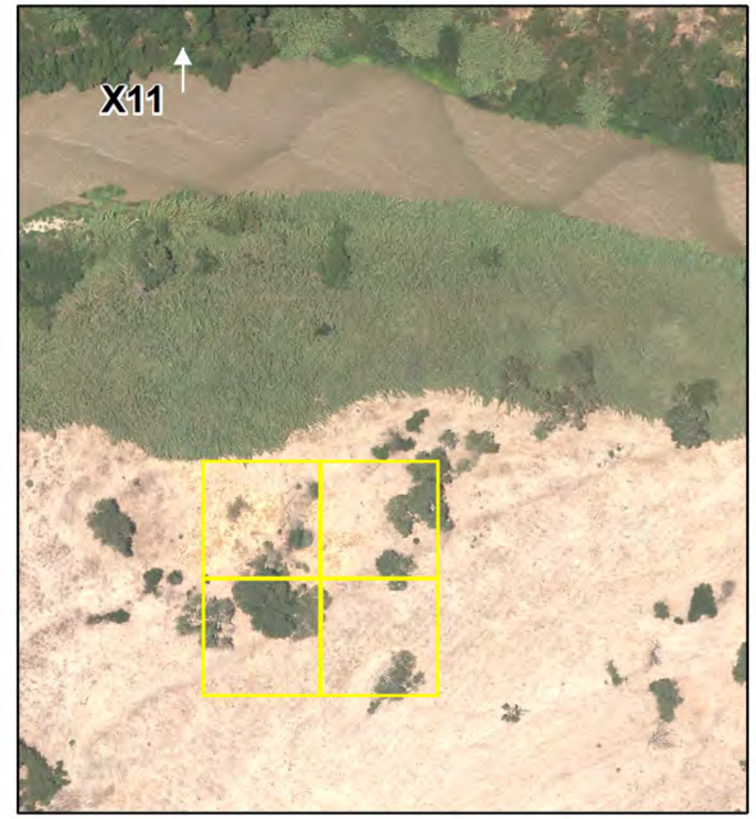
Time Series of NDVI and Air Photos
MC-4 Area for 1984 to 2019

Figure 3-9h

2006 Air Photo (Date Unknown)

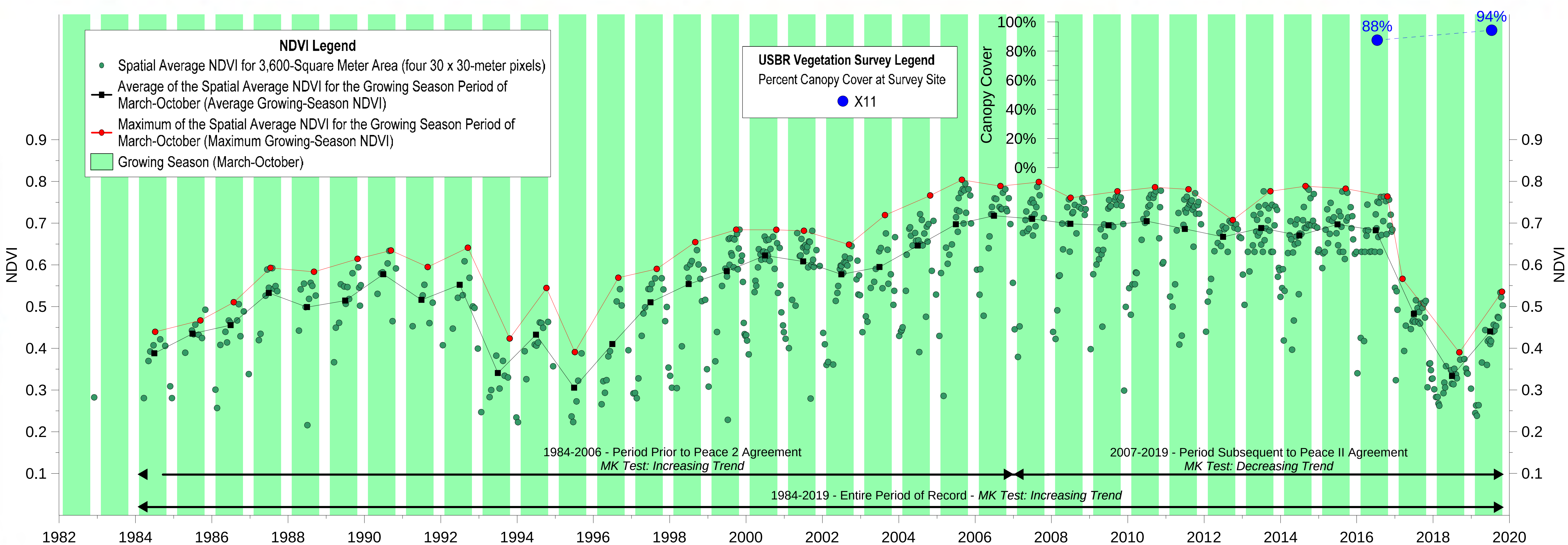
2017 Air Photo (July 3, 2017)

2018 Air Photo (July 2, 2018)

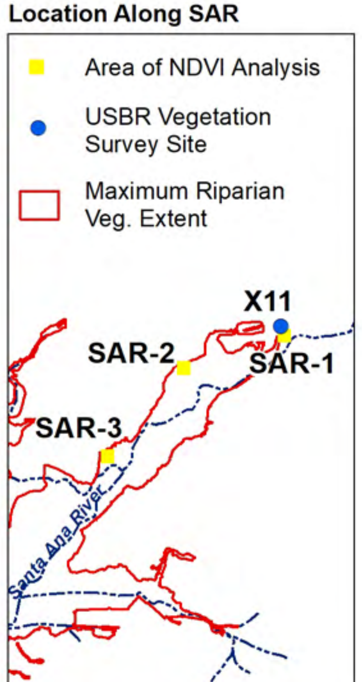


2019 Air Photo (July 4-5, 2019)

NDVI 30 x 30 Meter Pixel



Location Along SAR



Prepared by:
WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 20200310
Filename: 18-19_NDVI_SAR-1.grf

MK Test = Mann-Kendall Test Result

2019 Annual Report
Prado Basin Habitat Sustainability Committee

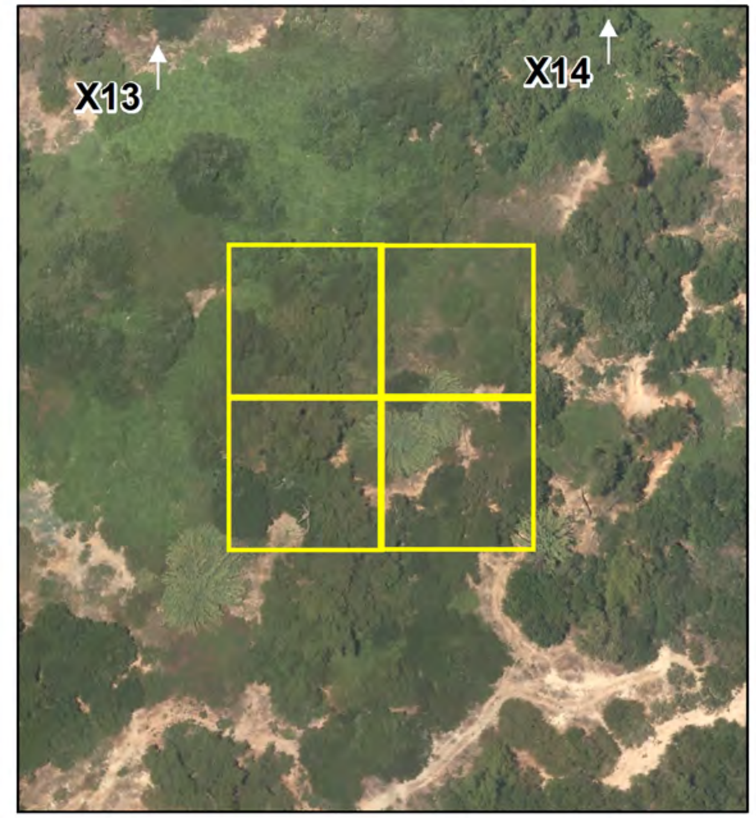
Time Series of NDVI and Air Photos
SAR-1 Area for 1984 to 2019

Figure 3-9i

2006 Air Photo (Date Unknown)

2017 Air Photo (July 3, 2017)

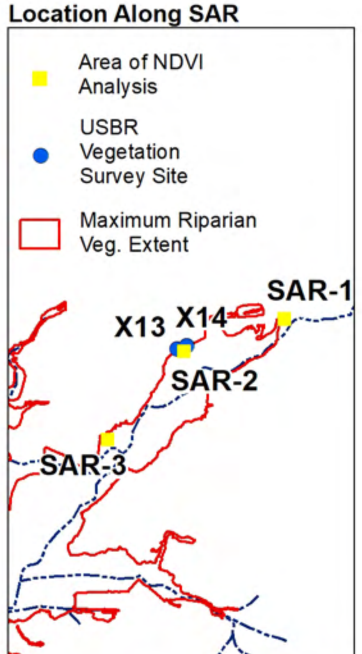
2018 Air Photo (July 2, 2018)

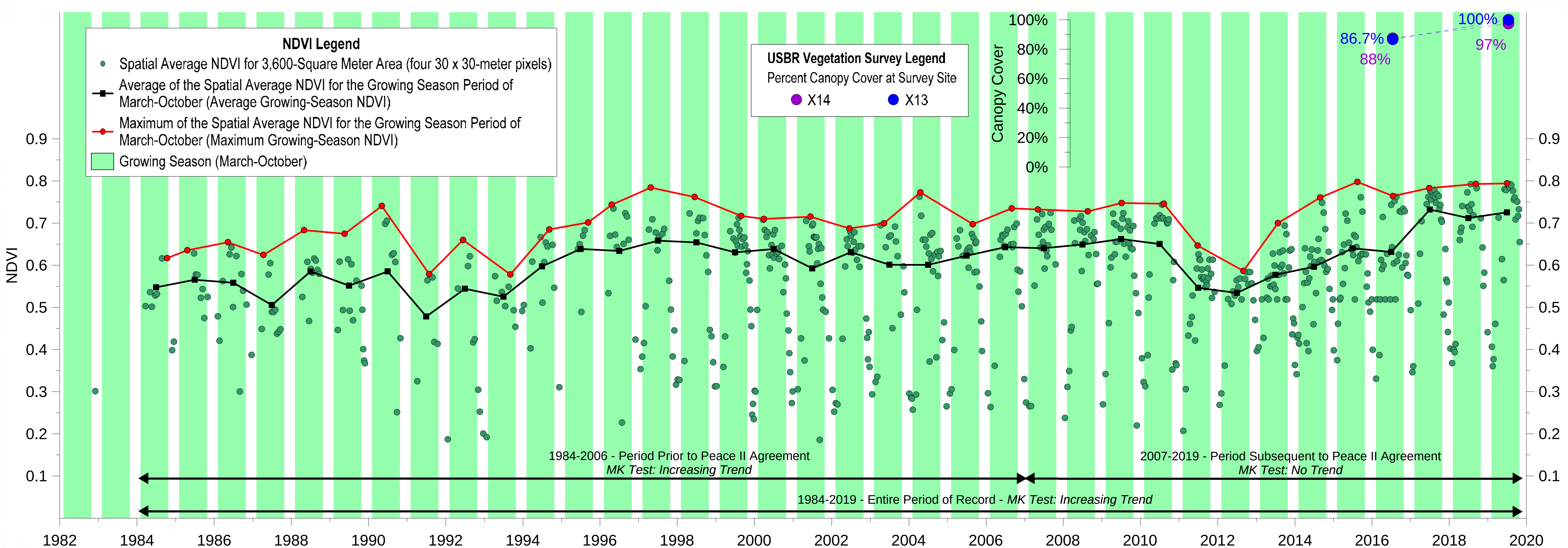


2019 Air Photo (July 4-5, 2019)

NDVI 30 x 30 Meter Pixel

Location Along SAR





Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 20200310
Filename: 18-19_NDVI_SAR-2.grf

MK Test = Mann-Kendall Test Result

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Prado Basin Habitat Sustainability Committee

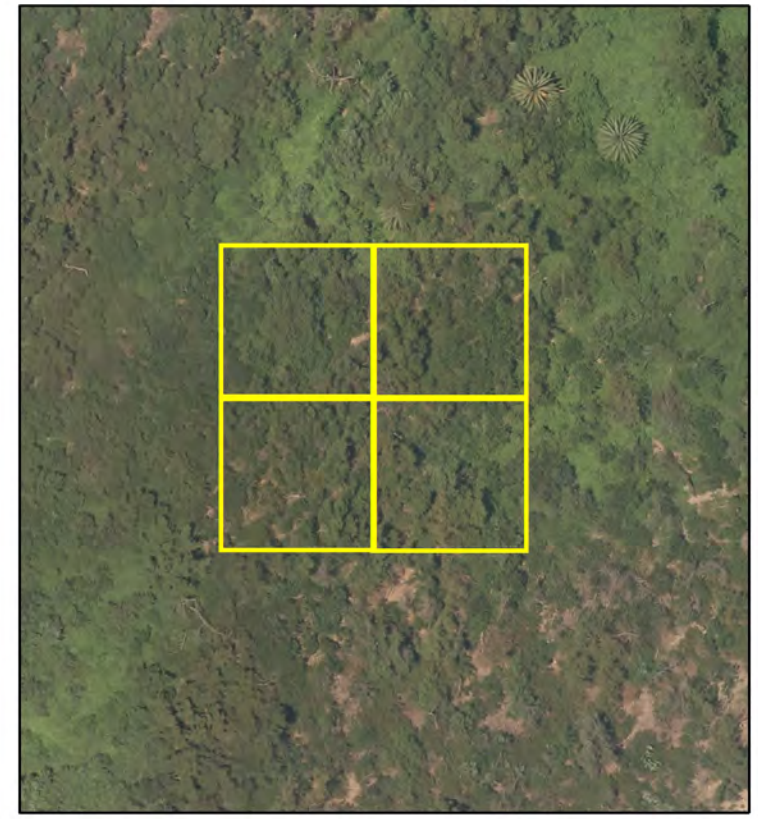
Time Series of NDVI and Air Photos
SAR-2 Area for 1984-2019

Figure 3-9j

2006 Air Photo (Date Unknown)

2017 Air Photo (July 3, 2017)

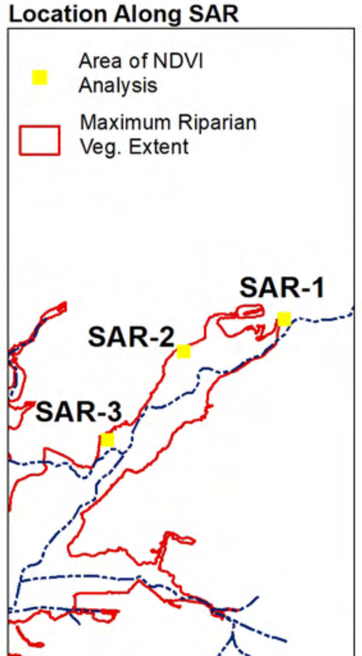
2018 Air Photo (July 2, 2018)

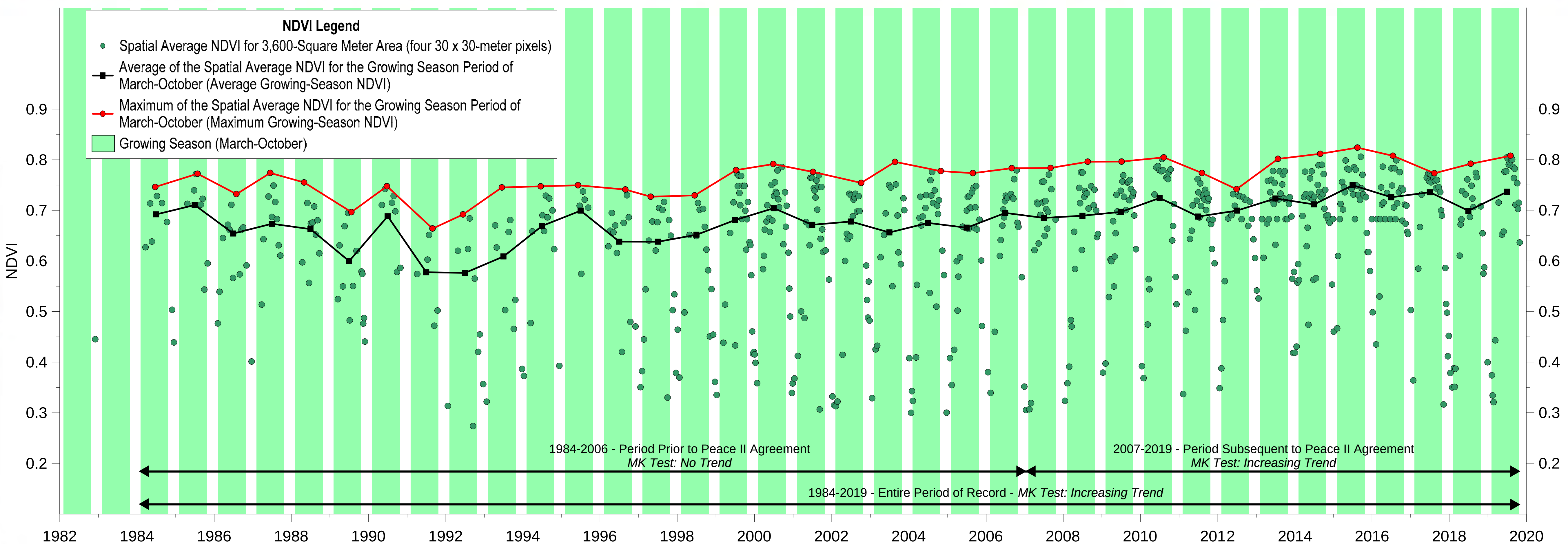


2019 Air Photo (July 4-5, 2019)

NDVI 30 x 30 Meter Pixel

Location Along SAR





Prepared by:

WEI
Wildermuth Environmental, Inc.

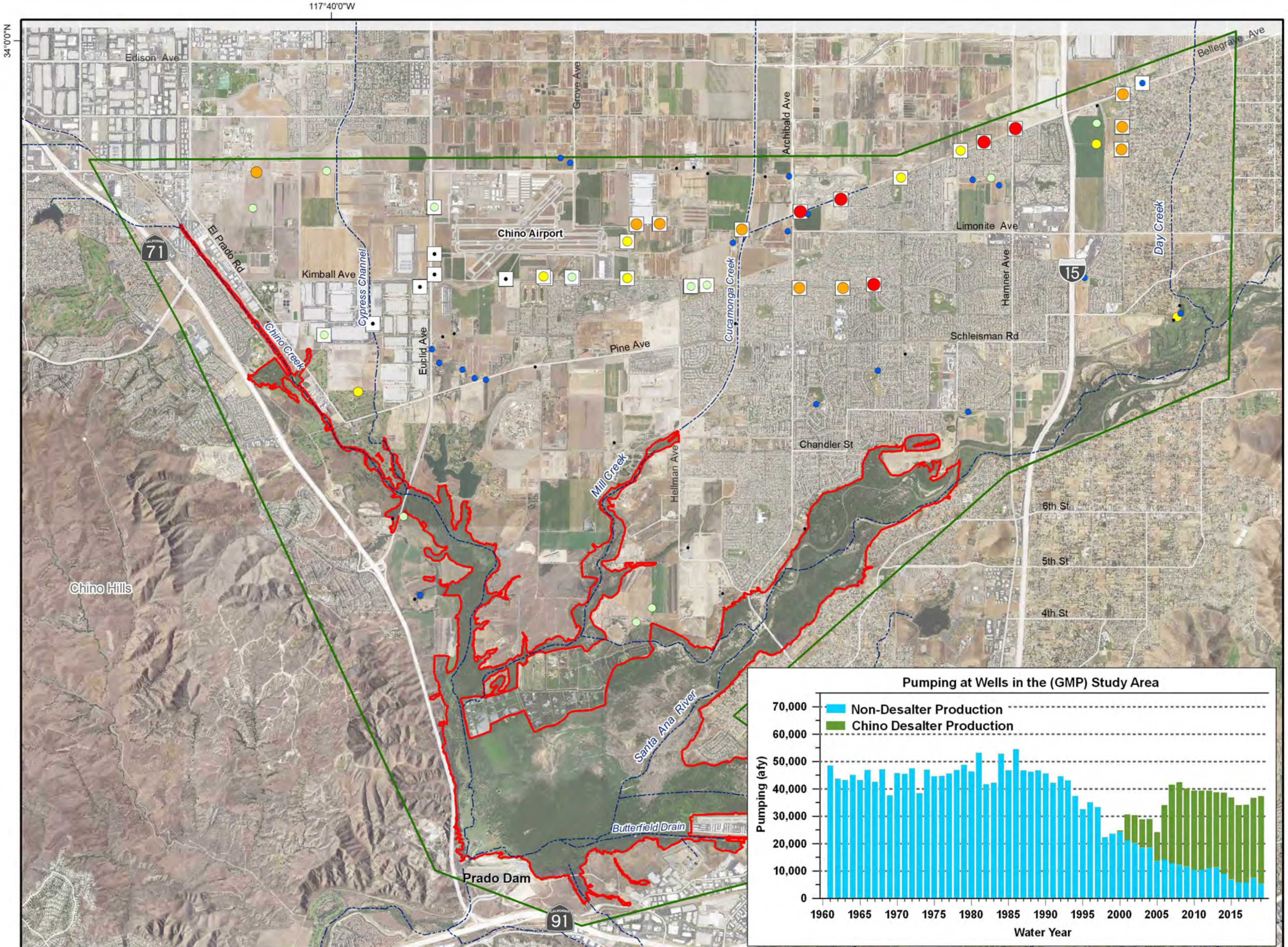
Author: RT
Date: 20200310
Filename: NDVI_SAR-3_Airphoto.grf

MK Test = Mann-Kendall Test Result

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Time Series of NDVI and Air Photos
SAR-3 Area for 1984 to 2019

Figure 3-9k



Groundwater Pumping Water Year 2019 (af)

- < 10
- 10 - 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,500
- 2,500 - 5,000
- > 5,000

Chino Basin Desalter Authority Well

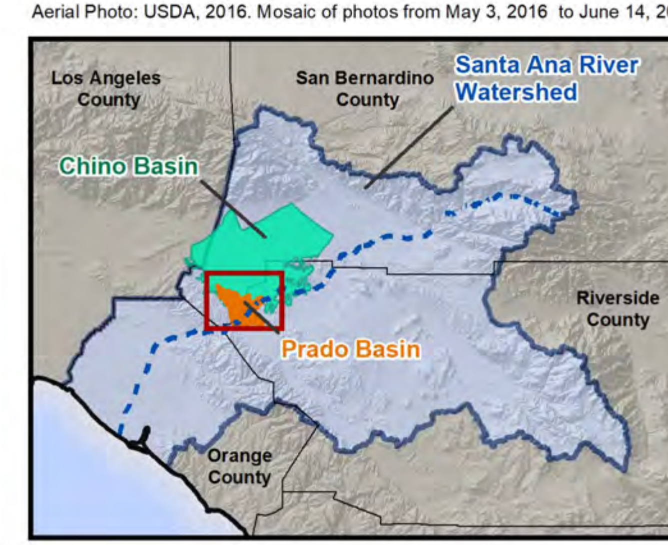
Groundwater Monitoring Program (GMP) Study Area

Maximum Extent of Riparian Vegetation in Prado Basin

Concrete-Lined Channels

Unlined Rivers and Streams

Aerial Photo: USDA, 2016. Mosaic of photos from May 3, 2016 to June 14, 2016



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: SO
Date: 4/20/2020
File: Figure 3-10_ Production_WY 2019

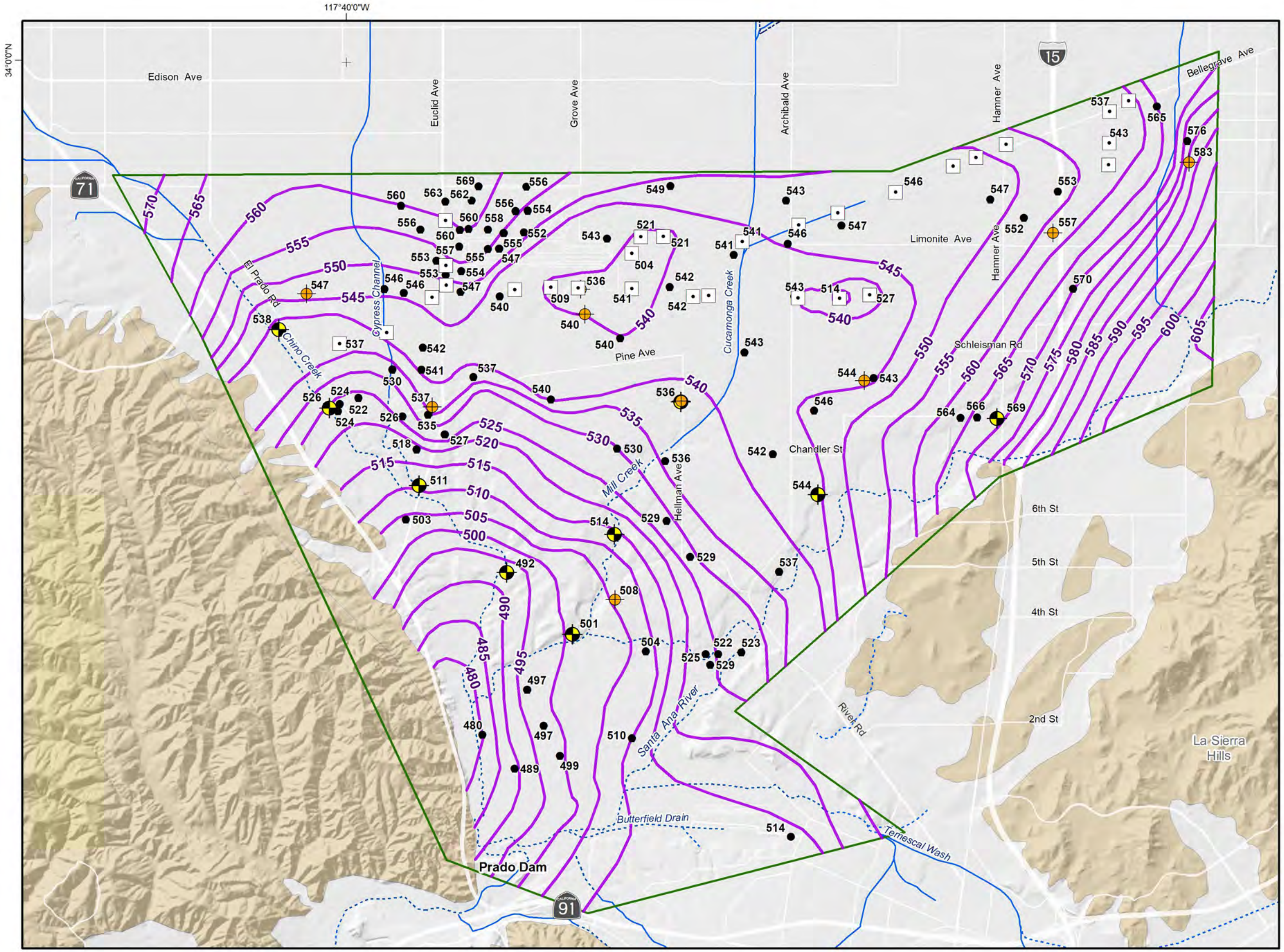
0 1 2 Miles

0 1 2 3 Kilometers

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Groundwater Pumping in Water Year 2019

Figure 3-10



Legend

- Equal Elevation Contour of Groundwater Elevation (feet above mean sea level)
- 505 — Measured Groundwater Elevation in September 2016 used to draw contours (feet above mean sea level)
- Chino Basin Desalter Authority Well
- PBHSP Monitoring Well
- HCMP Monitoring Well
- Other Well
- Groundwater Monitoring Program (GMP) Study Area
- Maximum Extent of the Riparian Vegetation in Prado Basin
- Concrete-Lined Channels
- Unlined Rivers and Streams

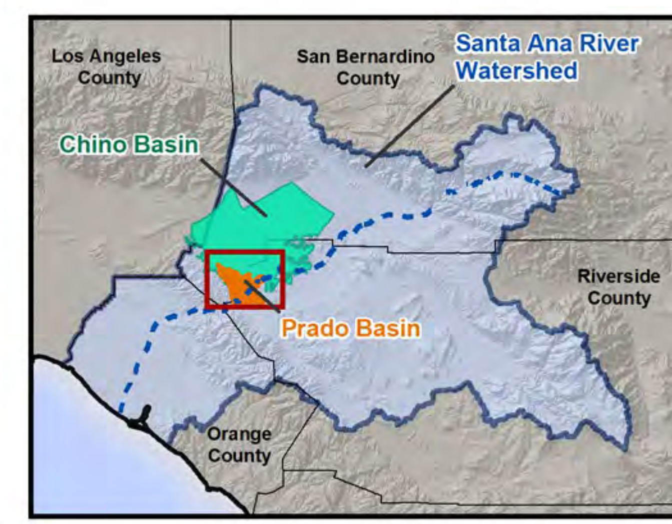
Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 4/10/2020
File: Figure 3-11a_f2016_GWLE_Contours

0 1 2 Miles
0 1 2 3 Kilometers

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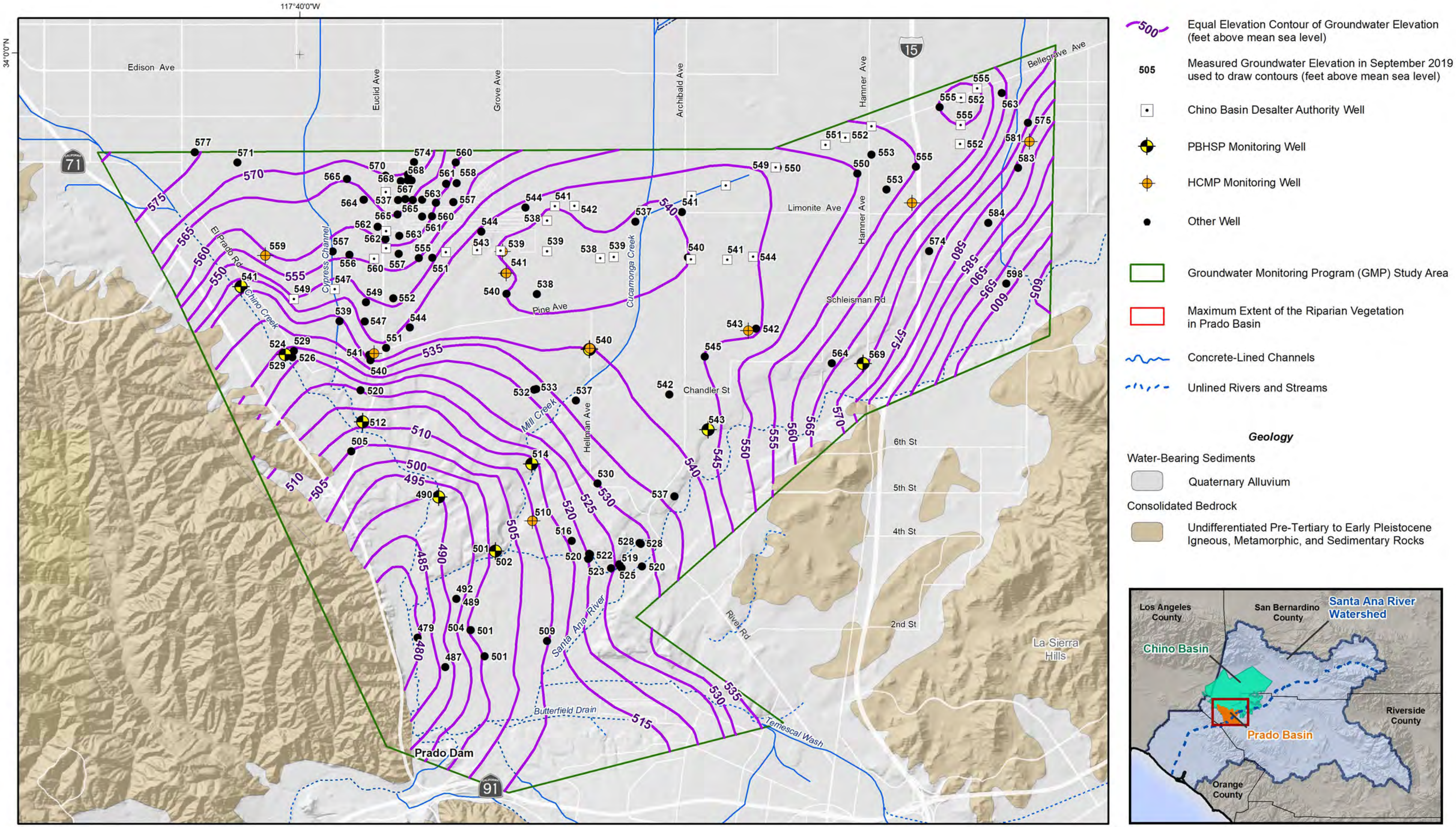
Prado Basin Habitat Sustainability Committee

Map of Groundwater Elevation
September 2016 - Shallow Aquifer System

Figure 3-11a



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

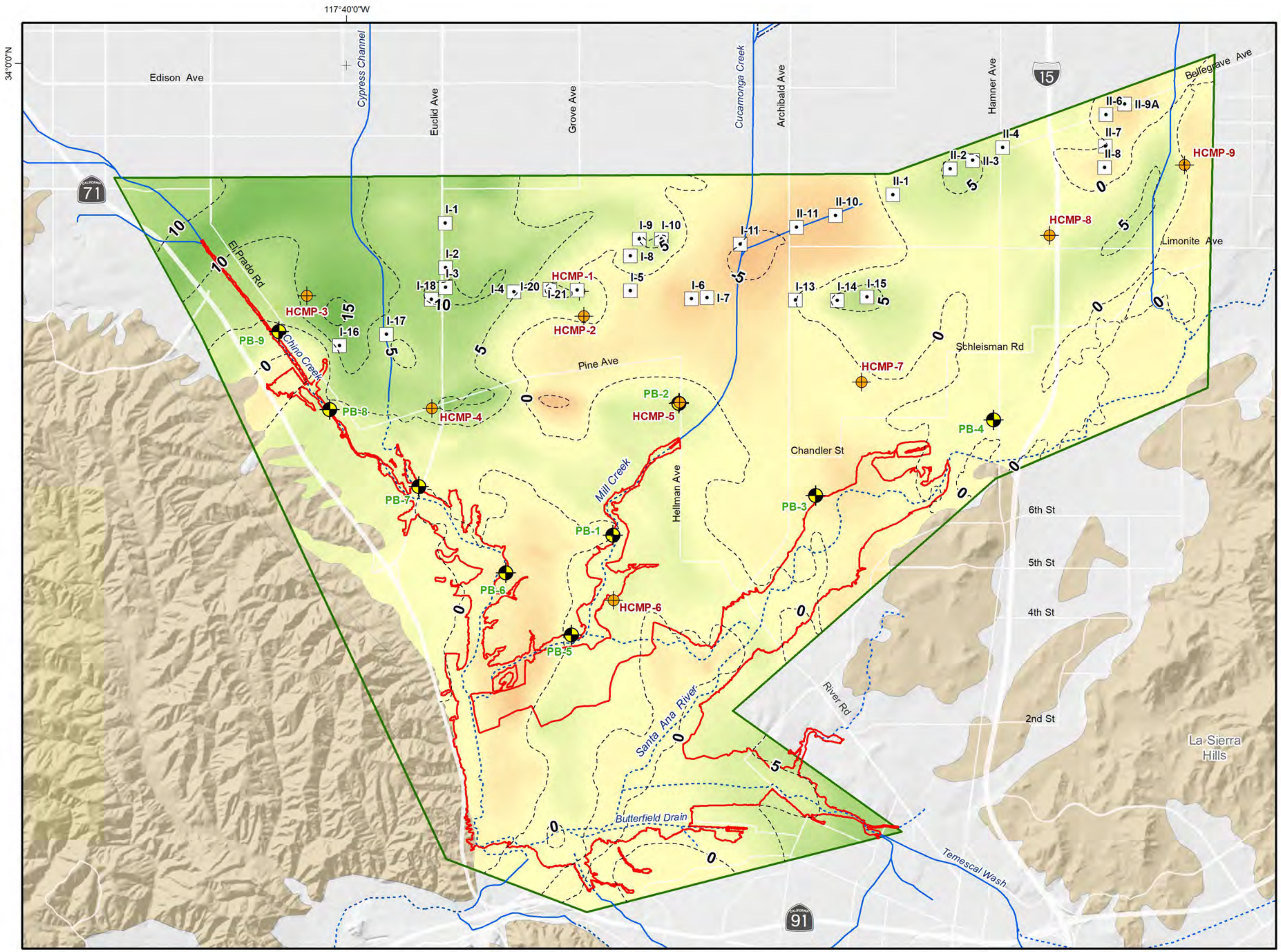
Author: EM
Date: 4/10/2020
File: Figure 3-11b_f2019_GWLE_Contours

0 1 2 Miles
0 1 2 3 Kilometers

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Map of Groundwater Elevation
September 2019 - Shallow Aquifer System

Figure 3-11b



\+ 25
0
\- 25

Change in Groundwater Elevation from September 2016 to September 2019

Contour of Change in Groundwater Elevation from September 2016 to September 2019 (feet)

Chino Basin Desalter Well

HCMP Monitoring Well

PBHSP Monitoring Well

Groundwater Monitoring Program (GMP) Study Area

Maximum Extent of the Riparian Vegetation in Prado Basin

Concrete-Lined Channels

Unlined Rivers and Streams

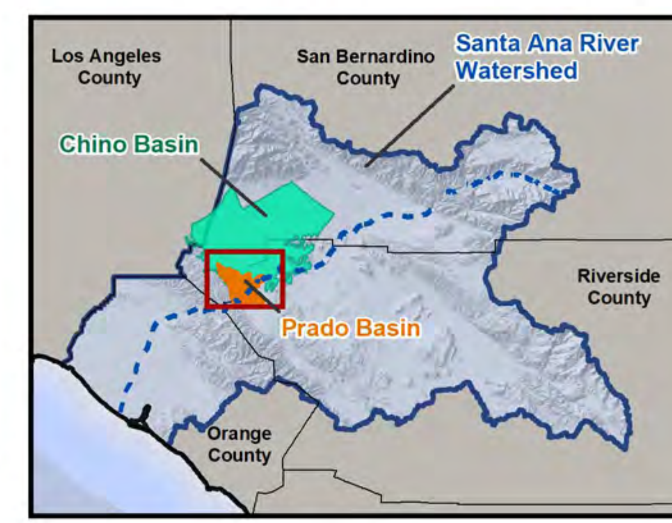
Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 4/10/2020
File: Figure 3-12_f16-f19_GWLE_change_map

0 1 2 Miles

0 1 2 3 Kilometers

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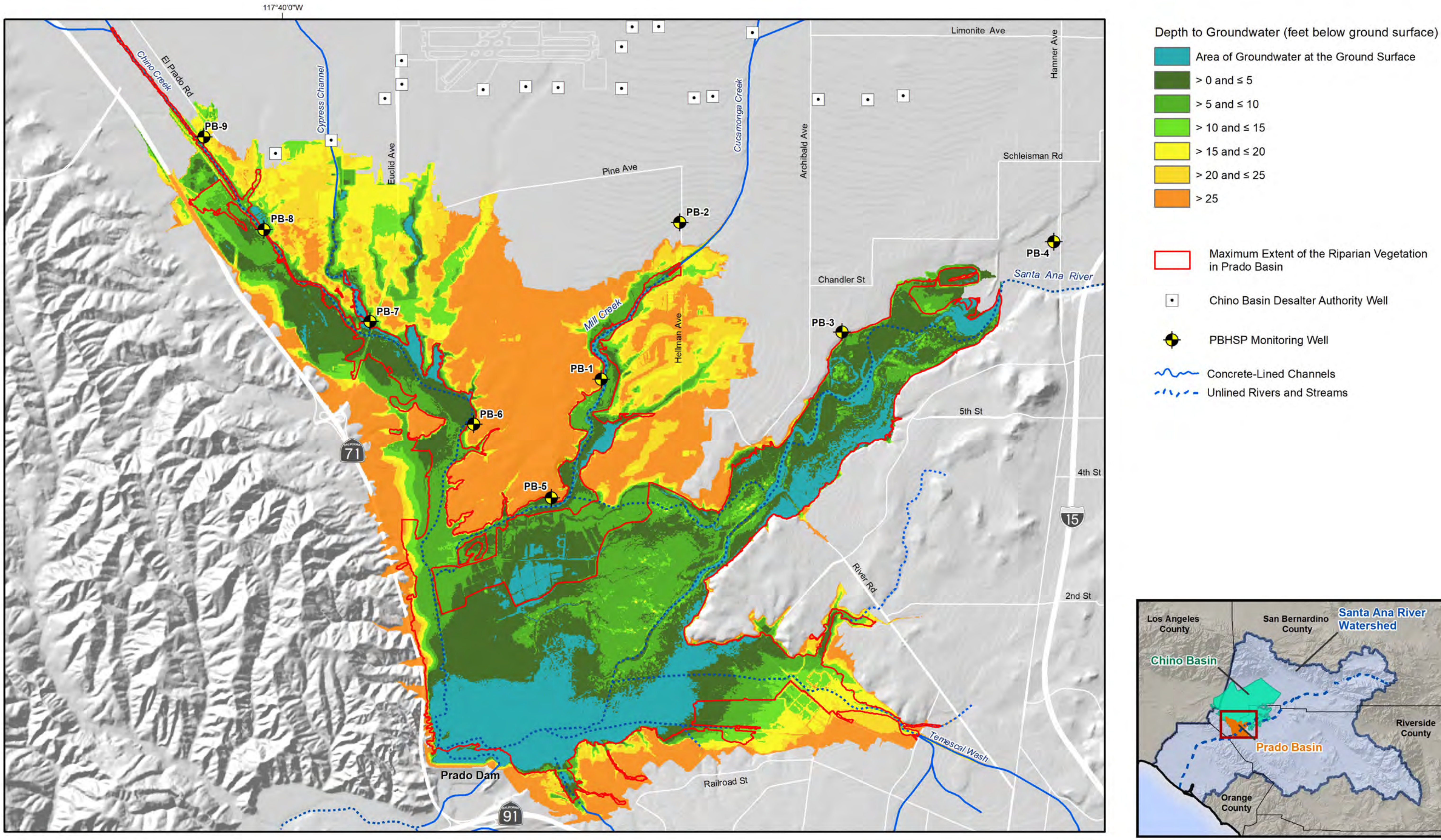
Prado Basin Habitat Sustainability Committee

Change in Groundwater Elevation
September 2016 to September 2019

Figure 3-12



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 4/28/2020
File: Figure 3-13_f2019_DTW

0 1 2 Miles

0 1 2 3 Kilometers

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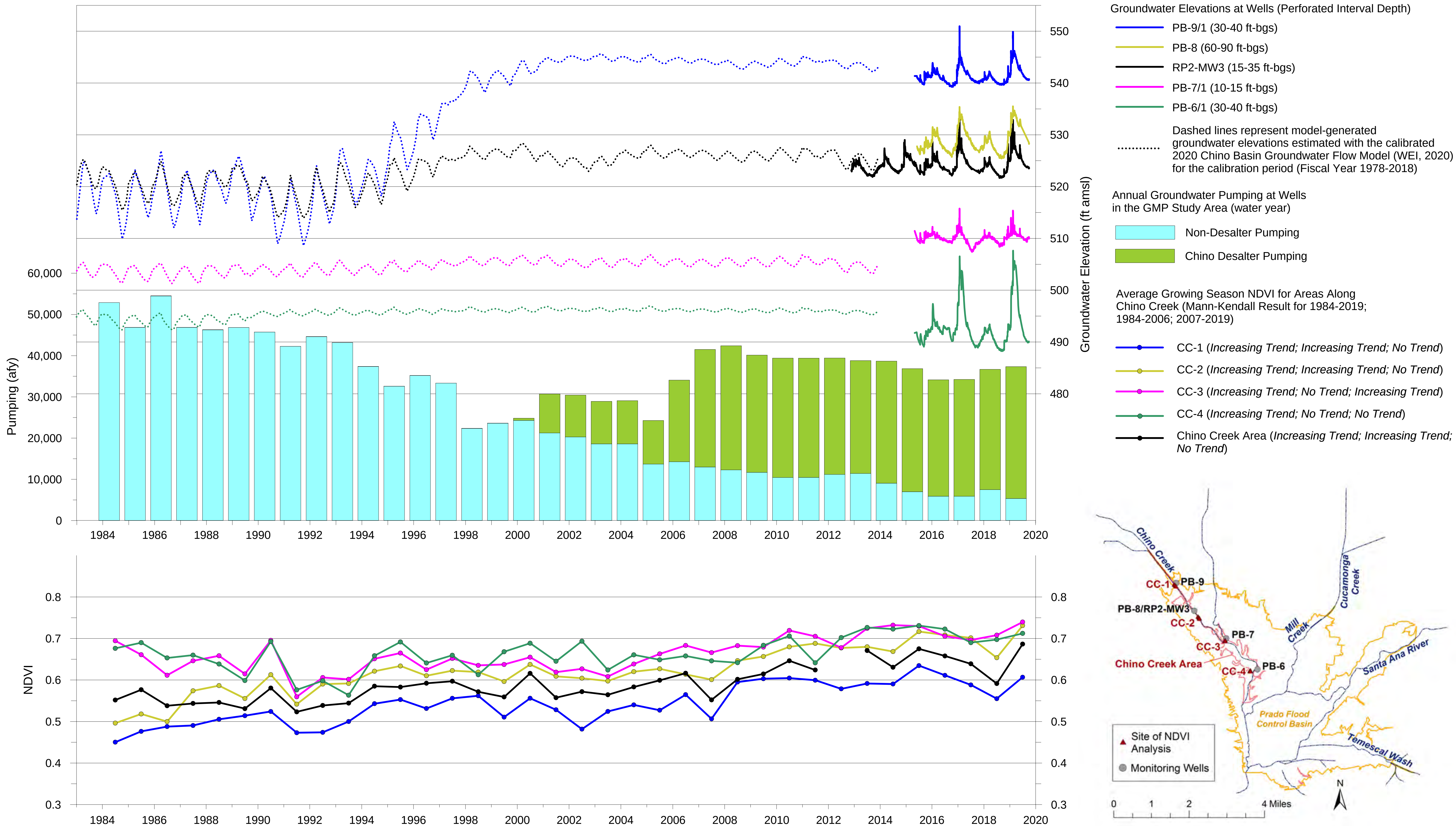
Prado Basin Habitat Sustainability Committee

Depth to Groundwater
September 2019

Figure 3-13



Prepared by:

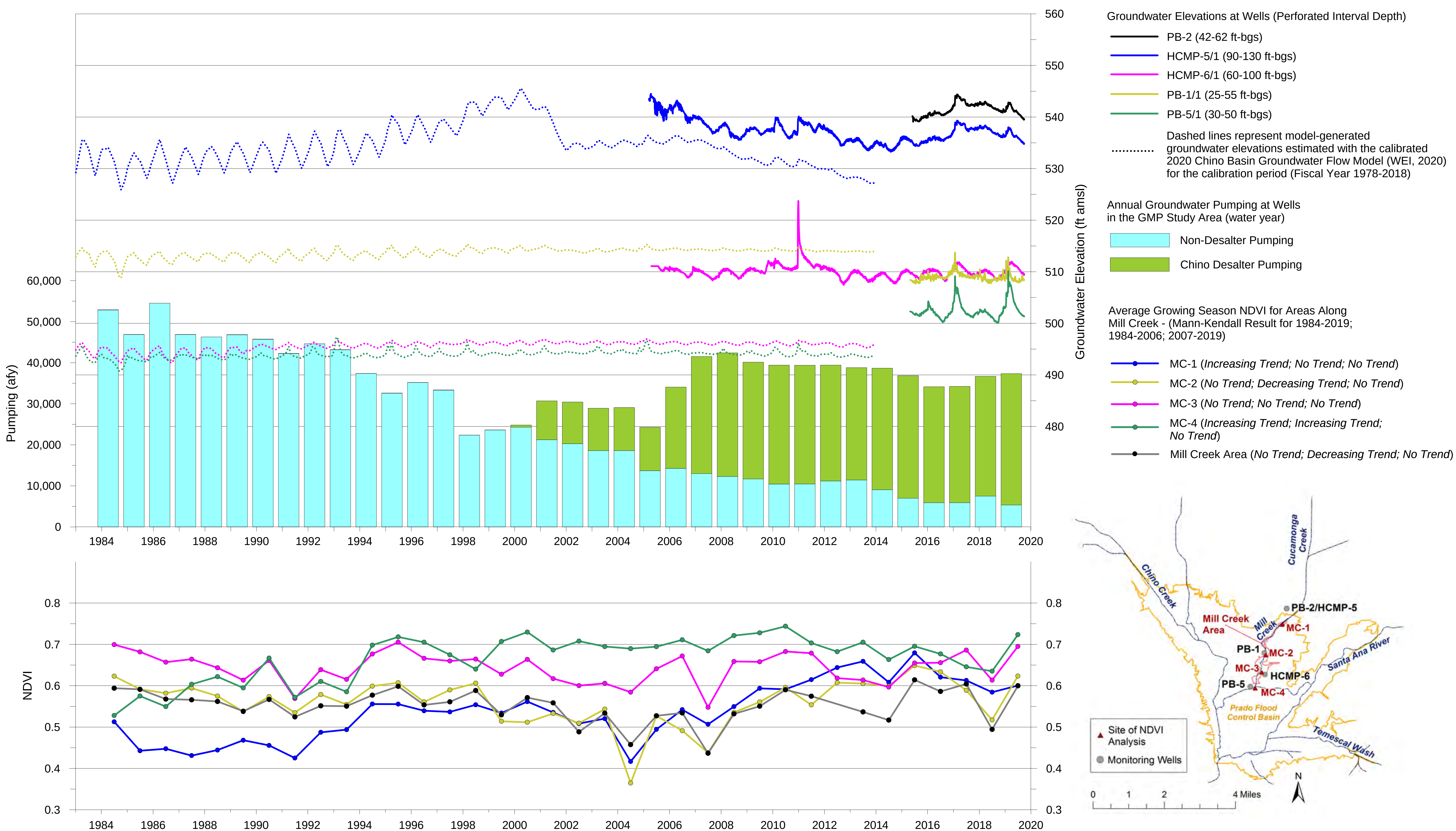
WEI
Wildermuth Environmental, Inc.

Author: SO
Date: 20190121
Filename: Prod_GWLs_SAR.grf

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Groundwater Pumping and Groundwater Levels versus NDVI
Chino Creek Area for 1984-2019

Figure 3-14a



Prepared by:

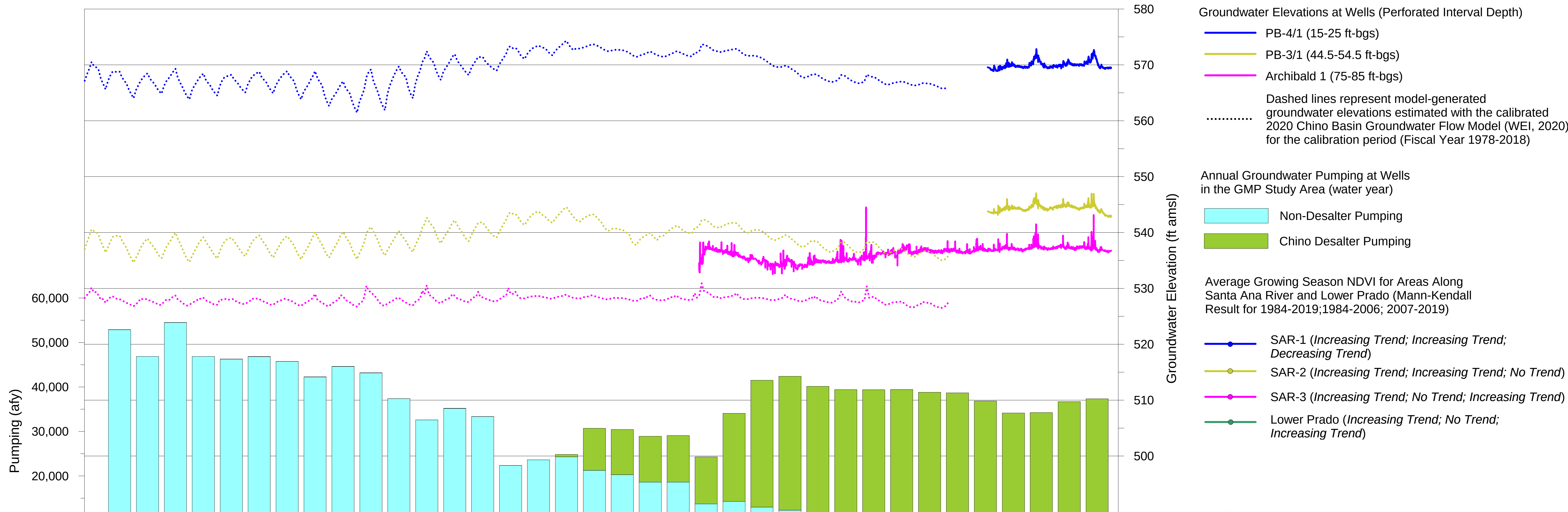
WEI
Wildermuth Environmental, Inc.

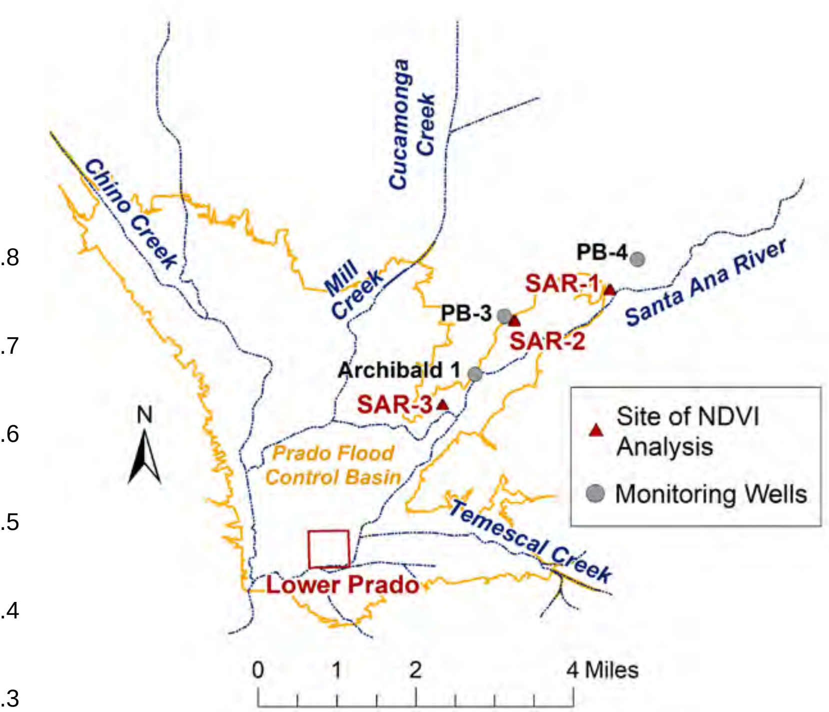
Author: SO
Date: 20190121
Filename: Flows_WLs_MillCreek.grf

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Groundwater Pumping and Groundwater Levels versus NDVI
Mill Creek Area for 1984-2019

Figure 3-14b





Groundwater Pumping and Groundwater Levels versus NDVI

Santa Ana River and Lower Prado Area for 1984-2019

Figure 3-14c

Prepared by:
WEI
Wildermuth Environmental, Inc.
Author: SO
Date: 20190121
Filename: Prod_GWLs_SAR.grf

Figure 3-16
Annual Precipitation in the Chino Basin - Water Years 1896-2019

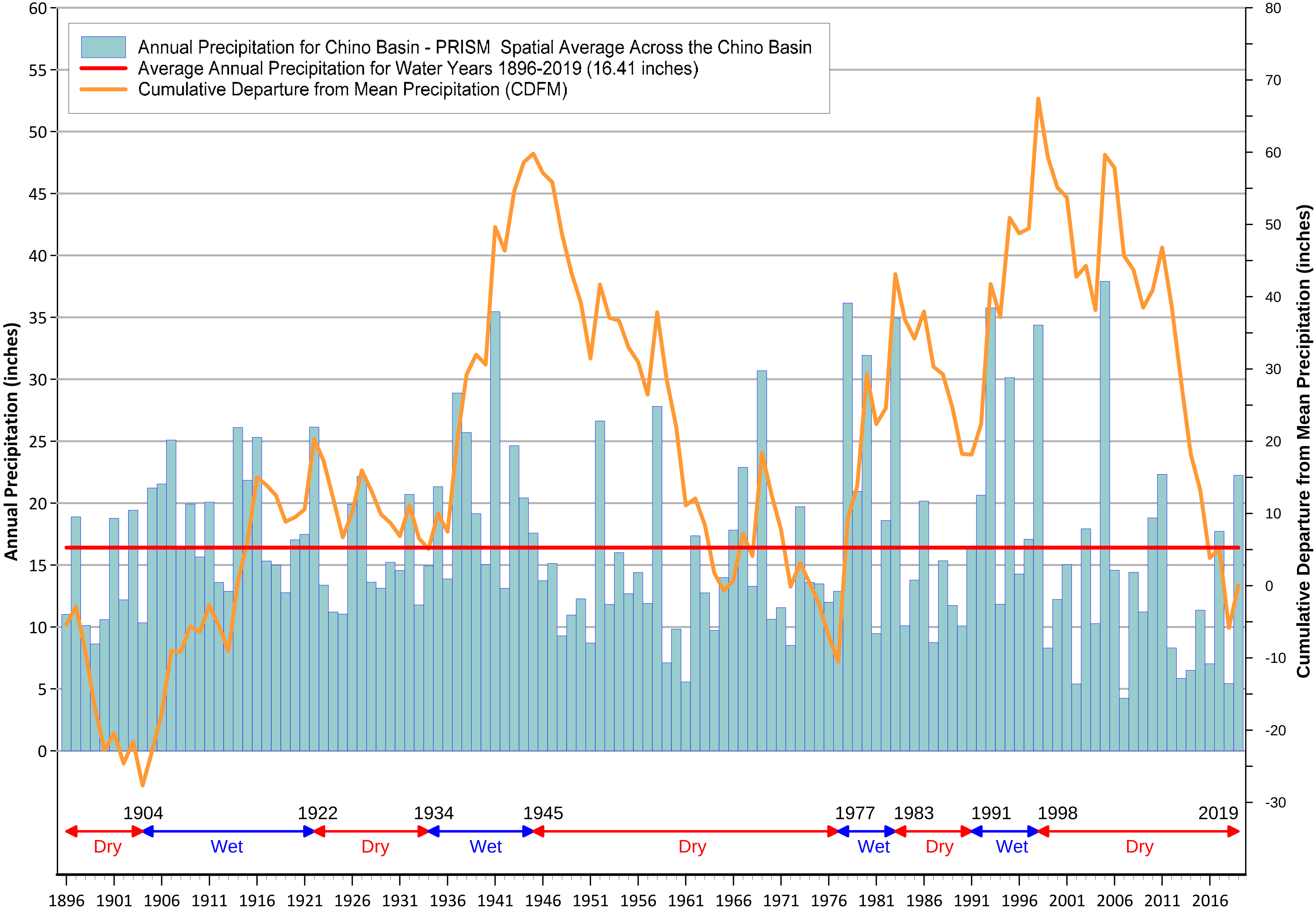
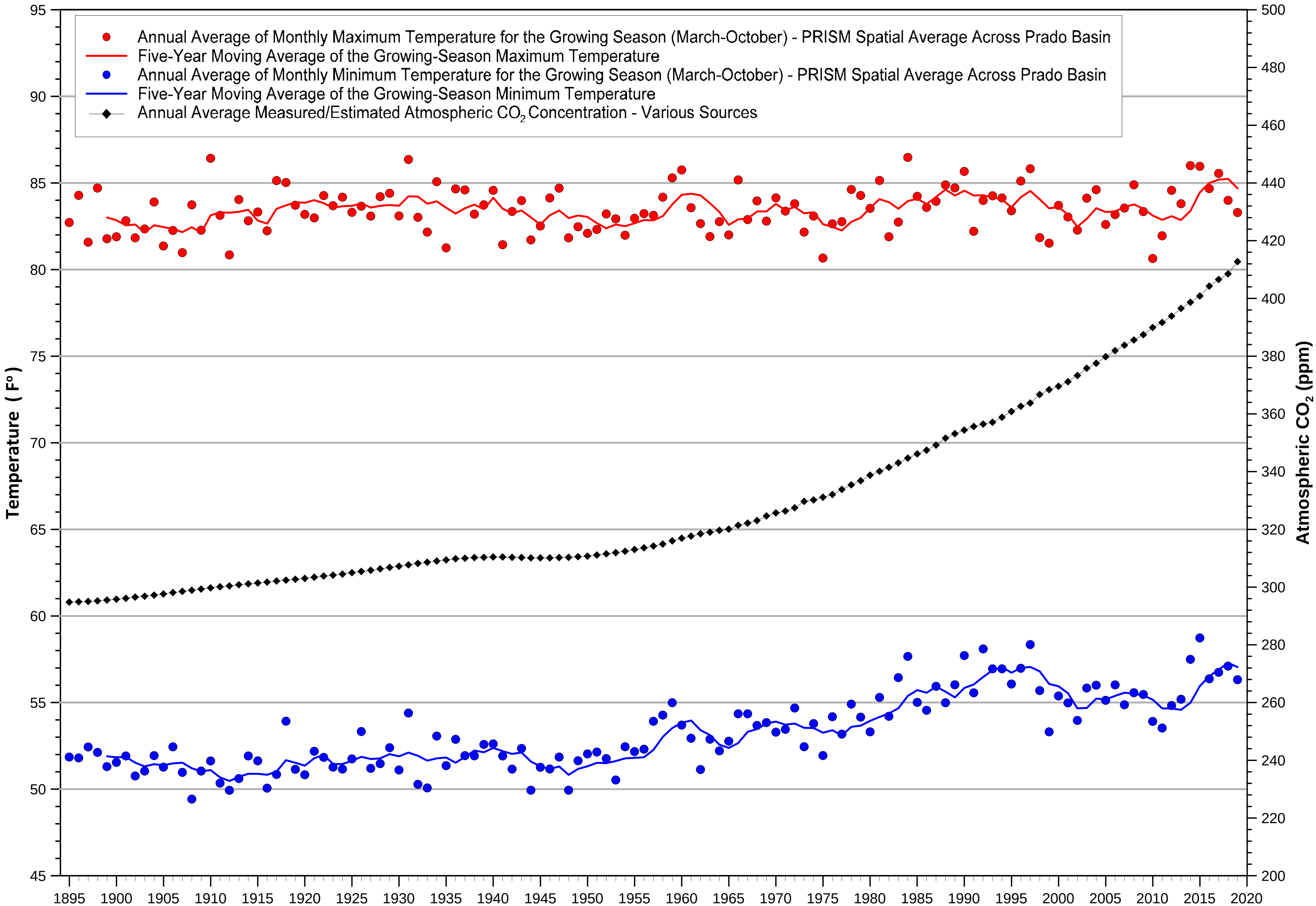
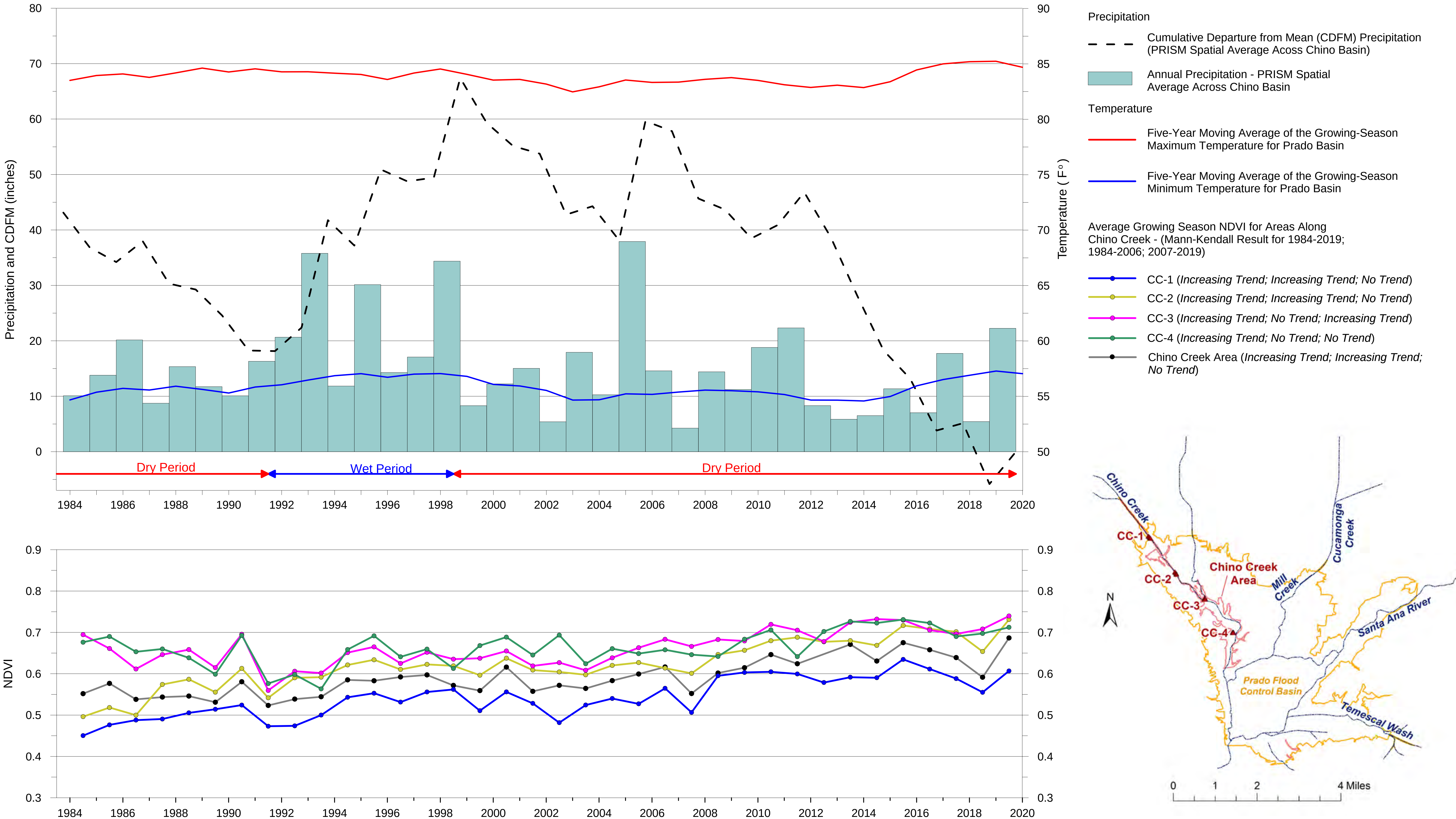


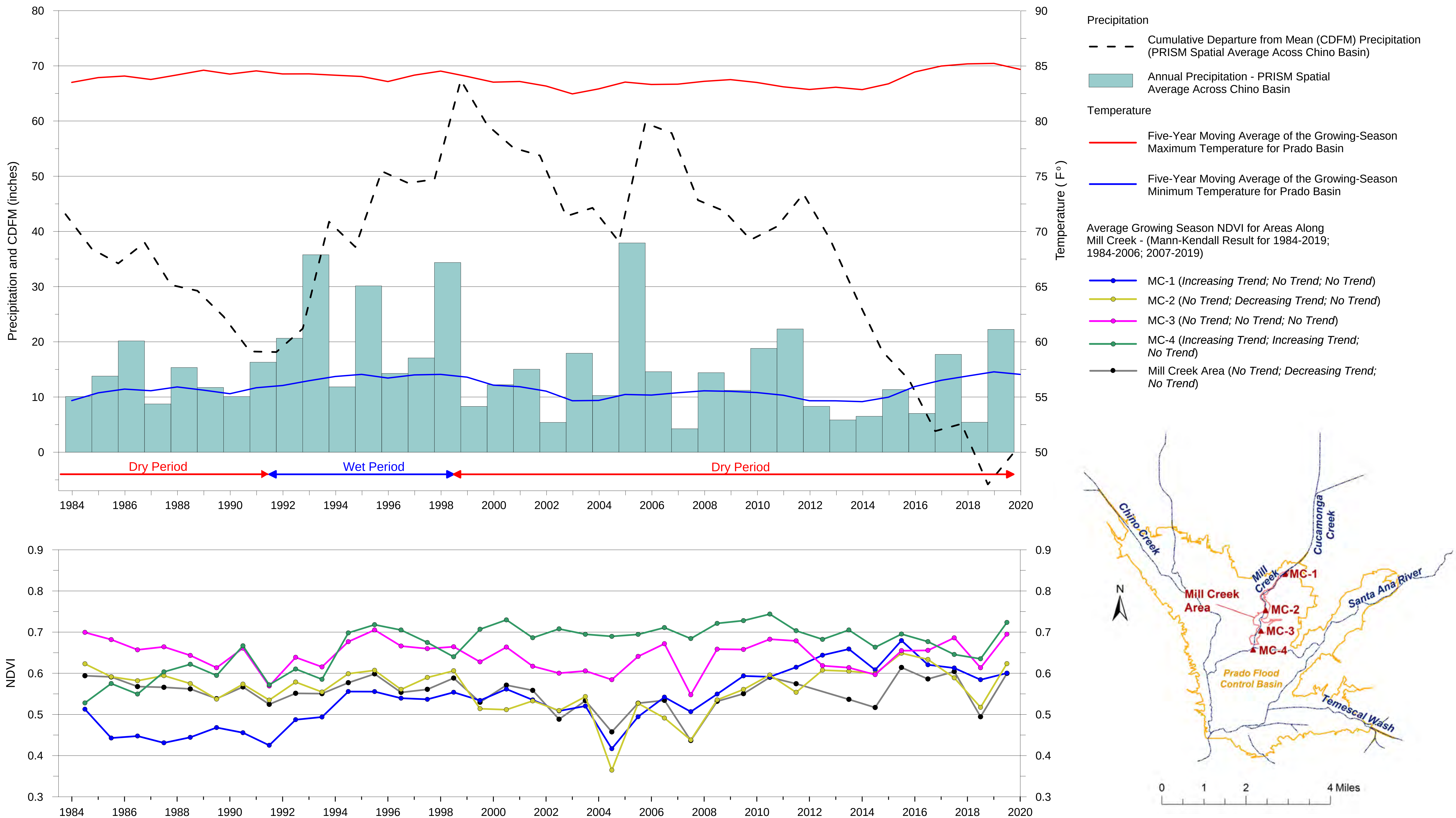
Figure 3-17
Maximum and Minimum Temperature in Prado Basin - 1895-2019





Climate versus NDVI
Chino Creek Area for 1984-2019

Figure 3-18a



Prepared by:

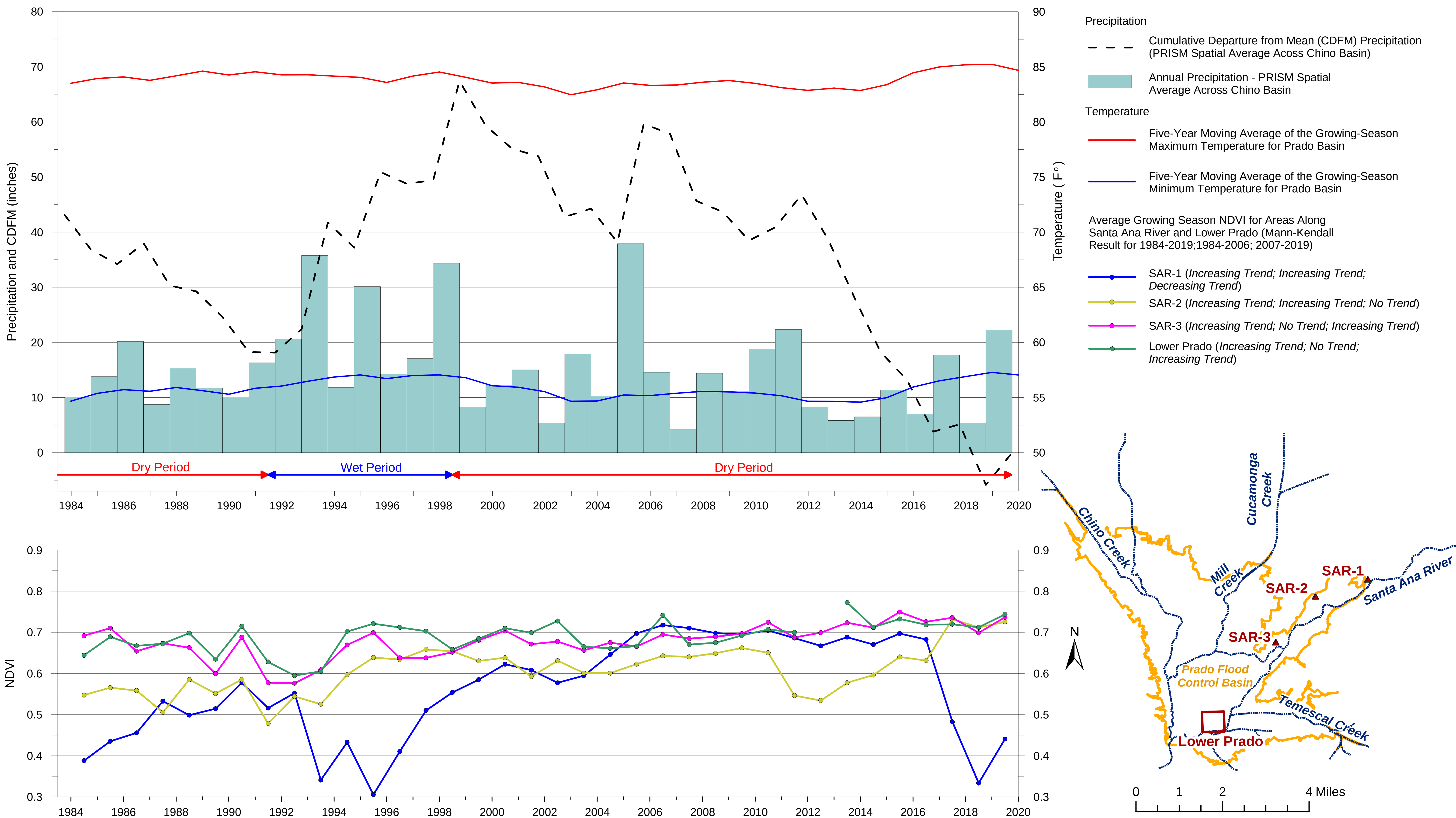
WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 20200415
Filename: CDFM_Temp_NDVI_ChinoCreek.grf

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Climate versus NDVI
Mill Creek Area for 1984-2019

Figure 3-18b



Prepared by:

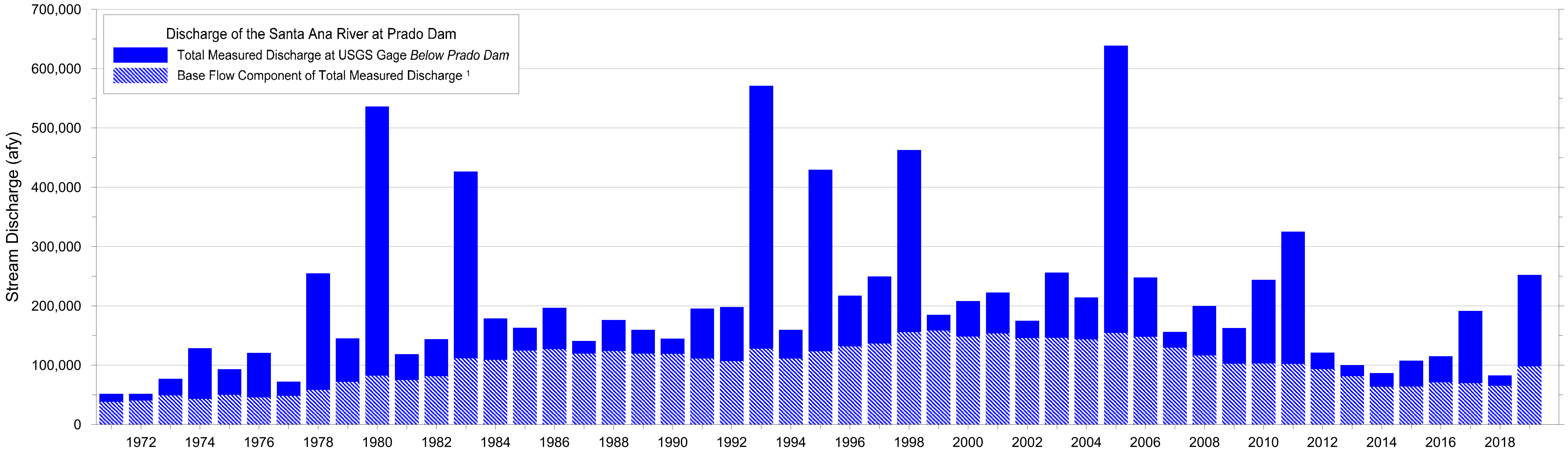
WEI
Wildermuth Environmental, Inc.

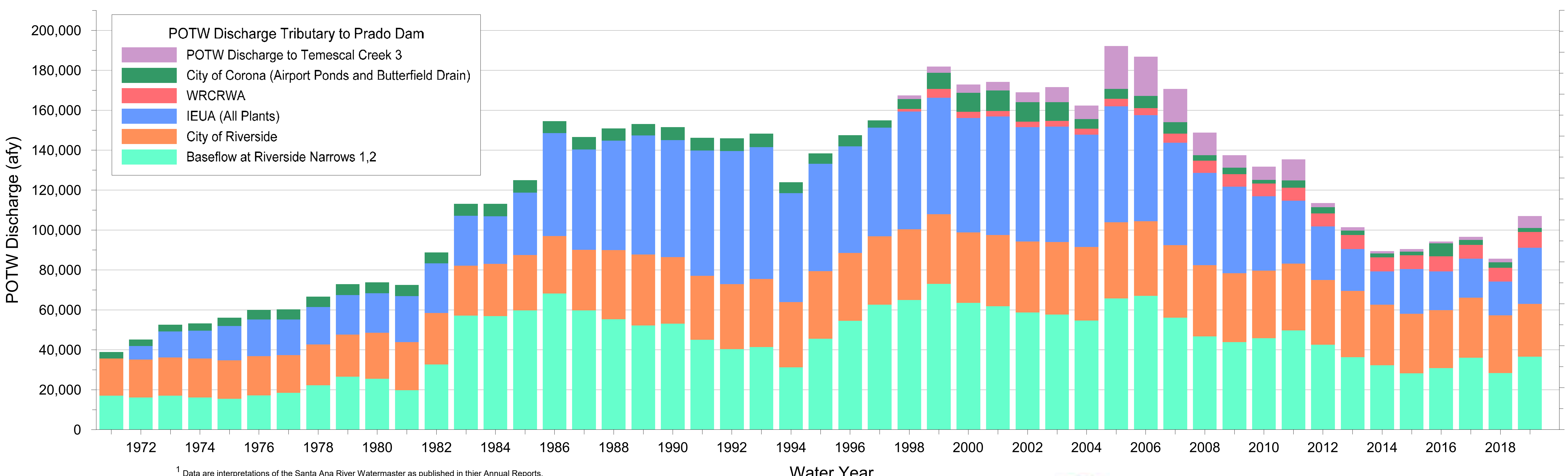
Author: RT
Date: 20200415
Filename: CDFM_Temp_NDVI_ChinoCreek.grf

2019 Annual Report
Prado Basin Habitat Sustainability Committee

Climate versus NDVI
Santa Ana River and Lower Prado Area for 1984-2019

Figure 3-18c





[1] Data are interpretations of the Santa Ana River Watermaster as published in thier Annual Reports.

[2] Baseflow at Riverside Narrows includes POTW discharge from RIX and Rialto plants, rising groundwater, and dry weather runoff

[3] Includes discharge from EVMWD, EMWD, and LLWD plants

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 20200403
Filename: 2019 Figure 3-19 SW Discharge.grf

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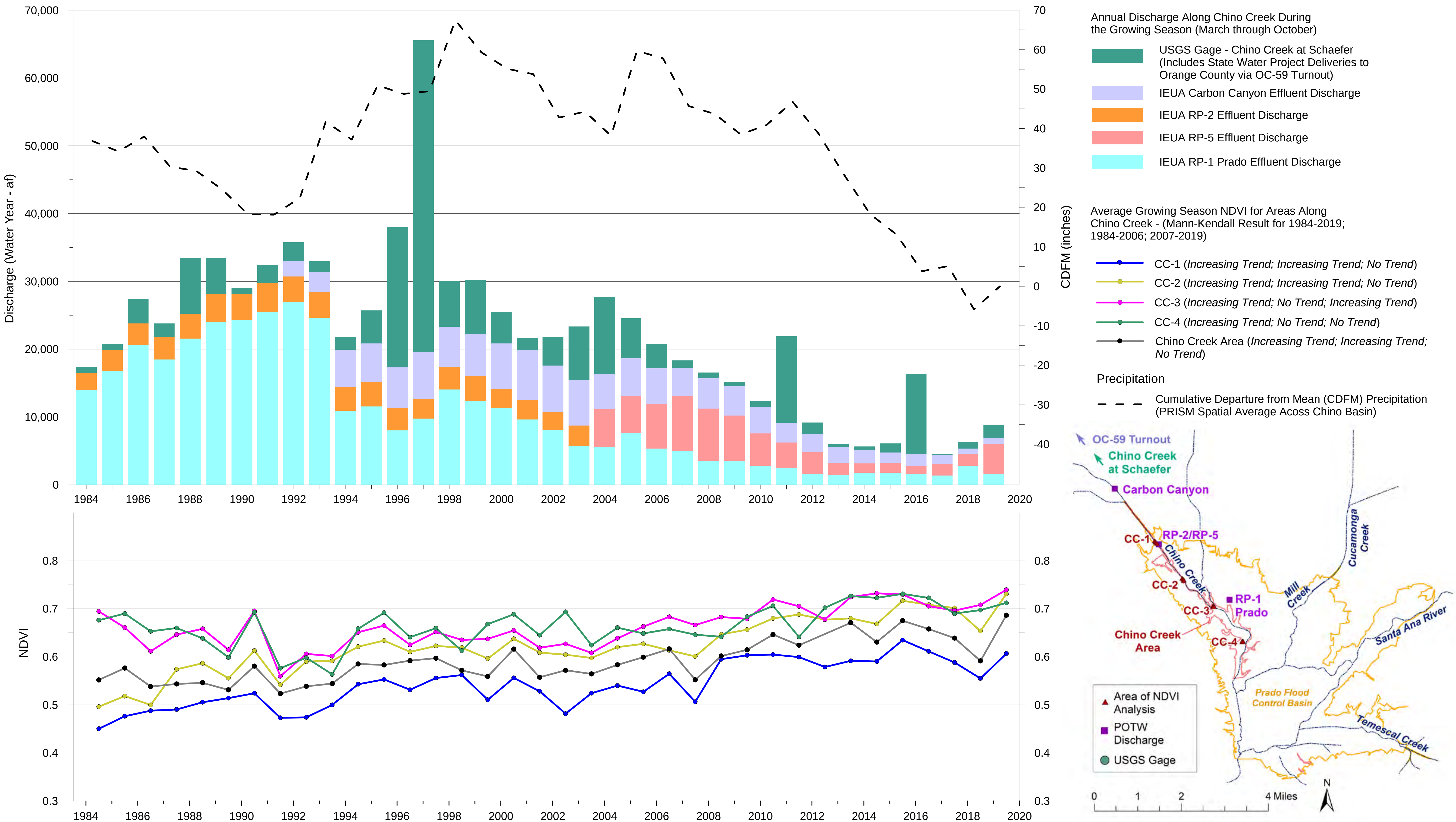
Prado Basin Habitat Sustainability Committee

Discharge Tributary to Prado Dam
Water Year 1960-2019

Figure 3-19



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 20200415
Filename: SW Discharge_NDVI_Chino Creek.grf

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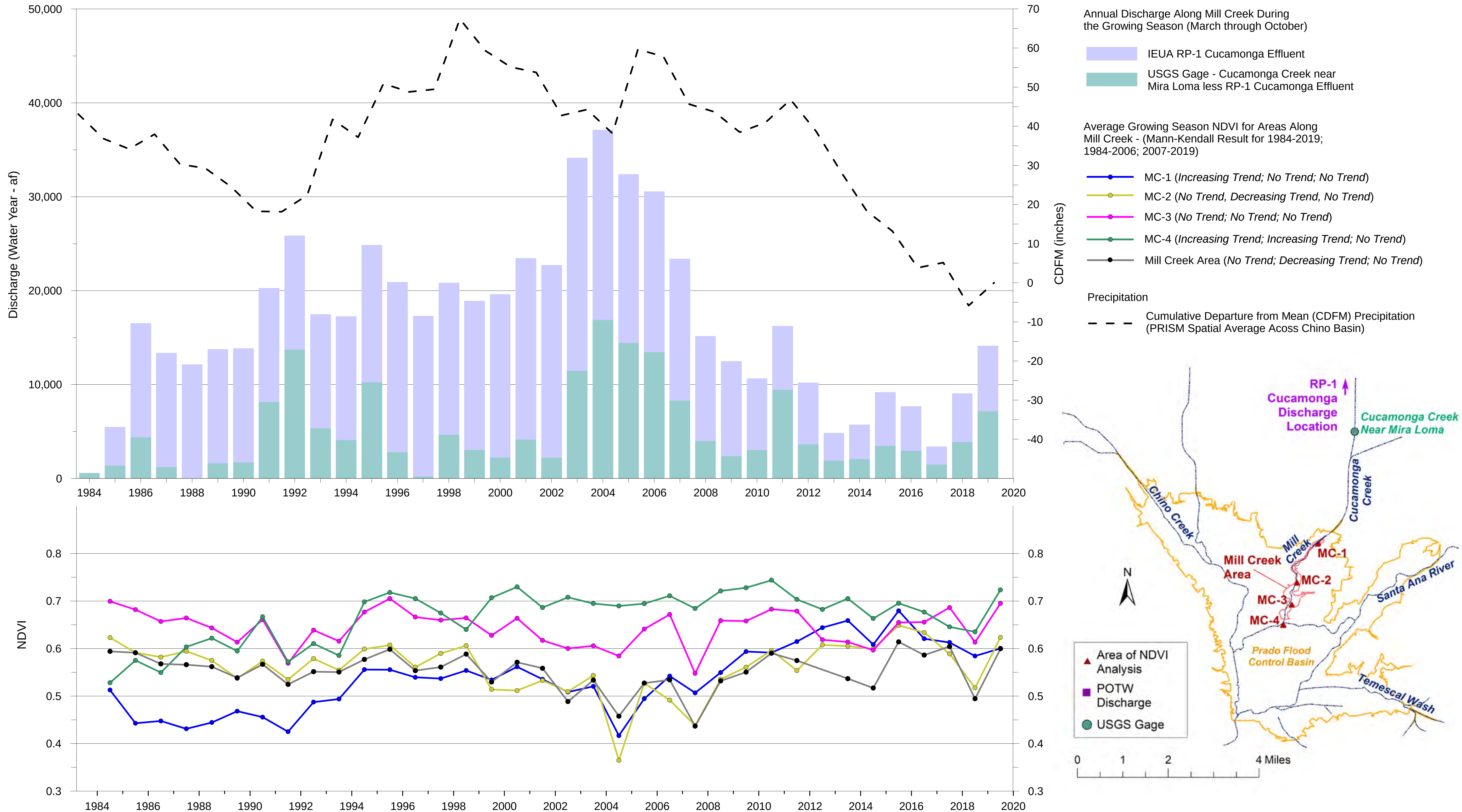
Prado Basin Habitat Sustainability Committee

Surface-Water Discharge versus NDVI
Chino Creek Area for 1984-2019

Figure 3-20a



Prepared by:

WEI Wildermuth Environmental, Inc.

Author: RT
Date: 20200415
Filename: SW Discharge_NDVI_Mill Creek.grf

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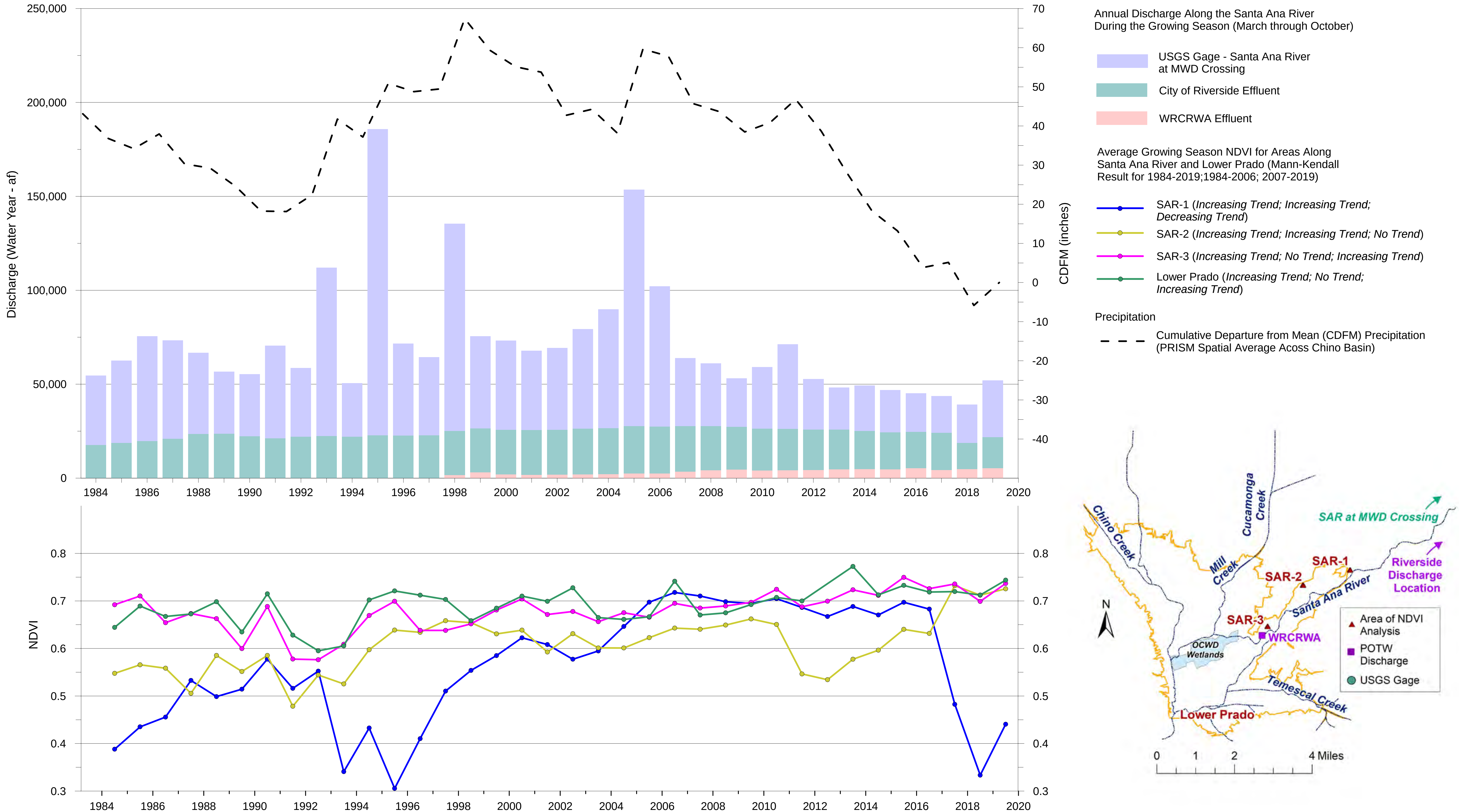
Prado Basin Habitat Sustainability Committee

Surface-Water Discharge versus NDVI
Mill Creek Area for 1984-2019

Figure 3-20b



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 20200415
Filename: SW Discharge_NDVI_SAR and LP.grf

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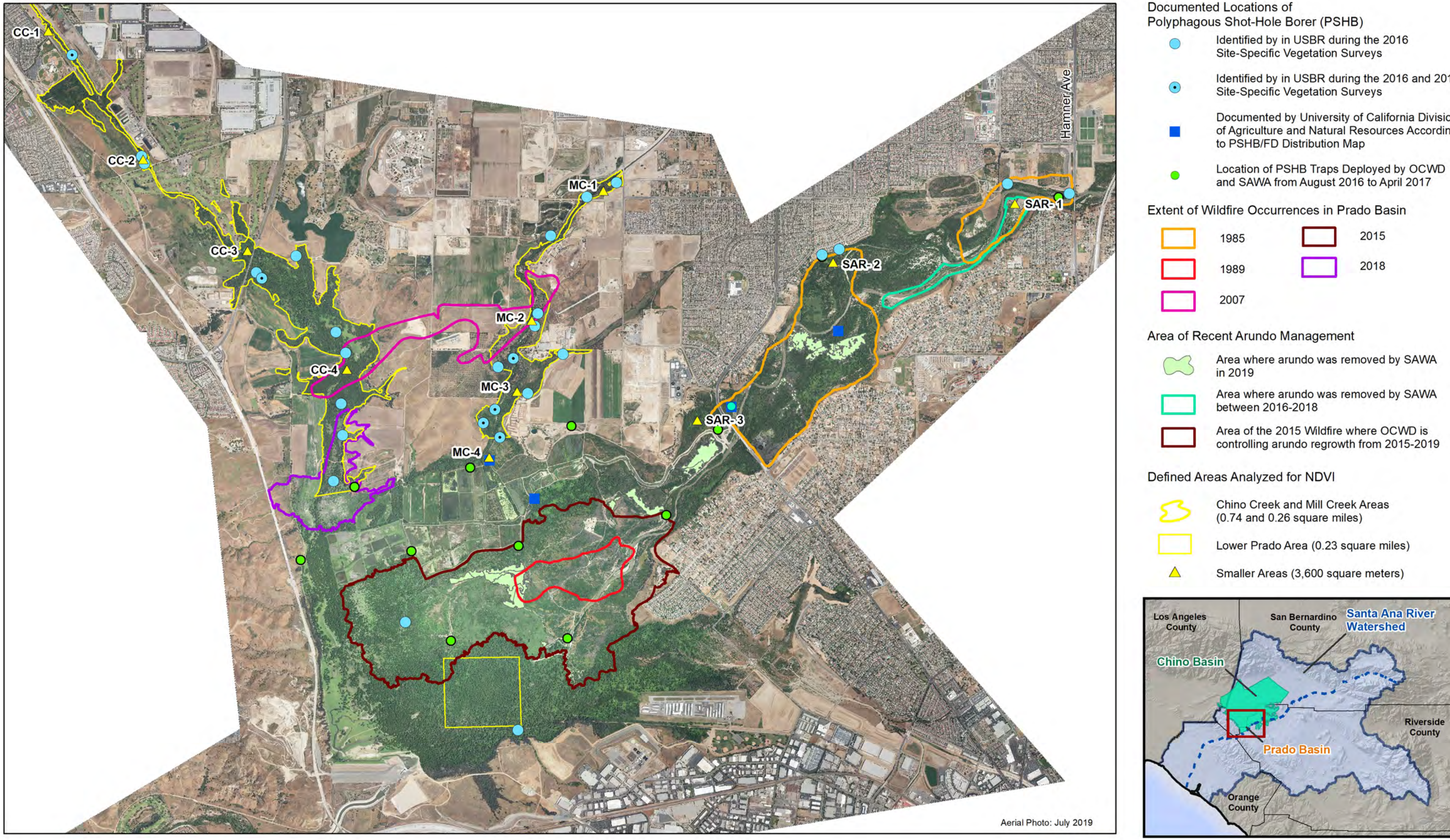
Prado Basin Habitat Sustainability Committee

Surface-Water Discharge versus NDVI
Santa Ana River and Lower Prado Area for 1984-2019

Figure 3-20c



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WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 4/20/2020
File: Figure 3-21_2019_other factors

0 1 2 Miles
0 1 2 3 Kilometers

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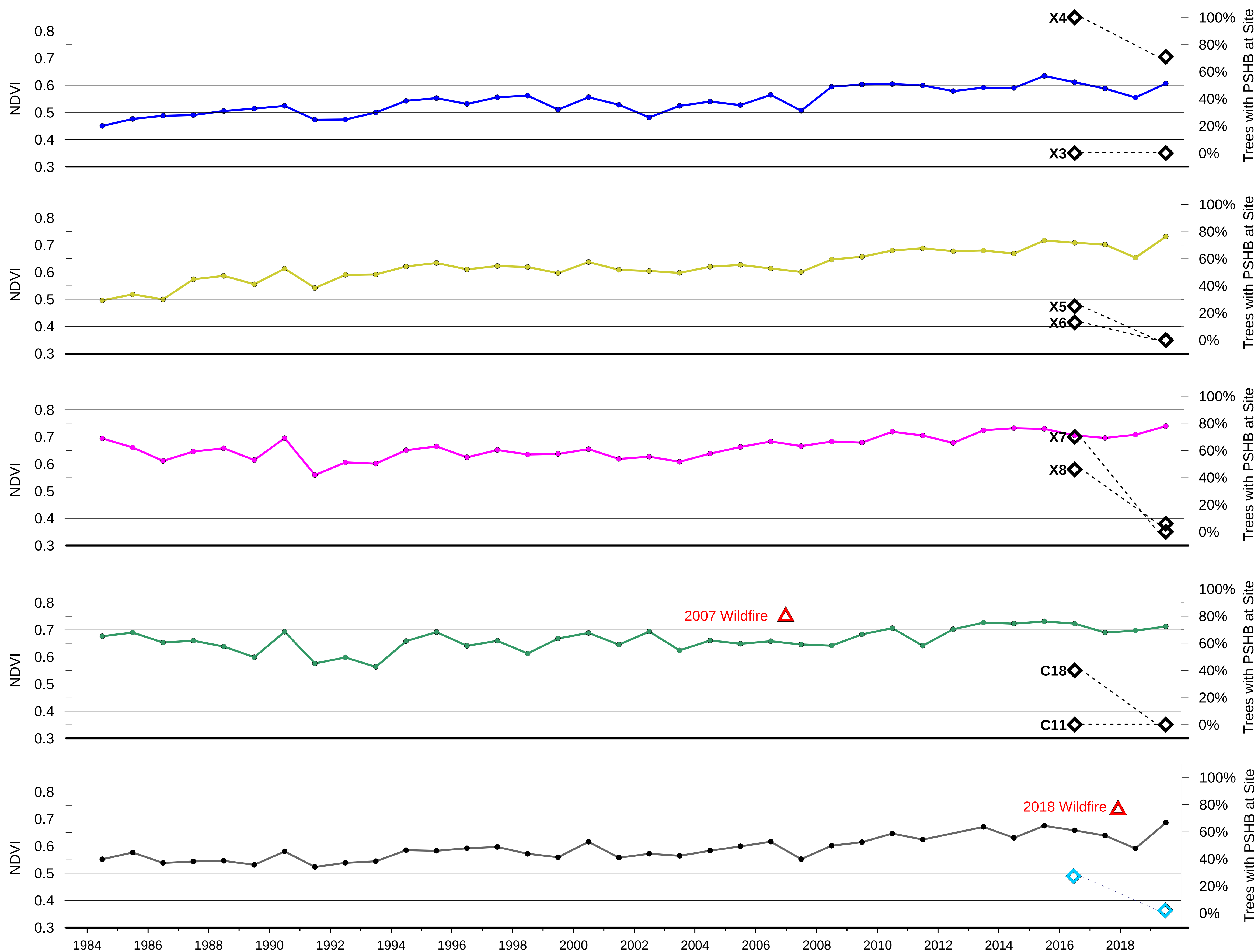
Location Map of Other Factors That Can Affect Riparian Habitat

Figure 3-21

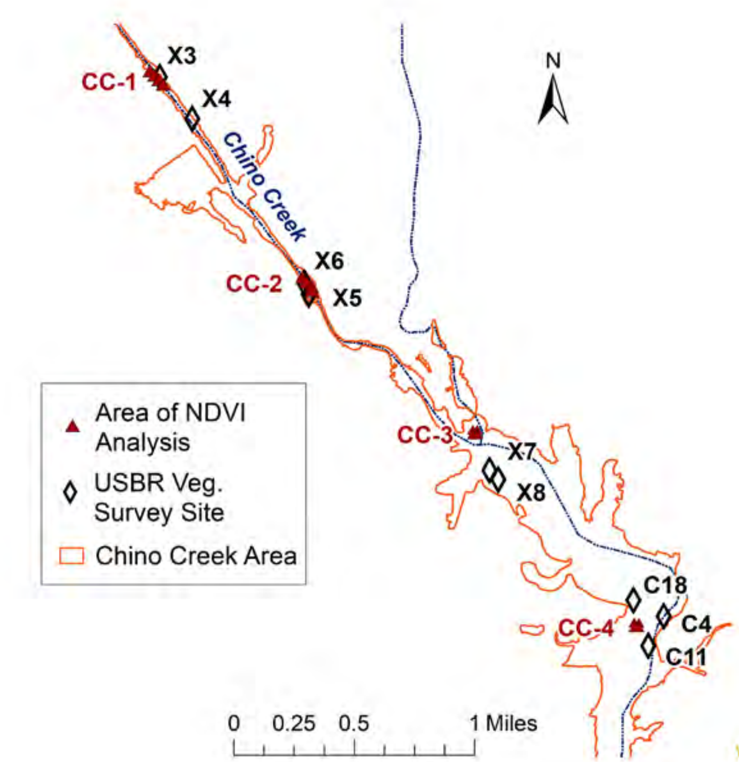


Average Growing Season NDVI for Areas Along Chino Creek - (Mann-Kendall Result for 1984-2019; 1984-2006; 2007-2019)

- CC-1 (*Increasing Trend; Increasing Trend; No Trend*)
- CC-2 (*Increasing Trend; Increasing Trend; No Trend*)
- CC-3 (*Increasing Trend; No Trend; Increasing Trend*)
- CC-4 (*Increasing Trend; No Trend; No Trend*)
- Chino Creek Area (*Increasing Trend; Increasing Trend; No Trend*)

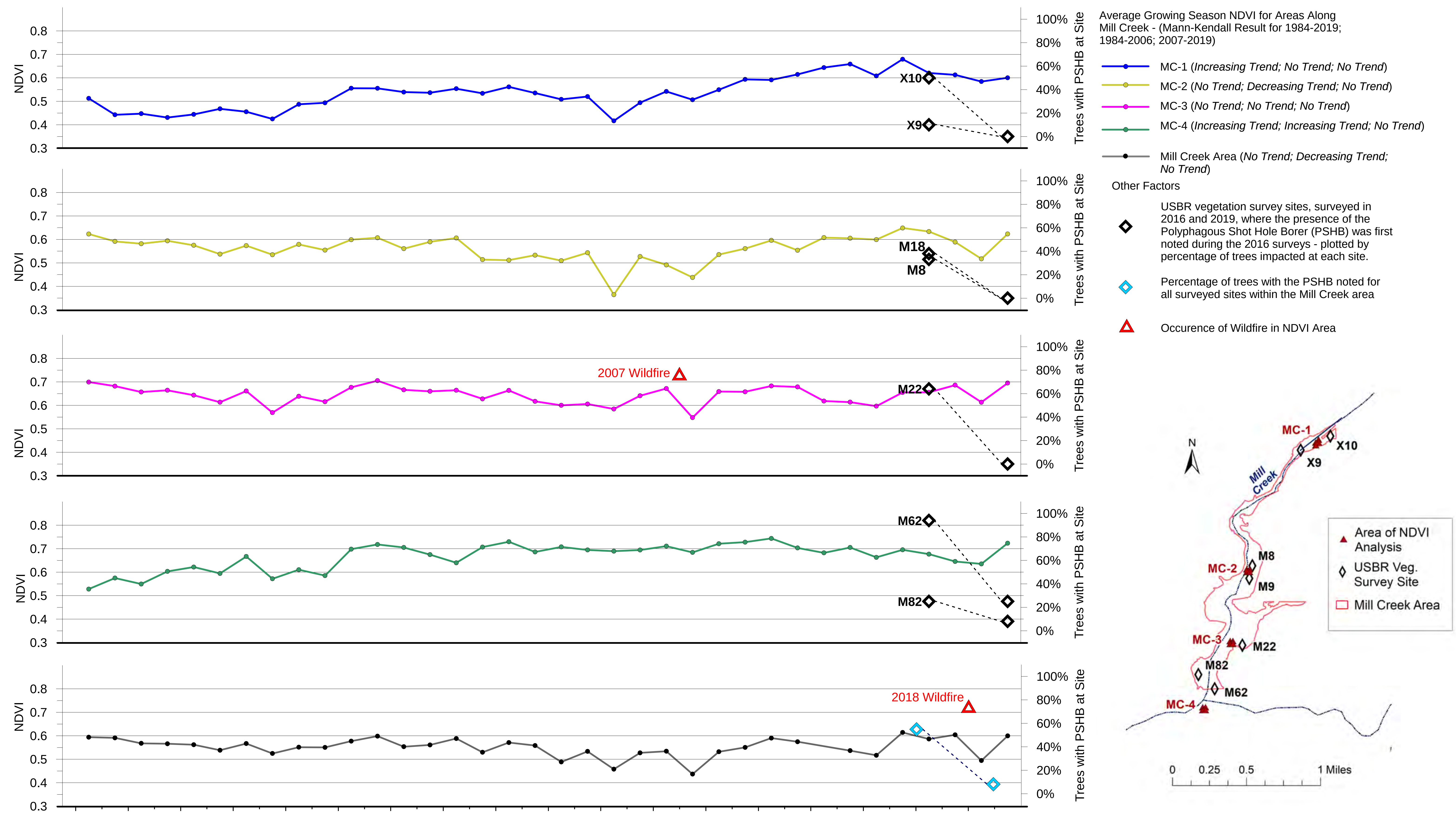
Other Factors

- USBR vegetation survey sites, surveyed in 2016 and 2019, where the presence of the Polyphagous Shot Hole Borer (PSHB) was first noted during the 2016 surveys - plotted by percentage of trees impacted at each site.
- Percentage of trees with the PSHB noted for all surveyed sites within the Chino Creek area
- Occurence of Wildfire in NDVI Area



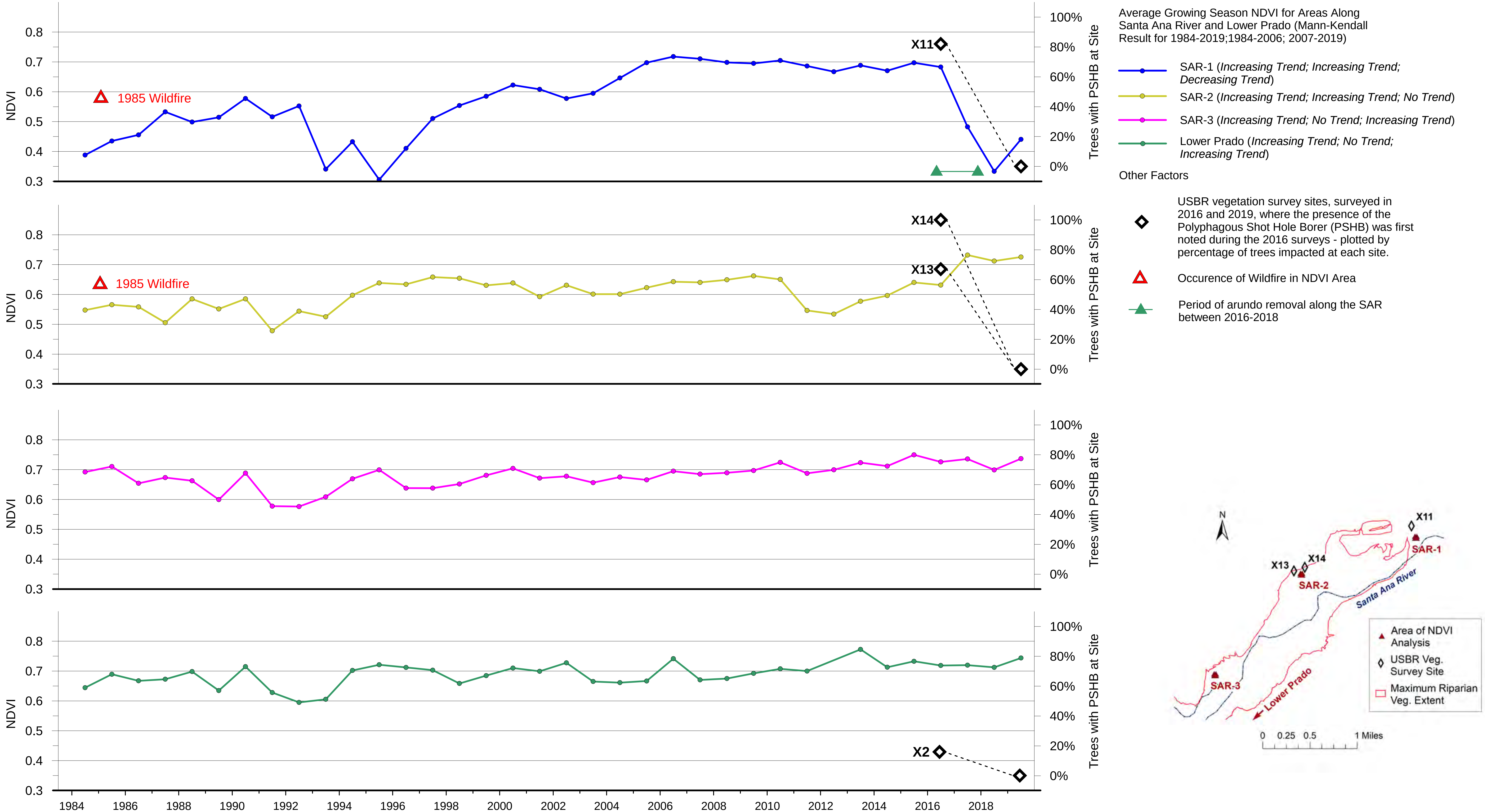
Other Factors That Can Affect Riparian Habitat versus NDVI
Chino Creek Area for 1984-2019

Figure 3-22a



Other Factors That Can Affect Riparian Habitat versus NDVI
Mill Creek Area for 1984-2019

Figure 3-22b



Prepared by:

WEI Wildermuth Environmental, Inc.

Author: RT
Date: 20200415
Filename: Other Factors_NDVI_CC.grf

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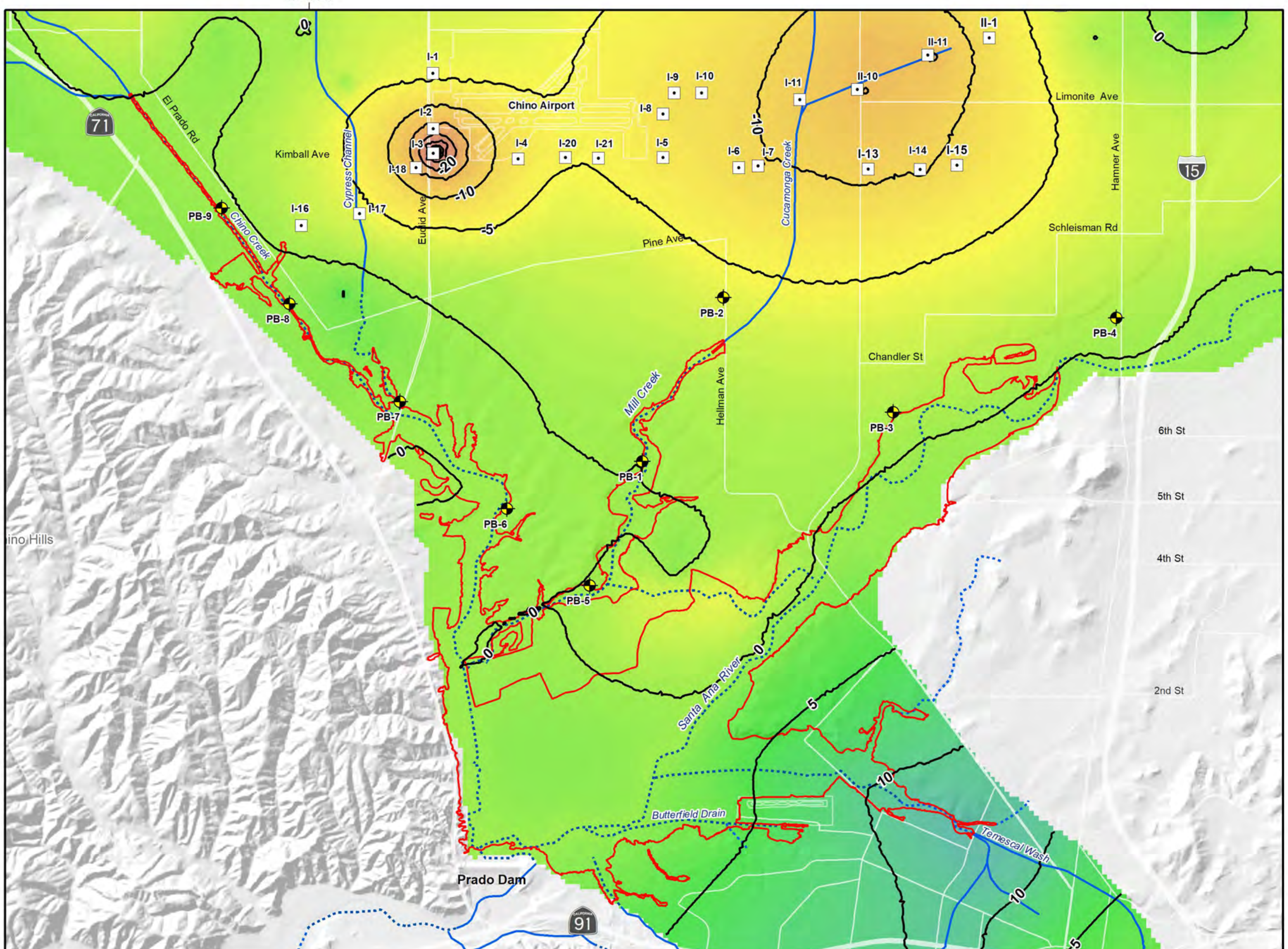
Other Factors That Can Affect Riparian Habitat versus NDVI
Santa Ana River and Lower Prado Area for 1984-2019

Figure 3-22c



Contours of Model-Predicted Change in Groundwater Levels*
July 2018 to July 2030, feet

Hydraulic Head Change (ft) *July 2018 to July 2030*

25 Increase
0
-25 Decrease

Chino Basin Desalter Well

PBHSP Monitoring Well

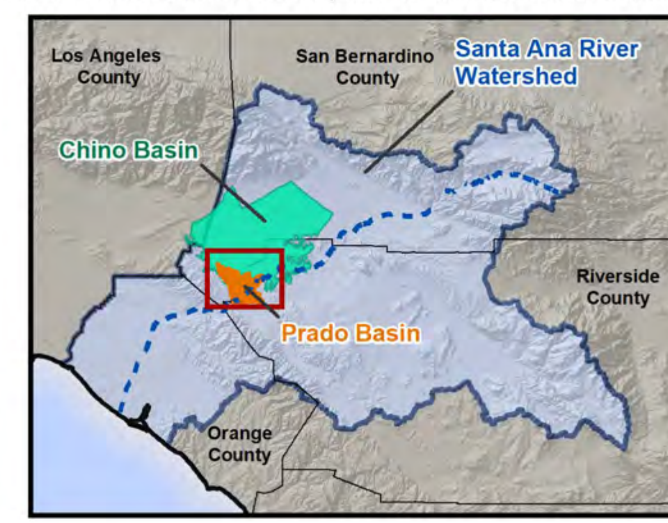
Concrete-Lined Channels

Unlined Rivers and Streams

Maximum Riparian Vegetation Extent in Prado Basin

* Model Predicted Change in Groundwater Levels from the planning scenario 2020 SYR1 for the recalculation of Safe Yield using the updated Chino Basin groundwater-flow model (WEI, 2020)

Aerial Photo: USDA, 2016. Mosaic of photos from June 2, 2016 to June14, 2016



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 5/11/2020
File: Figure 3-23_Model 2018-30

0 1 2 Miles
0 1 2 3 Kilometers

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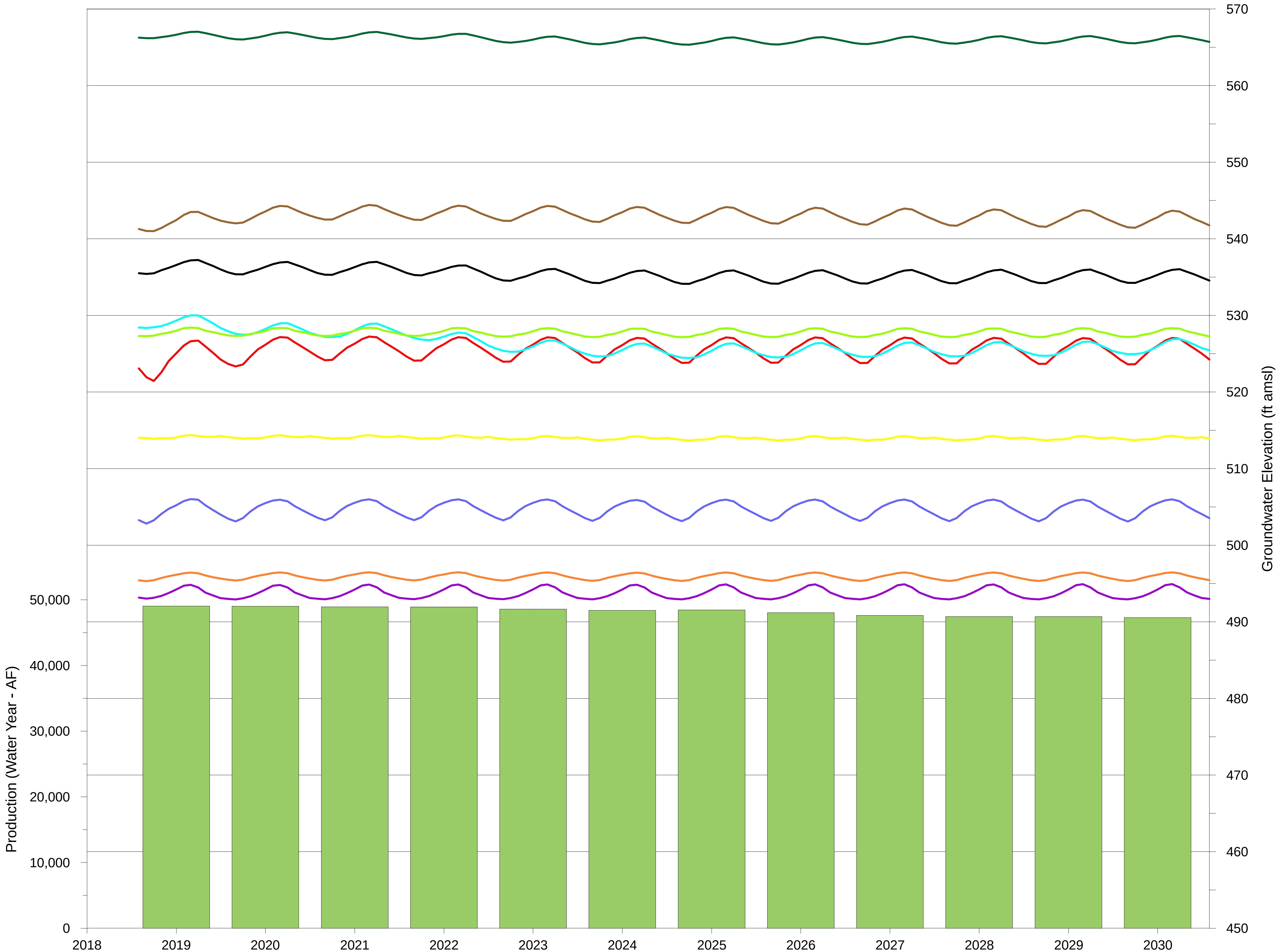
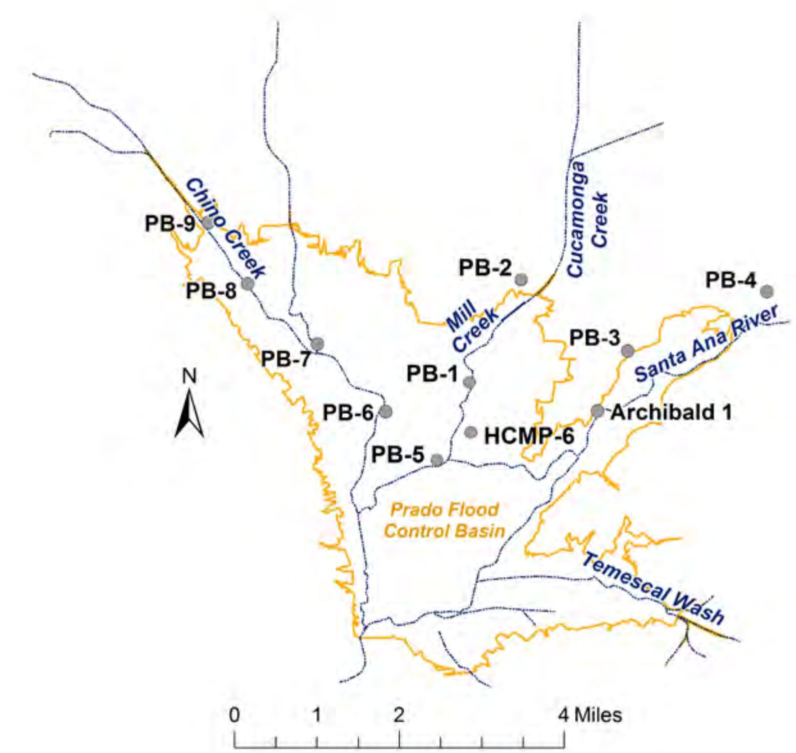
Predicted Change in Groundwater Levels
2018 to 2030 -- Scenario 2020 SYR1

Figure 3-23



*Model Simulated Groundwater Elevations and Pumping from the planning scenario 2020 SYR1 for the 2020 recalculation of Safe Yield using the updated Chino Basin groundwater-flow model (WEI, 2020)

Well Locations



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 20200415
Filename: Projected_PROD_GWE_2018-2030.grf

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Predicted Change in Groundwater Levels
2018-2030 - Scenario 2020 SYR1

Figure 3-24

Section 4 – Conclusions and Recommendations

The monitoring and mitigation requirements in the Peace II SEIR call for annual reporting for the PBHSP:

> *Annual reports will be prepared and will include recommendations for ongoing monitoring and any adaptive management actions required to mitigate any measured loss or prospective loss of riparian habitat that may be attributable to the Peace II Agreement.*

The following describes the main conclusions of this annual report and provides recommendations for future monitoring, reporting, and mitigation, if any.

4.1 Main Conclusions and Recommendations

4.1.1 Conclusions

The main conclusions of the PBHSC Annual Report for WY 2019 are:

- The quality of riparian habitat has been characterized through analyses of air photos and NDVI maps and NDVI time-series charts for large and small areas located throughout the Prado Basin. In addition, the USBR conducted a vegetation survey at specific sites across the Prado Basin in September 2019. The analyses indicate a general increase in the greenness and health of the riparian vegetation across most of the Prado Basin from 2018 to 2019.

- Groundwater levels have remained relatively stable and within their historical range of short-term and long-term variability and are therefore not the likely cause of the observed increases in NDVI and greening of riparian habitat from 2018 to 2019. In addition, the PBHSP has recognized no trend in degradation of the riparian habitat that is contemporaneous with decreasing groundwater levels during Peace II Agreement implementation.

- The Prado Basin experienced a prolonged dry period and a warming trend over the last 21 years, and from 2015 to 2018, the NDVI declined across much of the Prado Basin. During WY 2019, the area experienced above-average precipitation and slightly lower temperatures. These cooler, wetter conditions are likely a contributing cause of the observed increases in NDVI and the greening of riparian habitat from 2018 to 2019.

- Stream discharge in Chino Creek, Mill Creek, and the SAR increased during the 2019 growing season compared to the previous seven years. These increases in stream discharge are likely a contributing cause of the observed increases in NDVI and the greening of riparian habitat from 2018 to 2019.

- The PSHB is an identified pest in the Prado Basin which can adversely impact tree health and result in reduced canopy cover or tree mortality. USBR vegetation surveys performed in 2016 and 2019 at 37 sites along Chino Creek, Mill Creek, and the SAR noted the presence of the PSHB. The 2019 survey results indicated a significant decrease in the presence of the

PSHB and a reduction in the percentage of stressed trees across the Prado Basin. These observations indicate that the reduced presence of the PSHB in 2019 is a contributing cause of the observed increases in NDVI and the greening of riparian habitat from 2018 to 2019.

- Previous analyses of groundwater/surface water interactions in the Prado Basin indicate that the northern reaches of Mill Creek and the SAR are losing reaches, characterized by streambed recharge, and most other areas along Chino and Mill Creeks are gaining reaches, characterized by groundwater discharge. However, at most locations in the Prado Basin, groundwater/surface-water interactions are complex, and there appear to be multiple transient source waters that feed the shallow groundwater. In WY 2018, a pilot program was initiated to help better characterize the source of shallow groundwater used by the riparian vegetation and the groundwater/surface-water interactions in these locations. Thus far, the data collected for the pilot monitoring program are limited but show promise, and more time and data are needed to make interpretations.

- The most recent Chino Basin groundwater-model projections indicate two areas within the Prado Basin where groundwater levels are projected to decline during 2018-2030: the northernmost reaches of Mill Creek and the SAR. These projected declines in groundwater levels are expected to be minor (< 3 ft), and based on the current (2019) depth to groundwater in these areas, are not a concern for the prospective loss of riparian habitat.

4.1.2 Recommendations

The monitoring and analyses of the riparian habitat, groundwater levels, precipitation, temperature, and surface-water discharge should continue with no change in scope. The monitoring and analysis of other factors—such as wildfires, the PSHB, arundo removal, and additional factors as needed—should also continue. Continued monitoring and analysis is required to identify the relationships between the riparian habitat and factors that can influence it during Peace II Agreement implementation.

The pilot monitoring program initiated in WY 2018 to characterize groundwater/surface water interactions along Chino Creek should continue, at least for the next water year. This includes monitoring groundwater at the four PBHSP monitoring wells and two adjacent surface-water sites using probes and collecting semi-annual grab samples.

The periodic riparian vegetation surveys at sites throughout the Prado Basin should continue at a frequency of every three years. The vegetation surveys will be used to quantitatively characterize the current state of riparian vegetation at the sites, to ground-truth the interpretations derived from regional riparian habitat monitoring, and to note the occurrence and effects of the PSHB. The next vegetation survey is scheduled for the summer of 2022. The OCWD also performs required monitoring of the flora and fauna in the Prado Basin. Future vegetation surveys for the PBHSP should be planned and performed in coordination with the OCWD, and the Watermaster, IEUA and OCWD should work to achieve efficiencies for this element of the monitoring program.

4.2 Recommended Mitigation Measures and/or Adjustments to the AMP

This annual report documented no trend in the degradation of the extent or quality of riparian habitat along Chino Creek, Mill Creek, or the SAR that is contemporaneous with decreasing groundwater levels during the implementation of the Peace II Agreement. As such, no mitigation measures are proposed at this time.

No adjustments to the AMP are recommended at this time.

4.3 Recommended PBHSP for Fiscal Year 2020/21

Based on preliminary analysis of the PBHSP data for WY 2019, a draft *Technical Memorandum Recommended Scope and Budget of the Prado Basin Habitat Sustainability for FY 2020/21* was submitted to the PBSHC in February 2020. In March 2020, Watermaster's Engineer presented the recommended scope and budget for FY 2020/21 to the PBHSC for consideration. There were no changes recommended by the PBHSC on the proposed FY 2020/21 scope of work, and a final scope of work and budget was submitted to the PBHSC and will go through the Watermaster and IEUA FY 2020/21 budgeting process in May and June of 2020. The scope of work for the PBHSP for FY 2020/21 is shown in Table 4-1 as a line-item cost estimate.

The following describes the scope-of-work by major task for the PBHSP for FY 2020/21:

Task 1—Groundwater-Level Monitoring Program. The monitoring of groundwater levels in the Prado Basin is a key component of the PBHSP because declining groundwater levels could be a factor related to Peace II implementation that adversely impacts riparian vegetation. Sixteen monitoring wells were installed specifically for the PBHSP in 2015. These wells, plus monitoring wells HCMP-5/1 and RP3-MW3, are monitored for groundwater levels. The 18 monitoring wells are equipped with integrated pressure-transducers/data-loggers that measure and record water-level measurements every 15 minutes. This task includes quarterly field visits to all 18 PBHSP monitoring wells to download data. All data will be checked and uploaded to the PBHSP database. This task is consistent with the work performed during the previous FY.

Task 2—Groundwater-Quality Monitoring Program. Since the PBHSP monitoring wells were constructed in 2015, groundwater-quality monitoring has been tailored to discern the groundwater/surface-water interactions that are important to the sustainability of riparian habitat in the Prado Basin. From FY 2015/16 through 2017/18, quarterly groundwater samples were collected from the 18 PBHSP monitoring wells and analyzed at a minimum for general minerals. The general mineral chemistry data collected was analyzed along with groundwater-level data, model-generated groundwater-flow directions, and surface-water quality and flow data to help characterize groundwater/surface-water interactions in the Prado Basin and determine the source of the shallow groundwater that is available for consumptive use by riparian vegetation.

During FY 2018/19, a pilot monitoring program was initiated at four monitoring wells at two locations along Chino Creek (PB-7 and PB-8). Probes were installed in the four monitoring wells to measure and record EC, temperature, and water levels at 15-minute intervals in coordination with similar high-frequency monitoring at two nearby surface water sites in Chino Creek (Tasks 3.3 and 3.4). Groundwater-quality samples were also collected quarterly at these wells and analyzed for EC, temperature, and general minerals to validate and support the high-frequency data. The purpose of the pilot monitoring program is to determine if the high-frequency data better reveals the groundwater/surface-water interactions and enhances the interpretation of the general mineral data derived from sampling. The data collected thus for this pilot monitoring program in FY 2018/19 and 2019/20 is limited but shows promise and will be charted and described in the annual report. In addition, there is no extended record for the same data collected at the nearby surface water probes in Chino Creek; they were lost during large storm events in FY 2018/19 and were reinstalled during FY 2019/20. Tasks 2.1 and 2.2 are to continue the pilot monitoring program in FY 2020/21 to collect high-frequency groundwater data to help discern the groundwater/surface water interactions near PB-7 and PB-8. The monitoring wells will be visited quarterly to download probe data and semiannually[23] to collect samples for laboratory analyses of the general mineral analytes listed in Table 4-2. All data will be checked and uploaded to the PBHSP database.

Task 3—Surface-Water Monitoring Program. Surface-water discharge data from the Santa Ana River and the tributaries that cross Prado Basin are evaluated to characterize the influence of surface-water discharge on riparian habitat. The surface-water monitoring program utilizes publicly available datasets, including: USGS daily discharge measurements at six sites along the Santa Ana River and its tributaries, daily discharge and water-quality data from Publicly-Owned Treatment Works (POTWs) that are tributary to Prado Basin, US Army Corps of Engineers (ACOE) daily measurements of reservoir elevation and releases from the reservoir at Prado Dam, and Watermaster's quarterly surface-water-quality monitoring at two sites along the Santa Ana River.

Tasks 3.1 and 3.2 include the annual collection of USGS, POTW, and ACOE data for water year 2020, and the processing, checking, and uploading of these data to the PBHSP database. These tasks do not include the processing, checking, and uploading of the Watermaster-collected Santa Ana River data; this is performed for another Watermaster task. The scope of these tasks is consistent with the work performed for the previous fiscal year.

Surface-water quality data are also collected and analyzed to help characterize groundwater/surface water interactions. During FY 2018/19, a pilot monitoring program was initiated at two locations along Chino Creek adjacent to wells PB-7 and PB-8. At these locations, probes were installed in Chino Creek to measure and record EC, temperature, and stage at 15-minute intervals in coordination with the similar high-frequency monitoring at PB-7 and PB-8 (Task 2). Grab samples of surface water were also collected quarterly for EC, temperature, and general mineral analyses. As described above for *Task 2 – Groundwater-Quality Monitoring Program*, the purpose of the pilot monitoring program is to determine if the high-frequency data better reveal groundwater/surface-water interactions and enhance the interpretation of the general

[23] Sample collection is being reduced from quarterly to semiannual in FY 2020/21. The data collected thus far demonstrate that semiannual data will be sufficient to continue to validate and support the high-frequency data.

mineral data derived from grab sampling. The data collected for this pilot monitoring program in 2018/19 is limited but shows promise and will be charted and described in the annual report.

Tasks 3.3 and 3.4 are to continue the pilot monitoring program in FY 2020/21 to collect the high-frequency surface-water data to help discern groundwater/surface water interactions near wells PB-7 and PB-8. The probes will be visited quarterly to download the data, and surface water samples will be collected semiannually[24] for laboratory analyses of the general mineral analytes listed in Table 4-2. All data will be checked and uploaded to the PBHSP database.

Task 4 – Climate Monitoring Program. Climatic data are evaluated in the vicinity of the Prado Basin to characterize trends and to determine if these trends contribute to impacts on riparian habitat. The climate monitoring program utilizes publicly available datasets. Two types of datasets are compiled: time-series data measured at weather stations and spatially gridded datasets. Task 4 includes the annual collection of the time-series data and spatially gridded datasets for water year 2020 (October 2019 – September 2020) and the checking and uploading of data to the PBHSP database. The scope of this task is consistent with the work performed for the previous fiscal year.

Task 5—Riparian Habitat Monitoring Program. Monitoring the extent and quality of riparian habitat in the Prado Basin is a fundamental component of the PBHSP's characterization how the riparian habitat changes over time. To characterize the impacts of Peace II implementation on the riparian habitat (if any), it is necessary to understand the long-term historical trends of its extent and quality and the factors that have affected it. The current riparian habitat monitoring program consists of both regional and site-specific components. The proposed riparian habitat monitoring program for FY 2020/21 is described in the subsections below.

Regional Monitoring. The regional monitoring of riparian habitat is performed via two independent methods that complement each other: mapping and analysis of the riparian habitat using (i) air photos and (ii) the normalized distribution the vegetation index (NDVI) derived from the Landsat remote-sensing program. Tasks 5.1, 5.2, and 5.3 are for the collection and compilation of the regional monitoring data, including:

- Perform a custom flight (via outside professional services) to acquire a high-resolution air photo (three-inch pixel) of the Prado Basin during summer 2020. The cost of the air photo is shared with OCWD.
- Catalog and review the 2020 high-resolution air photo in ArcGIS and digitize the extent of the riparian habitat.
- Collect, review, and upload the Landsat NDVI data for water year 2020.

Site-Specific Monitoring. The site-specific monitoring of the riparian habitat consists of periodic field surveys of the riparian vegetation at selected locations. These surveys provide an

[24] Sample collection is being reduced from quarterly to semiannual in FY 2020/21. The data collected thus far demonstrate that semiannual data will be sufficient to continue to validate and support the high-frequency data.

independent measurement of vegetation quality that can be used to "ground-truth" the regional riparian habitat monitoring. To date, the USBR, along with the OCWD,[25] has conducted field surveys once every three years. The most recent triennial field survey was conducted in the summer of 2019. The next field survey is scheduled for the summer of 2022. There is no scope or budget proposed for site-specific monitoring for FY 2020/21.

Task 6—Prepare Annual Report of the PBHSC. This task involves the analysis of the datasets generated by the PBHSP through water year 2020. The results and interpretations generated from the data analysis will be documented in the *Annual Report for Prado Basin Habitat Sustainability Committee for Water Year 2019/20*. This task includes the effort to prepare an administrative draft report for Watermaster and IEUA staff review, a draft report for PBHSC review, and a final report, including comments and responses. A PBHSC meeting will be conducted in May 2021 to review the draft report and facilitate comments on the report. The scope of this task is consistent with the work performed for the previous fiscal year.

Task 7—Project Management and Administration. This task includes the effort to prepare the PBHSP scope, schedule, and budget for the subsequent fiscal year. A draft *Technical Memorandum Recommended Scope and Budget of the Prado Basin Habitat Sustainability Program for FY 2021/22* will be submitted to the PBHSC in February 2021. A PBHSC meeting will be conducted in March 2021 to review the draft recommended scope and budget and facilitate comments. Also included in this task is project administration, including management of staffing and monthly financial reporting. The scope of this task is consistent with the work performed for the previous fiscal year.

The ongoing costs of the PBHSP are shared between Watermaster and the IEUA per the 2016 Agreement.[26] Watermaster is responsible for the costs associated with Tasks 1 through 3, and the IEUA and Watermaster split costs 50/50 for Tasks 4 through 7. The cost of the custom flight to collect a high-resolution air-photo in Task 4 is being shared 50/50 between the OCWD and Watermaster/the IEUA.

[25] OCWD staff provides assistance to the USBR in the field as in-kind services.

[26] Agreement Between Chino Basin Watermaster and Inland Empire Utilities Agency Regarding Reimbursement of the Peace II Subsequent Environmental Impact Report Mitigation Measure 4.4.5 (Prado Basin Habitat Sustainability Program). Signed September 2016.

Table 4-2
Parameter List for the Groundwater and Surface Water Quality Monitoring Programs for Fiscal Year 2020/21

Chemical Parameter	Method Detection Limit	Analysis Method
Alkalinity in CaCO3 units	2 mg/L	SM2320B
Ammonia Nitrogen	0.05 mg/L	EPA 350.1
Bicarbonate as HCO3 *Calculated*	2 mg/L	SM2320B
Calcium Total ICAP	1 mg/L	EPA 200.7
Carbonate as CO3 *Calculated*	2 mg/L	SM2320B
Chloride	1 mg/L	EPA 300.0
Hydroxide as OH *Calculated*	2 mg/L	SM2320B
Magnesium Total ICAP	0.1 mg/L	EPA 200.7
Nitrate as Nitrogen by IC	0.1 mg/L	EPA 300.0
Nitrate as NO3 *Calculated*	0.44 mg/L	EPA 300.0
Nitrite as Nitrogen by IC	0.05 mg/L	EPA 300.0
Nitrate plus Nitrite as Nitrogen *Calculated*	0.1 mg/L	EPA 300.0
PH (H3=past HT not compliant)	0.1 Units	SM4500-HB
Potassium Total ICAP	1 mg/L	EPA 200.7
Silica	0.5 mg/L	EPA 200.7
Sodium Total ICAP	1 mg/L	EPA 200.7
Specific Conductance, 25 C	2 umho/cm	SM2510B
Sulfate	0.5 mg/L	EPA 300.0
Total Dissolved Solids (TDS)	10 mg/L	E160.1/SM2540C
Total Hardness as CaCO3 by ICP	3 mg/L	SM 2340B
Total Organic Carbon	0.3 mg/L	SM5310C/E415.3
Turbidity	0.05 NTU	EPA 180.1

Table 4-1
Work Breakdown Structure and Cost Estimate
Prado Basin Habitat Sustainability Program: FY 2020/21

Task Description	No. of sites	Labor Total: Person Days	Labor Total: Total	Other Costs: Travel	Other Costs: Equip. Rental	Other Costs: Lab	Other Costs: Outside Pro	Other Costs: Equip	Other Costs: Total	Notes	Totals: Recommended Budget 2020/21	Totals: Budget 2019/20	Totals: Difference 2019/20 to 2020/21	Totals: IEUA Share 2019/20	Totals: CBWM Share 2020/21
Task 1: Groundwater Level Monitoring Program		**11.4**	**$13,896**						**$782**		**$14,678**	**$14,220**	**$458**	-	**$14,678**
1.1 Collect Transducer Data from PBHSP Wells (Quarterly)	18	5.0	$5,128	$590	$192				$782		$5,910				
1.2 Collect, Check, and Upload Transducer Data from PBHSP Wells (Quarterly)	18	6.4	$8,768						$0		$8,768				
Task 2: Groundwater Quality Monitoring Program		**3.3**	**$7,778**						**$2,362**		**$10,140**	**$15,514**	**-$5,374**	-	**$10,140**
2.1 Collect, Check, and Upload High-Frequency Probe Data from Pilot Monitoring Program (Quarterly)	4	3.4	$4,235	$240					$240		$4,475				
2.2 Collect, Check, and Upload Grab Sample General Mineral Chemistry Data (Semi-annually)	4	3.3	$3,543	$472	$250	$1,400			$2,122		$5,665				
Task 3: Surface Water Monitoring Program		**2.7**	**$13,062**						**$1,190**		**$14,252**	**$33,558**	**-$19,306**	-	**$14,252**
3.1 Collect, Check, and Upload Surface Water Discharge and Quality Data from POTWs, and Dam Level data from the ACOE (Annual)		1.9	$2,559						$0		$2,559				
3.2 Collect, Check, and Upload Surface Water Discharge and Quality Data from USGS gaging stations (Annual)		0.8	$1,096						$0		$1,096				
3.3 Collect, Check, and Upload High-Frequency Probe Data for Chino Creek from Pilot Monitoring Program (Quarterly)	2	4.8	$5,554	$240					$240		$5,794				
3.4 Collect, Check, and Upload Grab Surface Water Quality Field and Lab Data for Chino Creek from Pilot Monitoring Program (Semi-annually)	2	3.6	$3,852		$250	$700			$950		$4,802				
Task 4: Climate Monitoring Program		**1.3**	**$1,764**						**$275**		**$2,039**	**$1,980**	**$59**	**$1,019.50**	**$1,019.50**
4.1 Collect, Check, and Upload Climatic Data (Annual)		1.3	$1,764				$275		$275		$2,039				
Task 5: Riparian Habitat Monitoring Program		**22.3**	**$24,738**						**$10,000**		**$34,738**	**$80,044**	**-$45,306**	**$17,369.00**	**$17,369.0**
5.1 Perform a Custom Flight to Acquire a High-Resolution 2019 Air Photo of the Prado Basin		1.5	$2,860				$10,000		$10,000	1	12,860				
5.2 Catalog, Check, and Review the Extent of the Riparian Vegetation in the 2020 Air Photo of the Prado Basin		4.8	$7,642						$0		7,642				
5.3 Collect, Check, and Upload 2019 Landsat NDVI Data to the PBHSP Database		9.0	$14,236						$0		$14,236				
Task 6: Prepare Annual Report of the PBHSC		**57.3**	**$91,044**						**$180**		**$91,224**	**$100,434**	**-$9,210**	**$45,612.00**	**$45,612.0**
6.1 Analyze Data and Prepare Admin Draft Report for CBWM/IEUA		42.8	$66,268						$0		$66,268				
6.2 Meet with CBWM/IEUA to Review Admin Draft Report		2.0	$3,912	$90					$90		$4,002				
6.3 Incorporate CBWM/IEUA Comments and Prepare Draft Report: Submit Draft Report to PBHSC		5.0	$7,680						$0		$7,680				
6.4 Meet with PBHSC to Review Draft Report		3.0	$5,720	$90					$90		$5,810				
6.5 Incorporate PBHSC Comments and Finalize Report		4.5	$7,464						$0		$7,464				
Task 7: Project Management and Administration		**11.1**	**$20,661**						**$90**		**$20,751**	**$21,675**	**-$924**	**$10,375.40**	**$10,375.40**
7.1 Prepare Scope and Budget for FY 2021/22		4.0	$7,528						$0		$7,528				
7.2 Meet with PBHSC to Review Scope and Budget for FY 2021/22		3.5	$6,624	$90					$90		$6,714				
7.3 Project Administration and Financial Reporting		3.6	$6,509						$0		$6,509				
Totals		**228**	**$172,942**	**$1,492**	**$500**	**$2,100**	**$10,275**	**$0**	**$14,879**		**$187,821**	**$267,425**	**-$79,604**	**$74,376**	**$113,446**

1 - This is half of the cost for the outside professional. OCWD will pay the other half.

Section 5 – References

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