Riparian Habitat Restoration Plan for Grayson Riverbend Preserve

San Joaquin River Mile 76-77
Stanislaus County, California

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Watershed Restoration Grant Program

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Stream Flow Enhancement Program

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EXECUTIVE SUMMARY

This restoration plan describes the basis of design, restoration design, and procedures River Partners will use to implement riparian and floodplain enhancements on the 285-acre Grayson Riverbend Preserve (GRP) in Stanislaus County, California. The primary goal of restoration at GRP is to improve ecosystem functions associated with healthy riparian and floodplain habitat including enhanced water quality, wildlife habitat for myriad species, streamflow enhancement, groundwater recharge, and carbon sequestration. Alongside restoration activities, agricultural water use will also be permanently retired, further enhancing streamflow in this reach of the San Joaquin River. GRP is an ecologically important area in the primary floodplain of the San Joaquin River, located immediately upstream of the San Joaquin River National Wildlife Refuge (SJRNWR) and Dos Rios Ranch where complimentary riparian and floodplain habitat restoration has been ongoing for more than 20 years. This region hosts several threatened and endangered species in remnant and restored riparian habitats, and is located within several overlapping conservation planning areas that focus on riverine habitat restoration, species recovery, and multi-benefit flood management.

The overarching restoration strategy at GRP is to employ process-based strategies to improve floodplain connectivity and establish a mosaic of native riparian vegetation communities to help support multiple riparian-obligate species through the climate extremes the site is subject to - cycles of drought and flood of varying duration and intensity. Based on rigorous ground- and desktop-based evaluations of GRP, it was determined that relatively minor modifications to existing field berms within the designated floodway at GRP could increase the frequency of inundation on-site and reduce flood damages to adjacent landowners and communities. In combination with active riparian revegetation, the functional habitat potential at GRP is very high, and will provide habitat for numerous threatened and endangered species and provide critical ecosystem services.

RIPARIAN HABITAT RESTORATION PLAN
FOR THE GRAYSON RIVERBEND PRESERVE
STANISLAUS COUNTY, CALIFORNIA

I. INTRODUCTION

A. Project Overview

The San Joaquin River is a heavily impacted ecosystem where natural processes have been disrupted by human intervention. Water diversion, flow regulation, riparian clearing, floodplain leveling, and an influx of non-native species serve as major stressors on native plant and wildlife communities within the system. The cumulative effects of these stressors are manifest in the numerous native plant and wildlife species that are threatened or endangered. Process-based restoration at the Grayson Riverbend Preserve (GRP), located immediately upstream of the San Joaquin River National Wildlife Refuge (SJRNWR) and River Partner's Dos Rios Ranch, is aimed at addressing numerous stressors through active revegetation and minor topographical modifications to the landscape.

Special-status wildlife targets include riparian brush rabbit (*Sylvilagus bachmani riparius*), San Joaquin "riparian" woodrat (*Neotoma fuscipes riparia*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), least Bell's vireo (*Vireo bellii pusillus*), Western yellow-billed cuckoo (*Coccycus americanus occidentalis*), Swainson's hawk (*Buteo swainsoni*), bank swallow (*Riparia riparia*), greater sandhill crane (*Grus canadensis tabida*), little willow flycatcher (*Empidonax traillii brewsteri*), and tricolored blackbird (*Agelaius tricolor*). Additional restoration target species include native Neotropical migrant songbirds, year-round resident and wintering migrant songbirds, shorebirds, waterfowl, and other land birds. Chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*Oncorhynchus mykiss*), and white sturgeon (*Acipenser transmontanus*), which have recently been documented spawning near the restoration site (Gruber 2012), will also benefit from improved floodplain accessibility and function. A biological monitoring program will allow for adaptive management during project implementation and will result in improved project outcomes.

In addition, River Partners aims to enhance streamflow through permanent retirement of agricultural irrigation; reduce flood damages by removing valuable infrastructure from the floodway and expanding flood space immediately downstream of the community of Grayson; and improve groundwater quality around domestic wells that supply municipal water for the community of Grayson by retiring agricultural applications of fertilizers and chemicals and through the expansion of floodplain inundation which may contribute to the dilution of legacy pollutants.

River Partners intends to transfer the fee title of the GRP to an appropriate public resource agency for long-term management. The site is completely located within the expansion boundary of the SJRNWR, making the USFWS a logical and potential long-term landowner. Any transaction of property ownership will include consultation and approval by the State of California.

B. Purpose of Restoration Plan

The primary purpose of this plan is to provide the basis of restoration design and guide permitting and implementation of restoration. The plan will:

- Identify project goals and objectives
- Characterize existing conditions at GRP
- Outline a conceptual site model that describes current understanding of the physical and biological factors that influence site ecology
- Describe benefits associated with restoration
- Describe restoration rationale and strategies
- Describe implementation approaches

C. Goals and Objectives

The overarching goal of restoration at GRP is to re-establish a functioning and dynamic riparian corridor that provides multiple benefits to people and wildlife in the area. Specific objectives in support of this goal include:

1. Establish 185 acres of self-sustaining native plant communities with a high probability of long-term survivorship
2. Reduce the extent of non-native invasive weeds
3. Provide approximately 80 acres of frequently inundated floodplain habitat
4. Enhance streamflow during summer and fall months by approximately 180 acre-feet per year on average
5. Reduce local repetitive flood damages
6. Provide local groundwater recharge and improve the quality of local groundwater
7. In collaboration with local stakeholders, identify up to three concepts for providing recreational and/or educational opportunities at GRP for local communities

D. Cooperative Relationships and Funding Sources

GRP is owned in fee title by River Partners and underlain with deed recordings in the form of Notices of Unrecorded Grant Agreements which compel the maintenance of habitat and streamflow enhancement values for 25 years. Funds to acquire the property from a willing seller were obtained from the California Wildlife Conservation Board (WCB) Proposition 1 Stream Flow Enhancement Program, and the land transfer was completed in 2016. Current funding for restoration planning at GRP was provided by the California Department of Fish and Wildlife (CDFW) Watershed Restoration Grant program and by the WCB Stream Flow Enhancement Grant program.

Habitat restoration in the GRP area has been strongly supported by dozens of local, state and federal conservation programs over the last 20 years. River Partners will recruit funds to complete restoration at GRP from partner agencies to be determined. In addition to CDFW and WCB, potential funding partners include the California Department of Water Resources (DWR), US Fish and Wildlife Service (USFWS), US Bureau of Reclamation (USBR), Reclamation District 2092 (RD 2092), and Stanislaus County.

Project monitoring, community engagement, and project communications will be supported by a collaborative of NGOs who have been working in this area for years and who have developed specific relationships with local partners, local chapters, and neighbors. Some of these NGO partners include Stanislaus County Audubon, the Northern San Joaquin Valley chapter of the California Native Plant Society, the California Invasive Plant Council, Point Blue Conservation Science, and Self-Help Enterprises. Ongoing and complimentary research carried out by students, faculty, and scientists at CSU Stanislaus, UC Merced, Cal Poly San Luis Obispo, and Lawrence Livermore National Laboratories will aid in the characterization of conservation outcomes as a result of restoration activities at GRP.

II. SITE DESCRIPTION

A. Location

The Grayson Riverbend Preserve (GRP) is owned in fee title by River Partners and is located immediately adjacent to Grayson, California, an unincorporated town (population 900) near the west bank of the San Joaquin River. The property is also adjacent to the southern border of the 8,000-acre San Joaquin River National Wildlife Refuge (SJRNWR), which is owned and managed by the US Fish and Wildlife Service (USFWS), and across the river from the 2,100-acre Dos Rios Ranch Preserve (Dos Rios), currently owned and being restored by River Partners (Figure 1).

The 285-acre GRP property includes over 2 miles of historic San Joaquin River channel frontage (now an overflow corridor) and approximately 100 acres of remnant riparian habitat. It also contains approximately 185 acres of developed agricultural fields that have historically been farmed to produce feed for dairy cows (irrigated corn, winter wheat, and alfalfa). These agricultural fields are currently in lease agreements between River Partners and local farmers and will continue to be farmed until restoration occurs. Continued farming reduces future restoration costs by keeping irrigation systems in operating condition (they will be used to support restoration until they are retired permanently), controlling weed growth and weed seedbed loading, and providing a revenue stream to support future restoration activities.

Ecological benefits of restoration at GRP are magnified by its location and close proximity to existing habitat and other restoration projects. The SJRNWR was created in 1987 to provide foraging and roosting habitat for the threatened Aleutian Canada Goose

(*Branta Canadensis leucopareia*), as well as other endangered species and migratory birds. In 1997, following extensive flooding in the San Joaquin Valley, an Inter-Agency Task Force led by the US Army Corps of Engineers identified the lands immediately downstream of the GRP as the nation's first Non-Structural Alternative flood control project (the 3,166-acre project called the Three Amigos project for the three adjoining landowners who sold their properties in lieu of receiving flood damage payments). The Three Amigos project expanded the fee-title ownership of the existing SJRNWR to include the West Unit and articulated a strategy for retiring flood control levees to allow floodwaters to reconnect to floodplains. Over 2,500 acres of riparian habitat and wetlands on the Three Amigos lands have been restored by the USFWS in collaboration with many State and federal partners, comprising the largest contiguous block of riparian habitat restoration in the Central Valley. The site has also provided measurable flood stage reduction benefits for downstream communities.

GRP is also located across the San Joaquin River from Dos Rios Ranch Preserve, a property owned and currently being restored by River Partners. When completed, this 2,100-acre site will have a diverse riparian forest structure similar to that found at the SJRNWR with new and unique high ground refugia for terrestrial species to use during flood events. In addition, the Dos Rios project was designed with diverse floodplain habitat features benefitting aquatic species during high river flows.

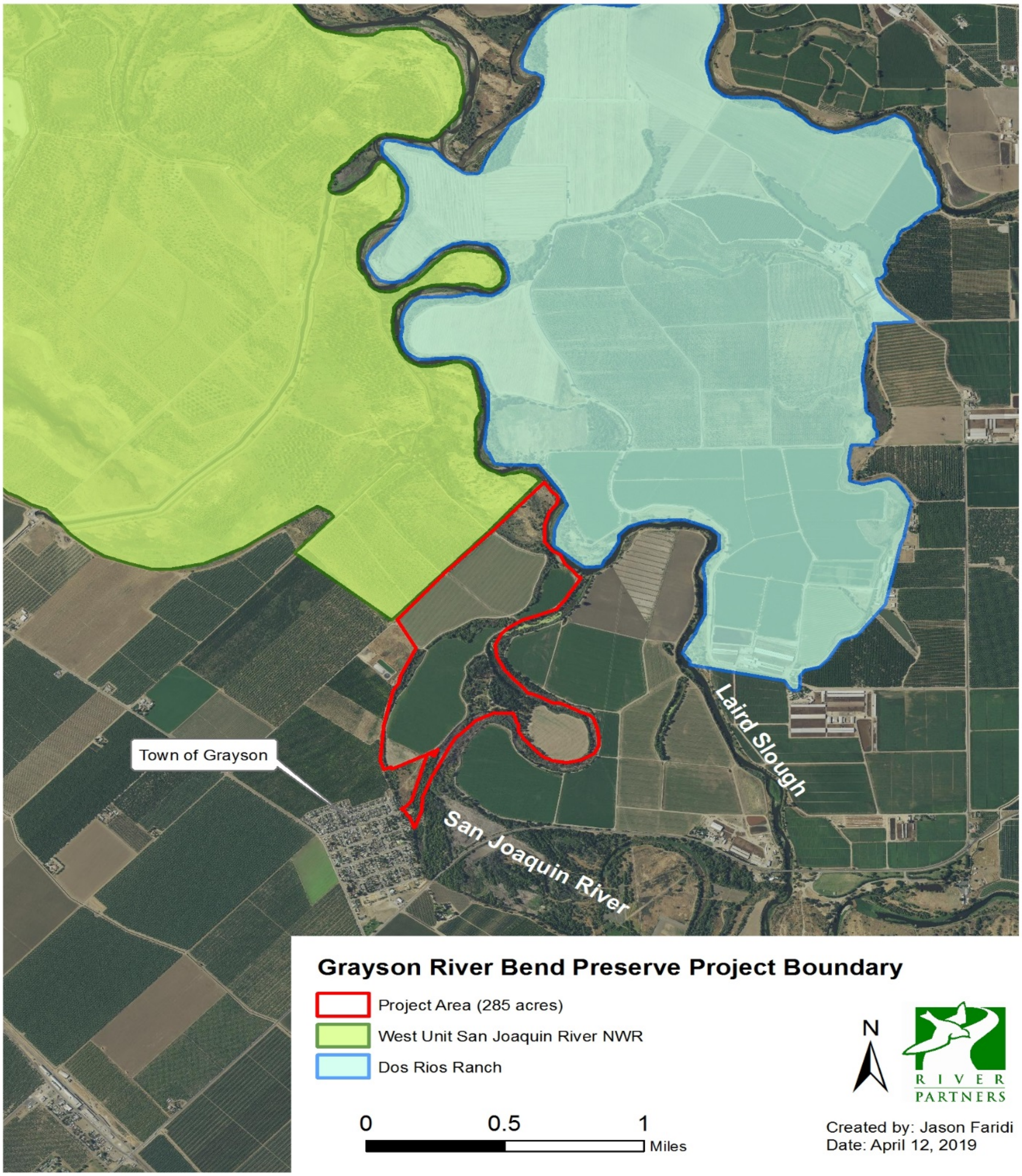

Figure 1. Project location map, Grayson Riverbend Preserve

B. Land Use History

Native Americans have occupied the San Joaquin Valley for over 8,000 years. Knowledge of Native American use of the GRP property is limited. However, we can surmise from general reports from the early 1800s that lands along the San Joaquin River were usually too wet for use as permanent dwelling sites, but were abundant with fish and wildlife that made them priority hunting grounds for many tribes. It would be easy to imagine that the low-lying fields of the GRP were visited regularly in the fall by bands of hunters to collect food from the river and basket-weaving materials from the riparian forest. Archeological surveys completed in the last two decades to support adjacent habitat restoration projects have identified no permanent settlements in and around the river's floodplain.

Once California was colonized by Spain in 1784 and later by Mexico in the early to mid-1800s, land was divided into "ranchos." Under Spanish and Mexican rule, these ranchos consisted of mainly grazing land for horses and cattle with small homesteads. However, with the influx of settlers spawned by the gold rush, settlements began to pop up throughout the state. The community of Grayson was established in the late 1840s by a band of seven men, among them Andrew Jackson Grayson of Louisiana who was a watercolor painter and enthusiast of Pacific Coast birds. The town initially served as a ferry crossing for gold miners. Later, the ferry crossing would serve as a small riverboat landing. Soon after the Gold Rush, lands began being converted to grazing and agricultural uses and the riverboat landing became a small shipping port. Grayson's Ferry remained in operation until it was replaced in 1893 by a bridge. This bridge spanned the old San Joaquin River Channel near the community of Grayson, which is located on all but the highest of flood elevations. Following the completion of Friant Dam in 1944, the shipping port in Grayson was abandoned and the town's population has been in decline ever since. A town sign in the shape of a steamboat at the corner of River Road and Grayson Road stands as a final reminder of the town's past.

A review of historic aerial photos provided several clues to past land-use and changes to this reach of the river. The historic aerial photo from 1937 (Figure 2) shows land cleared for farming on the high terrace with intact riparian vegetation along the main channel of the San Joaquin River. It also depicts erosion from the old San Joaquin River channel along the southern portion of the parcel, and a prior alignment of Grayson Road crossing the old channel immediately south of the GRP.

The 1967 aerial photo (Figure 3) shows flooded conditions, resulting in a high level of inundation across GRP flowing from Laird Slough into the old channel and onto lower elevation agricultural fields. The Grayson Road Bridge was washed out and subsequently rebuilt in a location further upstream where it remains today. Breaches and deposition of sediment on-site and at neighboring lands are evident from this photo.

The 1971 aerial photo (Figure 4) shows conditions during lower flows and it is clear that there is still a dynamic and intact off-channel wetland habitat mosaic along the western boundary of GRP. There is possibly some dry farming taking place but no irrigated agriculture yet.

In the 1998 aerial photo (Figure 5), there are multiple river breaches both upstream and downstream (current Dos Rios Restoration site) of GRP and the swollen river once again flowed into the old channel and across the property.

More current aerial photos from 2005 (Figure 6) and 2012 (Figure 7) clearly show the delineation between active agricultural lands and remnant riparian vegetation, which is mainly located along the old San Joaquin River channel and comprises approximately 60 acres. Within these remnant areas, the aerial photos show a mosaic of forest structures associated with native oak woodlands and willow species.

Before the land acquisition by River Partners, the GRP was owned by a farming family, who mainly produced row crops. Currently, portions of the project area are being leased to produce row crops or are being left fallow. The project area is surrounded by stone fruit orchards, row crops, the community of Grayson to the west, and the SJRNWR to the north.

Figure 2. Aerial photo of Grayson Riverbend Preserve, 1937

Figure 3. Aerial photo of Grayson Riverbend Preserve, 1967

Figure 4. Aerial photo of Grayson Riverbend Preserve, 1971

Figure 5. Aerial photo of Grayson Riverbend Preserve, 1998

Figure 6. Aerial photo of Grayson Riverbend Preserve, 2005

Figure 7. Aerial photo of Grayson Riverbend Preserve, 2012

C. Soils

Variable soil characteristics, developed over time by dynamic river processes, greatly affect vegetation composition, structure, and patterns. Soil texture, structure, and stratification affect the ability of plants to grow and survive. Agricultural operations and restoration designs must incorporate these soil factors and depth to water table for successful plant establishment, growth, and long-term survival.

The soils of the GRP restoration site have been greatly influenced by erosional and depositional processes associated with the San Joaquin River, which occupies a wide meander belt in this reach. Based on the NRCS Soil Survey for East Stanislaus County (NRCS Web Soil Survey 2006). Agricultural fields at GRP are composed of Columbia complex, Clear Lake Clay, Veritas, and Bolfar-Columbia complex soils (Figure 8, Table 1). All of these soils are suitable for the establishment of native riparian plants and have successfully been restored on conservation lands downstream using similar methods as those planned here. Remnant riparian areas are composed mainly of Columbia fine sandy loam - channeled soils. The site also borders the old channel of the San Joaquin River, which is comprised of Columbia soils – channeled (this soil type makes up a minimal amount of soils found on site).

In addition to the information provided by the soil survey, three backhoe pits were excavated by River Partners on April 5, 2018 to further assess site conditions (Figure 9). Field observations are provided in Table 2.

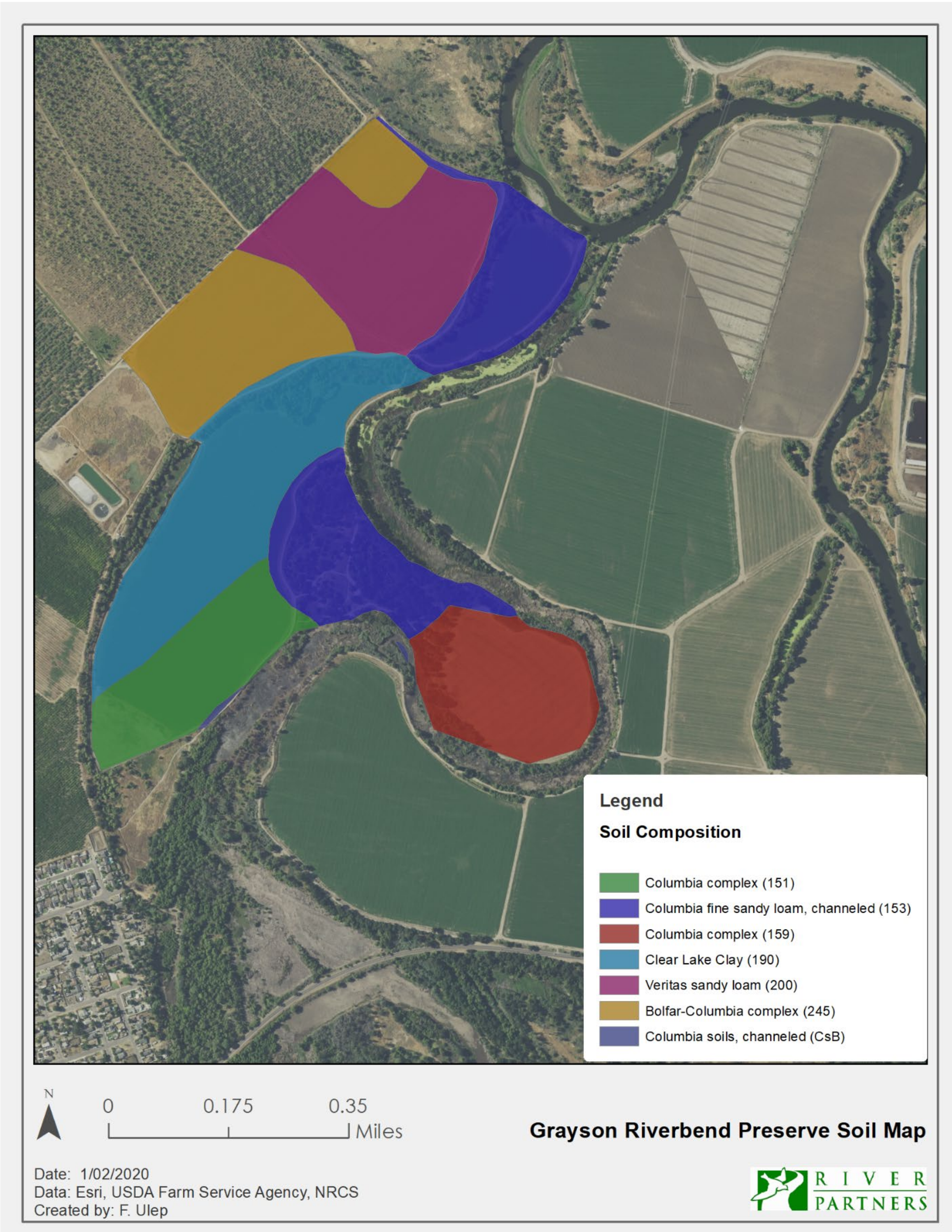

Figure 8. Soil mapping units at Grayson Riverbend Preserve (USDA NRCS Web Soil Survey)

Table 1. Summary of typical soil conditions found at Grayson Riverbend Preserve (USDA NRCS Web Soil Survey)

Soil Series	Mapping Unit	% Slope	Texture	Drainage	Permeability	Limitations to plant growth
Columbia complex	151	0 to 2%	Fine sandy loam	Somewhat poor	Moderately rapid	Flooding and high water table
Columbia fine sandy loam, channeled	153	0 to 2%	Fine sandy loam	Somewhat poor	Moderately rapid	Flooding and high water table
Columbia complex	159	0 to 2%	Fine sandy loam	Somewhat poor	Moderate	Flooding and high water table
Clear Lake Clay	190	0 to 2%	Clay	Moderately well-drained	Slow	None if irrigated
Veritas sandy loam	200	0 to 2%	Sandy loam	Moderately well-drained	Moderately rapid	Depth to hardpan
Bolfar-Columbia complex	245	0 to 2%	Loam to sandy loam	Poorly drained	Moderately slow	Flooding and high water table
Columbia soils, channeled	CsB	0 to 8%	Loam	Somewhat poorly drained	Moderate	None
Water	W					

Figure 9. Soil pit locations at Grayson RIverbend Preserve

Table 2. Observed soil conditions in backhoe pits excavated April 5, 2018

Soil Pit #	Soil Type	Typical pedon (NRCS)	Observed Stratification	Notes
1	Columbia Series fine sandy loam	**A: 0-16"** Fine sandy loam, common very fine roots, common very fine tubular roots, slightly acid pH 6.4 **C_{1-4}: 16-34"** fine sandy loam, massive, common very fine roots, slightly acid pH 6.8, moist masses of iron accumulation **C_{5-7}: 34-55"** Fine sandy loam, massive, very few fine roots, moderately alkaline pH 7.8, mostly moist masses of iron accumulation **Ab: 55-59"** Dark gray silty clay loam, very few fine roots, moderately alkaline pH 8.0, moist masses of iron accumulation	**A: 0-14"** Fine sandy loam, common medium, fine and very fine roots **Sand lens 14-18"** Coarse sand, few medium roots **C: 18-65"** Fine sandy loam, very few fine roots, masses of iron accumulation and mottling **Ab: 65-108"** Gray clay loam, massive, no roots, many redoximorphic features **Water: 108"**	Soil pit indicates variable soil textures, seasonal inundation to shallow depths, and possible rooting limitations in buried sand lenses at 6' or less which may support drought-tolerant shallow-rooted species. Vegetation surrounding the pit is phreatophytic suggesting that deep-rooting to perennial groundwater is possible through buried sand lenses although this was not observed in this pit.
2	Columbia complex, sandy sub stratum	**A: 0-12"** Fine sandy loam, as above **C:12-41"** Sandy loam, as above **Ab: 41-60"** Stratified sand to loamy sand, as above	**A: 0-14"** Fine sandy loam, common fine and very fine roots **C: 14-84"** Sandy loam, common very fine roots **Ab: 84-126"** Stratified sand to loamy sand, no roots, abundant redoximorphic features **Water: 126"**	Soil pit indicates sandy textures, seasonal inundation to shallow depths, and possible rooting limitations in buried sand lenses at 6' or less which may support drought-tolerant shallow-rooted species or phreatophytes able to root deeper than 10'.

Soil Pit #	Soil Type	Typical pedon (NRCS)	Observed Stratification	Notes
3	Clear Lake clay	**A: 0-13"** Dark gray clay, few faint redoximorphic features, massive when wet, hard, firm, very sticky, neutral pH7.0, many fine roots **B_{ssg}: 13-45"** Dark gray clay, massive, extremely hard and sticky, many slickensides, moderately alkaline pH 8.0, grass remains in cleavage planes **B_{ssk}: 45 – 60"** Grayish brown clay, masses of iron accumulations, massive, very hard, very firm, few fine roots, moderately alkaline pH8.0	**A: 0-26"** Clay, abundant redoximorphic features, massive, very sticky, many fine roots and grass **B_{ssk}: 26-96"** Heavy clay, abundant redoximorphic features, abundant slickensides, no roots **Water: 96"**	Soil pit indicates heavy clay textures, seasonal inundation, and saturation to the soil surface, ponding. Anaerobic conditions will prohibit the growth of most perennial shrubs and trees. Soil is ideal for wetland hydrology, and obligate wetland vegetation.

D. Topography

Topography at the regional and site scale affect the frequency and dynamics of flooding, as well as how water will drain from the site as floods recede. The majority of the project area has been historically graded and leveled to accommodate agricultural needs including irrigation and drainage. However, there are several remnant riparian areas with more topographical diversity.

Based on examination of CVFED LiDAR data from 2008 at both a regional scale (Figure 10) and site scale (Figure 11), several characteristics to note include:

- The gradient of the mainstem San Joaquin River channel between the old and new San Joaquin River split and subsequent confluence is very shallow - approximately 0.01%.
- Elevations across the project area range from 30 feet above mean sea level near the original San Joaquin River channel to approximately 42 feet within the higher fields.
- The lower agricultural fields consistently slope away from the adjacent channel, with slopes of between 0.5 - 1%.
- The larger of the two lower agricultural fields (furthest from the mainstem) is completely surrounded by high ground or farmer berms – the lowest elevation around the field is 38 feet (elevation of the farmer berm towards the downstream end of the field)
- The culvert at the downstream end of the larger of the two lower agricultural fields has a significant berm that blocks a remnant backwater channel into the field.
- There are several depressional features and overall topographical diversity in the remnant riparian area that sits within the narrow neck of the meander bend.

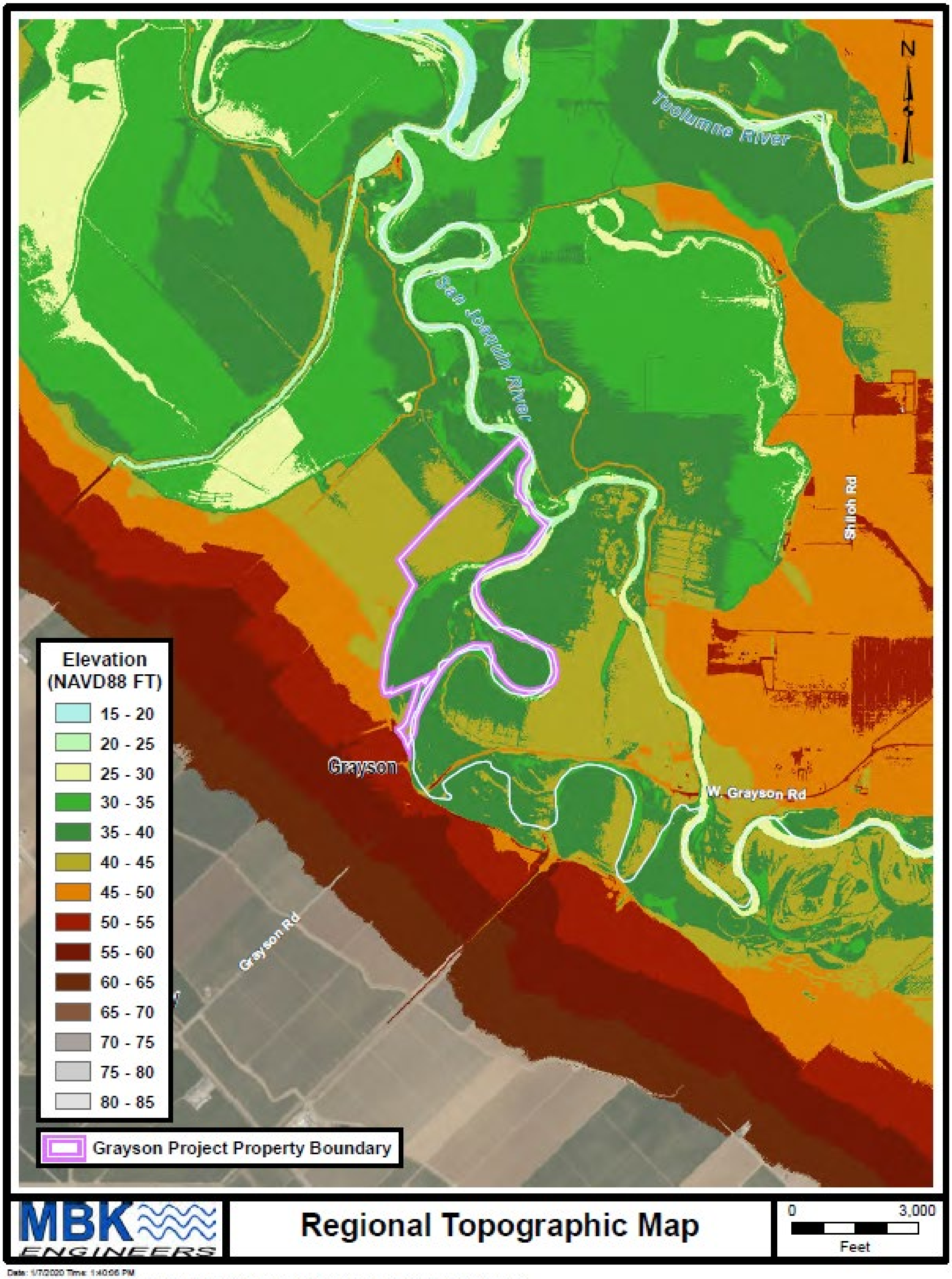

Figure 10. Regional topographic map based on 2008 CVFED LiDAR

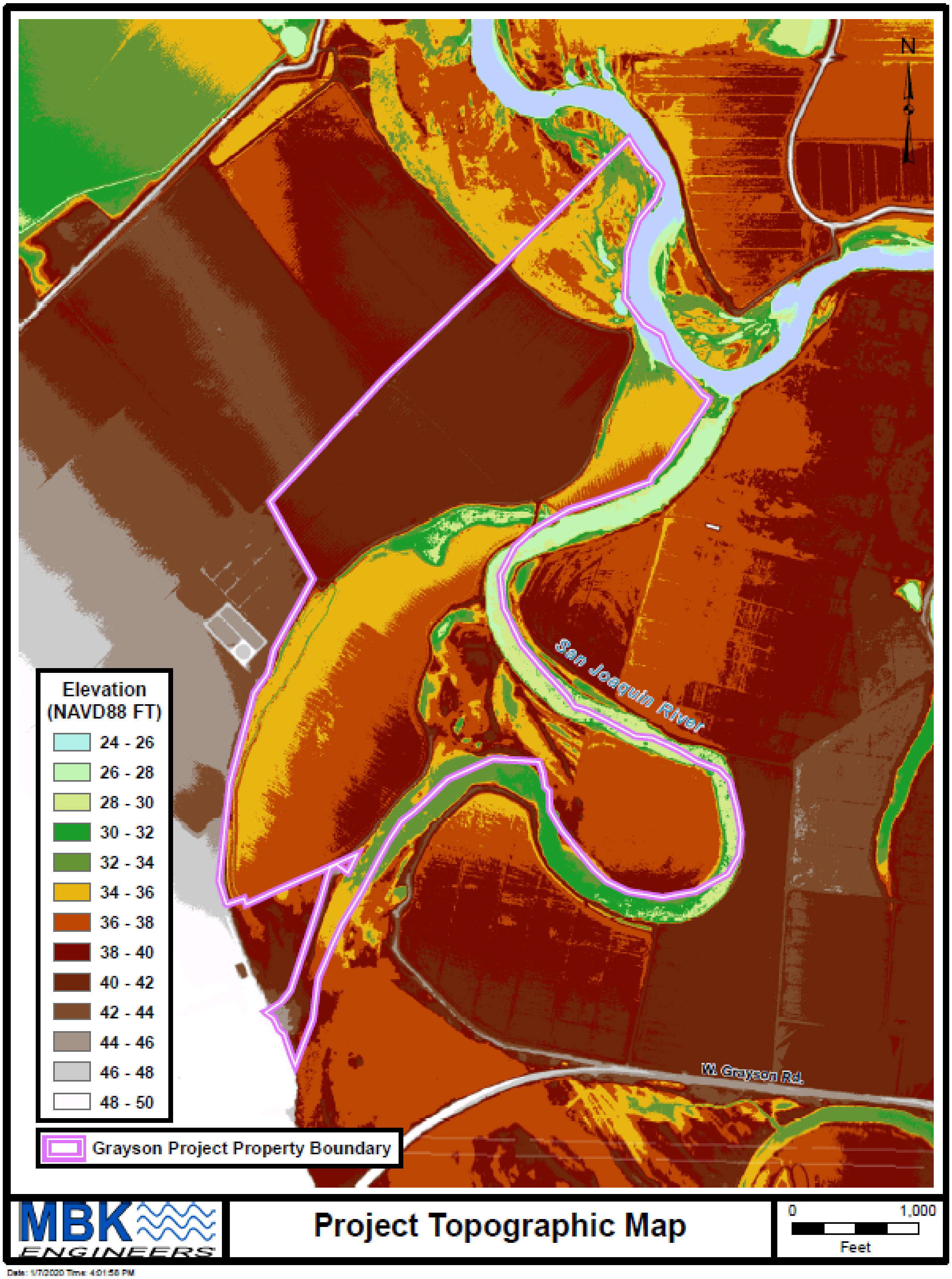

Figure 11. Site scale topography at Grayson Riverbend Preserve based on 2008 CVFED LiDAR

E. Hydrology

GRP includes over 2 miles of perennial river frontage, including streambanks of both the San Joaquin River (historic Laird Slough) and the old San Joaquin River channel, which today acts as both a backwater channel and flood overflow corridor depending on the magnitude of flows. In high water events, water flows through the old channel, ccasionally overtopping Grayson Road Bridge just upstream of GRP. The old San Joaquin River channel is currently the subject of a DWR-funded Small Communities Flood Risk Reduction Project feasibility study led by the Stanislaus County Department of Public Works, which is considering alternatives that would reopen the historic channel to allow increased flows to pass through this corridor, including GRP.

1. Historical Conditions

Historically, flooding on the San Joaquin River was generally caused by rainfall runoff during winter and snowmelt during spring/summer. The vast majority of runoff from the entire San Joaquin River watershed south of the Tuolumne watershed passed through the San Joaquin River at GRP. Prior to the construction of Friant Dam (1942), high late spring and early summer flows declined gradually with low flows occurring in the fall and early winter. Prior to widespread levee building and channel constriction, slower river velocities, coupled with consequent sediment deposition, resulted in complex geomorphic channel patterns. The San Joaquin River was a highly sinuous river surrounded by an extensive floodplain including oxbow lakes, sloughs, ponds, and sandbars. Remnant features can be seen at GRP in historic aerial photos and LiDAR.

Sometime around the turn of the 20th century, the San Joaquin River avulsed and began to flow through Laird Slough. Several attempts were made to divert flow back to the original channel by blocking Laird Slough, but floods in 1892 and 1911 filled the old channel with sediment and left Grayson far from the new river channel.

2. Current Conditions

The hydrology of the San Joaquin River has been severely modified by upstream reservoirs (Cain *et al*, 2003). The total flow volume from the San Joaquin River and its principle tributary, the Merced River, has been reduced by over 80 percent due to flow regulation at upstream reservoirs. As a result, the frequency of overbank flows has also been dramatically reduced. Furthermore, the channel configuration and natural geomorphic processes that shaped the floodplains and riparian forests of the San Joaquin River and GRP have been altered by project levees, local farm levees, and bank revetment. These features, combined with flow alterations, have dramatically reduced the area of frequently inundated floodplain habitat. Removal of these features, as well as probable changes in the flow regime resulting from the Bay-Delta Water Quality Control Plan and/or Voluntary Settlement Agreement, will significantly increase the frequency of inundation.

Although within the historic floodplain of the San Joaquin River, most of GRP has been significantly disconnected from the river, and only small remnant stands of mature riparian forest remain. Farm levees surround agricultural fields and sedimentation in the old San Joaquin River channel corridor impedes healthy river-floodplain exchange.

During most flow conditions, GRP remains dry. As the river rises during the ascending limb of a flood event, the San Joaquin River first backwaters into GRP through the old channel at the downstream end of the property at the confluence of the historic and current San Joaquin River channels (Figure 12). The lowest-lying lands at GRP don't start inundating until the river reaches approximately 6,500 cfs. During larger flood events and as flows continue to rise, the river eventually overtops its banks and flows into the old San Joaquin River channel upstream of GRP (by the Grayson Road bridge where it crosses the current San Joaquin River) and starts to flow past GRP from upstream.

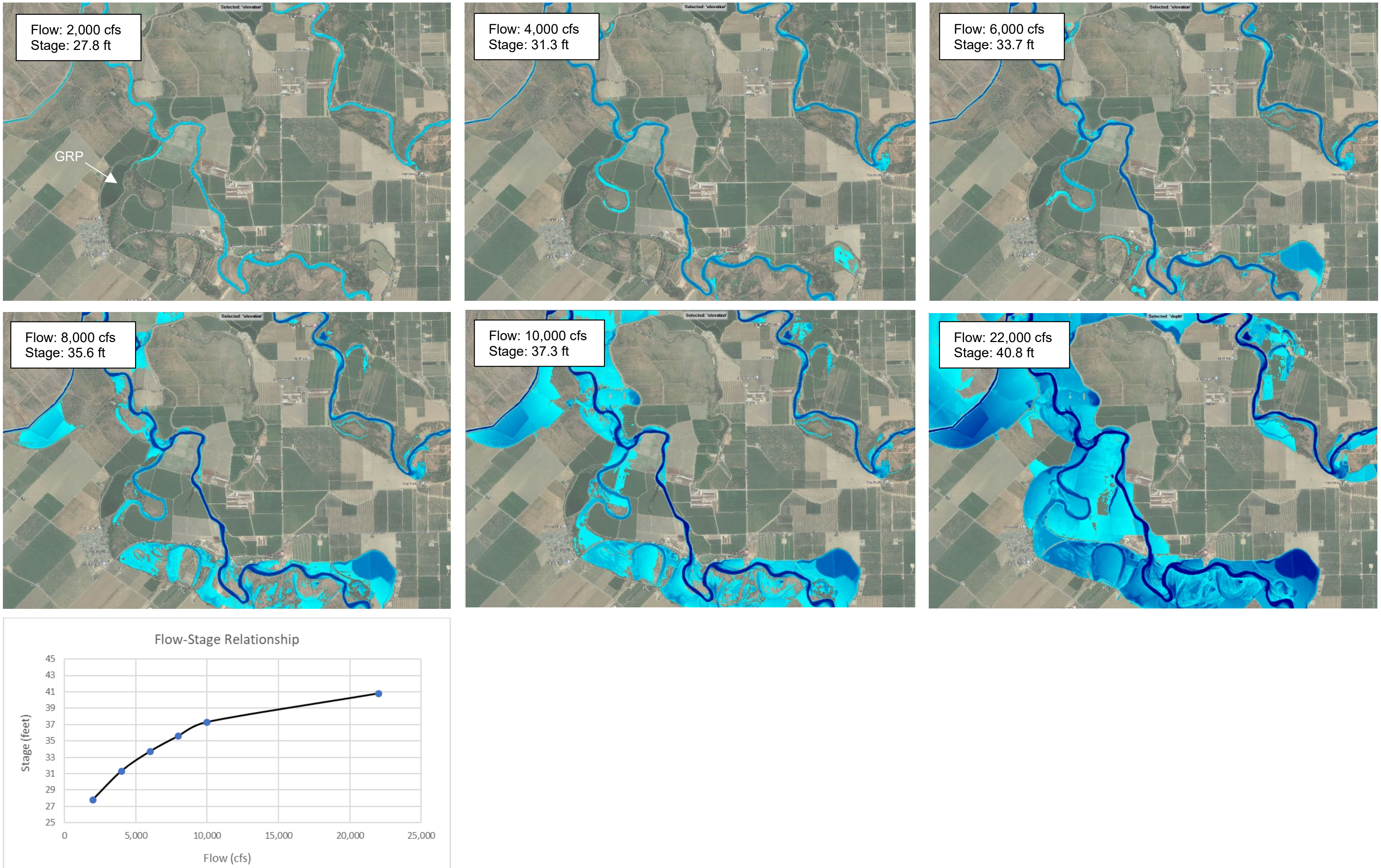

Figure 12. Flow-Stage relationship at Grayson Riverbend Preserve. The six maps are snapshots from the 2D hydraulic model showing sequentially increasing flows and resultant river stage and the graph shows these values plotted.

F. Salinity

Salt levels in the soil are not expected to have a major impact on plants during various stages of plant establishment. Challenges may arise in the future once irrigation ceases and the concentrated salts in the soil start moving toward the surface of the fields. Salts naturally occur within soils from minerals found in the earth's crust. With the presence of water, salts within the soil are conveyed throughout the soil profile allowing it to leave and enter the system. Irrigation of the site will not only flush out salts within the soil, but also has the potential to deposit more salts from other areas the irrigation water is flowing through. As irrigation is halted, evaporation of water will transport salts within the soil, leaving a higher concentration of salts in the upper regions of the soil profile. However, continued and prolonged inundation from overbank flooding through time will leach salts out of the soil profile. We anticipate that although salts may accumulate in the upper soil in dry years, soil salinity will generally decrease with the cessation of irrigation on the property and the increased frequency of flushing floods.

G. Vegetation

1. Pre-development Conditions

Based on soils, flooding frequency, and proximity to the river, pre-development site conditions likely supported a mixed riparian forest with valley oak (*Quercus lobata*) dominating in more elevated areas and more mesic species such as Fremont cottonwoods (*Populus fremontii*), arroyo willow (*Salix lasiolepis*), and sandbar willow (*Salix exigua*) occupying lower areas. Native grasses, forbs, and sedges likely dominated the understory - all similar to what is found in mature native riparian forests today.

2. Current on-site Conditions

The project site was initially evaluated using the 2018 Great Valley Ecoregion Vegetation GIS data set (CSU Chico Geographic Information Center), and subsequently ground-truthed to qualitatively verify GIS-mapped vegetation (Figure 13). No significant discrepancies were discovered during ground-truthing. Currently, 180 acres of GRP is actively being farmed in crops such as corn, alfalfa, and winter wheat. These farmed acres provide virtually no habitat value to wildlife except for the occasional foraging for birds. Additionally, the field edges of the farmed fields are covered with a plethora of noxious weeds including Johnson grass (*Sorghum halepense*), perennial pepperweed (*Lepidium latifolium*), Russian knapweed (*Acroptilon repens*), common reed (*Phragmites australis*), milk thistle (*Silybum marianum*), tree tobacco (*Nicotiana glauca*), black mustard (*Brassica nigra*), eucalyptus (*Eucalyptus spp.*), curly dock (*Rumex crispus*), fig (*Ficus carica*), and poison hemlock (*Conium maculate)*.

The remainder of GRP consists of 105 acres of remnant native riparian vegetation. Within these remnant areas, a variety of native vegetative species were documented during on-site surveys (Table 3). Most of this remnant vegetation occurs along the banks of the old San Joaquin River channel in narrow bands of 50 – 100 feet. These bands of vegetation consist mainly of mature cottonwoods and willows, as well as a variety of non-native vegetation similar to the field edges of the agricultural fields. However, a portion of the remnant vegetation consists of a well-developed oak woodland. This 28-acre oak woodland has developed into a mature canopy of valley oaks and contains a variety of other riparian species.

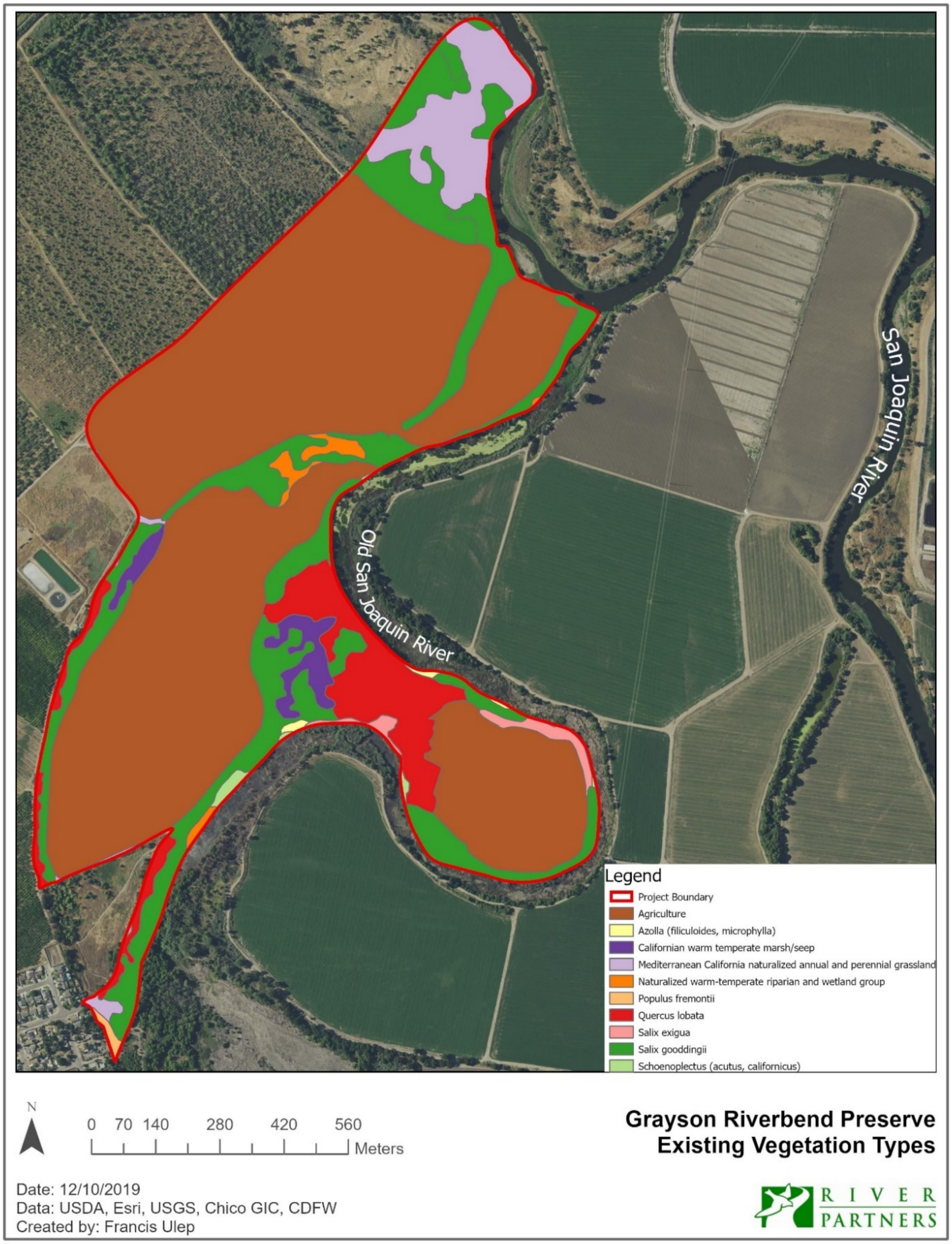

Figure 13. Existing vegetation at Grayson Riverbend Preserve mapped using the CSU Chico Geographic Information Center 2018 Great Valley Ecoregion vegetation data layer

Table 3. Summary of existing native plant species in riparian areas at Grayson Riverbend Preserve

Common Name	Scientific Name
Woody	
Arroyo willow	*Salix lasiolepis*
Black willow	*Salix goodingii*
Box elder	*Acer negundo*
Buttonbush	*Cephalanthus occidentalis*
California blackberry	*Rubus ursinus*
California rose	*Rosa californica*
Golden currant	*Ribes aureum*
Elderberry	*Sambucus mexicanas*
Fremont cottonwood	*Populus fremontii*
Oregon ash	*Fraxinus latifolia*
Sandbar willow	*Salix exigua*
Valley oak	*Quercus lobata*
Mulefat	*Baccharis salicfolia*
Herbaceous Species	
Creeping wild rye	*Elymus triticoides*
Evening primrose	*Oenothera hookeri*
Gumplant	*Grindelia camporum*
Mugwort	*Artemisia douglasiana*
Narrowleaf milkweed	*Asclepeias fasicularis*
Santa Barbara (basket) sedge	*Carex barbarae*
Common sunflower	*Helianthus annuus*
Dotted smartweed	*Persicaria punctata*
Alkali bulrush	*Bolboschoenus maritimus*
Cocklebur	*Xanthium strumarium*
Spikeweed	*Hemizonia pungens*
Stinging nettle	*Urtica dioica*

3. Current off-site Conditions

Properties surrounding GRP are a mix of active farming, managed floodplain and wildlife habitat, and residential development. Land-use on the east side of the San Joaquin River includes a mix of cultivated land (orchards, row crops, and dairies) and small remnants of riparian and wetland habitat. Adjacent to the southwest side of GRP are cultivated lands (orchards and row crops) and urban development (the community of Grayson). To the southeast of GRP is the riparian corridor of the old San Joaquin River channel.

Over 1,400 acres of remnant riparian habitat exists on the SJRNWR, immediately north of GRP, and an additional 2,500 acres of riparian habitat and wetlands have been or are currently being restored. In remnant riparian areas, sandbar willow (*Salix exigua*), box-elder (*Acer negundo*), buttonbush (*Cephalanthus occidentalis*), and Oregon ash

(*Fraxinus latifolia*) are frequent; California rose (*Rosa californica*) is occasional; Fremont cottonwood is present as widely spaced individuals or small groups; and valley oak occurs as scattered individuals and a few closed-canopy groves on Christman Island, a unit of the SJRNWR. Sapling valley oaks (5-20 feet tall) are common. Elderberry (*Sambucus nigra ssp caerulea*) is very rare but can be found where floodwater recedes more rapidly. Natives dominate the understory of much of the riparian area. California blackberry (*Rubus ursinus*), mugwort (*Artemisia douglasiana*), Western goldenrod (*Euthamia occidentalis*), Santa Barbara sedge (*Carex barbarae*), and creeping wildrye (*Elymus triticoides*) are common, and in many places have excluded the non-natives.

H. Wildlife

Even though wildlife habitat has been greatly impacted at GRP by human activity, wildlife is still active on the project site. Formal wildlife surveys have not been conducted on the property. Based on California Natural Diversity Database records and USFWS wildlife surveys and observations on the adjacent SJRNWR, wildlife likely to be present currently or historically at GRP include: riparian brush rabbit *(Sylvilagus bachmani riparius)*, riparian woodrat *(Neotoma fuscipes riparia)*, pocket-gopher (*Thomomys bottae*), meadow vole (*Microtus californicus*), desert cottontail (*Sylvilagus audobonii*), North American beaver (*Castor canadensis*), American mink (*Neovison vison*), North American river otter (*Lontra canadensis*), coyote (*Canis latrans*), Neotropical riparian songbirds, wintering waterfowl, and resident and migrating Swainson's hawks. The Project site, which has many of the same physical site characteristics as the SJRNWR, has the potential to support the same richness of wildlife species as the SJRNWR and nearby NRCS easements.

III. CONCEPTUAL SITE MODEL

The principles described in this section will guide implementation of restoration at GRP. This conceptual site model presents our understanding of the physical and biological factors that influence site ecology and provides the foundation for restoration approaches and strategies.

A. Past Environmental Conditions

Prior to European settlement, GRP was part of a dynamic floodplain that supported structurally diverse riparian vegetation. The entire San Joaquin River once flowed through GRP and a ferry crossing across the river channel was utilized for commerce during the gold rush era. However, in the late 19th century, the river changed course and started flowing through Laird Slough. Several attempts were made to redirect the flow of the channel to its original path, but none were successful.

Channel movement under undammed conditions resulted in numerous flood-channels across the floodplain where river processes created seedbeds for many woody species and sustained this vegetation long enough to provide habitat for a rich diversity of wildlife. Gold mining activities in the 1800s and conversion of the floodplain to agricultural uses along the San Joaquin and its tributary rivers in the 1900s removed much of the riparian vegetation in the area, typically leaving a narrow band along the river.

Prior to development, GRP likely supported a mosaic of different conditions and communities. The closest approximation to the density of trees that may have existed historically on the floodplains of the San Joaquin River at GRP can be seen at Caswell Memorial State Park on the Stanislaus River. However, because dams upstream of Caswell have greatly modified river flows, even this forest does not likely represent the original condition.

Hydrologic modifications have severely altered the ability of native riparian trees and shrubs to successfully establish along river margins because seed-beds are not exposed at the same time that trees release seed and because river levels drop at rates faster than germinated seedlings can match. This often results in the development of "doghair thickets" of willows and cottonwoods on the river's edge that perish in the fall with drops in river stages at the end of the irrigation season. This hydrologic limitation, coupled with a dramatic influx of competition for growing space from non-native invasive plants, creates an extreme limitation to native vegetation establishment and succession at GRP.

B. Likely Successional Patterns without Restoration

Without restoration, GRP will continue to provide unsuitable conditions and poor habitat for most riparian-obligate species, including the species being targeted by this project. In the absence of farming, succession is likely to follow the same pattern observed on abandoned flood-prone agricultural lands on most Central Valley Rivers. Currently, aggressive non-native species, such as common reed, Johnson grass, perennial pepperweed, yellow starthistle, and annual grasses flourish on the rich soils and ample soil moisture found at GRP and have out-competed the native vegetation for sunlight and moisture. In addition, these weeds and the lack of flooding have provided ideal habitat for non-native rodents, which in turn can girdle young trees or consume seeds and acorns. With these pressures, native plant recruitment has been slowed, and will inevitably be replaced completely by non-native plants over the next few decades.

C. Comparison of Site to Nearby Vegetation (Reference Sites)

One of the fundamental components of a restoration plan is the identification of reference sites to use as guides for developing the list of species to be planted and their pattern across the restoration site. Due to the long history of human modifications to flow patterns, vegetation, and topography at GRP, reference sites for the property are rare.

Historical aerial photography from 1937 (Figure 2) and 1971 (Figure 4) shows a dynamic riparian landscape within the floodway, with varying individual plant statures and density across the lower fields at GRP and adjacent lands. Larger trees, such as valley oak, black willow, and cottonwood appear to be present in clusters, while other areas have signature wetland pools and floodplain terraces with abundant native grasses and forbs, which would suggest a different soil composition or depth to water table. Similar vegetation can be seen at the Refuge to the north of the project site.

IV. RESTORATION APPROACHES

A. Employ Active, Process-based Restoration Techniques

Passive restoration involves removing stressors or disturbances (e.g. agriculture or grazing) and allowing natural succession to occur on the site. In areas where flooding still resembles the historic recession limb of the annual hydrograph, riparian vegetation may naturally recruit. Unfortunately, non-native weeds germinate and rapidly outgrow tree seedlings, slowing their growth and eventually killing them through shading effects and resource competition. This passive method has rarely been successful in the Central Valley for large-scale restoration projects and logistics of weed control would be complex and expensive. Additionally, passive restoration typically results in forests of low species and structural diversity, which limit wildlife value compared to a more diverse forest, composed of several species of trees and shrubs.

Active, process-based restoration employed by River Partners includes the use of modern farming techniques to efficiently and rapidly establish riparian vegetation, overcoming the limitations to plant establishment and growth described above. As an added step, intervention in the form of levee removal or topographical modification, may be required to initiate natural biological responses where river processes are still funcitioning. This type of restoration has been extremely successful on over 2,500 acres of the Refuge. When coupled with modification to topography which increases the frequency of flooding, these active process-based methods are highly successful. Tasks include site clearing and earthwork, native plant species propagation and planting, on-going weed control, and irrigation throughout the growing season for up to three years. Advantages of this method include the ability to conduct large-scale restoration resulting in diverse riparian vegetation and high-quality wildlife habitat in a relatively short number of years. Since this method utilizes essentially the same techniques as those used to establish commercial orchards, overall costs can be reduced and local farmers can be contracted to carry out portions of the implementation, a great outreach benefit.

B. Optimize Design Based on Constraints, Opportunities, and Management Objectives

The riparian vegetation to be restored would be a pragmatic design that considers current physical and biological site conditions (i.e., leveled fields, altered hydrograph, weed pressure, etc.), wildlife needs, and landowner and neighbor concerns. The design is not based strictly on a “historical” or “climax” vegetation target. Based on these conditions, most of the site is well suited for the rapid establishment of native riparian forest and floodplain communities.

To promote streamflow enhancement objectives of the project, overall evapotranspiration before and after the project will be calculated using the METRIC

(Mapping EvapoTranspiration at high Resolution with Internal Calibration) Model created at Cal Poly - San Luis Obispo's Irrigation Training and Research Center. This model uses satellite imagery and a calibrated algorithm to calculate evapotranspiration at 30m resolution. Reductions in evapotranspiration demands associated with the conversion of the property from irrigated agriculture to restored riparian forest will represent a streamflow enhancement. The retirement of 8 downstream riparian diversions at the SJRNWR and Dos Rios Ranch over 12 river miles ensures that this streamflow benefit will support wildlife habitat for this river reach.

Two flood management planning studies are currently underway or recently completed that focus on Grayson. Stanislaus County and California Department of Water Resources are studying the flood damages to Grayson Road that occur during a 100-year flood event, and the US Army Corps of Engineers completed a feasibility study for the community of Grayson in 2018. Both of these studies identify the primary flood damages or risks in the area are associated with Grayson Road becoming impassible for extended periods during high water. This is a major traffic artery for Stanislaus County and blockages here delay access to critical medical facilities. Alternatives under consideration include raising the road bed, installing additional culverts, and dredging the channel upstream. The GRP habitat restoration project would benefit from each of these alternatives as they would increase flood frequency for the restored habitat.

C. Consider Multiple Time Frames

Over the past 20 years, River Partners has developed a proven "two-stage forest" design to integrate both short and long term goals for habitat restoration. In this design, fast-growing species such as cottonwoods and willows are planted with slow-growing species such as valley oak in a shared vegetation community. In "stage one", the willows and cottonwoods provide a quick overstory canopy that provides structure and cover for wildlife, as well as shading out many non-native trees, grasses, and forbs. As these quick-growing stage one species mature (20-30 years) and begin to die off, the transition to the "stage two" forest begins and the slower growing oaks start filling in the overstory and this forest may persist for hundreds of years.

As our understanding of the effects of climate change develops, we can look to prior restoration projects in this region to understand how hydrology will change in the coming years as a result of warming temperatures, and how this will influence habitat quality. Current models predict that as the climate warms, more precipitation will fall on the Sierra Nevada as rain rather than snow, and it will fall in higher intensity, flashier storms. This translates into more frequent and higher intensity floods for the GRP. Some models predict that the 100-year flood event will become a 50-year event before the year 2040. The restoration design for the GRP accounts for this by planning for droughts and floods with a diverse planting palette that is responsive to each precipitation challenge. At SJRNWR and Dos Rios Ranch, we have watched over the years as planted willows and cottonwoods grow robustly in wet years gaining dominance over shrubs that prefer seasonal dryness. Conversely, we have seen water-loving species die to the ground after several years of drought, with shrubs like elderberry and blackberry gaining the advantage of the lack of flood inundation.

Seasonal fluctuations such as these will become more pronounced as flooding regimes change, so this restoration plan includes a high diversity of plant species to accommodate an uncertain future.

D. Use an Adaptive Management Approach

Using an adaptive management approach provides a framework to evaluate project progress and respond to new information. Maintaining feedback between project planning, implementation, monitoring, and evaluation is essential to making recommendations on future restoration activities, site management (short- and long-term), and ultimately project success. During project installation, biologists will visit the site regularly and provide feedback to the installation team to keep the project in the best possible condition.

V. PROPOSED RESTORATION ACTIONS

Based on desktop analysis and on-the-ground observations of site topography, and to improve the efificiency and ease of restoration planning and implementation, GRP has been divided into five distinct Restoration Fields (Figure 14). These five fields have minor gradient changes due to leveling from previous agricultural practices. Remaining areas include remnant riparian forest and are more variable in elevation.

Based on a thorough field- and desktop-based characterization of existing site conditions, constraints, and opportunities, in combination with the development of restoration objectives, a conceptual site model, and site-appropriate restoration approaches, a comprehensive suite of restoration actions at GRP was developed (Figure 15). These actions can be lumped into two categories – Floodplain Restoration (berm degrade) and Riparian Restoration (native plantings), and are discussed in detail in following sections.

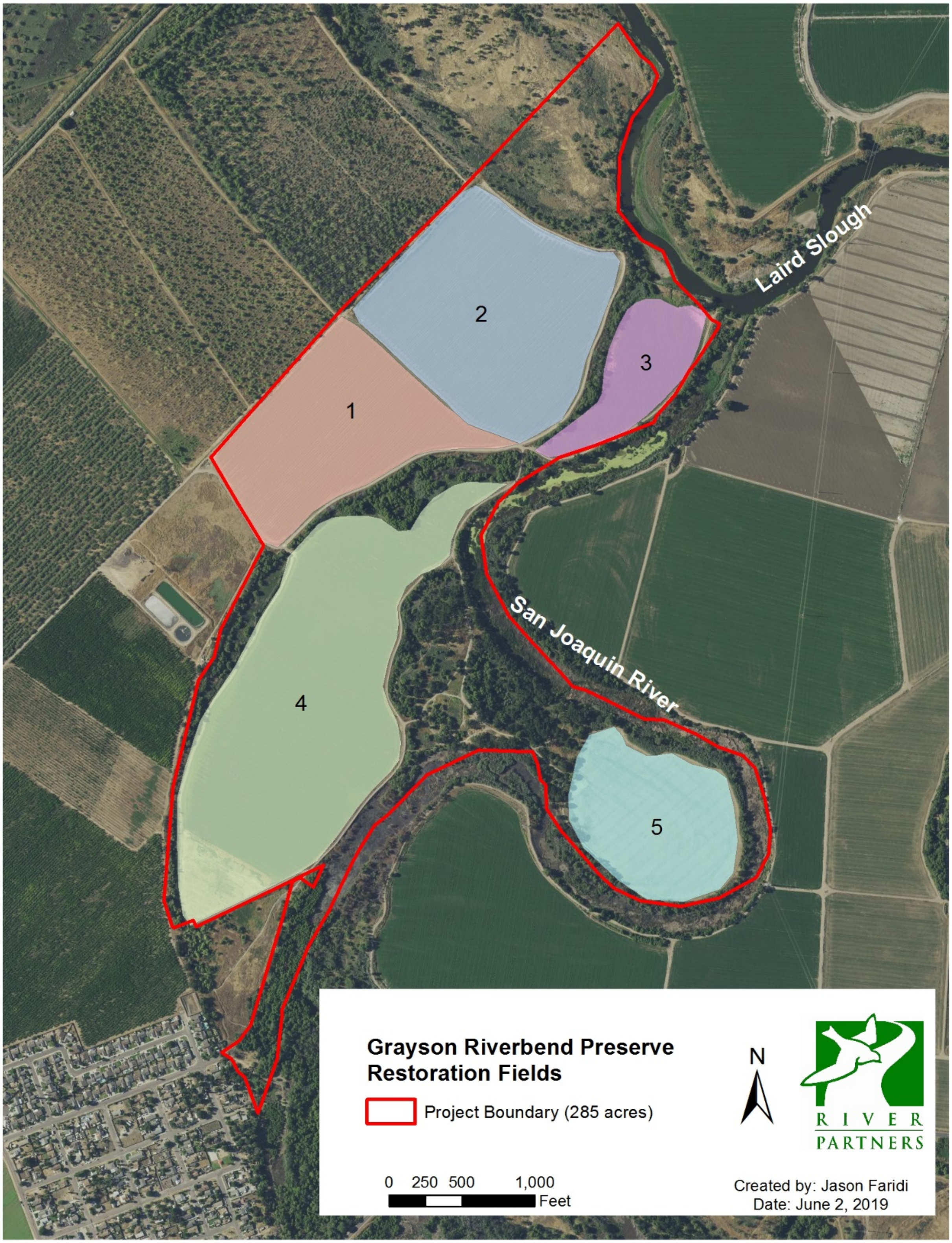

Figure 14. Restoration Fields at Grayson Riverbend Preserve

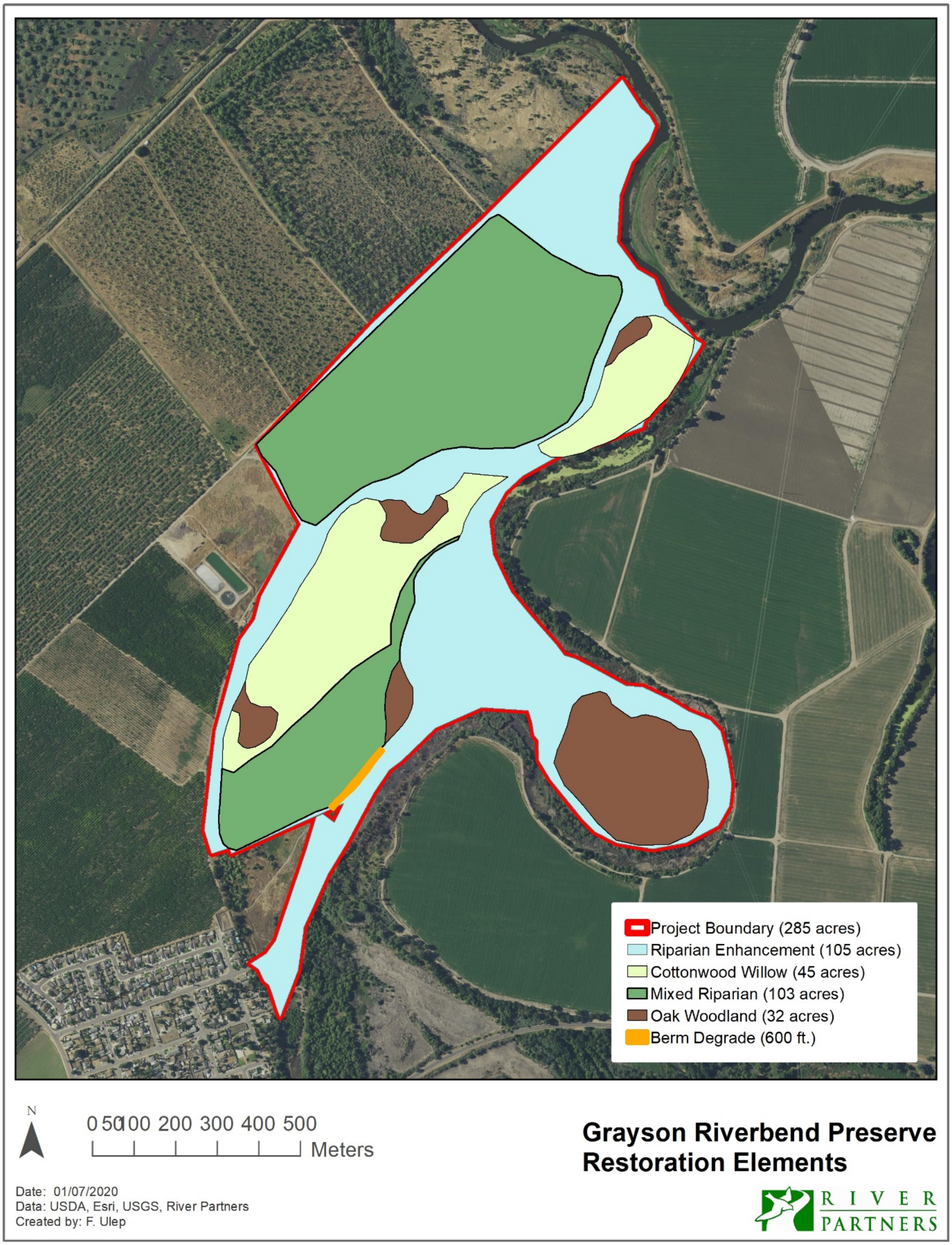

Figure 15. Overview of restoration elements at Grayson Riverbend Preserve

A. Design Considerations

When designing a restoration project, physical and biological factors influence the selection of vegetation associations and essentially dictate the site's potential. Based on these site factors, GRP can support a variety of riparian tree, shrub, and herbaceous species. However, wildlife objectives and management issues also need to be taken into consideration when developing a restoration plan. We refer to these factors as design considerations (Table 4).

Table 4. Design considerations for restoration at Grayson RIverbend Preserve

Objective	Example of Project Design Considerations
Provide immediate (< 4 years) habitat benefits and high probability of long-term survivorship	Areas at GRP are likely to mature to oak woodland in the long-term (>25-80 years) but will support fast-growing cottonwood, willow, and other species in the short-term, providing several generations of targeted bird species with nesting and foraging habitat. Planting both maximizes quality habitat as the slow-growing, but shade-tolerant, oaks mature.
Maintain high plant species and vegetative structural diversity	Point Blue data suggests that bird diversity is highest in areas with 5-7 shrub species over a 50-m^2 area. Design considerations include varying density across the site to allow light gaps and create structural differences (grouping trees together will create pockets of shade and light gaps), creating vegetation patches (grouping small shrubs together will mimic larger plants and may attract desirable wildlife species faster than if they were grown apart), and herbaceous plantings between plant rows (Geupel et al. 1997).
Provide rapid cover for riparian brush rabbits, woodrats, and neotropical migratory birds	Incorporate designs that have a high proportion of low stature plants to increase cover (include some trees to provide a trellis system).
Decrease habitat for the Brown-headed Cowbirds	Reduce the amount of forest-field edge habitat and increase amounts of "interior" habitat. Reduce weed populations.
Provide suitable refugia for riparian brush rabbits during times of flooding	Plant dense shrub and herbaceous understory cover on high ground, areas not prone to flooding.
Provide VELB habitat	Plant its host plant, elderberry throughout the project site.
Provide floodplain resources for juvenile salmon	To encourage phytoplankton growth, group native grasses and forbs in open areas in lower elevation areas on the floodplain.

B. Floodplain Restoration

1. Berm Degrade

Floodplain restoration at GRP currently consists of removing 600 feet of a farmer berm along the old San Joaquin River channel adjacent to Field 4 (Figure 15). The berm will be removed down to adjacent grade (approximately 38 feet in elevation). Field 4 is completely surrounded by high ground and the farmer berm and is disconnected from the adjacent channel until river levels get high enough to overtop the farmer berm.

Removing this section of berm will reconnect the old channel to historic floodplain habitat in Field 4, resulting in more frequently inundated floodplain habitat and a return of more natural geomorphic processes to the site. A typical profile and cross section of the current berm degrade design is shown in Figure 16.

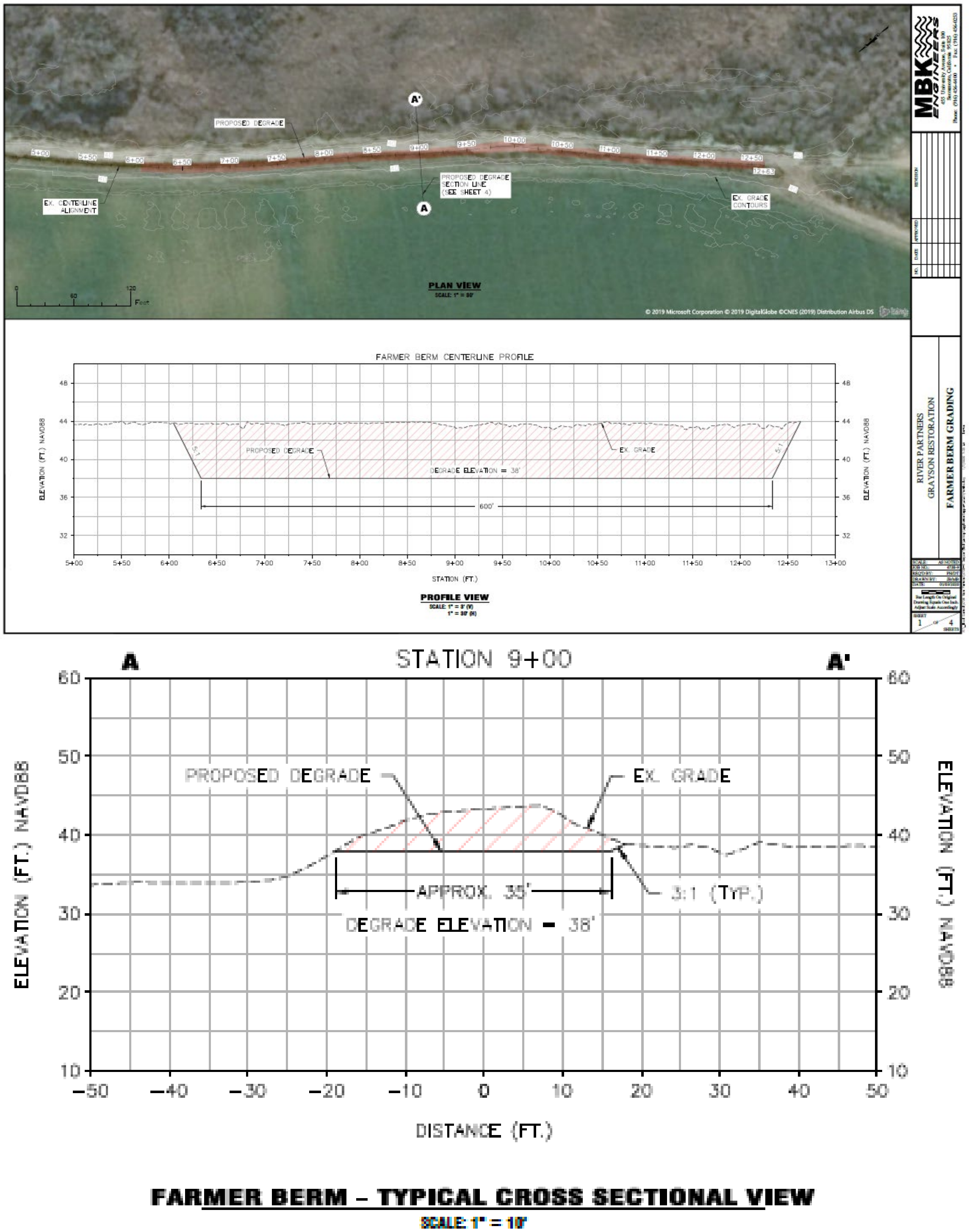

Figure 16. Typical profile and cross section of berm degrade

2. Future Conceptual Design Elements

During the latter stages of the restoration planning process, and as a result of the application of a recently available tool, additional potential floodplain restoration design elements were identified. The Salmon Habitat Quantification Tool (HQT) became openly available in the fall of 2019. Several current River Partners staff were deeply involved in its development and decided it would be a good tool to use at GRP for evaluating the habitat benefits of our restoration design. The HQT is a hydrospatial planning tool that uses 2D hydraulic model outputs of depth and velocity to estimate the amount of suitable rearing habitat available for juvenile Chinook salmon. During the evaluation process, additional restoration elements were identified.

Specifically, removing two field culverts and their associated embankments in Field 4 would likely provide additional frequently inundated floodplain habitat (Figure 17). As GRP floods up through a backwatering effect from the mainstem San Joaquin River, removal of these structures to adjacent grade would allow for inundation starting at the downstream end of Field 4 at much lower elevations (approximately 30 feet) compared to the berm degrade (which would start inundating the upstream end of Field 4 above 38 feet), providing inundation of Field 4 at a much larger range of flows. This action would also likely improve egress for juvenile salmon from the site

As this design element came about late in the planning process, there has not been adequate time to fully evaluate benefits and potential impacts. Thus, this element is currently considered to be a promising conceptual design element that we will explore further with future funding sources and if viable, incorporate formally into the restoration plan for GRP.

Figure 17. Location of the two field culverts in Field 4

C. Riparian Restoration: Planting Design

River Partners has developed a site-specific planting design that represents a synthesis of the available information on the site conditions, project objectives, and recommendations from a variety of partners. Figure 18 shows planned plant communities for the project.

Plant communities are based on the vegetation series concept described by Sawyer and Keeler-Wolf (1995). Alliances are named for the dominant plant species, but also contains other associated plant species. The similar "association" concept provides a useful descriptive label for vegetation differences that allow for design flexibility depending upon project goals. It does not specify arrangement, density, or other quantifiable factors that must also be addressed to translate the conceptual design to field implementation.

The composition and density of the association are based on several site-specific factors:

- Soil properties (texture, stratification, seasonal water table)
- Topography/hydrology (flood regime)
- Proximity to existing vegetation
- Habitat characteristics for targeted species
- Management considerations.

The plant composition for GRP has been selected from locally occurring species and designed to promote quick growth of an herbaceous floodplain community along with several varying types of riparian forest. In years 2 and 3 of the project, an herbaceous understory layer will be planted added to each of the forests communities for additional forage and cover.

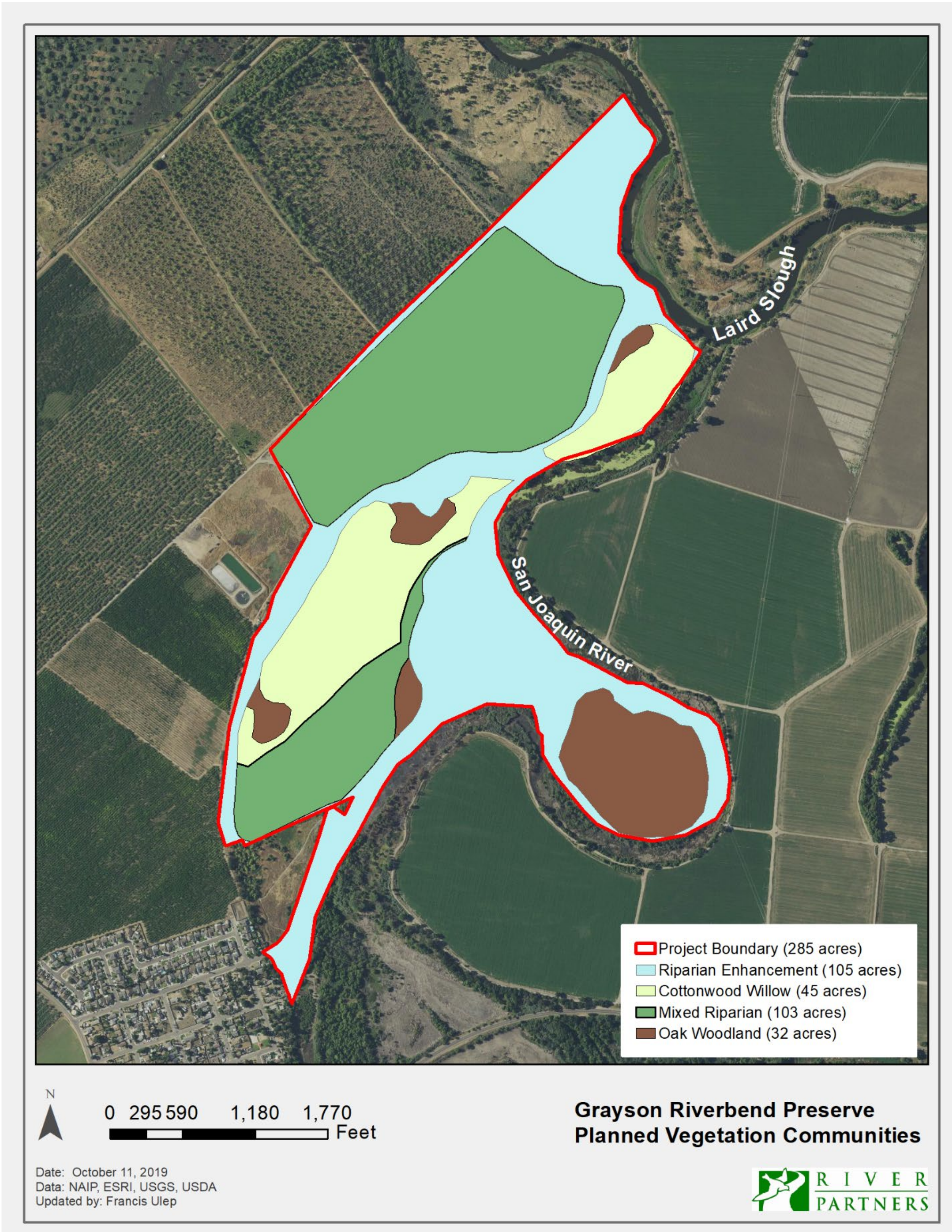

Figure 18. Planned vegetation communities at Grayson Riverbend Preserve

1. Rationale for Plant Communities

Using site factors and design considerations, River Partners developed three woody plant associations, all with an herbaceous understory layer (Table 5). The planting pattern for the woody plant associations has been designed to achieve a network of dense riparian vegetation for enhanced predator cover, breeding sites, and dispersal corridors for endangered riparian mammals and other wildlife of conservation concern, as described above. These woody plant communities will benefit a variety of mammalian species including the riparian brush rabbit, as well as many of the Neotropical migrant songbirds which require dense shrubby vegetation (RHJV, 2004). Abundant blackberry, rose, golden currant and sandbar willow in the planting design will form dense thickets, that will expand forming a lush riparian shrub habitat. Coyote brush, blue elderberry, and shrubby willows will function as trellis species and provide habitat structure. The recommended plant associations and species lists are based upon both what remains along the San Joaquin River and upon inferences based upon soil types, depths to water table, and conditions which support more diverse communities elsewhere in the Central Valley.

Table 5. Rationale for planned vegetation communities at Grayson Riverbend Preserve

Community	Alliance	Planting Location Characteristics	Design Characteristics	Habitat Benefits
Mixed Riparian Forest	*Acer negundo* Forest Alliance	Fields: 1, 2, 4 Soil: sandy loams Water table: <12 ft.	Large variety of woody and shrub species	• Provide quick structure and habitat favored by many riparian focal bird species (Common Yellow-throat, Yellow-billed Cuckoo).
Oak Woodland	*Quercus lobata* Woodland Alliance	Fields: 3, 4, 5 Soil: varies Water table: varies 4 < 12 ft.	High canopy, with dense grassy and herbaceous understory	• Produces abundant food supply and provides important shelter in the form of cavities for nesting birds.
Cottonwood Willow Forest	*Populus fremntii-Fraxinus velutina-Salix gooddingii* Forest Alliance	Fields: 3, 4 Soil: sandy loam Water table: < 6 ft.	Large variety of woody species. High percentage of willows and cottonwood in design	• Favored by many riparian focal bird species (Common Yellow-throat, Yellow-billed Cuckoo). Because of rapid growth, provides quick structure and habitat for wildlife
Herbaceous Understory	*Leymus cinereus - Leymus triticoides* Herbaceous Alliance	All plant associations	Densely planted; composed of aggressive herbaceous understory species	• Reduce invasions by non-native weeds. • Provide mosaic of vegetation for nesting habitat and substrate for riparian focal bird species.

Many focal riparian bird species depend upon structurally diverse riparian habitat with dense understory cover (RHJV 2004). Studies by Point Blue suggest that shrub cover is the most important variable influencing nest site and there is a positive relationship between tree and shrub richness and bird diversity (Small et al. 1999, Geupel et al. 1997). Additionally, PRBO recommends planting dense shrub patches interspersed with tree/shrub patches, resulting in a semi-open canopy (Hammond et al. 2002).

River Partners expects at least 70% survival of its restoration plantings at the end of the three year maintenance period. After maintenance is discontinued, plant survival will depend upon differences of soil textures and water table depths. Variable plant survival may result in a network of shrub patches at this site with heterogeneous habitat structure that will still enhance wildlife survival and dispersal.

2. Composition and Location of Planting Communities

The overall density and numbers of each plant species are presented by planting area in Tables 6-10. Based on specific physical and biological conditions, River Partners developed several vegetation associations that vary by species composition, depending on their location or physical characteristics and project design requirements.

Table 6. Summary of tree and shrub planting at Grayson Riverbend Preserve

Estimated Acres: 147		
Common Name	**Scientific Name**	**Total Number**
Tree Species		
Arroyo willow	*Salix lasiolepis*	3,376
Valley oak	*Quercus lobate*	4,744
Black willow	*Salix goodingii*	2,971
Box-elder	*Acer negundo*	3,081
Fremont cottonwood	*Populus fremontii*	3,230
Oregon ash	*Fraxinus latifolia*	2,324
	Total Trees	**19,726**
Shrub Species		
Blackberry[f]	*Rubus ursinus*	4,425
California rose[f]	*Rosa californica*	4,245
Buttonbush	*Cephalanthus occidentalis*	2,036
Golden currant[f]	*Ribes aureum*	4,099
Coyote brush[f]	*Baccharis pilularis*	613
Elderberry	*Sambucus Mexicana*	1,516
Quail bush	*Atriplex lentiformis*	613
Sandbar willow[f]	*Salix exigua*	3,050
Mulefat	*Baccharis salicifolia*	581
	Total Shrubs	**21,178**
	TOTAL	**41,517**

i. Mixed Riparian Forest (*Acer negundo* Forest Alliance)

This association will be planted in Fields 1 and 2. Designed to focus on creating a diverse canopy of trees, this community consists of a balanced percentage of riparian overstory trees that includes willows, cottonwood, Oregon ash and box-elder (Table 7). The planting palette includes a higher percentage of rose, blackberry, and golden currant, which will provide the dense shrub understory crucial to targeted wildlife species.

Table 7. Composition of the Mixed Riparian Forest community, Grayson RIverbend Preserve

Estimated Acres: 103				
Common Name	**Scientific Name**	**Percent Composition (%)**	**Density (plants/acre)**	**Total Number**
Tree Species				
Arroyo willow	*Salix lasiolepis*	8%	18.16	1,870
Black willow	*Salix goodingii*	8%	18.16	1,870
Fremont cottonwood	*Populus fremontii*	8%	18.16	1,870
Oregon ash	*Fraxinus latifolius*	6%	13.62	1,403
Box-elder	*Acer negundo*	8%	18.16	1,870
Valley oak	*Quercus lobata*	12%	27.24	2,806
Total Trees		**50%**	**113.5**	**11,689**
Shrub Species				
Blackberry[f]	*Rubus ursinus*	10%	22.7	2,338
California rose[f]	*Rosa californica*	10%	22.7	2,338
Coyote brush[f]	*Baccharis pilularis*	2%	4.54	468
Buttonbush	*Cephalanthus occidentalis*	4%	9.08	935
Sandbar willow[f]	*Salix exigua*	8%	18.16	1,870
Elderberry	*Sambucus mexicana*	4%	9.08	935
Golden currant[f]	*Ribes aureum*	10%	22.7	2,338
Quail bush	*Atriplex lentiformis*	2%	4.54	468
Total Shrubs		**50%**	**113.5**	**11,690**
Totals		**100%**	**227**	**23,379**

[f] represents flexible stem plant species

ii. Oak Woodland Community (*Quercus lobata* Woodland Alliance)

This association, as its title suggests, is specifically designed to develop into dense oak woodland. While this community has a mix of fast-growing willows and cottonwood to provide early vegetative structure, it consists of a high percentage of shrub species to increase diversity in the understory. The dense shrubby vegetation, including rose and blackberry, targets the riparian brush rabbit, riparian woodrat, and many focal riparian bird species (Table 8). The higher density of elderberry shrubs will provide habitat for the valley elderberry longhorn beetle.

Table 8. Composition of the Oak Woodland community, Grayson Riverbend Preserve

Estimated Acres: 32				
Common Name	**Scientific Name**	**Percent Composition (%)**	**Density (plants/acre)**	**Total Number**
Tree Species				
Arroyo willow	*Salix lasiolepis*	4%	9	291
Valley oak	*Quercus lobata*	18%	41	1,308
Black willow	*Salix goodingii*	4%	9	291
Box-elder	*Acer negundo*	8%	18	581
Fremont cottonwood	*Populus fremontii*	2%	5	145
Oregon ash	*Fraxinus latifolia*	4%	9	291
Total Trees		**40%**	**91**	**2,907**
Shrub Species				
California rose[f]	*Rosa californica*	12%	27	872
Blackberry[f]	*Rubus ursinus*	12%	27	872
Buttonbush	*Cephalanthus occidentalis*	4%	9	291
Mulefat	*Baccharis salicifolia*	8%	18	581
Sandbar willow[f]	*Salix exigua*	2%	5	145
Coyote brush[f]	*Baccharis pilularis*	2%	5	145
Elderberry	*Sambucus mexicana*	8%	18	581
Golden currant[f]	*Ribes aureum*	10%	23	726
Quail bush	*Atriplex lentiformis*	2%	5	145
Total Shrubs		**60%**	**137**	**4,358**
Totals		**100%**	**227**	**7,265**

[f] represents flexible stem plant species

iii. Cottonwood Willow Forest Community (*Populus fremntii-Fraxinus velutina-Salix gooddingii* Forest Alliance)

This association will be planted in Fields 3 and 4. This community is designed to focus on creating a fast-growing canopy of trees, including include willows, cottonwood, Oregon ash and box-elder (Table 9). The understory palette focuses on species most suited for inundation, as this field floods most frequently.

Table 9. Composition of the Cottonwood Willow Forest community, Grayson Riverbend Preserve

Estimated Acres: 45				
Common Name	**Scientific Name**	**Percent Composition (%)**	**Density (plants/acre)**	**Total Number**
Tree Species				
Arroyo willow	*Salix lasiolepis*	12%	27	1,215
Black willow	*Salix goodingii*	8%	18	810
Fremont cottonwood	*Populus fremontii*	12%	27	1,215
Oregon ash	*Fraxinus latifolius*	6%	14	630
Box-elder	*Acer negundo*	6%	14	630
Valley oak	*Quercus lobata*	6%	14	630
Total Trees		**50%**	**114**	**5,130**
Shrub Species				
Blackberry[f]	*Rubus ursinus*	12%	27	1,215
California rose[f]	*Rosa californica*	10%	23	1,035
Buttonbush	*Cephalanthus occidentalis*	8%	18	810
Sandbar willow[f]	*Salix exigua*	10%	23	1,035
Golden currant[f]	*Ribes aureum*	10%	23	1,035
Total Shrubs		**50%**	**114**	**5,130**
Totals		**100%**	**227**	**10,260**

[f] represents flexible stem plant species

iv. Herbaceous Understory (*Leymus cinereus - Leymus triticoides* Herbaceous Alliance)

In the absence of active understory restoration, many of the existing invasive weeds at GRP would thrive. Weeds such as Russian knapweed, perennial pepperweed, Johnson grass, and common reed would take over the site and threaten not only the planted communities but also the remnant habitat at GRP. These invasive species tend to out-compete native species and form monotypic stands with no habitat value. Restored areas could still be at risk of invasion after three years of maintenance. Consequently, planting a dense, aggressive understory throughout the restoration area (Table 10) will aid in preventing or limiting the establishment of non-natives. Creeping wildrye is a native grass species that can competitively exclude non-native perennial pepperweed and other invasives and tolerate flooding after it becomes established. Native grasses, such as creeping wildrye and purple needlegrass will be drill seeded, while various forb species seed will be broadcasted.

Table 10. Potential composition of Herbaceous Understory, Grayson Riverbend Preserve

Common Name	Scientific Name
Creeping wildrye	*Elymus triticoides*
Gumplant	*Grindelia camporum*
Mugwort	*Artemisia douglasiana*
Creeping rush	*Juncus balticus*
Santa Barbara sedge	*Carex barbarae*
California loosestrife	*Lythrum californicum*
Dogbane	*Apocynum cannabininum*
Hedge nettle	*Stachys ajugoides*
Narrowleaf milkweed	*Asclepias fascicularis*
Marsh fleabane	*Pluchea odorata*
Western goldenrod	*Euthamia occidentalis*
Telegraph weed	*Heterotheca grandiflora*
Evening primrose	*Oenothera villosa*
Stinging nettle	*Urtica dioica*
Purple Needgrass	*Stipa pulchra*
Deer Grass	*Muhlenbergia rigens*

3. Planting Tiles and Baseline Data

River Partners has developed a computer database system that identifies the plant species at a particular row and planting location within the field. This planning tool allows us to develop specific planting patterns that will create a vegetation mosaic of structural patterns within the restoration planting. Each plant will receive a computer-generated label that lists its row and plant number, location, plant species name and number code. The labels will be installed on stakes in the field prior to planting, allowing us to clearly communicate the plan to the planting crew. In the future, the database will be an important adaptive management tool because it will allow us to discern any patterns in a plant species' survival rate or growth patterns across a field.

Within each planting association, the sub-units are expressed as "tiles" (Appendix I). Each tile covers an area of 5 rows by 10 planting locations within each row and is approximately 1/5 of an acre. Each tile will be replicated as often as needed to fill in the area for a particular association. Within each tile, plants are arranged so that we can create a mosaic of vegetative structure across the field.

4. Riparian Enhancement

The Riparian Enhancement Area is a catch-all term for areas within the project boundary that are not intensively planted with woody or herbaceous species. Enhancement activities will occur on 105 acres, which occupies the existing riparian along the river channel. The primary focus of the enhancement area is to target invasive species. Because limited funding precludes covering a large area, River Partners recommends prioritizing areas and target species.

VI. ANTICIPATED RESTORATION OUTCOMES

GRP is located in an ecologically significant location. The project area is ideal for nonstructural flood management because the floodplain is minimally protected from flooding by private berms and the old river channel runs along the eastern edge of the property. By converting existing agricultural fields into native habitat, this project is able to improve floodplain-river channel connectivity, reduce flood impacts to properties both upstream and downstream of the site, and restoring critical wildlife habitat for endangered and other at-risk species. Conserving and restoring land within the floodway of the San Joaquin River will benefit many riparian species, such as the riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle, least Bell's vireo and other focal riparian bird species, as well as fish species, such as the Chinook salmon and steelhead trout.

Riparian areas host the most diverse array of wildlife species seen in California. Restoration of GRP will have a number of ecological benefits, which are magnified by the project's location and close proximity to existing habitat and other restoration projects. Actively restoring the site will provide critical habitat and conditions for a variety of species over a relatively short time.

A. Targeted Wildlife

Altered river hydrology, land clearing, topographic leveling associated with agricultural land development, and invasion by noxious species have critically degraded riparian habitat in the Central Valley. A primary goal of this project is to provide greater access to critical floodplain habitat, as well as design and create high-quality riparian habitat for at-risk wildlife species at GRP and expand the footprint of already existing habitat at the SJRNWR (Table 11). Currently, the SJRNWR supports a variety of at-risk species such as the endangered riparian brush rabbit, endangered riparian woodrat, Central Valley fall-run Chinook salmon *(Oncorhynchus tshawytscha)*, threatened Central Valley steelhead *(Oncorhynchus mykiss)*, recently delisted Aleutian cackling goose *(Branta hutchinsii leucopareia)*, threatened (State-listed) Swainson's hawk *(Buteo swainsoni)* , and other riparian bird species.

With the advent of significant habitat restoration projects implemented on the SJRNWR, avian monitoring conducted by Point Blue Conservation Science (Point Blue) assessed targeted avian species use of newly established vegetation structure. Throughout the years, Point Blue observed yellow warblers (*Dendroica petechia*; California species of special concern; see Dybala et al. 2014) and relatively high densities of nesting song sparrows (*Melospiza melodia*; California species of special concern) and blue grosbeaks (*Guiraca caerulea*; reduced in much of their historical range) on the SJRNWR. Most notably, in June 2005, Point Blue also detected a breeding and nesting pair of endangered least Bell's vireos *(Vireo bellii pusillus)* in a recently restored field at SJRNWR, approximately 2.5 miles from the GRP. A breeding pair of least Bell's vireos returned to the same area in 2006 and another male was sighted along Hospital Creek in 2011 (Howell et al. 2010), 2012 (Eric Hopson Personal Observation), and 2016 (Dybala 2016). The Merced NWR has also monitored a nesting pair of vireos, and vireos have also been observed in the Yolo Bypass.

Although valley elderberry longhorn beetle *(Desmocerus californicus dimorphus)* (VELB) presence has not been monitored on the SJRNWR since 2006, numerous elderberry shrubs exist in restored fields and remnant habitat. Elderberry shrubs at the SJRNWR, in addition to areas along the historic San Joaquin River channel at GRP, may support the threatened valley elderberry longhorn beetle. In 1998, exit holes were observed five miles upstream from GRP along the San Joaquin River according to CDFW's California Natural Diversity Database (CNDDB).

Table 11. Target wildlife species that could benefit from restoration at Grayson Riverbend Preserve

Common Name	Scientific Name	Listed Status
Riparian brush rabbit	*Sylvilagus bachmani riparius*	Endangered (State and Federal)
Riparian woodrat	*Neotoma fuscipes riparia*	Endangered (Federal)
Least Bell's vireo	*Vireo bellii pusillus*	Endangered (State and Federal)
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	Threatened (Federal)
Swainson's hawk	*Buteo swainsoni*	Threatened (State)
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	Threatened (State and Federal)
Bank swallow	*Riparia riparia*	Threatened (State)
Little willow flycatcher	*Empidonax traillii brewsteri*	Endangered (State)
Northern harrier	*Circus cyaneus*	CA Species of Special Concern
Yellow warbler	*Dendroica petechial*	CA Species of Special Concern
Song sparrow	*Melospiza melodia*	CA Species of Special Concern
Tricolored blackbird	*Agelaius tricolor*	CA Species of Special Concern
Loggerheaded shrike	*Lanius ludovicianus*	CA Species of Special Concern
Chinook salmon	*Oncorhynchus tshawytscha*	Threatened (State and Federal)
Steelhead trout	*Oncorhynchus mykiss*	Threatened (Federal)
White sturgeon	*Acipenser transmontanus*	Threatened (Federal)

1. Riparian Brush Rabbit

Historically, this species occurred in riparian forests along portions of the San Joaquin River and its tributaries on the valley floor (Williams et al. 1998; Kelt et al. 2014). One of the most critically endangered species in California, riparian brush rabbit populations have been threatened by clearing and leveling of riparian habitat for conversion to agriculture, wildfire, disease, predation, and flooding. Approximately 6% of native riparian forests remain in the San Joaquin Valley (Kelt et al. 2014), mirroring broaderscale loss of riparian habitat across the Central Valley (Seavy et al. 2012). Creating high-quality habitat for the riparian brush rabbit within the Project area would directly contribute towards the recovery of the species.

Although precise habitat needs of the riparian brush rabbit are still being studied, riparian corridors with abundant shrubs, vines, and an herbaceous understory that allow rabbits to successfully live and move between bigger patches of habitat are critically important. The corridor must be continuous but can be narrow; although it should not be very narrow for long distances. A riparian corridor 76 m (250 ft.) wide should be adequate to provide quality habitat for the rabbit (Dan Williams, personal communication), although large patches of contiguous habitat would be the most desirable option. In 2014, the discovery of a riparian brush rabbit at Dos Rios supports the assertion that rabbits can use narrow corridors since the rabbit was located in a habitat patch approximately 145-feet wide along the Tuolumne River. The elevation of the habitat in relationship to flood water levels and the distance between flood-prone habitat and non-flooded uplands also should be considered.

Existing conditions at the GRP, including small habitat patch sizes, narrow and discontinuous riparian corridors, and lack of adequate flood refugia, are not high-quality habitat for riparian brush rabbit. However, portions of the project site have similar characteristics to habitat in the South Delta where small pockets of brush rabbits continue to persist. With active restoration, GRP could provide the exact habitat characteristics and pathways to high-ground flood refugia needed for the species.

2. Riparian Woodrat

The endangered riparian woodrat historically occurred along the San Joaquin, Stanislaus, and Tuolumne Rivers. Currently, the only known populations of woodrats are at Caswell Memorial State Park (Caswell) on the Stanislaus River and on the Refuge (Matocq et al. 2012). Both of these populations are small and isolated, increasing the possibility of localized extinction due to a devastating flood or fire. Loss and fragmentation of habitat through the conversion of riparian habitat to agriculture and altered hydrology of valley rivers by dam construction are primary reasons for the decline of the riparian woodrat (Williams et al. 1998; Matocq et al. 2012).

Riparian woodrats inhabit areas with dense shrub cover, typically willow thickets with a valley oak overstory. This species eats leaves, fruits, flowers, and nuts. Woodrats live in stick nest houses positioned against logs on the ground, often located in dense brush, or occasionally in cavities of trees and in hollow logs (Williams et al. 1998). These houses are quite common in Caswell State Park, where the population seems to be more robust. It is interesting to note that on the Refuge, where the woodrat is known to exist, a stick house has never been located.

As with the riparian brush rabbit, historic habitat and refugia from flooding have been converted to cultivated fields, orchards, and vineyards, which do not provide suitable habitat for this species. Many habitat requirements of the woodrat are similar to the riparian brush rabbit. Therefore, recommendations for riparian corridors would be similar to those for the rabbit. For reasons similar to those listed for the riparian brush rabbit, current site conditions on most of the Project site are not suitable habitat for the riparian woodrat, although with enhancement the existing oak woodland and narrow bands of riparian habitat along the historic San Joaquin River could possibly support a small population.

3. Valley Elderberry Longhorn Beetle (VELB)

The threatened valley elderberry longhorn beetle is endemic to riparian oak woodlands in California's Central Valley (Barr 1991). The beetle is found only in association with its host plant, elderberry (*Sambucus* spp.), where it spends its entire life cycle that takes 1-2 years to complete.

Adults feed on the foliage and possibly flowers. Females lay eggs in bark crevices and, after hatching, larvae bore into the pith of larger stems. The beetle spends most of its life cycle in the larval stage, living within the stems of the elderberry plant and, after maturity, it emerges through an exit hole in the stem. Barr (1991) conducted extensive surveys, which determined the extent of the beetle's distribution and established that it requires elderberry with stems of a minimum diameter of approximately 2.5 cm (1 in). Research has also indicated that VELB has limited dispersal abilities, which suggests isolated riparian habitat is less likely to be colonized (Collinge et al. 2001). Additionally, VELB or its host plant may be negatively impacted by insecticide or herbicide.

This project will establish connected patches of elderberry shrubs which may serve as suitable habitat for VELB.

4. Least Bell's Vireo

The historic range of the endangered least Bell's vireo extended from Tehama County, California to Baja California in Mexico. Formerly abundant in riparian forests of the Central Valley of California, loss of habitat through conversion to agriculture and urban uses, as well as the invasion of California by the parasitic brown-headed cowbird (*Molothrus ater*) have contributed to its decline (RHJV, 2004). Currently, least Bell's vireo is restricted to eight counties in southern California and Yolo County.
Breeding habitat includes 3-5-year-old willow thickets within a dense herbaceous understory (e.g., native mugwort). Nests are usually low in a shrub or tree, near the edge of a thicket. A critical structural component is a dense shrub layer 0.6-3 meters above ground (TNC 2000).

Brood parasitism by brown-headed cowbirds is a significant threat to vireo populations. Grazing in riparian areas has reduced the habitat preferred by the least Bell's vireo. Grazed areas, row crops, and orchards provide foraging habitat for the brown-headed cowbird (RHJV, 2004). Vireos that are forced into fragmented or marginal nesting areas are more vulnerable to parasitism. Minimizing habitat patchiness may reduce rates of cowbird parasitism and restoration projects targeting the vireo should be located in areas free of brown-headed cowbirds. A recent analysis of brown-headed cowbird parasitism on the Refuge suggested that, for other species with nesting habits similar to the vireo, rates of parasitism are not so high that they should cause concern for restoring vireo habitat (Dettling et al. 2012). Restoring quality breeding habitat and cowbird control have led to population recovery in some areas (Kus 1998, TNC 2000), and current research also suggests that habitat restoration does not lead to an increase in cowbird nest parasitism in vireos (Dybala et al. 2014). Water availability, vegetation structure, and proximity to natural habitat are known to be key components of restoration success and habitat use by the vireo (Kus 1998).

The last documented breeding in the Central Valley was during the 1940s and the vireo was considered extirpated from the Central Valley by 1980. However, in June 2005, Point Blue discovered a breeding pair with young in a former agricultural field that had been restored by River Partners to riparian habitat on the Refuge (Howell et al. 2010). This 3-year-old restoration, which is just north of GRP, consisted of a cottonwood/willow community with a dense native herbaceous understory (native mugwort). A pair of vireos were also documented on the Refuge in 2006 and a single male was found in 2011, 2012, and 2016. Currently, there is minimal breeding and nesting habitat for the least Bell's vireo on the Project site. However, since the property has been privately held, surveys have not been completed to date.

5. Other Riparian Bird Species

Songbirds are excellent indicators of ecosystem health because they are abundant, distributed within and across habitats, and are sensitive to changes in the food supply, vegetation cover, and predator densities (RHJV 2004). The Riparian Habitat Joint Venture (RVJV) has identified several species of birds, termed riparian focal species, as indicators of ecologically healthy riparian systems. Reproductive success of these focal species on breeding grounds is affected by many factors including, habitat patch size and shape, fragmentation, and surrounding land use (RHJV 2004). Twelve of the focal species identified by RVJV currently breed on or near GRP, or would likely do so with properly designed restoration. These species utilize a variety of different portions of riparian corridors. Some species thrive on the floodplain (e.g., gravel bar, woodland, and wetland), while others can be found in different types of vegetation (e.g., dense shrubs, tree-tops, various understory structure. Figure 19 illustrates the types of habitat these focal species certain prefer and Table 12 summarizes the wide range of spatial and structural habitat requirements among the species. For example, the common yellowthroat (*Geothlypis trichas*) can have a breeding and foraging territory as small as 0.5 ha (1 ac), while the western yellow-billed cuckoo needs a minimum of 20 ha (50 ac). Some species are not compatible living adjacent to agricultural operations, while the blue grosbeak will nest along roadways and forage in certain types of cultivated crops (RHJV 2004). In general, creating large blocks of properly designed vegetative structure, with more opportunities for songbirds to nest away from edges, should increase diversity and abundance (and potentially reproductive success) of many species. Size of riparian forest patches has been shown to be a critical determinant of avian response to restoration in the Central Valley (Gardali and Holmes 2011).

The western yellow-billed cuckoo, listed as federally threatened in 2014, is the focal bird species with the largest territory requirement. Thus, this species can be used to evaluate if restoration projects are designed in a way that will provide benefits to the larger community. Restoration projects benefiting the western yellow-billed cuckoo should restore habitat patches a minimum of 20-40 ha (50-100 ac) in size, with a minimum width of 100-200 m (325-650 ft), which would provide marginal habitat. Optimal habitat for a pair would be greater than 80 ha (200 ac), with a width of greater than 600 m (1970 ft). Sites less than 15 ha (38 ac) in size and less than 100 m wide are unsuitable for the western yellow-billed cuckoo (RHJV 2004). The cuckoo also relies on upland areas in addition to riparian areas for consistent food sources. The cuckoo's primary food source, katydid and sphinx moth larvae, hibernate underground and are not available in lowland floodplains during late-spring flooding. Therefore, upland refugia habitats for foraging in wet years should also be a component of cuckoo habitat restoration projects (RHJV 2004).

The tricolored blackbird would also benefit from restoration activities with the addition of both nesting and foraging habitat at GRP. Tricolored Blackbird Statewide Survey, bulrush, and cattails are critical nesting substrate (Meese 2014) and many present along the San Joaquin River at GRP. There is also a historic account from 1914 of a breeding colony of tri-colored blackbirds in Steenstrup Slough (Mailliard 1914), at the adjacent Dos Rios Ranch.

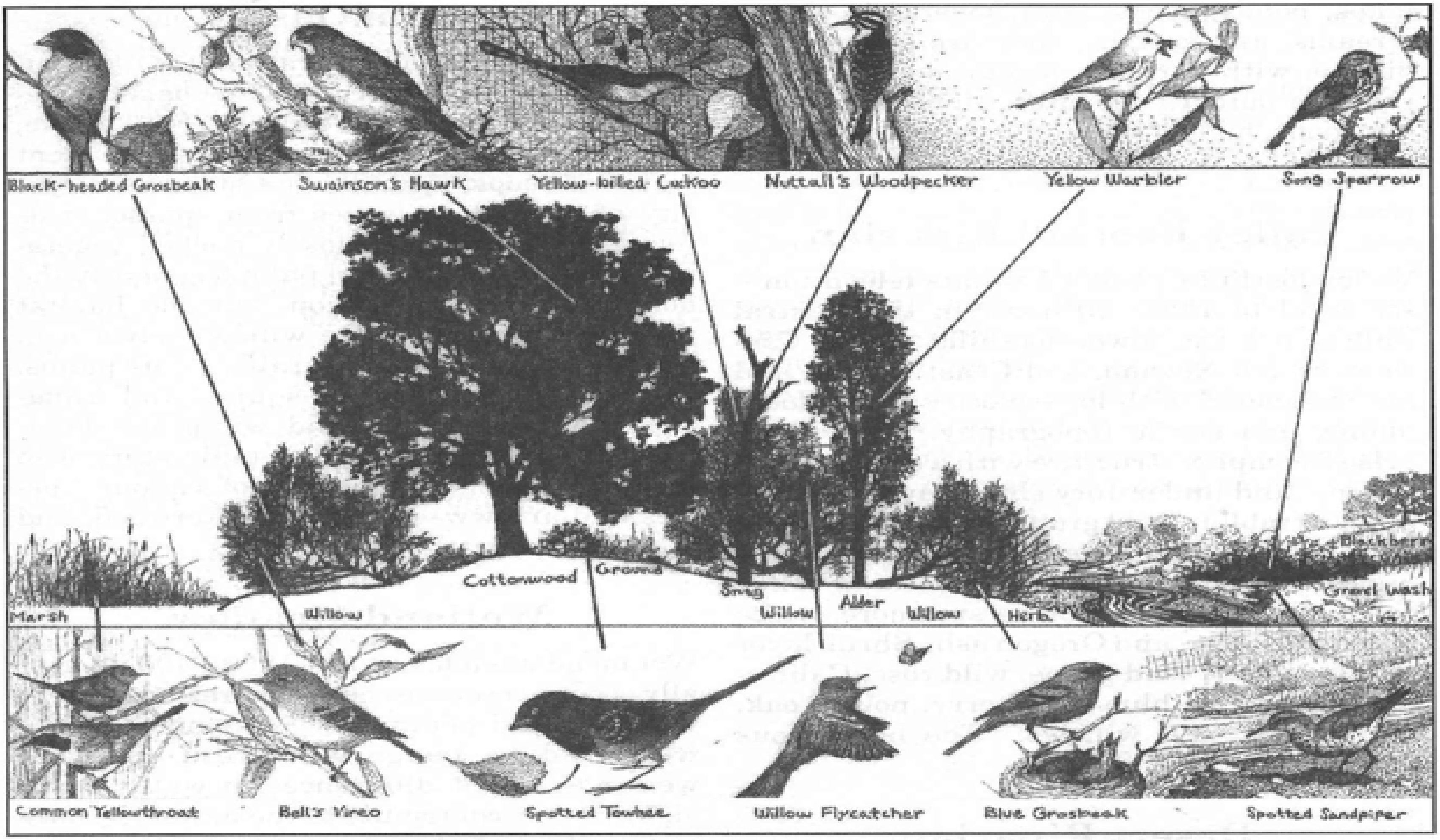

Figure 19. Avian riparian habitat usage and species requirements (RHJV, 2004)

Table 12. Summary of riparian bird focal species habitat requirements (RHJV, 2004)

Bird Species	Territory/Patch Size	Proximity to Water	Vegetation Structure	Nesting
Least Bell's vireo (*Vireo bellii pusillus*)	0.8-1.2 ha (2-3ac); >250 m wide patch	Within 300 m	Dense willow shrubs 3-5 m tall; mugwort understory	Nest low, within 1 m of ground
Bank swallow[1] (*Riparia riparia*)	8-20 cm between nest burrows	In riparian zone	----	Burrows in alluvial soils
Black-headed grosbeak (*Pheucticus melanocephalus*)	200 m x 50 m	50-300 m	Vertical complex - Cottonwood, willows, wild grape	Nest height 3-4 m
Blue grosbeak (*Guiraca caerulea*)	----	In riparian zone	Low herbaceous, upright stems, open canopy	Nest height 0.6-3 m
Common yellowthroat (*Geothlypis trichas*)	0.4-2 ha (1-5 ac)	In riparian zone	Tall emergent wetland edges	Nest height 0-0.6 m
Song sparrow (*Melospiza melodia*)	Variable	Near, within 50 m	Open canopy; dense herbaceous layer	Low to ground; <1 m
Swainson's hawk (*Buteo swainsoni*)	Variable, depending on proximity to foraging habitat	Not riparian obligate	Tall trees in riparian zone near open foraging areas	Nest in tall trees
Warbling vireo (*Vireo gilvus*)	1.2 ha (3 ac)	Associated with streams	Large trees with a semi-open canopy	Variable height
Willow flycatcher[1] (*Empidonax traillii*)	<1.0 ha (<2.5 ac)	Nests near water	Dense willows; 0-3 m height of dense cover, low tree cover	Nests near water; height 0.6-3 m
Wilson's warbler[1] (*Wilsonia pusilla*)	0.4-1.2 ha (1-3 ac)	Nests near water	Willow, alder, and shrub thickets	Usually nests on ground
Yellow-breasted chat (*Icteria virens*)	<5 ha (<12 ac)	Prefers near wetlands	Dense thickets of willows and blackberries	Nests in vines and shrubs
Western yellow-billed cuckoo (*Coccycus americanus occidentalis*)	20-80 ha (50-200 ac)	Nests near or over water	Willow-cottonwood thickets	Nest 1.3-13 m high
California yellow warbler (*Dendroica petechial brewsteri*)	0.06-0.75 ha (0.15-1.9 ac)	Wet areas	Willows, cottonwoods, early successional	----

[1] Only occurs during its migration season

6. Anadromous Fish

Historically, anadromous native fish, specifically Chinook salmon, flourished in the rivers and floodplains of the Central Valley. These fish evolved an opportunistic life cycle strategy over thousands of years to account for the dynamic nature of waterways in the western part of the United States. However, since the Gold Rush era the rivers and floodplains so important to the Chinook salmon, have been greatly impacted by water diversion, levees disconnecting floodplains from the river channel, conversion of lands to agriculture and urban development. These impacts have altered flow regimes, reduced habitat and contributed to the overall decline of the species.

GRP was once a part of the critical habitat for multiple runs of the Chinook salmon (spring and fall). It provides an oasis for out-migrating juveniles to take a break from the mainstem San Joaquin River and feed on a variety of zooplankton growing on the floodplain. It also offered shaded off-channel refugia for adult fish return from the ocean during the spring and summer months.

GRP is in a unique position to support multiple regional plans and goals. The USFWS Anadromous Fish Restoration Program (AFRP) goal is to at least double natural production of anadromous fish in California’s Central Valley streams on a long term sustainable basis. While the San Joaquin River Restoration Program has a mandate to create a sustainable spring-run salmon population in the mainstem San Joaquin River from Friant Dam to the confluence with the Merced River. Furthermore, the National Marine Fisheries Service (NMFS) Recovery Plan for evolutionarily significant units of Chinook salmon and steelhead populations highlights riparian and floodplain habitat restoration along the San Joaquin River as priority Recovery Actions for these species (NMFS 2014).

B. Floodplain Restoration

Field 4 is completely surrounded by high ground and the farmer berm and is disconnected from the adjacent channel until river levels get high enough to overtop the farmer berm. Removing this section of berm will reconnect the old channel to historic floodplain habitat in Field 4, resulting in more frequently inundated floodplain habitat. Field 4 will simultanesouly be restored with native riparian vegetation communities, thereby providing ideal off-channel rearing habitat for juvenile Chinook salmon and other native aquatic species. The berm removal will also promote the return of natural geomorphic processes throughout Field 4, helping it evolve back into a dynamic floodplain feature similar to what we see from historical aerial imagery (Figure 4).

In addition, removing the berm will reduce local velocities and pressure on adjacent flood infrastructure. Removing the berm and irrigation infrastructure will help alleviate historical flood damages as these will no longer be needed at the site (or repaired if damaged). GRP will also become a critical component of future flood risk reduction efforts as the state advances concepts to improve connectivity of the old San Joaquin River corridor in order to increase conveyance. The Hydraulic Impact Analysis conducted for the site (Appendix II) shows neglible negative impacts (increased water surface elevations) from proposed restoration elements.

From preliminary evaluation using the Salmon HQT, removing the two field culverts shows promise in terms of providing more frequent floodplain inundation suitable for juvenile Chinook salmon, but additional analysis is needed to determine if removing these features provides additional habitat benefit commensurate with cost.

C. Streamflow Enhancement

After the third year of irrigating native plantings, irrigation will cease at GRP and irrigation infrastructure will be removed, leaving valuable water instream during critical months of the year. Based on twenty years of experience, River Partners has optimized irrigation to ensure plant establishment using the least amount of water possible. Three years of initial irrigation has proven to be the optimal timing to ensure plant establishment. We are committed to turning off all water use at GRP by December 2024. In addition, based on the evapotranspiration study conducted for GRP by the Irrigation Training and Research Center at Cal Poly – San Luis Obispo, the transition from irrigated agriculture to native riparian vegetation at GRP will in the long-term (10-20 years) reduce total evapotranspiration demands by approximately 180-200 acre-feet per year on average (Appendix III), further enhancing water availability for the river.

VII. RESTORATION IMPLEMENTATION

A. Environmental Compliance

1. Herbicide Application Permits

River Partners holds the appropriate permits to apply herbicides and reports monthly to the Stanislaus County Ag Commissioner.

2. CEQA

Reclamation District 2092 has agreed to serve as the Lead Agency under CEQA for this project. As the most proximal flood management agency to GRP, RD 2092 has discretionary authority over any proposed activities in the designated floodway in this area. A Notice of Completion (Negative Declaration) was filed with the State Clearinghouse on December 19, 2019 and a Notice of Determination was filed with Stanislaus County on January 28, 2020.

3. Designated Floodway Encroachment Permit

This plan has been analyzed for its effect on the design flood and 100-yr flood, and a Hydraulic Impact Report has been prepared by the project engineer to articulate flood stage influences of the project (Appendix II). An encroachment permit application was submitted to the Central Valley Flood Protection Board on January 31, 2020.

4. Cultural Resources Consultation

River Partners contracted with the Sonoma State University Anthropological Studies Center to complete a cultural resources Letter Report for the site, which is an initial desktop-based evaluation of available historical records relevant to potential cultural and historical resources. River Partners will reach out to tribal contacts associated with the tribes identified in the Letter Report as being culturally affiliated with the project area. River Partners will contact and document outreach, share this plan, and incorporate any comments received prior to final design, permitting, and implementation. Should this outreach yield any concern about the presence or potential disturbance of cultural resources, River Partners will develop avoidance protocols to address the concerns.

5. Endangered Species Consultation

The activities proposed here will not impact a threatened or endangered species with the potential to occur on the GRP. The methods described here are consistent with prior consultations performed for restoration projects at the SJRNWR and Dos Rios Ranch and will lead to enhanced habitat quality for many species.

Despite this avoidance approach, River Partners' biologists will continue to monitor the site for all species listed on the CNDDB and USFWS 9-quad lists through all appropriate seasons, and document any occurrence of special-status species. Should any sensitive species be observed on-site, River Partners biologists will initiate consultation with the appropriate agencies to avoid or mitigate disturbances.

6. Lake and Streambed Alteration Agreement

River Partners submitted a complete general application for a Lake and Streambed Alteration Agreement with CDFW on January 30, 2020. We anticipate a finding that the proposed project will not substantially alter a river, stream, or lake as per California Fish and Game Code Section 1600 nor will it impact riparian vegetation, wetlands, or oter sensitive habitat types. If CDFW determines that the project requires a Lake and Streambed Alteration Agreement, River Partners will integrate the required measures associated with the permit into project design and implementation.

B. Berm Removal

River Partners will degrade the berm per grading plans. It is anticipated that approximately 1,600 cubic yards of material will be redistributed within the eastern portion of Field 4 starting from the berm and moving out into the field. The material will be spread in a way to maintain the use of the head ditch required for flood irrigation of native plantings. Berm removal will occur prior to field prep so fill is incorporated into field prep activities.

C. Field Layout

As part of project implementation, numbers have been assigned to the existing agricultural fields (Figure 14). These field numbers allow for improved communication between science and field staff at River Partners, as well as allow for easier referencing with outside partners and funders.

1. All Fields

All the fields will be planted in whole or part with native woody vegetation (trees and shrubs) at a density of 227 plants/acre. The woody vegetation will be in planted in rows, approximately 16 feet apart. For ease of implementation and to reduce costs associated with irrigation modifications, the rows in each field will be oriented in the same manner as the fields were traditionally farmed in order to take advantage of existing irrigation layout (Figure 20). Rows may be curved to follow natural contours and/or to create a more natural looking forest. The in-row plant spacing will be approximately 12 feet. The 12 x 16 feet arrangement yields a plant density of 227 plants per acre, designed with the assumption that not all plants will survive. All fields will be planted in their entirety and flood irrigated if possible.

2. Fields 1, 2, 3, and 5

Fields 1, 2, 3 and 5 will be planted completely with a native woody community (trees and shrubs) at a density of 227 plants/acre. Fields 1 and 2 will be completely planted with the Mixed Riparian Community. Field 3 will mostly be planted mostly as a Cottonwood Willow community, with a small portion of the northwest portion of the field planted with the Oak Woodland Community. Field 5 will be planted entirely with the oak woodland community.

3. Field 4

Field 4 consist of three different plant communities, Mixed Riparian, Cottonwood Willow, and Oak Woodland, which will be planted at a density of 227 plants/acre. Three small patches of Oak Woodland will be interplanted within the Mixed Riparian and Cottonwood Riparian communities.

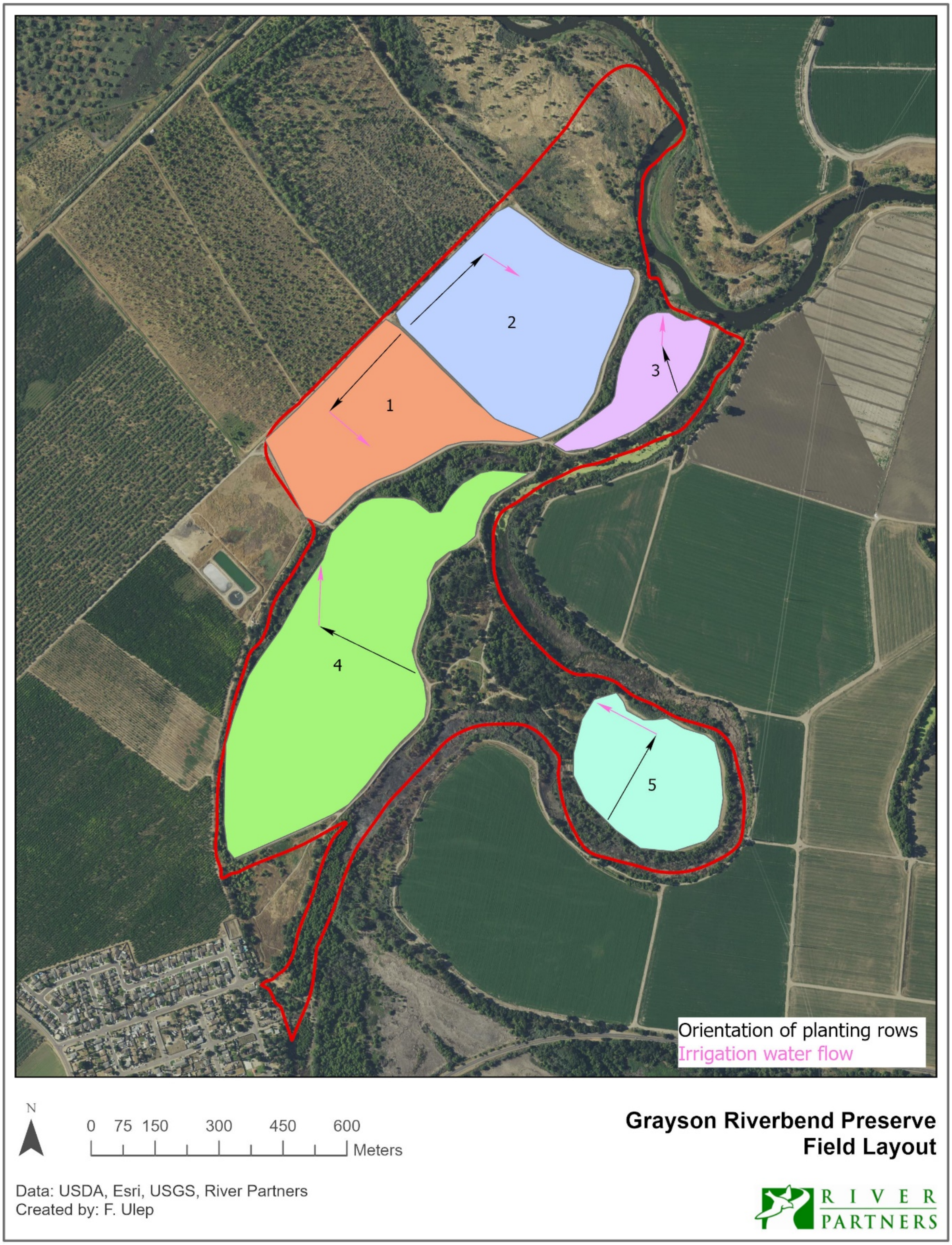

Figure 20. Orientation of planting rows at Grayson Riverbend Preserve. Black arrows indicate direction of plantings (parallel to arrow) and pink arrows indicate direction of field drainage.

D. Site Preparation

1. Restoration Fields

All fields will be disked twice to a depth of 4 inches to loosen the soil and remove any perennial weed roots. Once fields are cleared, planting bed rows will be formed by a furrow ridger. These planting bed rows will be slightly above the soil surface to ensure drainage of water away from the crown of the plant.

2. Riparian Enhancement Area

The areas designated for riparian enhancement will be mowed during the early portion of the growing season to reduce weed growth. Spot treatment with herbicide will be utilized to eliminate perennial pepperweed and salt cedar in the existing riparian areas. Finally, hand pulling weeds will be utilized in areas to minimize overspray on native plants.

E. Irrigation System

River Partners will use an existing well to flood irrigate most of the fields. However, Fields 3 and 4 are intended to be planted with the oak woodland community, which is generally designed in higher elevation locations, so they may require drip irrigation. After the private levee degradation, spoils may be spread across Field 3 and 4. Thus, field staff will assess the need for drip irrigation at that time.

F. Plant Material Collection and Propagation

Field cuttings of willows and cottonwood will be collected from the remnant habitat at GRP and planted in winter 2021. River Partners will collect seed and contract with nurseries to grow out container stock of remaining plant species for a spring 2021 planting. For herbaceous species (native grasses, sedges, forbs), River Partners will collect seeds from local areas for direct seeding or broadcasting and to contract with nurseries to grow out plugs.

G. Plant Installation

1. Woody Species

Planting of willow and cottonwood stem-cuttings (18-24” long) will take place on February 2021. Other native trees and shrubs will be propagated by nurseries in one gallon pots and planted in spring 2021. Valley oak acorns will be collected in fall 2020, held in cold storage, and will be direct seeded in spring 2021.

2. Herbaceous Species

Native grass will be drilled and native forb seeds will be broadcasted between planting rows in Year 2. River Partners will plant three species, creeping wildrye (6 lbs PLS/acre), mugwort (0.5 lbs PLS/acre), and gumplant (2 lbs PLS/acre), each occupying one third of the plantable area. Based on the seed availability in Year 2, other native forbs (Table 10) will be intermixed and broadcasted with the mugwort and gumplant treated aisleways.

H. Plant Maintenance

1. Plant Protectors

Installed milk cartons will protect plants from herbivory and herbicide drift. Adding 4 inches of wood shavings will aid in retaining soil moisture and minimizing weed growth. In the event that native trees and shrubs naturally recruit into the fields, River Partners will place protectors around young plants.

2. Weed Control

During the growing season, weeds will be controlled as needed by disking or spraying Herbicides with glyphosate as the active ingredient will be utilized on the planting rows. The aisles between the planting rows will be mowed as needed to remove weeds during the growing season. This targeted weed control approach is intended to reduce the weed seed source and dispersal potential of existing weeds during the restoration maintenance period.

3. Irrigation Schedule

Because of the dry summers typical of the climate in the area, irrigation will be required. Irrigation will be applied with the goal that plants will become self-sufficient after the third growing season.

In the first growing season, the rapidly growing seedlings mainly only root in the surface zone (the top 1-2 feet) of the soil profile. This “rooting zone” must be kept moist throughout the season to ensure optimum growth and survival. On loam soils, a frequency of once every 10 days is usually sufficient; irrigation on sandy soils may need to be more frequent. The intervals between irrigations are dependent upon soil texture, depth to water table, the weather conditions, and plant water stress. Since the planting communities planned to consist of a mixture of species with different water demands, the plants must be carefully observed to maintain a balance of soil moisture that is acceptable for xeric species like valley oak and elderberry as well as more mesic species like sandbar and arroyo willow.

The strategy for the second and third year is to train the roots to grow to a deeper rooting zone. Roots at depth (5-15 feet) have a much higher rate of success and may be able to tap into the shallow water table on the site and out-compete more shallow-rooted weeds. Less frequent deep watering encourages roots to grow deeper, well below the roots of the weeds, allowing the exclusive use of this deep moisture. As the roots grow deeper, the times between irrigations become longer (10-12 days in year one, 4 weeks in year two, 4-6 weeks in year three), which allows the soil surface layers to dry, thereby reducing weed vigor.

4. Herbivore Control

Herbivores can have a large impact on young plants. A number of measures can help control or minimize their effects (Table 13). Cultural practices such as mowing or spraying can discourage most of these herbivores. One of the advantages of active restoration is that typically, more plants are planted than the herbivores can eat. Mortality of plants is expected to occur over time and is built into the planting design. Some damage by herbivores is tolerable and will not necessarily impact the success of the planting.

Table 13. Summary of herbivore control methods at Grayson Riverbend Preserve

Herbivore	Type of Damage	Comment on measure(s) or plant response
Voles (*Microtus californicus*)	Eat bark and cambium at the base of sapling, usually girdling the entire stem. Dig-up and eat recently planted acorns.	Saplings resprout unless vole population is high. Voles live only in dense herbaceous (weed) cover and never stop moving when in the open to avoid predators. Remove dense weed cover through herbicides or mowing.
Pocket Gophers (*Thomomys bottae)*	Eat root systems (probably killing more saplings than any other vertebrate pest).	Control of weed cover allows predators to hunt gophers. However, gophers can persist in an open, weed-free field. Frequent disking, weed mulch control or flooding reduces populations. A variety of birds will prey on gophers if given the opportunity. Raptor perches and owl boxes may increase predation.
Ground Squirrels (*Otospermophilus beecheyi*)	Dig up and shred plants and protectors.	Flooding or disking can reduce populations.
Rabbits	Browse early spring growth.	Rabbits are target wildlife species, plant at high densities to provide forage and cover.

VIII. MONITORING AND REPORTING

The goal of project monitoring will include evaluating the success of the project in achieving key project objectives, providing information to guide adaptive project management, and improving the knowledge base for restoration planning of future projects. Results will be measured through performance monitoring and avian monitoring.

A. Field Reports

Field managers and biologists will complete regular reports documenting project activities and observations. The reports will note planting and maintenance activities, weed pressure, plant growth, soil moisture, vandalism, rodent damage, irrigation system performance, and the effectiveness of field operations. These reports allow the review of performance and timing of events throughout the restoration process.

B. Wildlife Monitoring

River Partners will be working closely with its partners and neighbors to perform frequent wildlife monitoring at GRP and the adjacent San Joaquin River National Wildlife Refuge.

1. Avian Monitoring

River Partners will contract with Point Blue Conservation Science to conduct avian point count surveys to determine species richness, diversity and breeding status. Both existing riparian and future re-vegetated sites will be monitored so that comparisons can be made between the two. Data compiled at the sites will also be compared with nearby habitats of similar age. Point-count surveys in the spring and summer and winter bird surveys will be done. The data from these surveys will quantify bird use of the site before and after restoration of the site.

2. Mammal Monitoring

To assess our management objectives for many wildlife species, River Partners will install approximately 8 wildlife viewing cameras that will periodically be rotated within the GRP project boundary. These remote cameras, programmed to activate when an infrared motion detector is triggered, are an effective tool for documenting species presence, distribution, and behavior. Biologists will regularly collect and upload the images recorded from each camera.

C. Hydrological Monitoring

A network of shallow groundwater wells will be installed and instrumented with remote continuous loggers that measure temperature and water depth. This network will be able to capture floodplain surface inundation dynamics including timing, depth, and duration of inundation, as well as subsurface flow directionality and streamflow augmentation. The temperature meadurements will help understand thermal suitability of inundated habitat for juvenile salmonids.

D. Photo Points

Photographs can provide qualitative information in vegetation changes at a restoration site. Photopoint monitoring is an easy and effective method to monitor vegetation and ecosystem change. Photos are taken from the same point at regular intervals over a period of time. With precise descriptions and documentation, photos can be replicated by different people many years apart. At the start of the project, River Partners will establish annual photo point locations and document photo location, direction, focal point, and camera lens. During the project, biologists will return to each location in late summer/early fall to replicate the photo and capture maximum plant growth observed that year. In addition, River Partner will utilize aerial photographs and drone videos to compare changes over time.

E. Annual Reports

The annual report documents the site activities, reviews monitoring data, and recommends future management actions. These are produced at the end of the growing season to help managers evaluate and prioritize management actions.

F. Final Report

The final report summarizes project activities performance. The purpose of the report is to provide an overview of project activities; evaluate project performance in terms of goals, objectives, and special considerations of this restoration effort; identify challenges encountered and lessons learned, and provide long-term management suggestions.

IX. SAFETY ISSUES

The health and safety of our employees are an integral part of our work. Prior to any work at GRP, River Partners staff will be briefed on safety issues associated with the site. Employees will have a safety binder that will entail safety procedures and emergency information. All employees will be responsible for complying with safe work practices. In addition, River Partners will comply with the requirements of the Drug-Free Workplace Act of 1990 (Government code Section 8350 et seq.) and will provide a drug-free workplace.

In case an employee incurs any injuries or illnesses while on the job, they are instructed to contact the office to inform someone of the situation and to contact the nearest health care provider.

A. Standard Field Procedures

All employees have a safety binder that describes safe work practices, and they are responsible for complying with these practices. In case of injuries or illnesses while on the job, employees will:

- Call 911, or
- Call US Healthworks Medical Group at (209) 575-5801 located at 1524 McHenry Ave # 500, Modesto CA.
- Contact the River Partners office at (530) 894-5401 and immediate supervisor.

B. Flood and Fire Contingencies

Flooding is likely to have minimal impact on restoration activities on the site. Regulated flows on the river have reduced the frequency of widespread flooding, although out of bank flooding will occur with heavy precipitation if San Joaquin River flows are high. Riparian species are extremely well adapted to surviving winter and early spring floods.

There is minimal historical data of wildfire on the site. Weed control activities will reduce the abundance of dry vegetative fuels, thus lowering the probability of wildfire, and cccess roads will be mapped for fire escape routes.

X. PROJECT IMPLEMENTATION TIMELINE

The timeline for the project is shown over three years in Table 14.

Table 14. General implementation timeline for restoration at Grayson Riverbend Preserve

	2020				2021				2022				2023			
TASK	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Planning/Permitting																
Berm Degrade																
Field Preparation																
Planting																
Infrastructure Removal																
Maintenance																
Monitoring																

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Appendix I

Plant Community Tiles

Planting Tile for Mixed Riparian

Plant number	Row number 1	2	3	4	5
1	CO	SW	BB	BE	BW
2	BB	RO	BW	AS	RO
3	BE	AW	RO	OK	SW
4	AS	GC	BU	GC	AS
5	OK	CO	AW	QB	EB
6	GC	BU	OK	OK	BW
7	AW	BW	EB	BE	RO
8	OK	RO	BE	GC	OK
9	CB	SW	GC	AW	BB
10	BB	CO	BB	SW	CO

Planting Tile for Oak Woodland

Plant number	Row number 1	2	3	4	5
1	OK	BB	BE	OK	BB
2	GC	BW	GC	RO	AW
3	RO	RO	CO	EB	BB
4	OK	AW	BU	BE	GC
5	GC	QB	OK	SW	OK
6	MF	BE	MF	BB	MF
7	OK	EB	BU	AS	BE
8	BB	RO	OK	BB	RO
9	BW	CB	GC	EB	RO
10	MF	OK	EB	AS	OK

Planting Tile for Cottonwood-Willow Forest

Plant number	Row number 1	2	3	4	5
1	AW	OK	AS	BB	CO
2	BE	BW	SW	AW	GC
3	RO	BB	SW	BU	AS
4	BW	CO	RO	CO	BE
5	BU	GC	AW	GC	RO
6	SW	OK	GC	OK	BW
7	AW	AS	RO	BE	sw
8	RO	BU	BW	GC	CO
9	BB	AW	BU	SW	BB
10	CO	BB	CO	BB	AW

Plant abbreviations

blackberry	BB
box elder	BE
buttonbush	BU
coyote brush	CB
elderberry	EB
Oregon ash	AS
rose	RO
valley oak	OK
golden currant	GC
quail bush	QB
cottonwood	CO
black willow	BW
sandbar willow	SW
arroyo willow	AW
mulefat	MF

Appendix II

Grayson Riverbend Preserve Restoration Project

Grayson, Stanislaus County, California

Hydraulic Impact Analysis

Prepared for:

RIVER PARTNERS

Prepared by:

MBK ENGINEERS

January 31, 2020

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PE Certification

This report has been prepared by or under the supervision of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.

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Tables

Figures

1. Purpose

River Partners proposes to enhance and restore habitat along the San Joaquin River in Stanislaus County. The Grayson Riverbend Preserve Restoration Project (Project) is located along the banks of the San Joaquin River and Laird Slough, and neighbors the town of Grayson and the West Unit of the San Joaquin National Wildlife Refuge (**Figure 1**). The Project area is owned in-fee title by River Partners. The goal of the Project is to enhance and restore both degraded remnant riparian habitat and agricultural lands. This is achieved through replanting of native riparian forests and associated habitats. MBK Engineers (MBK) has prepared a hydraulic analysis of the proposed Project in support of the California Central Valley Flood Protection Board's (CVFPB) Encroachment Permit Application and is documented in this report.

2. Project Description

The Project consists of enhancing and restoring approximately 285 acres of habitat. The Project area is owned in fee title by River Partners and is located mostly within the floodplains of the San Joaquin River and CVFPB Designated Floodway. While most of the property is currently leased for agriculture, the site assessment revealed that nearly 106 acres of remnant, riparian, habitat still exists on the property. The restoration plan (**Figure 2**) will be aimed at both restoring the current agricultural fields to riparian and floodplain habitat, as well as enhancing the existing degraded remnant riparian areas. Three restoration plant communities are planned to feature: Mixed Riparian Forest, Oak Woodlands, and Cottonwood-Willow Riparian Forests. In addition, an existing farmer berm is proposed to be degraded to natural ground levels.

2.1 Habitat Restoration

The proposed habitat restoration areas for the Project site are shown in **Figure 2**. The habitat restoration consists of active vegetation restoration using three plant communities. The following sections describe each plant community, including a list and composition of the native plants in each type of location.

2.1.1 Mixed Riparian Forest Community

The Mixed Riparian Forest community has a diverse and even mix of trees and shrubs. This community will be planted at a density of approximately 227 plants/acre on approximately 103 acres of the Project site. **Table 1** lists the plants and density for the Mixed Riparian Forest Community.

Table 1. Mixed Riparian Forest Community

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	*Salix lasiolepis*	8%	18	1,870
Black willow	*Salix gooddingii*	8%	18	1,870
Fremont's cottonwood	*Populus fremontii*	8%	18	1,870
Oregon ash	*Fraxinus latifolius*	6%	14	1,403
Box Elder	*Acer negundo*	8%	18	1,870
Sandbar Willowf	*Salix exigua*	8%	18	1,870
Valley oak	*Quercus lobata*	12%	27	2,806
Total Trees		**58%**	**132**	**13,559**

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Shrub Species				
Blackberryf	*Rubus ursinus*	10%	23	2338
California rosef	*Rosa californica*	10%	23	2338
Coyote brushf	*Baccharis pilularis*	2%	4	468
Buttonbush	*Cephalanthus occidentalis*	4%	9	935
Elderberry	*Sambucus mexicana*	4%	9	935
Golden currantf	*Rives aureum*	10%	23	2338
Quailbush	*Atriplex lentiformis*	2%	4	468
Total Shrubs		**42%**	**95**	**9820**
Totals		**100%**	**227**	

2.1.2 Oak Woodland Community

The Oak Woodland Riparian Forest community also has a diverse mix of tree and shrub species. The association will be planted at a density of 227 plants/acre on approximately 32 acres of the Project site. **Table 2** lists the plants and density for the Oak Woodland community.

Table 2. Oak Woodland Community

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	*Salix lasiolepis*	4%	9	291
Valley oak	*Quercus lobata*	18%	41	1,308
Sandbar willow	*Salix exigua*	2%	4	145
Black willow	*Salix gooddingii*	4%	9	291
Box elder	*Acer negundo*	8%	18	581
Fremont's cottonwood	*Populus fremontii*	2%	4	145
Oregon ash	*Fraxinus latifolius*	4%	9	291
Total Trees		**42%**	**95**	**3,052**
Shrub Species				
California rose	*Rosa californica*	12%	27	872
California blackberry	*Rubus ursinus*	12%	27	872
Buttonbush	*Cephalanthus occidentalis*	4%	9	291
Mulefat	*Baccharis salicifolius*	8%	18	581
Coyote brushf	*Baccharis pilularis*	2%	5	145
Elderberry	*Sambucus mexicana*	8%	18	581
Golden currantf	*Ribes aureum*	10%	23	726
Quailbush	*Atriplex lentiformis*	2%	5	145
Total Shrubs		**58%**	**132**	**4,213**
Totals		**100%**	**227**	**7,265**

2.1.3 Cottonwood Willow Forest Community

The Cottonwood Willow Forest community has a high percentage of willow trees and a mix of shrub species. This community will be planted at a density of 227 plants/acre on approximately 12 acres of the Project site. **Table 3** lists the plants and density for this community.

Table 3. Willow Scrub Community

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	*Salix lasiolepis*	12%	27	327
Black willow	*Salix gooddingii*	8%	18	218
Fremont Cottonwood	*Populus fremontii*	12%	27	327
Oregon ash	*Fraxinus latifolius*	6%	14	163
Box elder	*Acer negundo*	6%	14	163
Sandbar willow	*Salix exigua*	10%	23	272
Valley oak	*Quercus lobate*	6%	14	163
Total Trees		**60%**	**136**	**1,633**
Shrub Species				
Blackberryf	*Rubus ursinus*	12%	27	327
California rose	*Rosa californica*	10%	23	272
Buttonbush	*Cephalanthus occidentalis*	8%	18	218
Golden currantf	*Ribes aureum*	10%	23	272
Total Shrubs		**40%**	**91**	**1,089**
Totals		**100%**	**227**	**2,722**

2.2 Farmer Berm Degrade

A farmer berm will be degraded by 600 lineal feet measured starting from the southerly end of the project area as shown in **Figure 2**. The berm is proposed to be degraded to elevation 38.0 feet North American Vertical Datum (NAVD88).

3. Hydraulic Model

A hydraulic model of the lower San Joaquin River flood control system was developed for this study using HEC-RAS version 5.0.7. HEC-RAS is capable of simulating one-dimensional (1D) and two-dimensional (2D) unsteady flow calculations through a full network of open channels. The Grayson HEC-RAS model simulates the lower San Joaquin River, from Newman to Vernalis, and includes both the Tuolumne River and Stanislaus River (**Figure 3**). The Grayson HEC-RAS model was developed using portions of an existing HEC-RAS model of the lower San Joaquin flood control project, developed by the California Department of Water Resources (DWR).

DWR's HEC-RAS model simulates the entire upper and lower San Joaquin flood control project, from Friant Dam down to the Sacramento-San Joaquin Delta. The model was developed as part of the Central Valley Floodplain Evaluation and Delineation Program (CVFED) and is available as part of DWR's Library of Models, referenced as Model No. 16001. The CVFED HEC-RAS model was truncated to the study area of interest, refined, and calibrated, to form the Grayson HEC-RAS model. The geometry refinements and calibration of the Grayson HEC-RAS model are described in the following sections.

3.1 Topography and Sources of Data

The Grayson HEC-RAS model and all of the results are referenced in the Universal Transverse Mercator (UTM) Zone 10 coordinate horizontal system and the North American Vertical Datum of 1988 (NAVD88). All horizontal and vertical units are in U.S. survey feet.

The primary source of topographic data for the development of the Grayson HEC-RAS model was Light Detection and Ranging (LiDAR) data compiled by DWR under the CVFED Program. The LiDAR data is comprised of points that densely cover the entire region. The minimum expected horizontal accuracy was tested to meet or exceed a 3.5-foot horizontal accuracy at 95 percent confidence level using RMSE(r) x 1.7308 as defined by the National Standards for Spatial Data Accuracy (NSSDA). Final ground surface LiDAR point elevation data in areas other than open terrain meet or exceed NSSDA standards of 0.6-foot root-mean-square error (RMSE) vertical (Accuracy z = 1.2 feet at the 95 percent confidence level). Accuracy was tested to meet a 0.6-foot fundamental vertical accuracy at 95 percent confidence level using RMSE(z) x 1.9600, as defined by the NSSDA.

3.2 HEC-RAS Model Geometry Development

The Grayson HEC-RAS model simulates the lower San Joaquin River, from Newman to Vernalis, and includes its major tributaries (i.e., Tuolumne River and Stanislaus River) along the reach. The Grayson HEC-RAS model simulates the system using both 1D and 2D HEC-RAS components. The river channels outside of the Project area were simulated using 1D cross sections. Since spatially varied vegetation is proposed for the Project area, a HEC-RAS 2D flow area was used to simulate the vegetation and proposed Project features. The 2D flow area extends from the San Joaquin River at Patterson, down to the San Joaquin River at Maze Road and includes the lower portion of the Tuolumne River.

Areas behind levees were simulated using storage areas (i.e., ponding area defined by an elevation-volume relationship). These storage areas were extended out far enough to capture the expected areas of flooding during a 100-year flood event. The Grayson HEC-RAS model schematic is shown in **Figure 3**.

3.3 Model Calibration

The Grayson HEC-RAS model was calibrated to the April 2006 flood event using observed data throughout the model domain. The calibration was performed to verify that the selected model parameters are reasonable and that the model can reasonably reproduce an actual flood event. The April 2006 flood event was selected for calibration as: the flood event was contained within the State-Federal project levee and non-project levees of the San Joaquin River; there is ample observed flow and stage data; availability of high water marks (HWM) throughout the Project reach; and flows are similar to the 1955 Design Flow.

3.4 Boundary Conditions

Upstream and downstream ends of the model were provided boundary conditions using flow data from the April 2006 flood event that was available from various gaging stations from DWR and U.S. Geological Survey (USGS). **Table 4** shows the location and source of flow and stage data used in the development of the boundary conditions.

Table 4. Boundary Conditions – April 2006 Calibration

HEC-RAS Location	Boundary Condition Type	Source
San Joaquin River – SJR8 RS 79.24	Upstream Flow	San Joaquin River near Newman - USGS Station #1127400
San Joaquin River – SJR8 RS 69.64	Upstream Flow	Orestimba Cr at River Road – USGS Station #11274538
Tuolumne River TLR1 RS 16.81	Upstream Flow	Tuolumne River At Modesto – USGS Station #11290000
Stanislaus River SSR1 RS 15.25	Upstream Flow	Stanislaus River at Ripon – USGS Station #11303000
San Joaquin River SJR 6 RS 32.59	Downstream Stage	San Joaquin River near Vernalis – USGS Station #11303500

Plots of the upstream flow boundary conditions are provided in **Figure 4**. The downstream stage boundary condition used in the calibration is plotted in **Figure 5**.

3.5 Levee Breaches

Six levee breaches that would affect model calibration of water surface elevation and flow were identified from aerial photos from August 2006 (Google, 2006). These levee breaches were to the north-west of Grayson on the non-State-Federal project levees of the San Joaquin River National Wildlife Refuge (SJNWR). The levee breach dimensions were estimated from aerial photos and coded into the calibration simulation. **Figure 6** shows the location of the levee breaches.

3.6 Observed Data

Observed stage and flow data for the April 2006 flood event was available from DWR and USGS gaging stations. The observed peak stage and flow at the gages were used to compare with the computed peak stage and flow from the April 2006 flood simulation. **Table 5** lists the available gages within the model domain.

Table 5. Stage and Flow Gages

Gage	HEC-RAS Location	Type
San Joaquin River at Crows Landing; USGS Gage Sta. #11274550	SJR R8 RS 67.91	Flow and Stage
San Joaquin River at Patterson; DWR Gage Sta. #B07200	SJR R8 RS 59.32	Flow and Stage
San Joaquin River at Maze Road; DWR Gage Sta. #B07040	SJR R7 RS 37.74	Flow and Stage

Surveyed high water marks from DWR (DWR and CVFED, 2015) were available along the San Joaquin River and Stanislaus River for the April 2006 flood event. The high water marks were used to calibrate Grayson HEC-RAS model by comparing the high water mark elevation with the computed maximum water surface elevation (WSE). The locations of the high water marks (HWMs) are shown in **Figure 7.**

3.7 Manning's Roughness Coefficient

For 1D cross sections, the Manning's roughness coefficients were assigned to the left bank, main channel, and right bank of the cross section. The Manning's roughness coefficients were based on the CVFED hydraulic model and adjusted using engineering judgement to calibrate the model. The final calibrated Manning's roughness coefficient for the 1D cross sections are listed in **Table 6**.

Table 6. April 2006 Calibration Manning's Roughness Coefficient – 1D Cross Sections

River	Channel Roughness Coefficient Range	Overbank Roughness Coefficient Range
Stanislaus River	0.045	0.04-0.1
Tuolumne River	0.045	0.055-0.09
San Joaquin River	0.045	0.05-0.085

Manning's roughness coefficients for the 2D flow area were assigned spatially, using a land use survey of Stanislaus County conducted by DWR (DWR, 2010). The Manning's roughness coefficient values were based on Table 3-1 from the *HEC-RAS River Analysis Stem Hydraulic Reference Manual Version 5.0 (February 2016)*, and adjusted using engineering judgement to calibrate the model. **Table 7** lists the calibrated Manning's roughness coefficients for the 2D flow area. Spatial variation of the Manning's roughness coefficient for the Grayson area is shown in **Figure 8**.

Table 7. April 2006 Calibration Manning's Roughness Coefficient – 2D Flow Area

Land Use/Veg/Habitat	Manning's Roughness Coefficient
Idle, Rice, Urban	0.03
Grass, Pasture, Fallow, Wetland, Truck Crop	0.035
Wetland	0.04
Field, Grain, River Channel, Open Water	0.04-0.045
Vineyard	0.05
Citrus, Deciduous, Native Vegetation	0.07
Young Riparian Forest	0.08

3.6 Results

The Grayson HEC-RAS model was simulated with the April 2006 boundary conditions from Section 3.4. For each of the gage locations in **Table 5**, plots of computed values versus observed values are plotted in **Figure 9** through **Figure 14**. **Table 8** tabulates the high water mark elevation, computed maximum water surface elevation, and the difference for each of the high water mark locations shown on **Figure 7**.

Figure 9, **Figure 11**, and **Figure 13** show that the model is reasonably quantifying flows in the Grayson Project reach. Computed maximum water surface elevations versus observed high water marks in the Project reach are shown in **Table 8**. The results show the Grayson model reasonably quantifies the maximum water surface elevation in the Project area and is adequate for evaluating impacts to water surface elevation.

Table 8. High Water Mark and Computed Maximum Water Surface Elevation Comparison

HWM ID	Surveyed HWM (ft.-NAVD88)	Computed WSE (ft.-NAVD88)	Difference (ft.)	Notes
1	41.10	41.58	0.48	
2	46.59	44.45	-2.14	
3	42.29	40.32	-1.97	
4	37.88	34.82	-3.06	
5	38.71	36.62	-2.09	
6	35.56	34.14	-1.42	
7	34.90	34.45	-0.45	
8	34.14	34.06	-0.08	
9	34.35	33.94	-0.41	
10	34.22	33.93	-0.29	
11	32.11	32.22	0.11	
12	33.43	33.04	-0.39	
13	35.54	33.89	-1.65	
14	32.59	33.43	0.84	
15	32.53	32.51	-0.02	
16	36.57	33.79	-2.78	
17	33.39	33.71	0.32	
18	32.73	33.77	1.04	
19	35.39	33.76	-1.63	
20	32.37	32.66	0.29	
21	33.14	33.92	0.78	
22	33.13	34.04	0.91	
23	34.21	34.22	0.01	
24	34.62	34.75	0.13	
25	34.26	34.35	0.09	
26	34.47	34.78	0.31	
27	36.40	35.13	-1.27	
28	35.03	35.51	0.48	
29	35.17	35.57	0.40	Maze Road
30	34.84	35.68	0.84	
31	40.16	40.10	-0.06	
32	39.85	40.19	0.34	
33	40.63	40.70	0.07	
34	41.53	41.03	-0.50	
35	43.47	42.39	-1.08	

HWM ID	Surveyed HWM (ft.-NAVD88)	Computed WSE (ft.-NAVD88)	Difference (ft.)	Notes
36	44.27	42.96	-1.31	
37	48.78	48.51	-0.27	
38	48.83	48.82	-0.01	
39	49.72	49.37	-0.35	
40	50.07	49.90	-0.17	
41	51.18	50.18	-1.00	
42	51.27	51.30	0.03	
43	51.87	51.75	-0.12	
44	52.26	52.52	0.26	
45	54.67	53.20	-1.47	E Las Palmas Ave
46	52.83	53.35	0.52	
47	52.39	53.53	1.14	
48	53.15	54.16	1.01	
49	54.96	54.73	-0.23	
50	54.77	54.83	0.06	
51	54.87	55.07	0.20	
52	52.81	54.57	1.76	Disturbed HWM per Surveyor
53	53.10	54.64	1.54	Disturbed HWM per Surveyor
54	54.35	54.89	0.54	
55	55.14	55.21	0.07	
56	54.19	55.35	1.16	
57	55.72	55.83	0.11	
58	56.95	56.71	-0.24	
59	56.68	57.05	0.37	
60	58.25	57.75	-0.50	
61	58.37	57.92	-0.45	
62	58.81	58.08	-0.73	
63	58.29	58.30	0.01	

4. Hydraulic Analysis

4.1 Methodology

The methodology to determine hydraulic impacts was to configure and evaluate hydraulic model simulations of *with-* and *without-project* conditions. The simulation results of the proposed project will be compared to the without-project condition to determine changes in water surface elevation.

4.2 Without-Project Condition

The without project condition hydraulic model geometry was developed from the April 2006 flood event calibration geometry. The without project condition geometry reflects full maturity of habitat on the SJNWR. Those areas on the SJNWR consist of wetlands and riparian forest planted between 2001 and 2015. A

Manning's roughness coefficient of 0.085 was assigned to those areas. All other Manning's roughness coefficients for the 1D cross sections, and other areas of the 2D flow area, remain the same from the calibration geometry. **Figure 15** shows the Manning's roughness coefficient for the without project condition in the Grayson vicinity, and tabulated by land use, in **Table 9**.

Table 9. Without Project Condition – Manning's Roughness Coefficients in 2D Flow Area

Land Use/Veg/Habitat	Manning's Roughness Coefficient
Idle, Rice, Urban	0.03
Grass, Pasture, Fallow, Young Wetland, Truck Crop	0.035
Wetland	0.04
Field, Grain, River Channel, Open Water	0.04 - 0.045
Vineyard	0.05
Heavy Vegetated Pond	0.06
Citrus, Deciduous, Native Vegetation	0.07
Cottonwood Willow and Oak Woodland association	0.07
Young Riparian Forest	0.08
Mixed Riparian and Riparian Forest	0.085

4.3 Project Condition

The project condition hydraulic model geometry was developed from the without project condition geometry. The project condition geometry reflects the proposed vegetation along with the farmer berm degrade, shown in **Figure 2** and described in Section 2.

The proposed vegetation communities were simulated by modifying the Manning's roughness coefficients in the respective areas of the model domain. **Table 10** lists the Manning's roughness coefficients of the project condition vegetation for the 2D flow area, as shown in **Figure 16**.

Table 10. Project Condition – Manning's Roughness Coefficient 2D Flow Area

Land Use/Veg/Habitat	Manning's Roughness Coefficient
Idle, Rice, Urban	0.03
Grass, Pasture, Fallow, Young wetland, Truck Crop	0.035
Wetland, west field	0.04
Field, Grain, River Channel, Open Water	0.045
Vineyard	0.05
Heavy Vegetated Pond	0.06
Citrus, Deciduous, Native Vegetation	0.07
Cottonwood Willow association	0.08
Oak Woodland association	0.08
Young Riparian forest	0.08
Riparian Forest	0.085
Mixed Riparian association	0.085

4.1 Hydrology

The with- and without- project condition hydraulic model geometries were simulated for two flow scenarios, to evaluate impacts to water surface elevation. The Grayson HEC-RAS was simulated in unsteady flow conditions for the USACE 1955 Design Flow for the San Joaquin River at Tuolumne River, and USACE Sacramento and San Joaquin River Basins Comprehensive Study 100-year flows.

The USACE 1955 Design Flow for the San Joaquin River at the Tuolumne River is 45,000 cfs (USACE Sacramento District, 1955). This flow was simulated in the hydraulic model by scaling the April 2006 flood event so that the peak flow in the San Joaquin River near Newman was 45,000 cfs. As per the preceding projects in the area, the USACE and CVFPB recommended that a concurrent flow of 15,000 cfs was simulated on the Tuolumne River at Modesto and 6,000 cfs on the Stanislaus River at Ripon, in order to represent the USACE 1955 Design Flow. **Figure 17** plots the upstream flow hydrographs for the USACE 1955 Design Flow simulation.

Flow boundary conditions for the USACE Comprehensive Study 100-year flood are from the USACE Comprehensive Study San Joaquin River UNET model simulation of the San Joaquin River at Vernalis storm centering flood event. **Figure 18** shows plots of the Grayson HEC-RAS model flow boundary hydrographs used in the USACE Comprehensive Study 100-year flood simulations. The peak flows for the USACE 1955 Design Flow and USACE Comp Study 100-year are tabulated in **Table 11**.

The downstream boundary condition for both of the flow scenarios is the rating curve for the USGS San Joaquin River near Vernalis gaging station (11303500). A plot of the rating curve is provided in **Figure 19**.

Table 11. Boundary Condition - Peak Flow

Flood Event	Peak Flow (cfs)		
	San Joaquin River near Newman	Tuolumne River at Modesto	Stanislaus River at Ripon
USACE 1955 Design Flow	45,000	15,000	6,000
USACE Comprehensive Study 100-Year	37,100	63,700	9,200

4.2 Results

For each of the hydrologic conditions, the with- and without project condition maximum water surface elevations were compared to determine the changes in the maximum water surface elevation due to the project. **Figure 20** and **Figure 22** show the changes due to the Project on the maximum water surface elevations for the USACE 1955 Design Flow and USACE Comprehensive Study 100-year flood, respectively. Increases in water surface elevation as a result of the proposed Project are shown as positive values, while decreases are shown as negative values.

5. Conclusion

River Partners proposes to enhance and restore 285 acres of habitat along the San Joaquin River in Stanislaus County. This hydraulic analysis assesses the Project's potential effects on the State and Federal Flood control system. The results of the hydraulic analysis indicate that both increases and decreases in WSE occur under the with-project condition. Increase in WSE of at most +0.18 feet occur within the Project area and Designated Floodway during a 1955 Design Flow condition (**Figure 20**). Similarly, an increase in WSE of at most +0.12 feet occur within the Project area and Designated Floodway during a 1-in-100 year Flow Condition (**Figure 22**). A majority of increases in WSEs also occur within the Designated Floodway and are incremental increases over a flooding depth of over 6 feet in most locations as shown in **Figure 24** and **Figure 25**.

Moreover, **Figure 20** and **Figure 22** shows flooding outside of the Designated Floodway to the west of Project area during the 1955 Design Flow and 1-in-100 year flow, respectively. The existing condition simulations of both the 1955 Design Flow and 1-in-100 year flow shows this area as flooded during the without-project conditions as shown in **Figure 26** and **Figure 27**. In these figures, the with-project flood extent, shown in red, closely follows the existing flood extent and a majority of these lands are zone within Federal Emergency Management Agencies (FEMA) flood hazard zone A, which is designated as areas with a 1% annual change of flooding. Therefore, the project is not expected to drastically increase flood risk to neighboring properties or the flood control infrastructures.

Aggradation and erosion potential are measured using change in flow velocity. Significant reductions in flow velocity may cause sedimentation, and significant increases in flow velocity could potentially erode bare soils. The Project conditions show localized changes in flow velocities, mostly on the order of -1.0 feet per second, in the Project area and this magnitude would not significantly increase potential for aggradation or erosion during both the 1955 Design Flow (**Figure 21**) and 1-in-100 year flow (**Figure 23**).

References

1. (CVFPB, 1990). *The Designated Floodway Program*. Central Valley Flood Protection Board. September 6, 1990.

2. (Google, 2006). *Google Earth Historical Imagery*. August 2006.

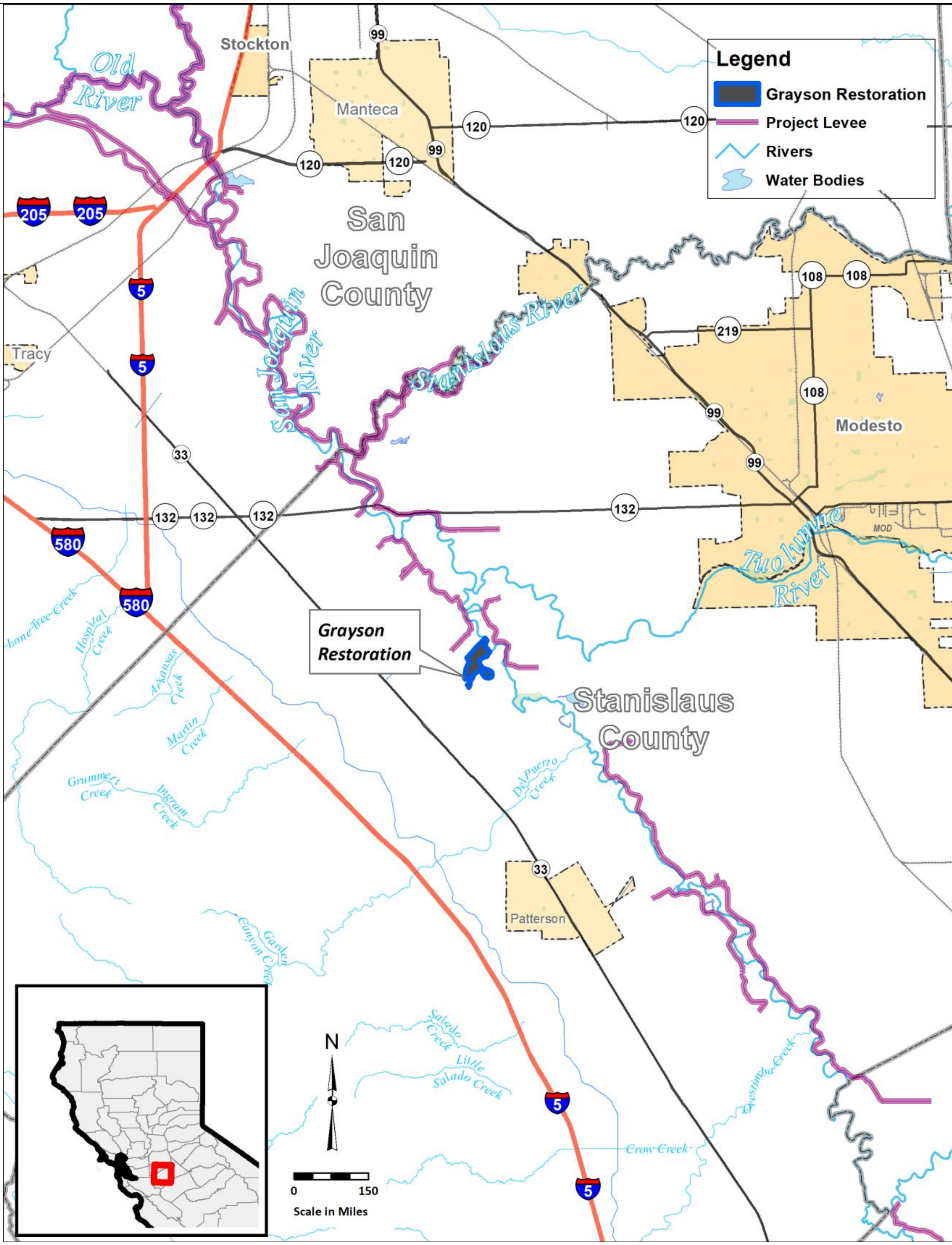
3. (DWR and CVFED, 2015). *DWR CVFED Program High Water Mark Data Compilation*. August 8, 2015.

4. (DWR, 2010). *DWR Division of Integrated Regional Water Management Land Use Survey*, Stanislaus County, California. 2010.

5. (USACE Sacramento District, 1955). *Design Memorandum No. 1, Lower San Joaquin River and Tributaries Project, California, San Joaquin River Levees General Design*. Sacramento California. December 23, 1955.

6. (Kukas, 2014). *Hydraulic Screening and Analysis Needed for USACE Review, U.S. Army Corps of Engineers (USACE), Sacramento District*. Sacramento, California. July 25, 2014.

Figures



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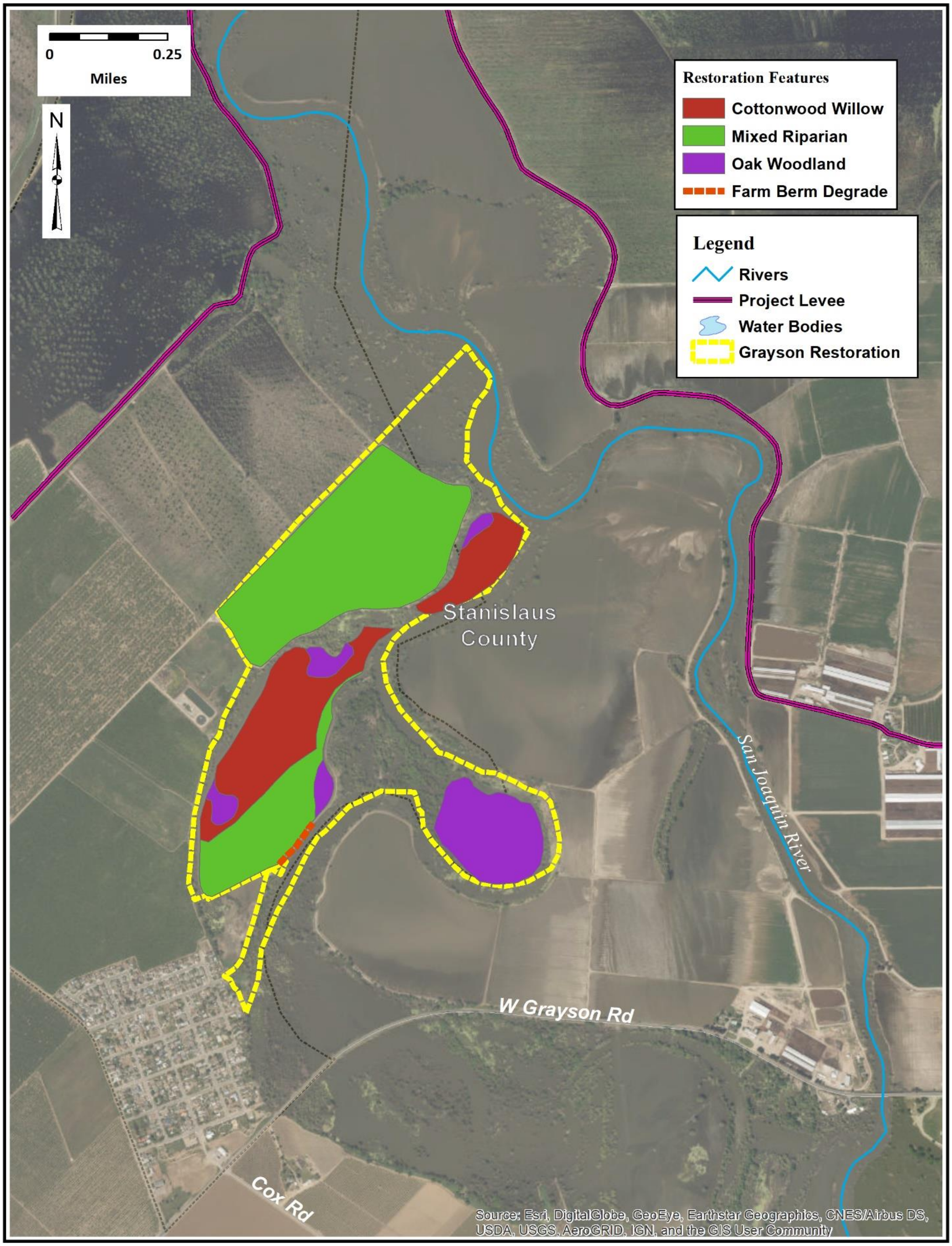
Grayson Riverbend Preserve
Restoration Project

Vicinity Map

Figure 1



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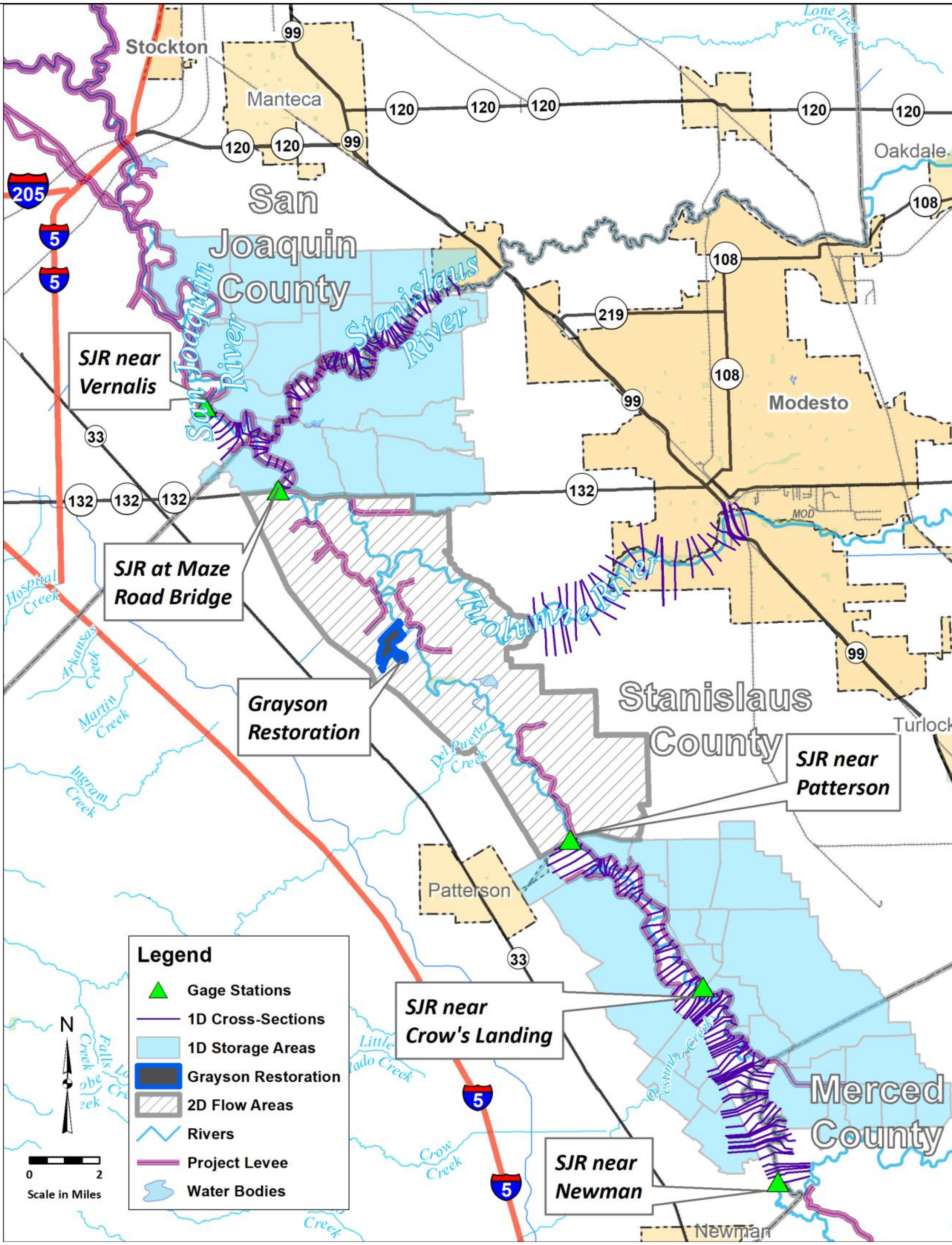
Grayson Riverbend Preserve Restoration Project

Restoration Features

Figure 2



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Grayson Riverbend Preserve Restoration Project

Model Extents & Gages

Figure 3

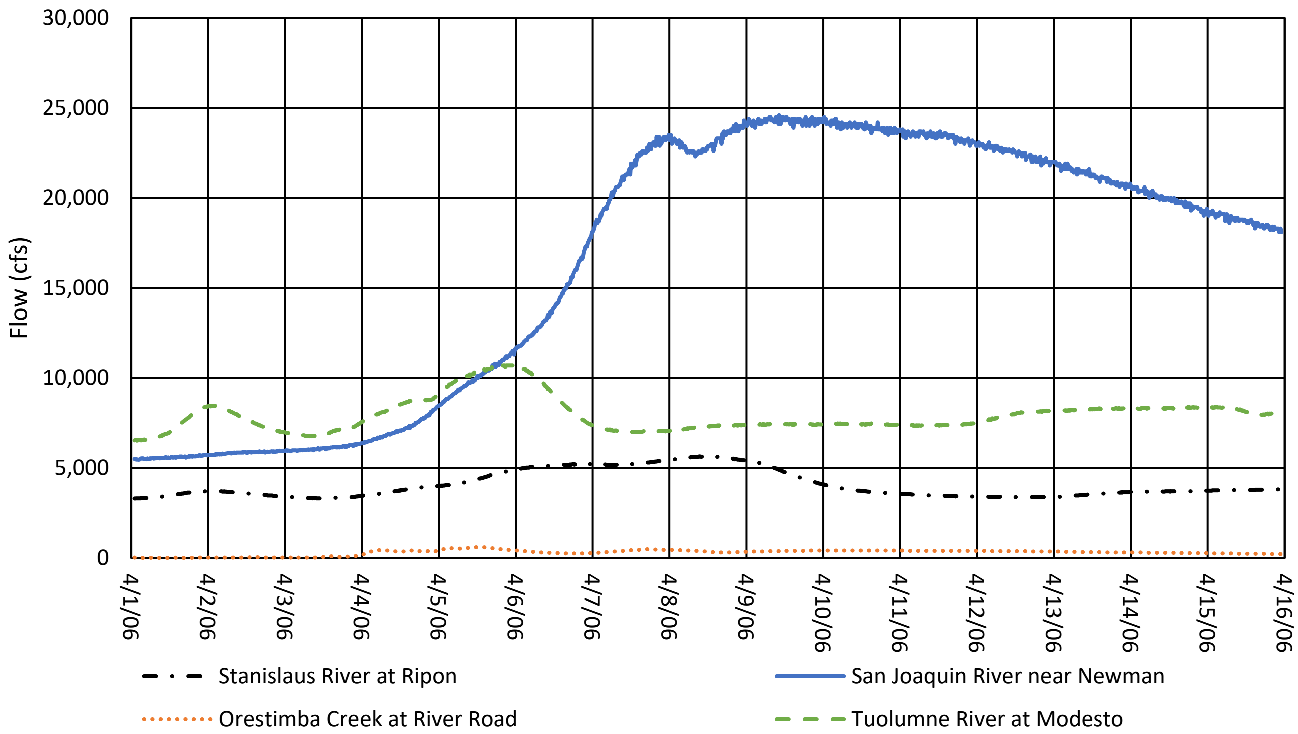


Figure 4. April 2006 Flood Event - Flow Boundary Conditions

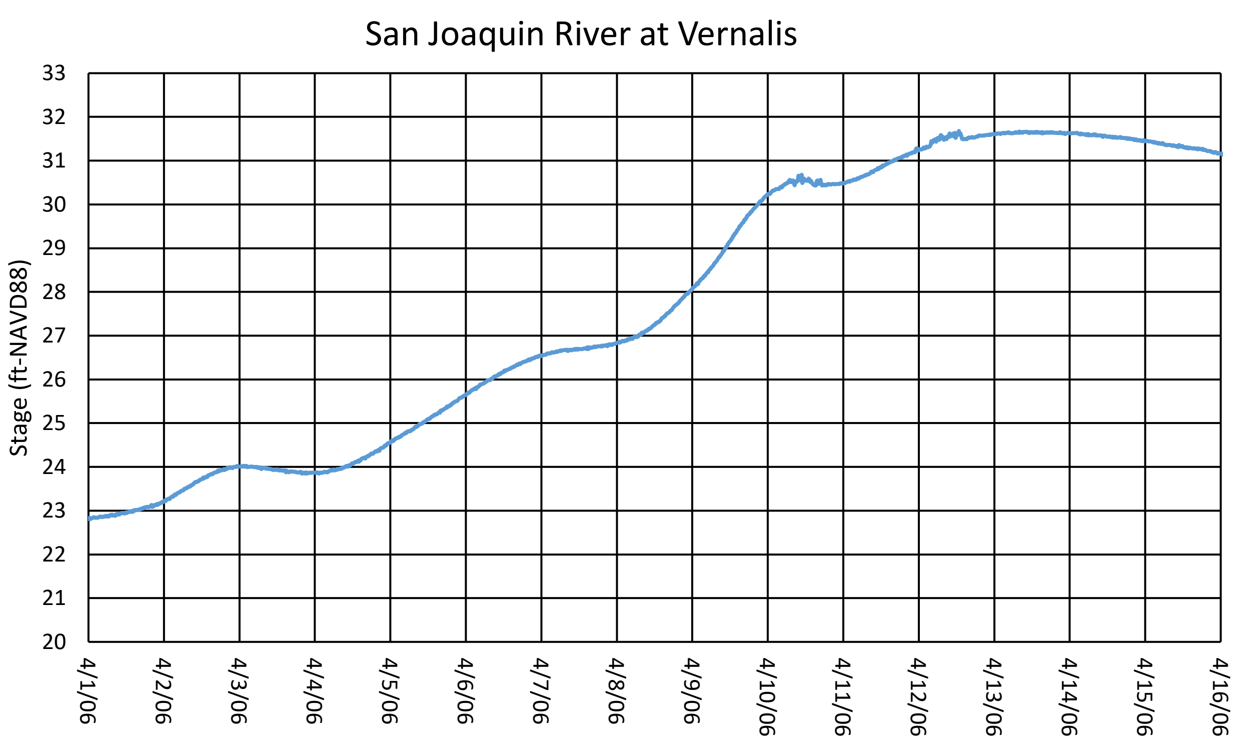
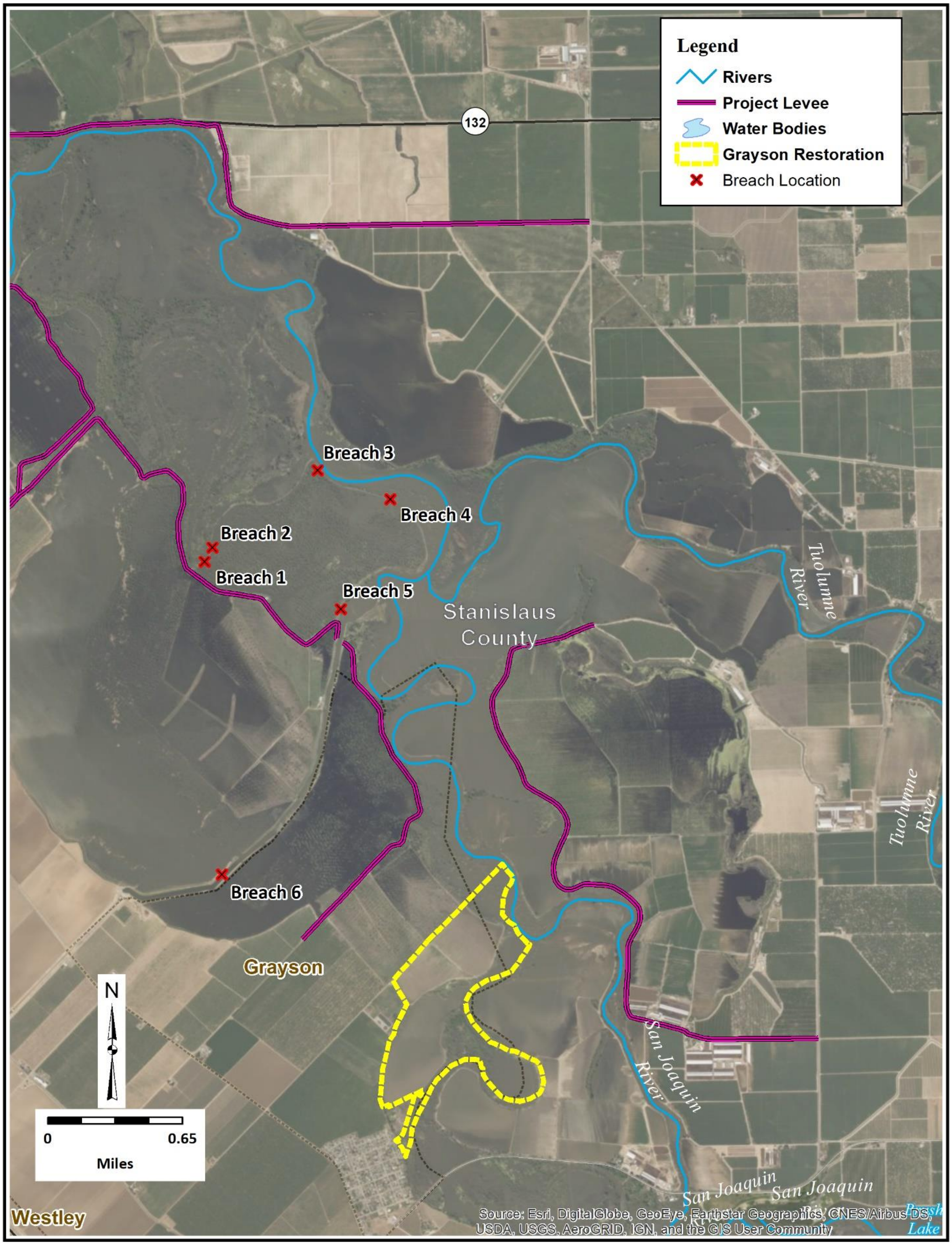


Figure 5. 2006 Flood Event - Stage Boundary Conditions



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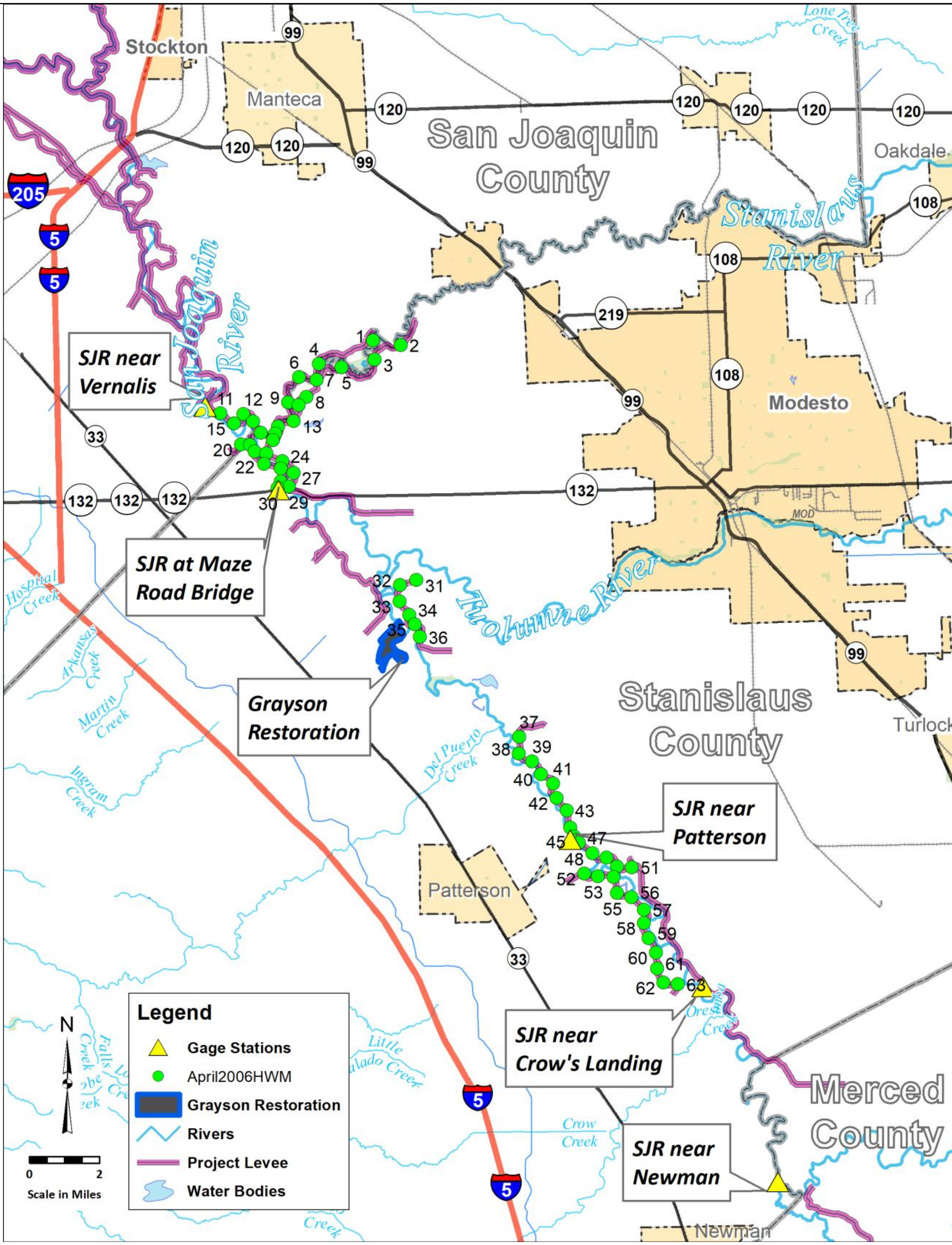
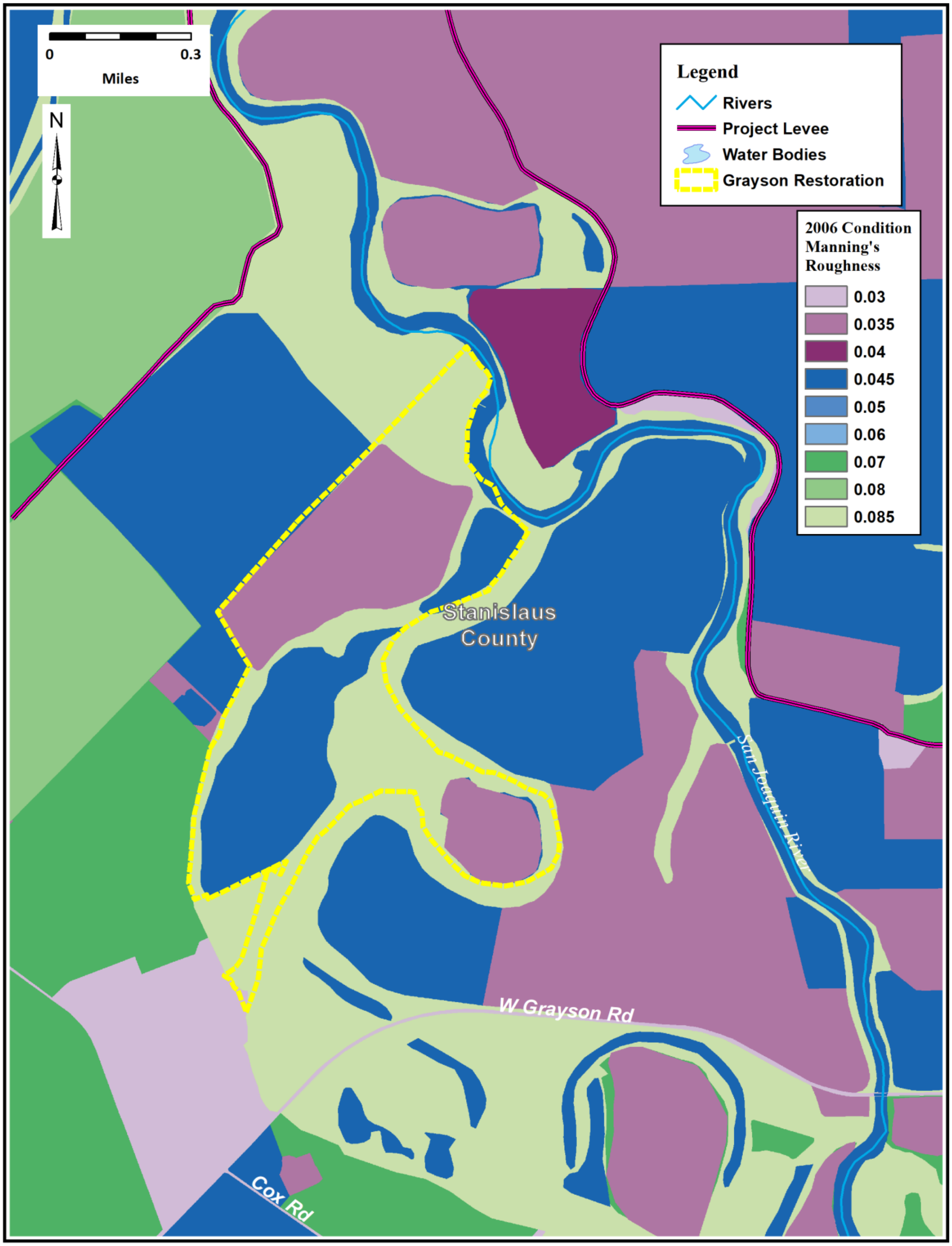
Grayson Riverbend Preserve
Restoration Project

2006 Breach Locations

Figure 6



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	High Water Mark Locations Figure 7



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Grayson Riverbend Preserve Restoration Project

Manning's Roughness Values - 2006 Event

Figure 8

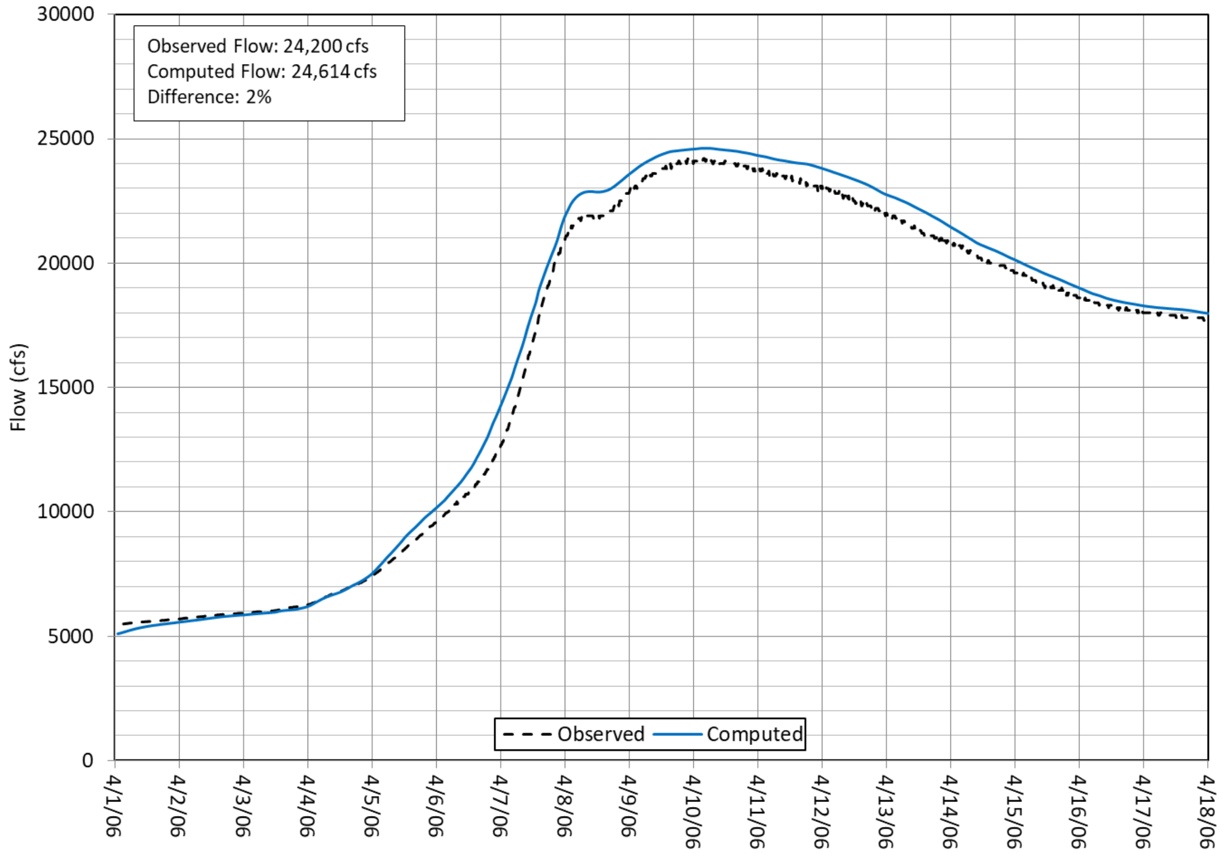


Figure 9. San Joaquin River at Crow's Landing – Flow

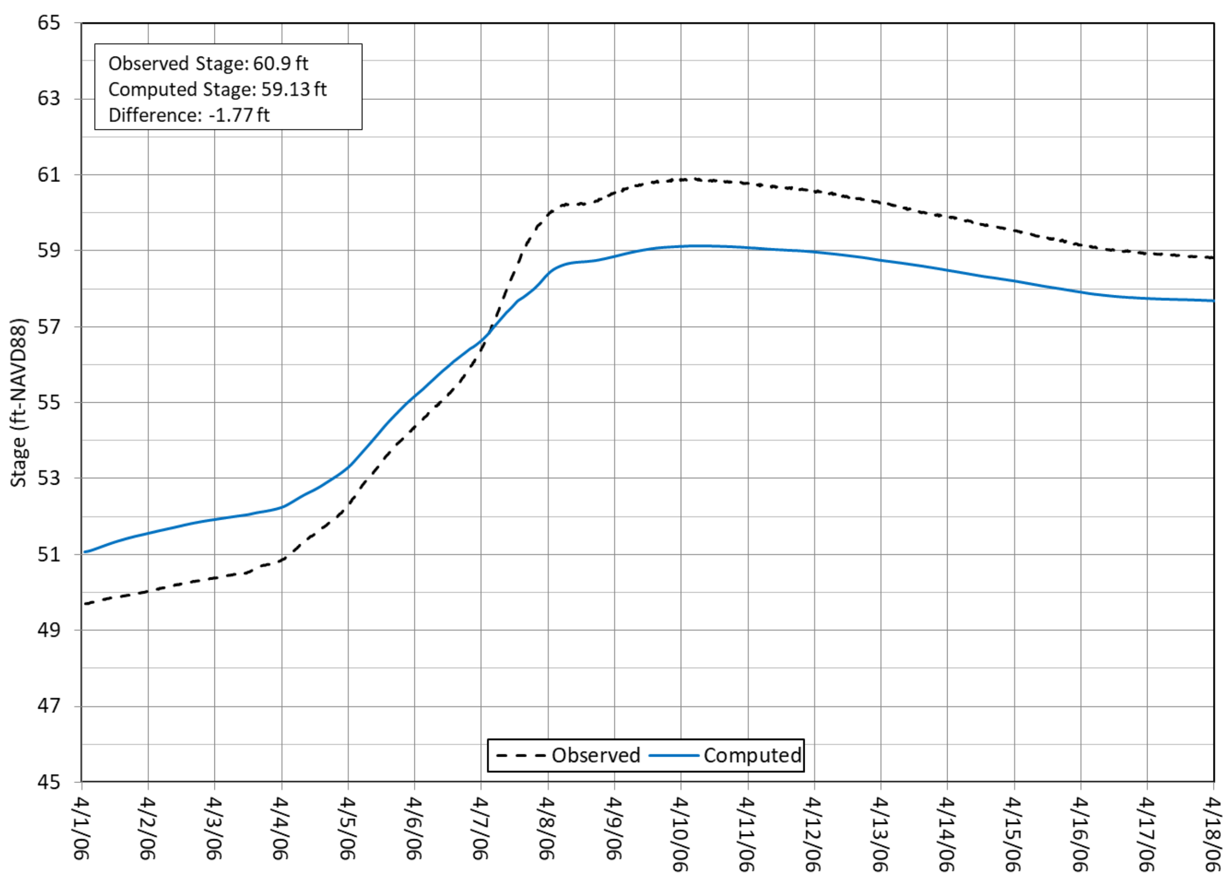


Figure 10. San Joaquin River at Crow's Landing – Stage

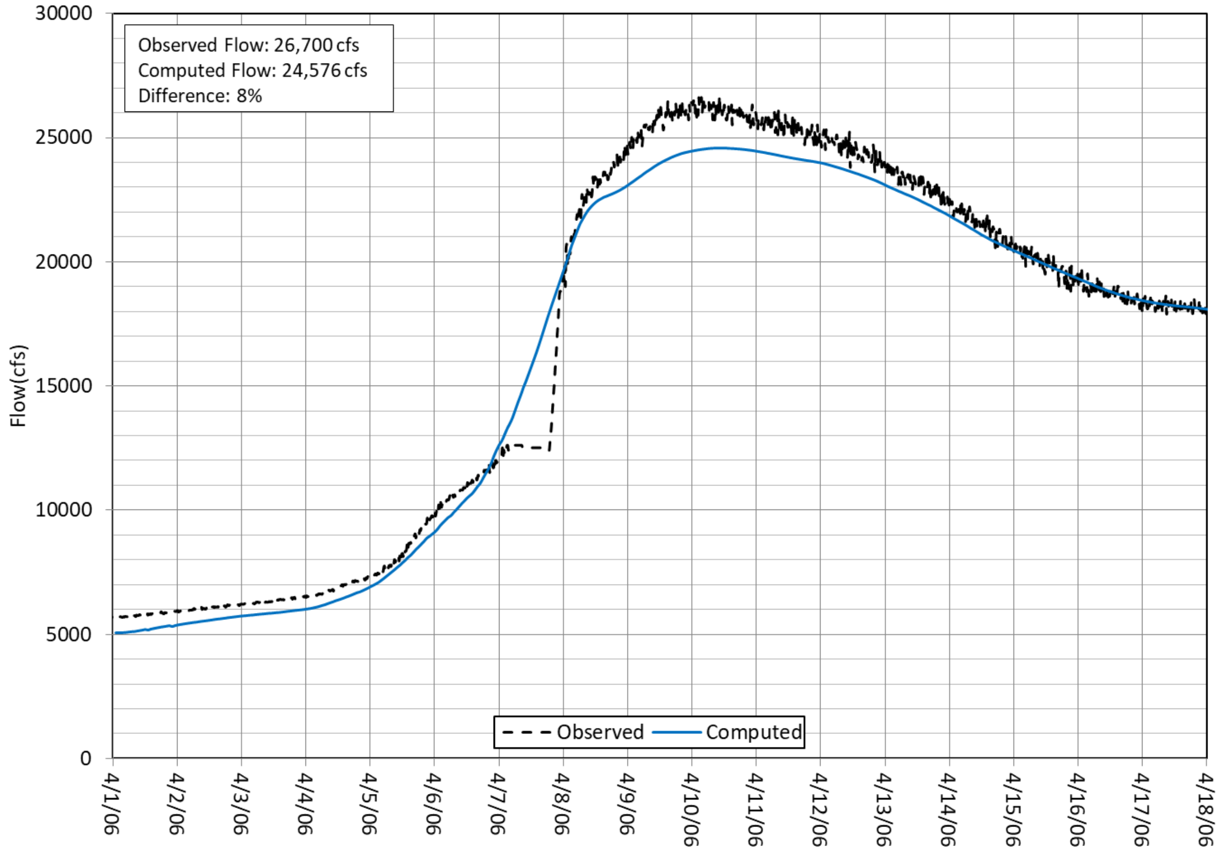


Figure 11. San Joaquin River at Patterson – Flow

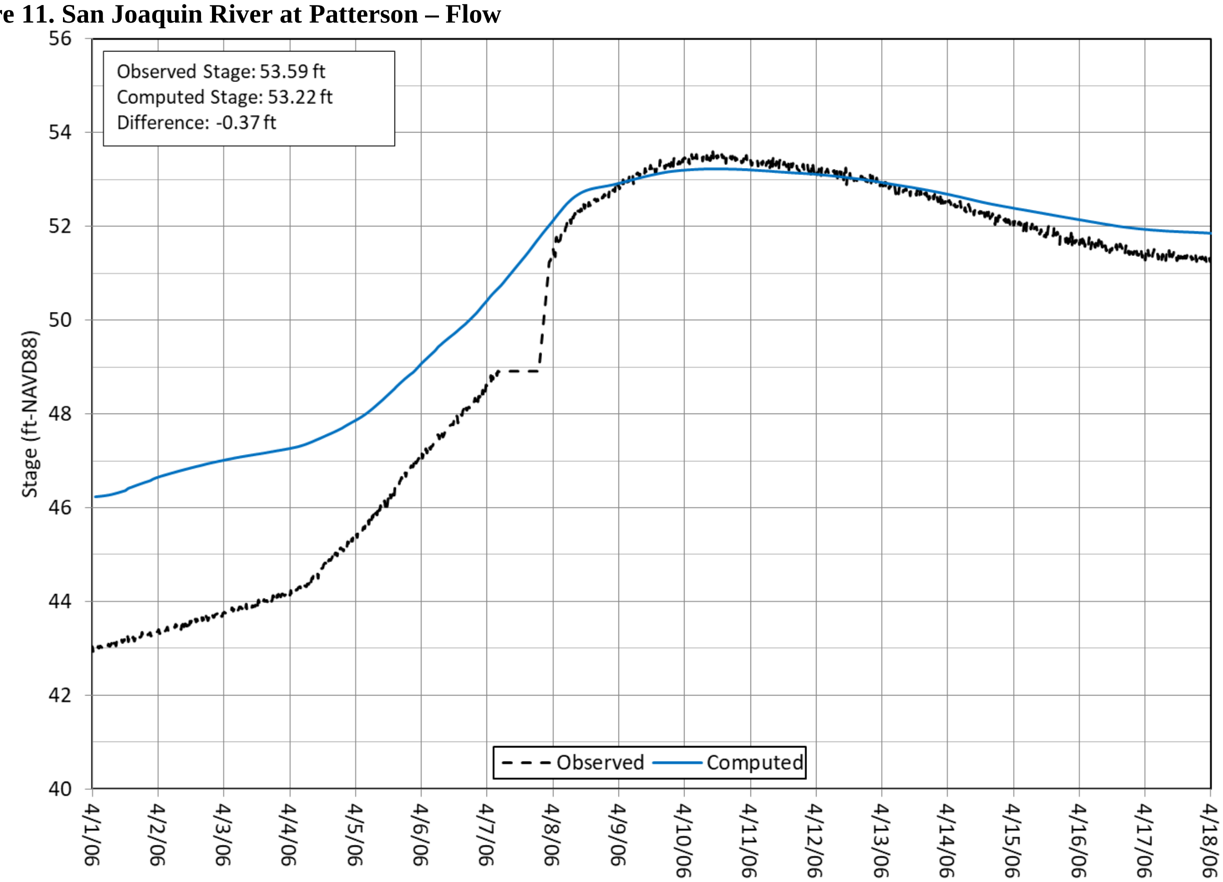


Figure 12. San Joaquin River at Patterson – Stage

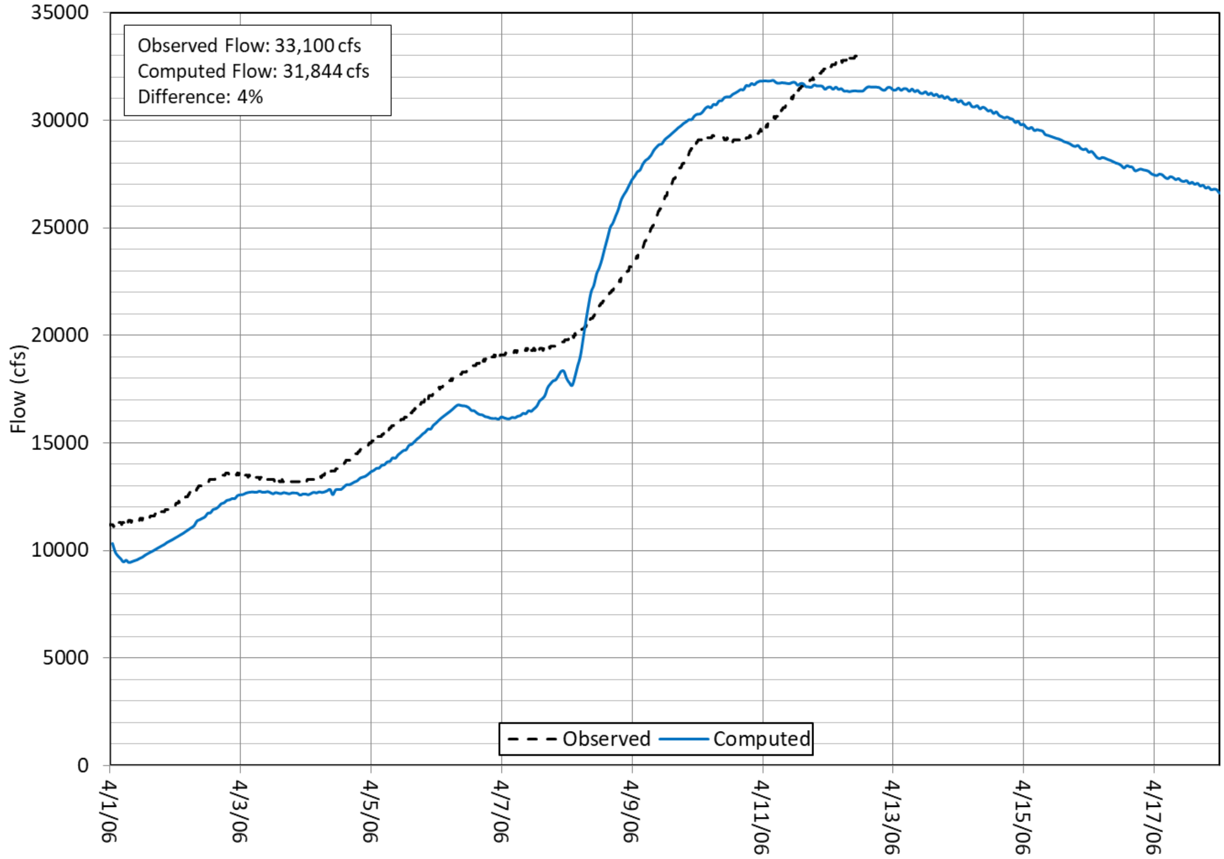


Figure 13. San Joaquin River at Maze Road – Flow

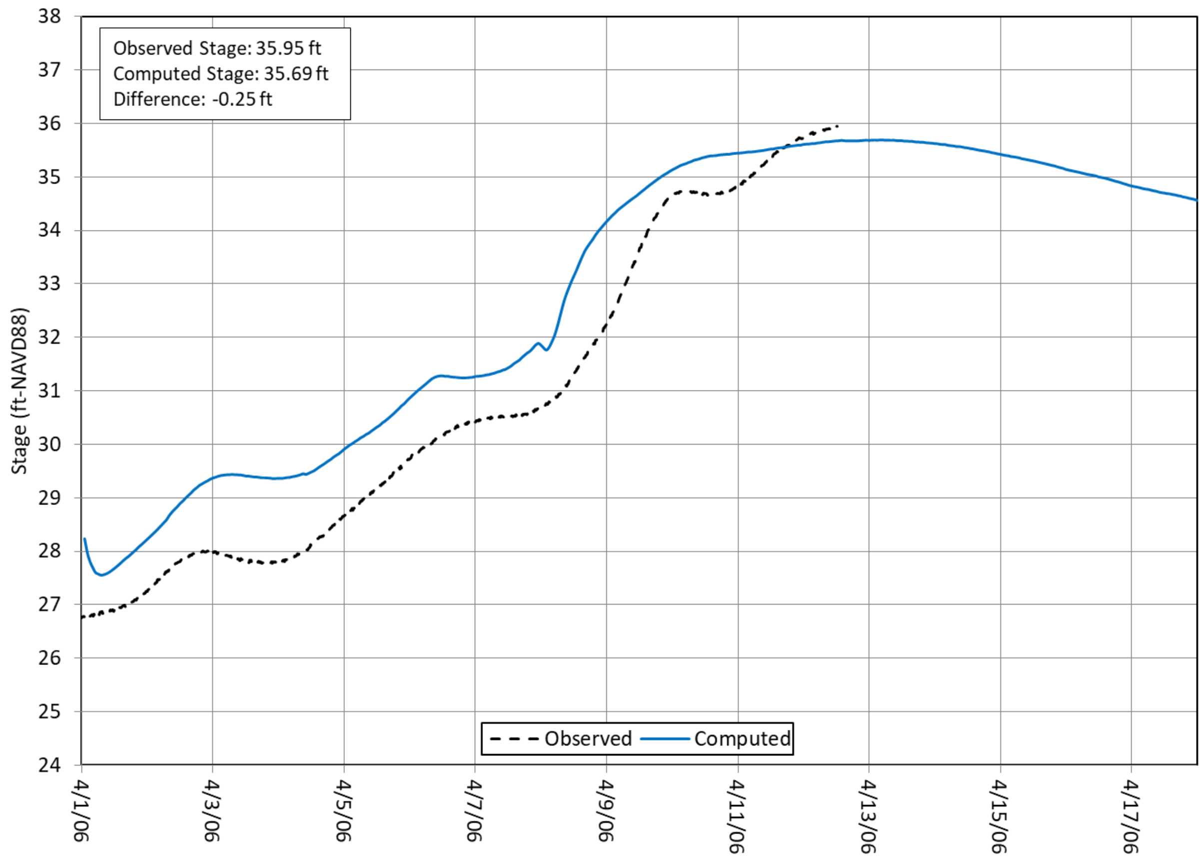
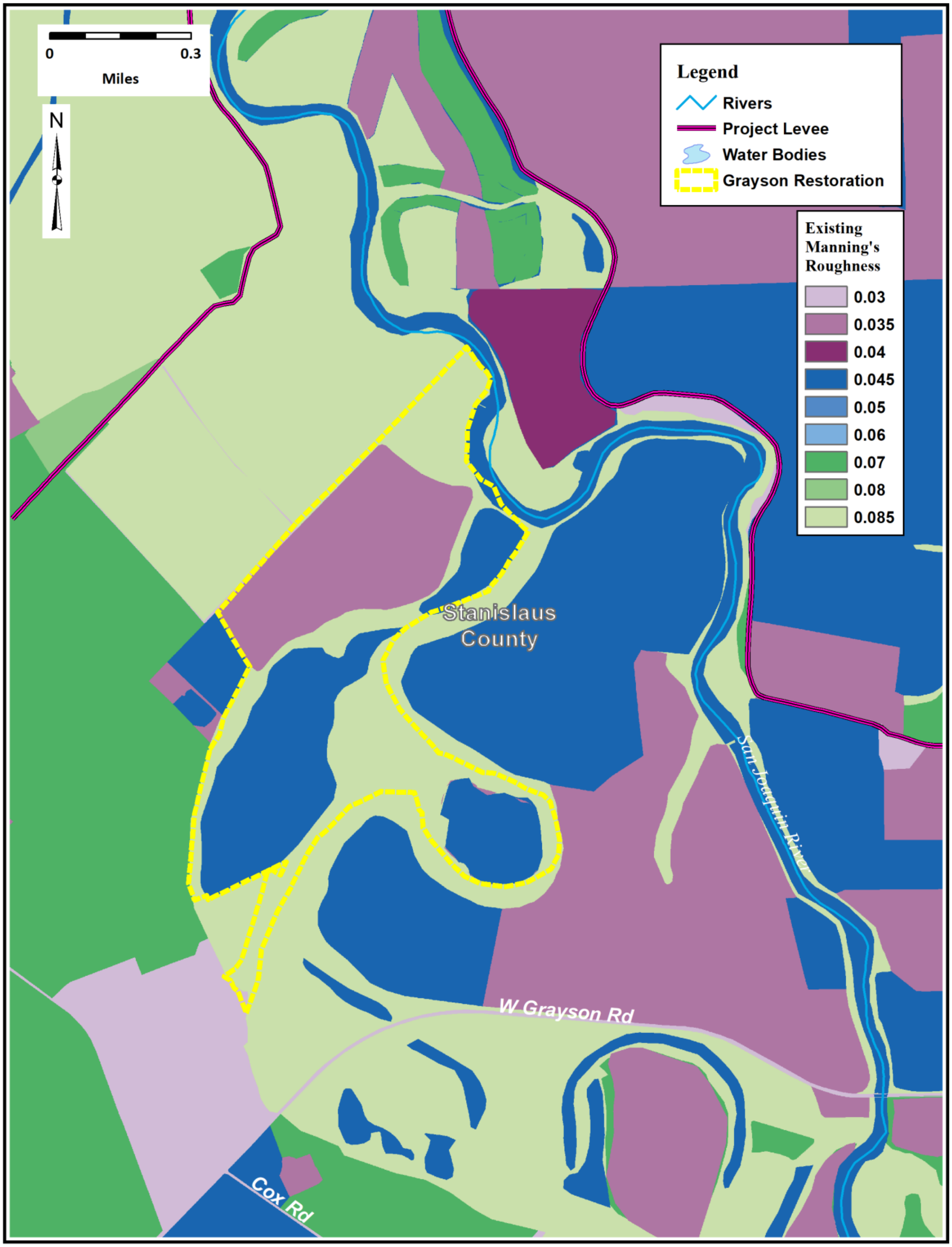


Figure 14. San Joaquin River at Maze Road – Stage



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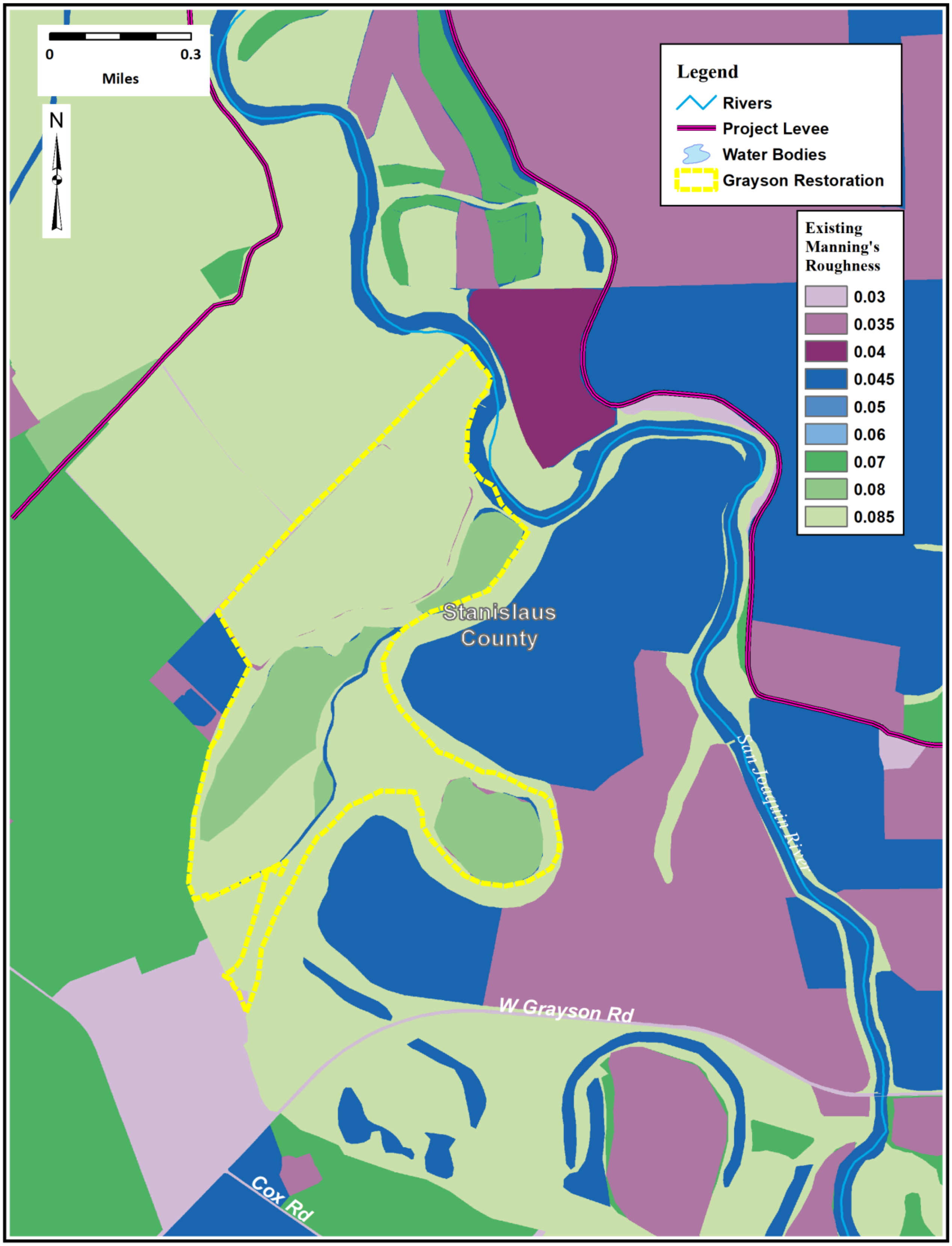
Grayson Riverbend Preserve Restoration Project

Manning's Roughness Coefficients Existing Condition

Figure 15



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Manning's Roughness Coefficients Project Condition
		Figure 16

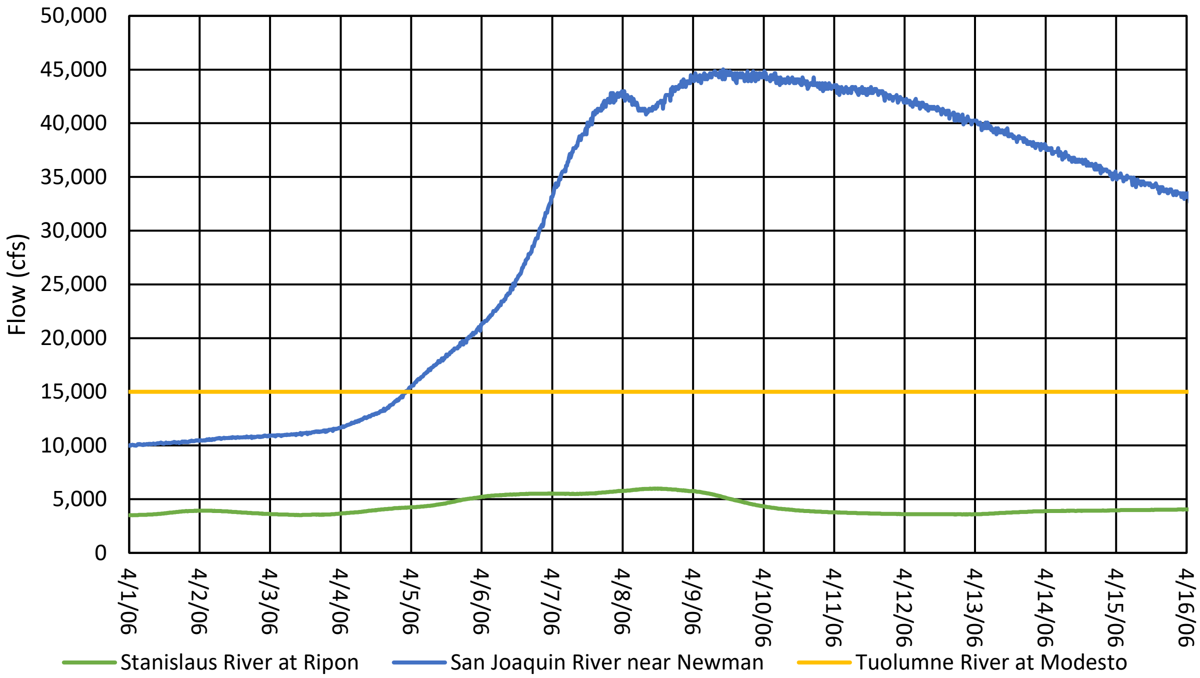


Figure 17. 1955 Design Flow Boundary Conditions

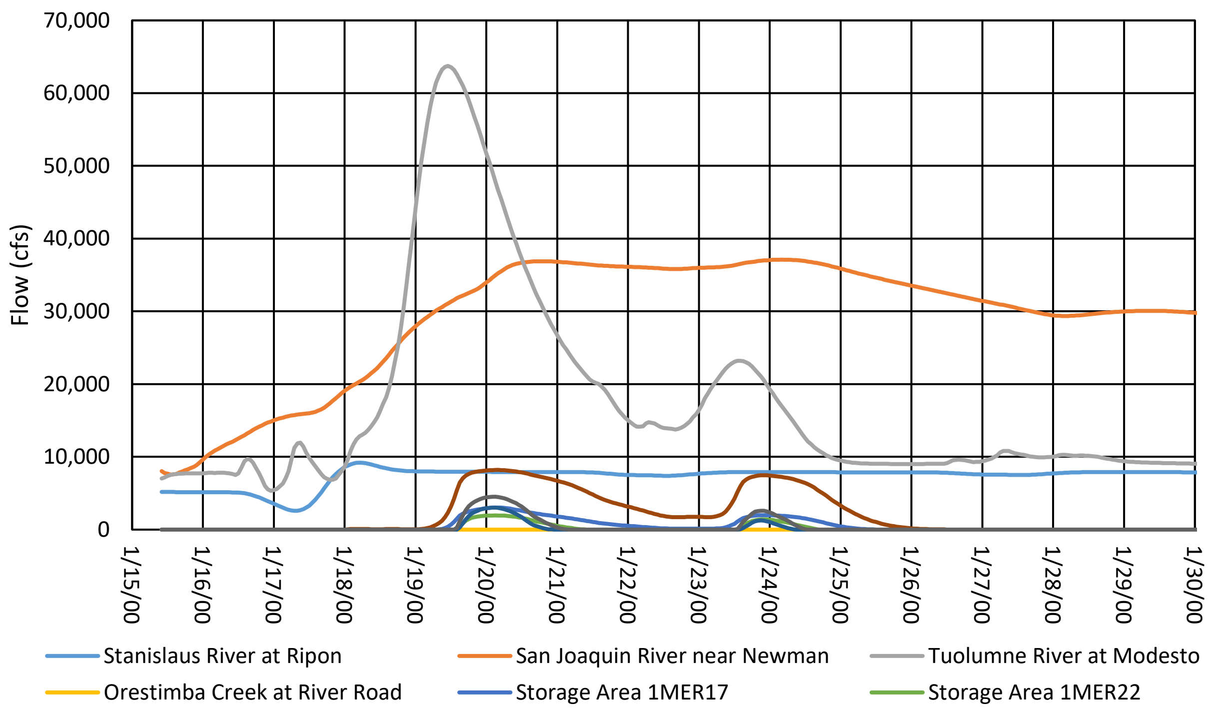


Figure 18. Comp Study 100-Year Flood Boundary Conditions

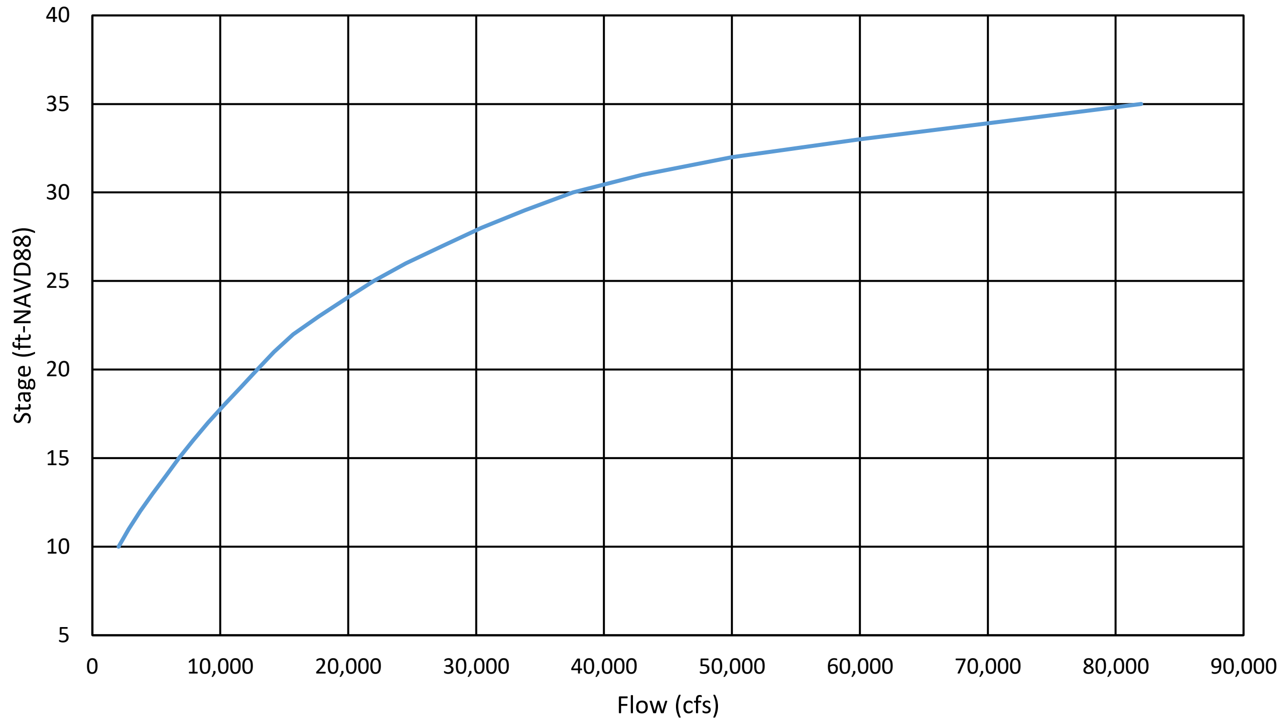
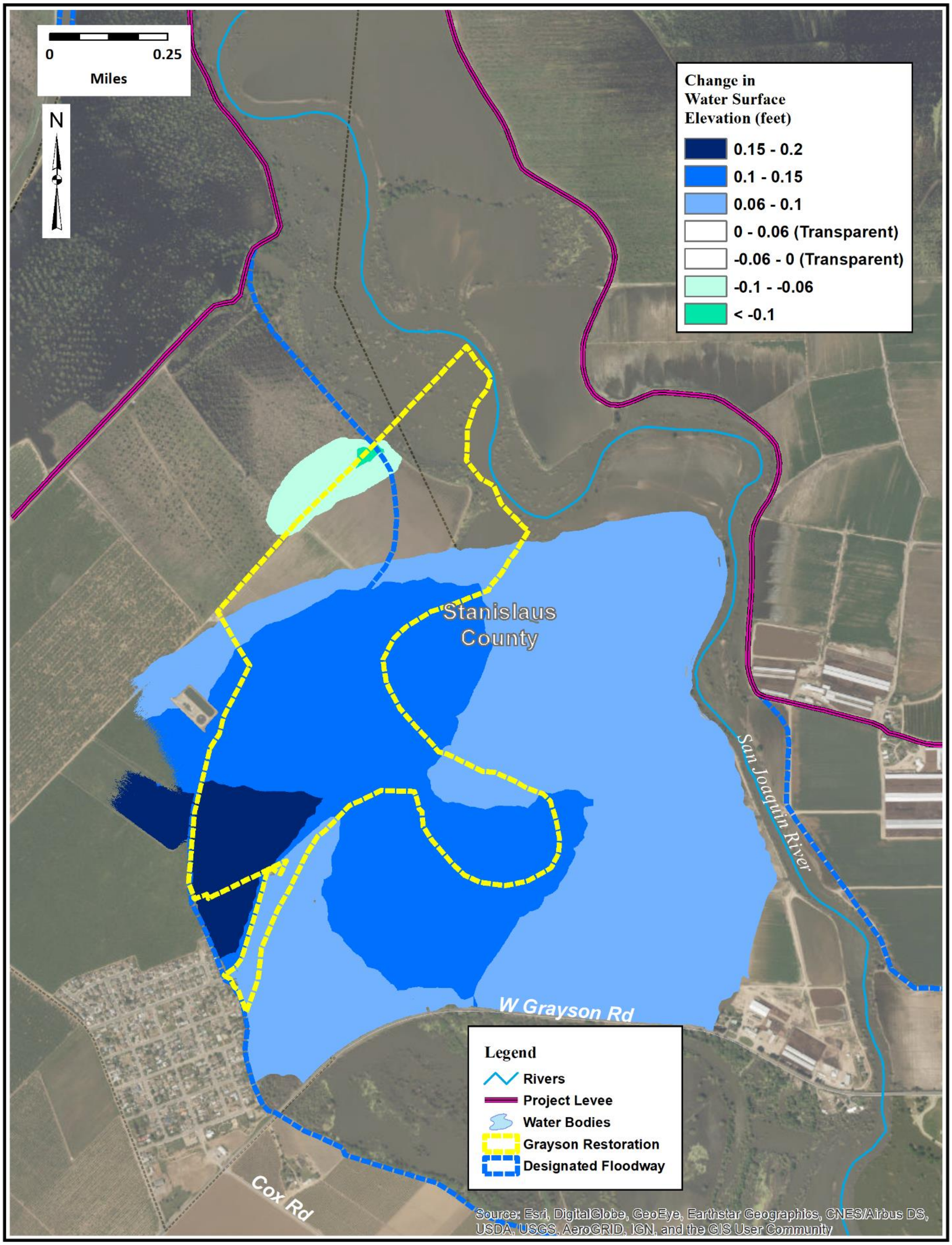
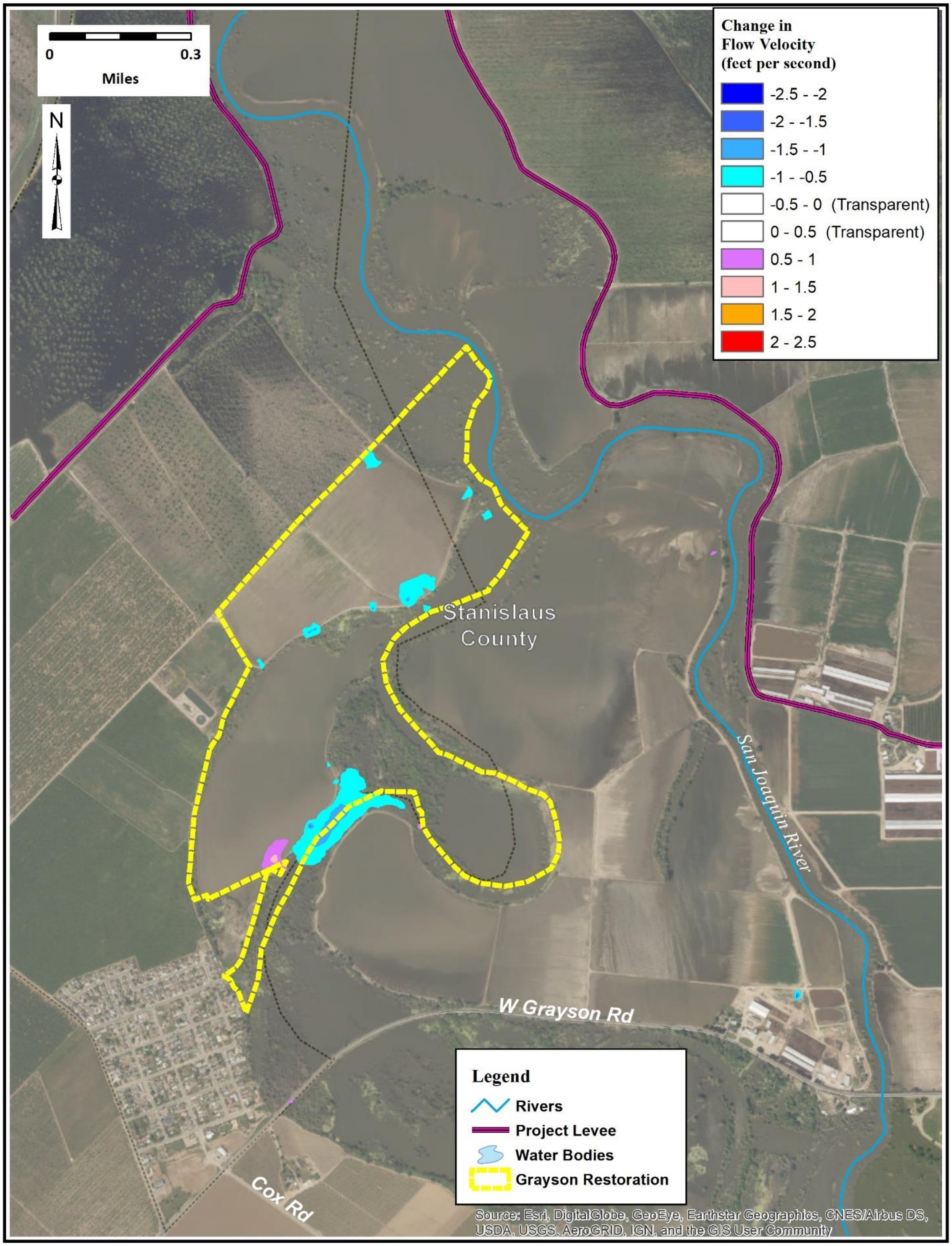


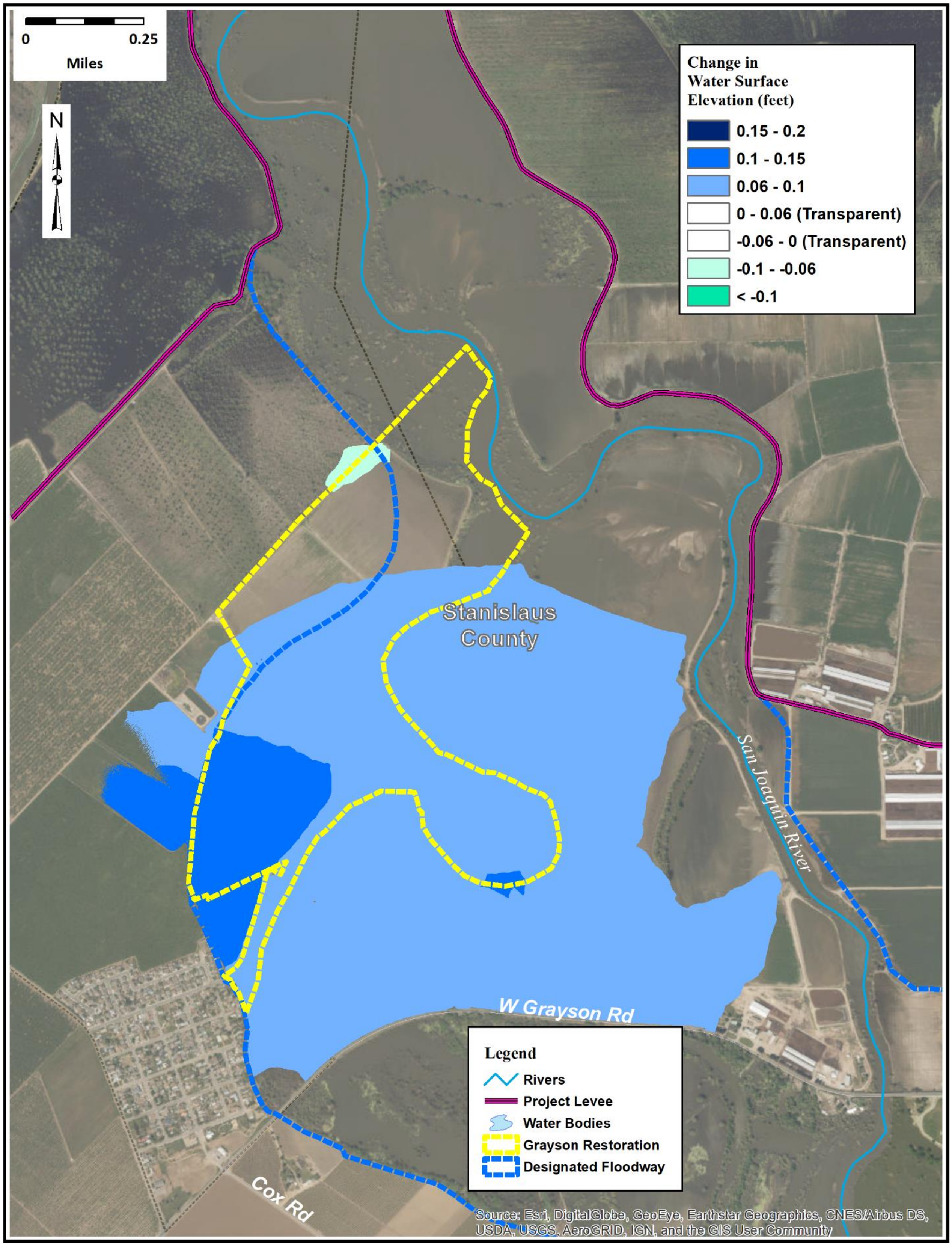
Figure 19. San Joaquin River near Vernalis Rating Curve



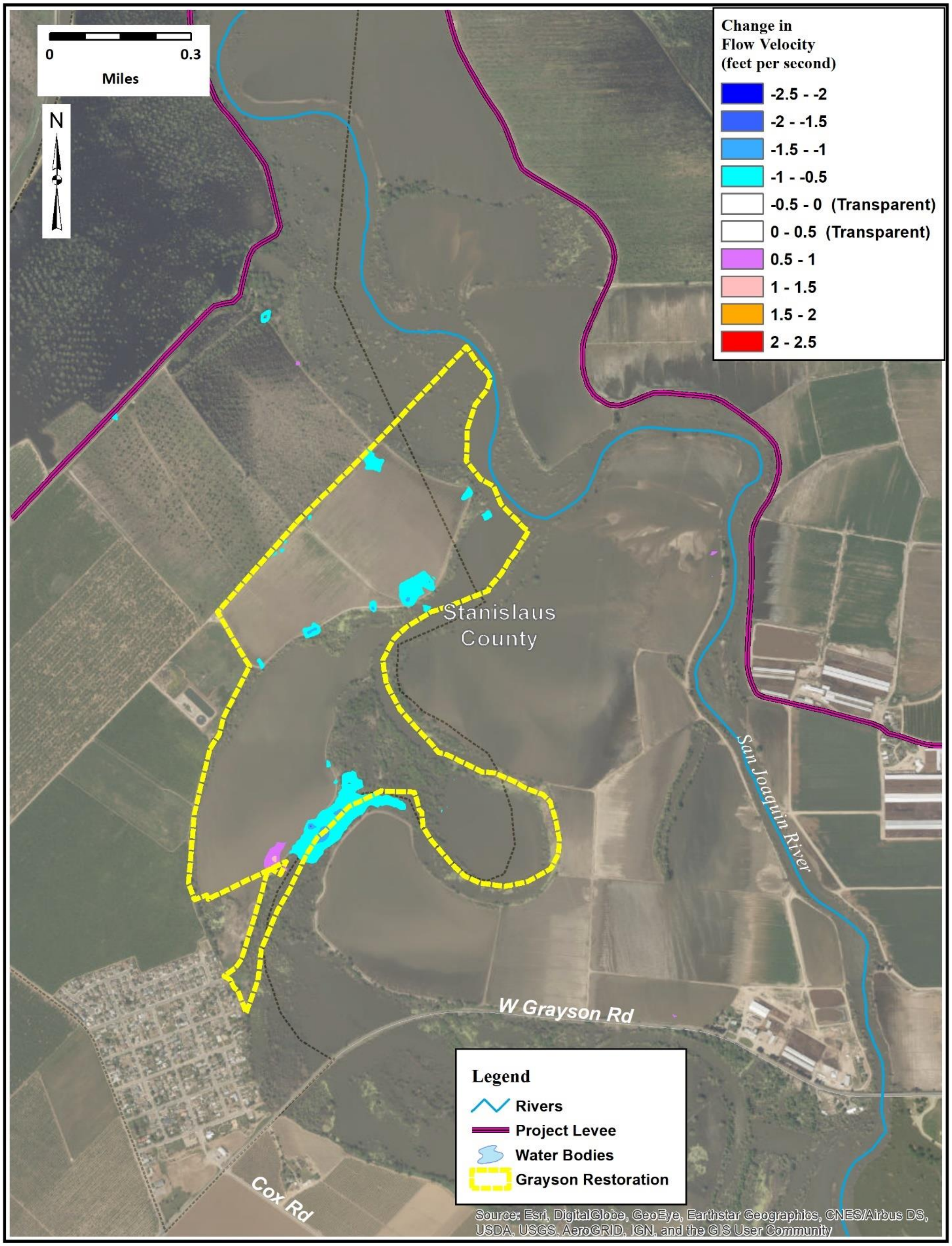
MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Change in Water Surface Elevation 1955 Design Flow
		Figure 20



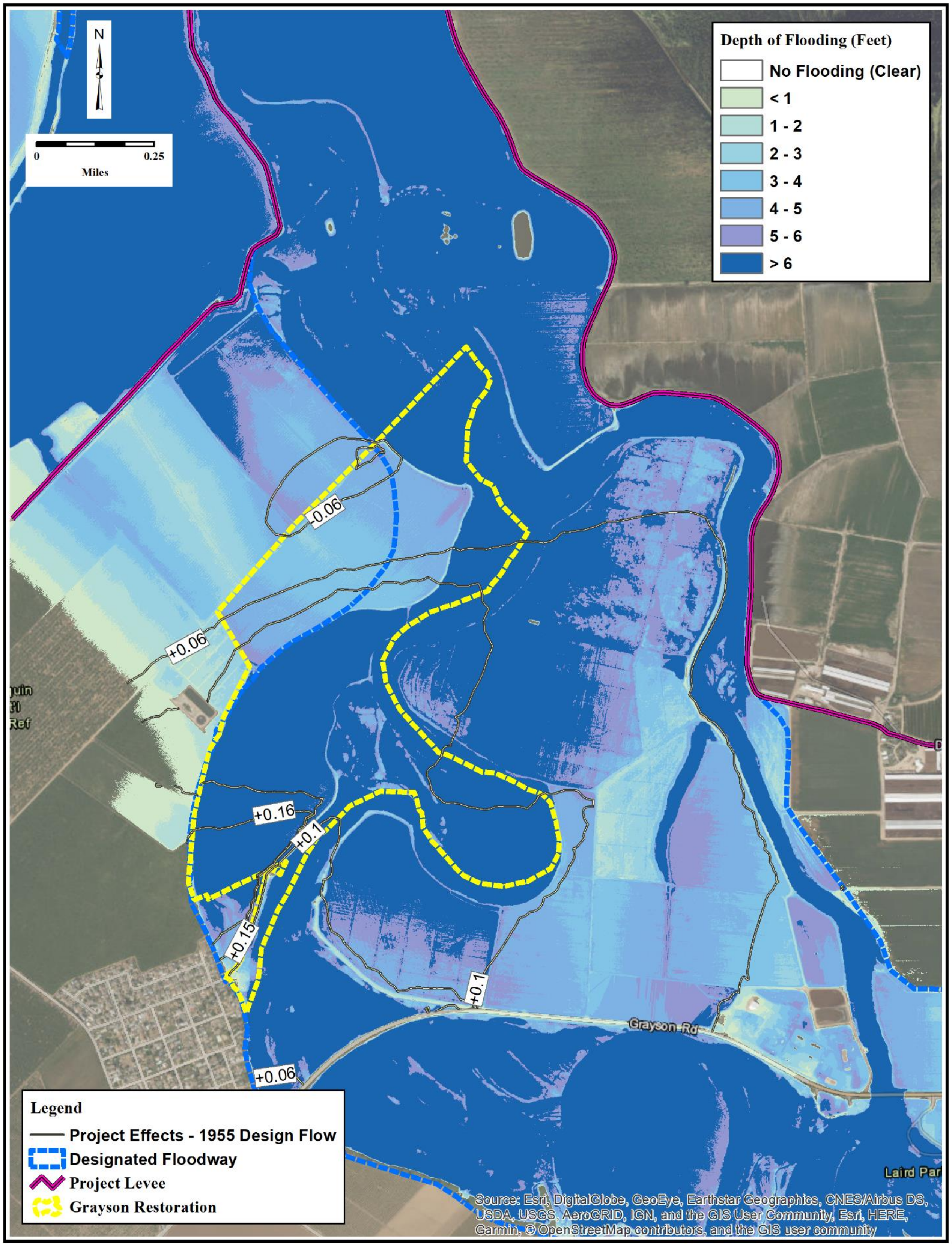
MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Change in Flow Velocity 1955 Design Flow
		Figure 21



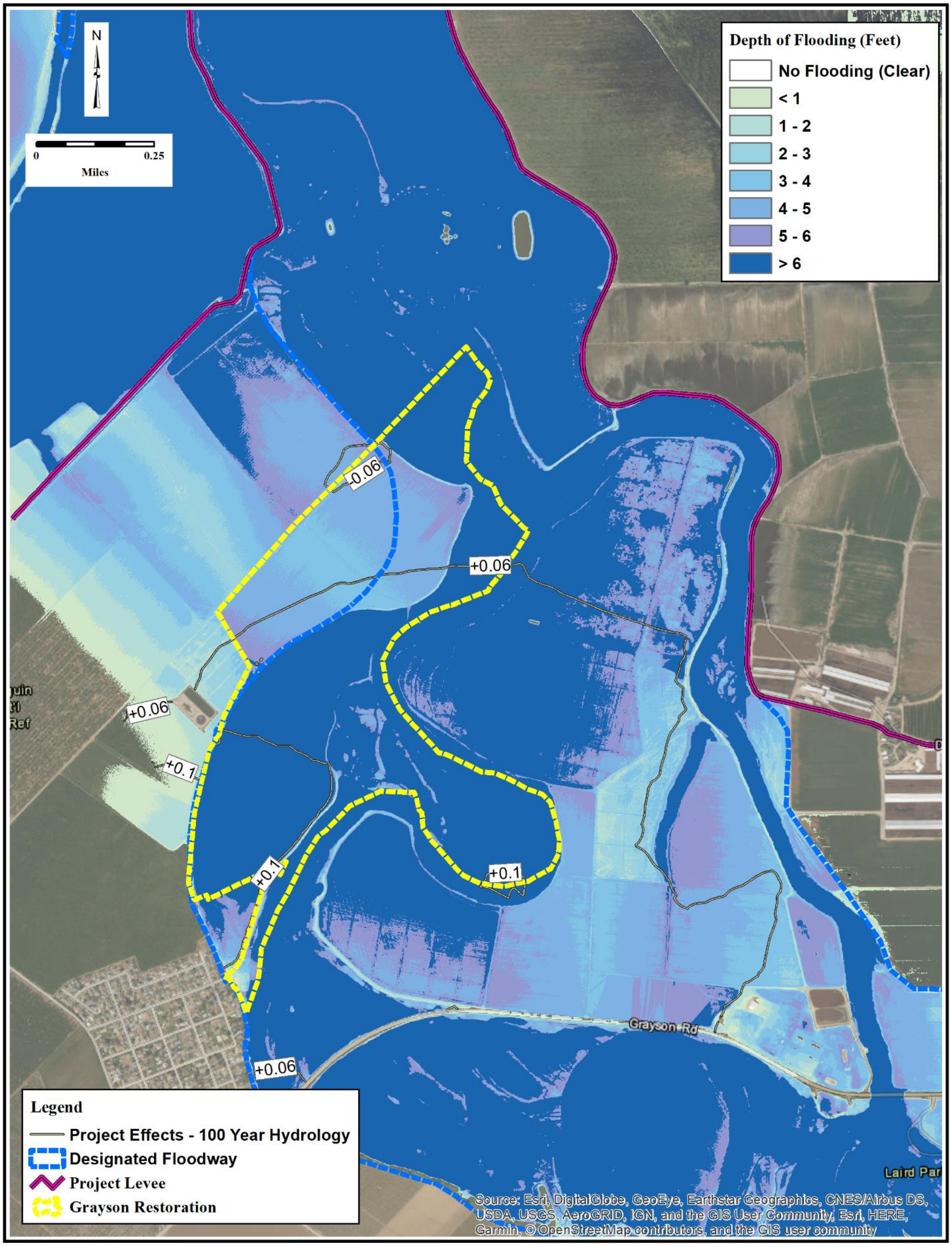
MBK ENGINEERS	**Grayson Riverbend Preserve Restoration Project**	**Change in Water Surface Elevation 1-in-100 Year Flow**
		Figure 22



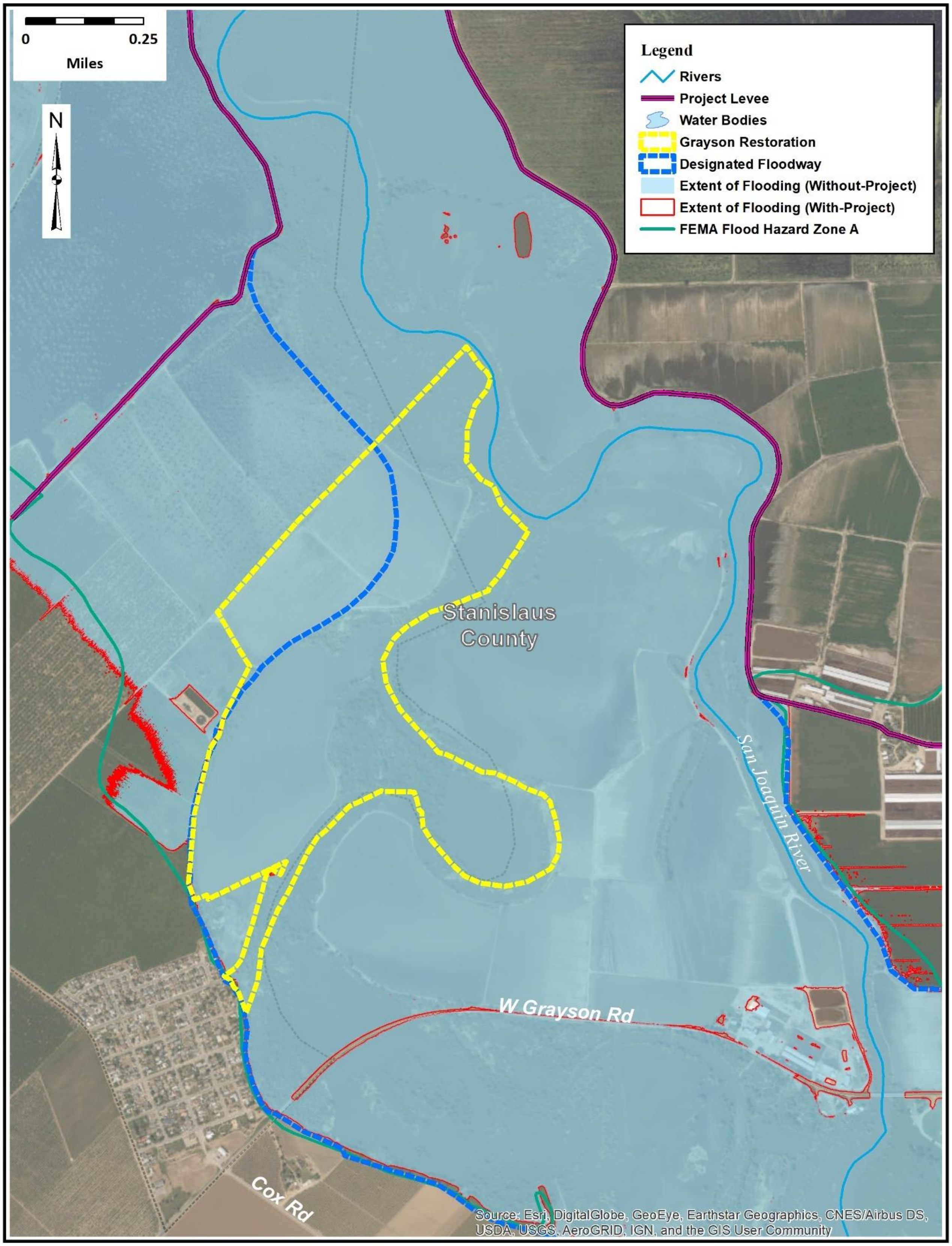
MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Change in Flow Velocity 1-in-100 Year Flow
		Figure 23



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Maximum Flood Depth 1955 Design Flow
		Figure 24



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Maximum Flood Depth 1-in-100 Year Flow
		Figure 25

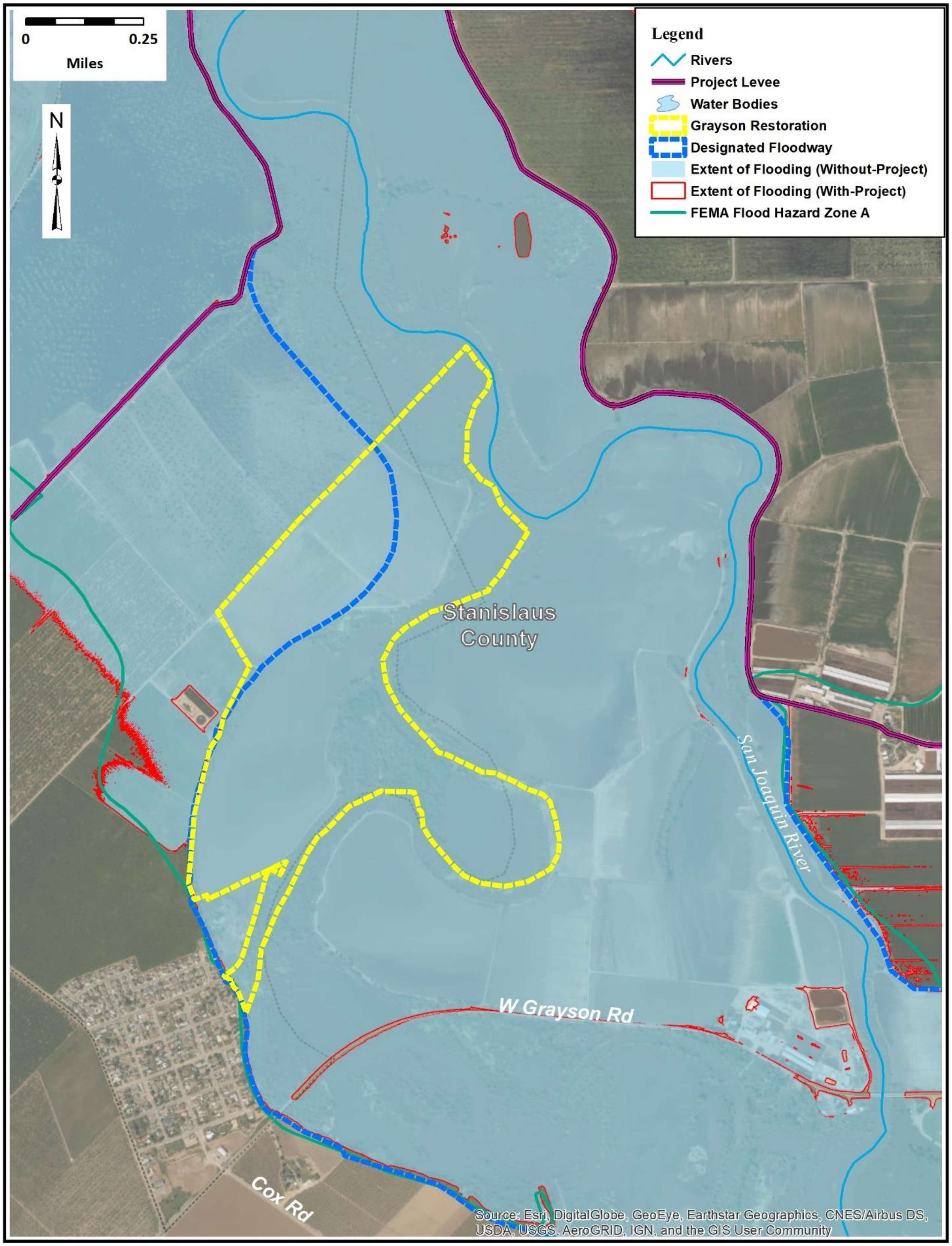


MBK ENGINEERS

Grayson Riverbend Preserve Restoration Project

Maximum Flood Extent 1955 Design Flow

Figure 26



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Maximum Flood Extent 1-in-100 Year Flow
		Figure 27

Appendix III

River Partners

Evapotranspiration at the Grayson Property

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River Partners
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Background

This report was prepared at the request of River Partners to examine historical and predicted future vegetation evapotranspiration on Grayson Ranch. Evapotranspiration is the water that evaporates from the soil and plant surfaces plus the water that moves through the plants into the atmosphere (transpiration).

The Grayson property is in Stanislaus County. River Partners is replacing the agricultural fields with native vegetation. This vegetation will be irrigated for approximately three years and then it will rely on rainfall and shallow groundwater into the future. The objectives of this study were to:

1. Determine, using remote sensing, the historic actual evapotranspiration from the fields and existing natural areas in Grayson.
2. Predict future evapotranspiration demands once the native areas mature in 10-20 years.

The process to measure the actual consumptive use in Grayson is called ITRC-METRIC (Irrigation Training and Research Center modified Mapping EvapoTRanspiration with Internal Calibration). This methodology has been used extensively throughout California (and worldwide) to determine actual evapotranspiration from vegetation.

The basic strategy for estimating future water requirements leverages ITRC-METRIC and the fact that this project borders rehabilitated areas in the San Joaquin National Wildlife Refuge (SJNWR). This area has been restored over time with various plantings that will be similar to those used in Grayson. Older restored sites were planted in 2002 and younger plantings in 2012. The fields in SJNWR will be used to predict the evapotranspiration in the Grayson post restoration. The fields in Grayson, SJNWR, and another River Partners' project (Dos Rios) are shown in Figure 1.

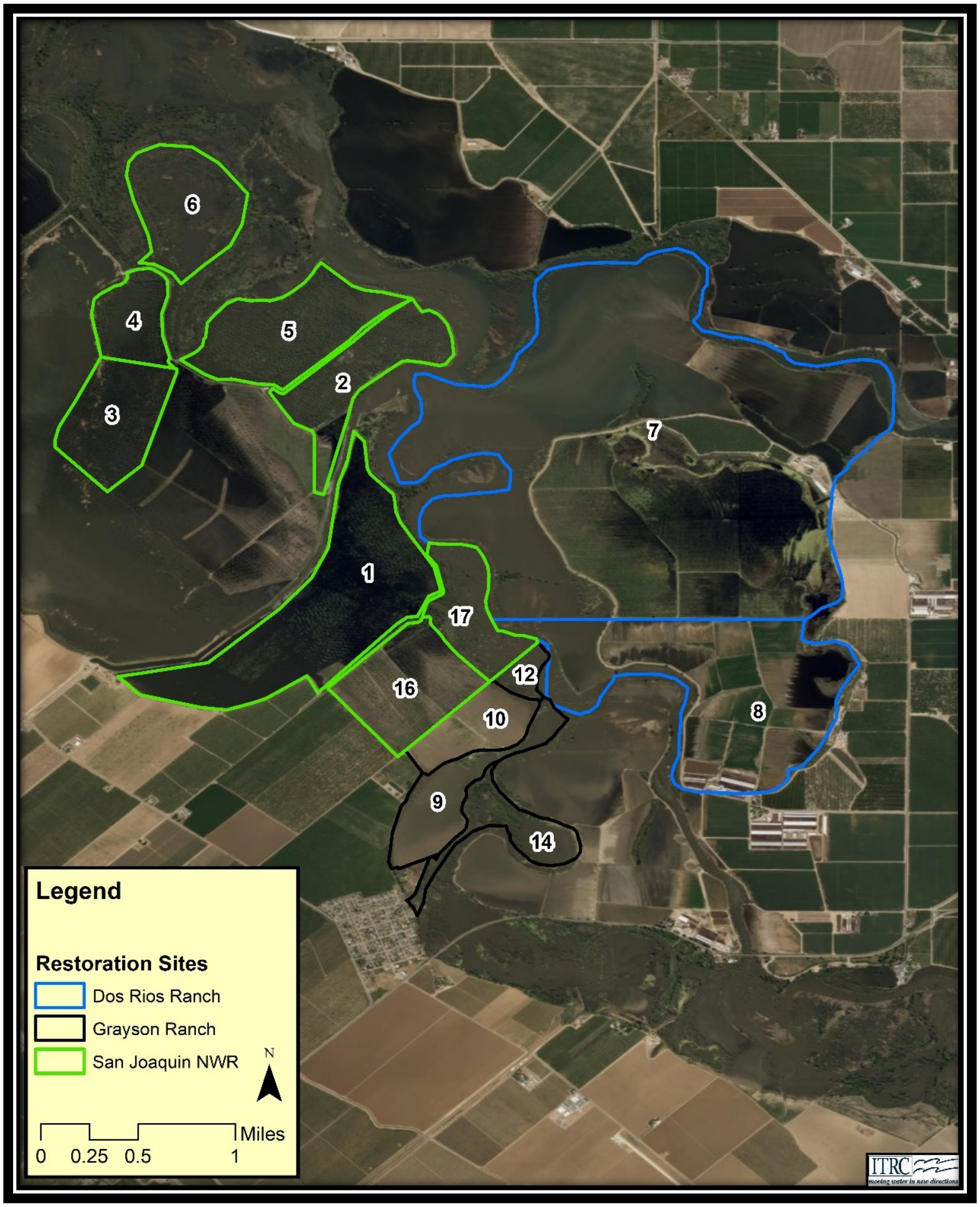


Figure 1. Grayson fields and nearby fields in Dos Rios and SJNWR

ITRC- METRIC Procedures

This *Procedures* section will discuss the information that was gathered and used to compute the actual crop evapotranspiration (ET). The ITRC-METRIC process is based on a surface energy balance and includes corrections for aerodynamic resistance. It depends upon both accurate and frequent LandSAT satellite thermal images and understanding of the cropping systems within a region. The METRIC programs have gradually evolved from research in the US and other countries with the objective of being able to directly estimate actual ET over large areas with limited data availability (such as crop type, irrigation method, irrigation practices, etc.). The image processing is relatively fast; however, the collection of significant background data (besides the satellite images) that are necessary to start the processing in a new area can be somewhat time-consuming. Proper use of METRIC also requires expert input/interpretation by those who run the program.

LandSAT 5, 7, and 8 image pixel resolution is 30 meters by 30 meters for all but the thermal band. The thermal band pixel resolution is 120 meters by 120 meters for LandSAT 5, 60 meters by 60 meters for LandSAT 7, and 100 meters by 100 meters for LandSAT 8. For this project, the thermal band was sharpened to 30-meter by 30-meter resolution using the nominal cubic spline that is provided in the raw images by USGS. ITRC has a more advanced thermal sharpening process, but that was not used because of time and budget constraints for this project. Inputs into the ITRC-METRIC model included:

- LandSAT imagery
- Digital elevation maps
- NASS CropScape data
- Corrected weather station data (hourly and daily)
- Corrected spatial grass reference evapotranspiration (ETo) maps (daily)
- Spreadsheet calculated values
- Tabulated constants

Satellite Images

LandSAT 5, 7 and 8 images available from the United States Geological Survey (USGS) on sixteen-day intervals were used for the METRIC process. Table 1 shows the time frame of available images from each satellite.

Table 1. Time frame of available images for LandSAT 5, 7, and 8

LandSAT 5	LandSAT 7**	LandSAT 8
June 1982 – Oct. 2011	June 1999 – Present	April 2013 – Present

***After May 2003, LandSAT 7 began producing images with missing data, or "bandgaps" because of a defective sensor/mirror. LandSAT 7 is only used as a backup if other LandSAT data is missing. Bandgaps are filled using interpolation techniques in GIS as described in the METRIC Application Manual Version 2.0.7 (Allen et al 2010)*

The area of interest is covered by the LandSAT image path 43, rows 34 and 35**.** Each path identifies a path, or single trip the LandSAT takes, and the rows are different portions of that path. The rows along the same path are taken on the same day and the center of the row image is taken at approximately the same time of the day (approximately 11 a.m. Pacific Standard Time).

The METRIC modeling process relies on surface temperature data from the LandSAT thermal band. Actual ETc cannot be computed for the regions covered by clouds or fog. Figure 2 compares a non-clouded image with a cloud-covered LandSAT image. The best quality (minimal clouds and fog) LandSAT images were selected for processing. Every LandSAT image available throughout the study period was evaluated manually.

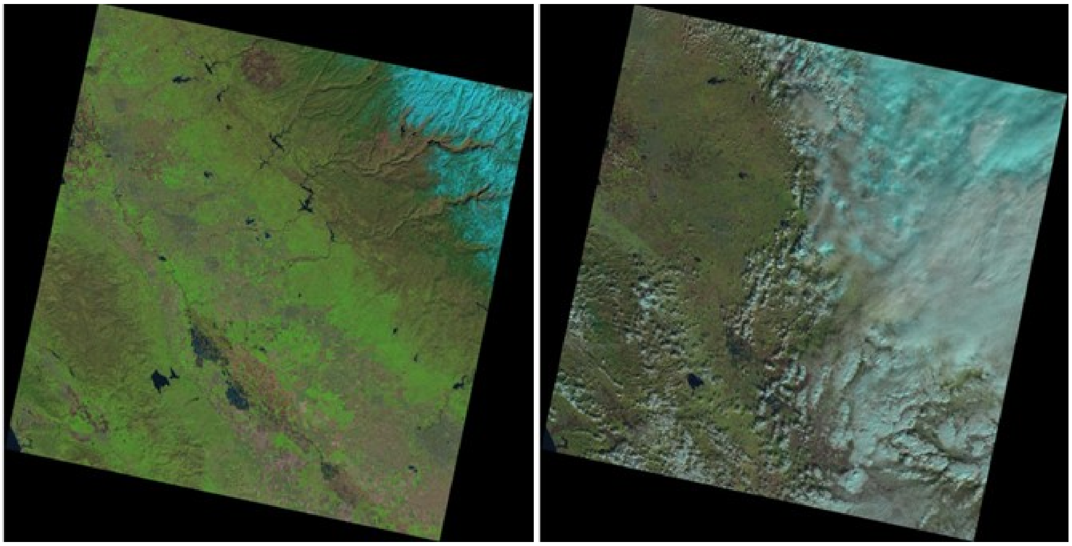


Figure 2. Cloud-free LandSAT image (left) and LandSAT image with clouds (right)

All relatively cloud-free available images were used for the modeling process. Table 2 shows the images processed for the study period. A total of 29 images were used to cover the newly processed 2015 to 2016 time frame. The images utilized from the previous years are also shown as a reference.

If a cloud-free image was not available during a month, the image with the fewest clouds was selected or LandSAT 7 imagery was used. If an image with clouds had to be used, the clouds were masked out of the results and replaced with interpolated results from images processed before and after the image date. For the cloud masking interpolation, the two previous and three subsequent processed images were used to estimate the actual pixel crop coefficient for the cloudy region.

Some months (generally during winter) had no usable images because of significant cloud cover. Available images, before and after the month with no data, were selected to be used to interpolate the missing image.

Table 2. Chosen image dates for METRIC processing

2008	2009	2010	2011	2013	2014	2015	2016
2/7/2008	1/16/2009*	2/12/2010	2/7/2011*	4/25/2013	1/22/2014	1/1/2015*	2/5/2016*
3/26/2008	2/1/2009*	4/1/2010	3/11/2011*	5/11/2013	2/23/2014	2/26/2015	2/29/2016
4/11/2008	3/13/2009	5/1/1935	4/4/2011	6/12/2013	3/11/2014	3/14/2015	3/16/2016
4/27/2008	4/30/2009	5/19/2010	5/6/2011	6/28/2013	3/19/2014*	4/15/2015	4/17/2016
5/13/2008	5/16/2009	6/20/2010	6/23/2011	7/14/2013	4/28/2014	5/1/2015	5/27/2016*
5/29/2008	6/17/2009	7/6/2010	7/9/2011	7/30/2013	5/14/2014	6/2/2015	6/28/2016*
6/14/2008	7/3/2009	7/22/2010	8/10/2011	8/15/2013	6/15/2014	6/18/2015	7/6/2016
6/30/2008	8/4/2009	8/7/2010	9/27/2011	8/31/2013	7/1/2014	7/4/2015	7/22/2016
7/16/2008	9/21/2009	8/23/2010	10/29/2011	9/16/2013	8/18/2014	8/21/2015	8/7/2016
8/1/2008	10/7/2009	9/24/2010	12/24/2011*	10/18/2013	9/3/2014	9/6/2015	8/23/2016
8/17/2008	11/16/2009*	10/10/2010	1/9/2012*	12/25/2013	10/5/2014	9/22/2015	9/8/2016
9/2/2008	12/2/2009*	11/11/2010	2/26/2012*	12/21/2013	11/14/2014*	10/16/2015*	9/24/2016
9/18/2008						11/1/2015*	10/26/2016
10/20/2008							11/3/2016*
							12/19/2016

Note: * indicates LandSAT 7, ** indicates LandSAT 8, and no asterisk indicates LandSAT 5 images

Weather Data

Hourly weather data for the project time frame was collected from California Irrigation Management Information System (CIMIS) weather stations located throughout the project area. Dozens of individual weather stations were used for the METRIC modeling process. Figure 3 shows the approximate locations of weather stations used in this project. Each station is listed in Table 3 showing the approximate range of time that the station was utilized. A station may have become active or inactive within this time frame.

The Los Banos #56 CIMIS station was utilized as the "primary" weather station. This station was selected because of its centralized location within the primary area of interest (see Figure 3). The same quality control procedure was used at all weather stations as will be described.

The weather component data collected from the weather stations included:

1. Solar radiation (W/m^2)
2. Vapor pressure (kPa)
3. Air temperature (ºC)
4. Wind speed (m/s)
5. Precipitation (mm)
6. Relative humidity (%)
7. Dew point temperature (ºC)
8. PM ETo (mm)

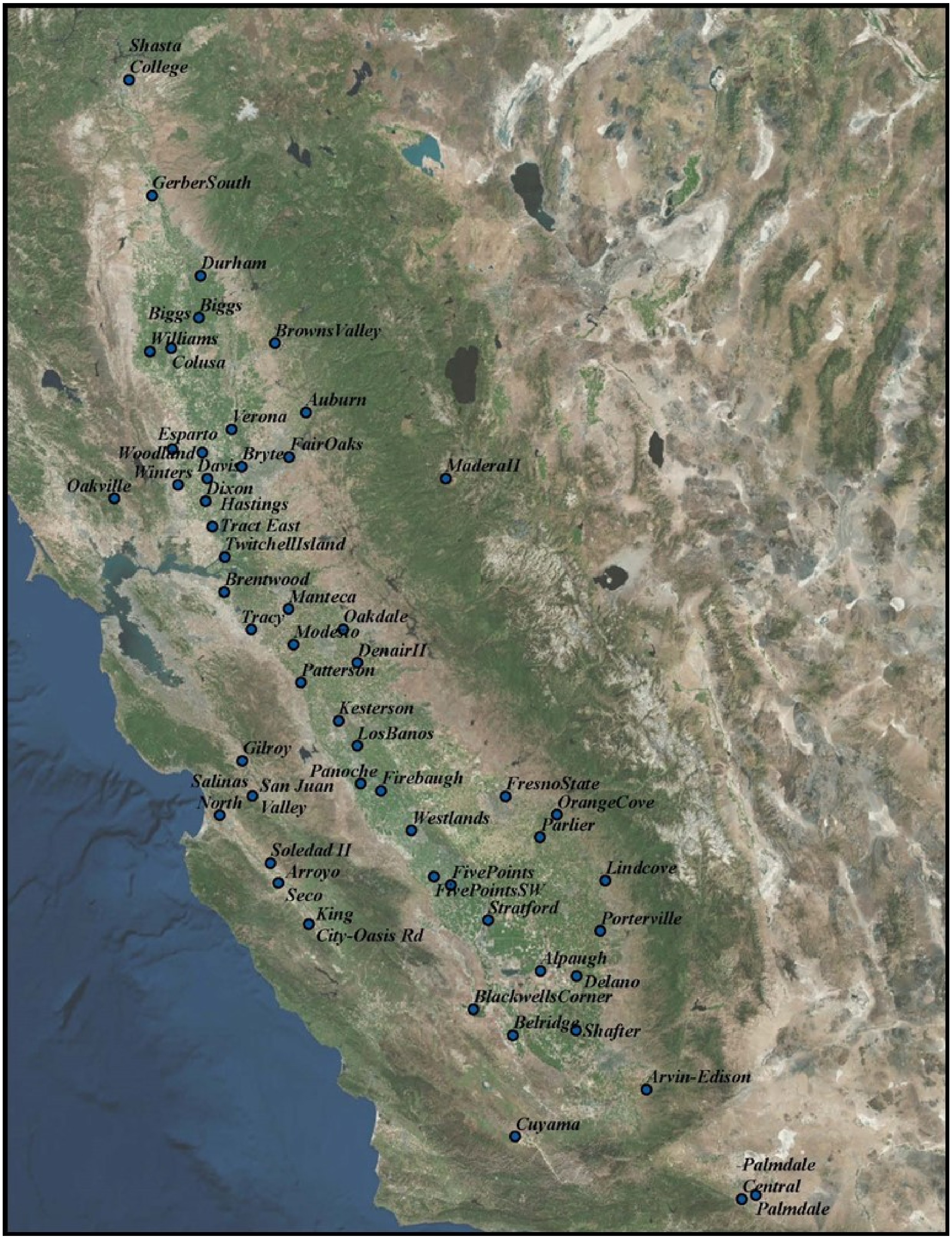


Figure 3. Locations of the CIMIS weather stations used in this evaluation

Table 3. Weather stations used for the METRIC modeling process

2008-2015 CIMIS Station		**2016-2017 CIMIS Station**	
Alpaugh	Kettleman	Alpaugh	Los Banos
Arvin-Edison	Lindcove	Arroyo Seco	Madera II
Auburn	Lodi West	Arvin-Edison	Manteca
Belridge	Los Banos	Auburn	Meloland
Blackwells Corner	Madera	Belridge	Merced
Brentwood	Madera II	Biggs	Modesto
Browns Valley	Manteca	Blackwells Corner	Oakdale
Bryte	Merced	Brentwood	Oakville
Colusa	Modesto	Browns Valley	Oasis
Davis	Oakdale	Bryte	Orange Cove
Delano	Orange Cove	Calipatria Mulberry	Palmdale
Denair II	Panoche	Colusa	Palmdale II
Dixon	Parlier	Cuyama	Panoche
Durham	Patterson	Davis	Parlier
Esparto	Porterville	Delano	Patterson
Fair Oaks	Shafter	Denair II	Porterville
Famoso*	Shasta College	Dixon	Ripley
Firebaugh	Stratford	Durham	Salinas North
Five Points	Tracy	Esparto	San Juan Valley
Five Points SW	Twitchell Island	Fair Oaks	Seeley
Fresno State	Verona	Firebaugh	Shafter
Gerber	Westlands	Five Points	Shasta College
Gerber South	Winters	Five Points SW	Stratford
Hastings Tract East	Woodland	Fresno State	Thermal South
Kesterson		Gerber South	Tracy
		Gilroy	Twitchell Island
		Hastings Tract East	Verona
		Indio II	Westlands
		Kesterson	Westmorland North
		King City-Oasis Rd	Williams
		La Quinta II	Winters
		Lindcove	Woodland
		Lodi West	

Hourly weather data from the primary station went through a quality control check and correction procedure. A detailed procedure on the quality control conducted can be found in FAO Irrigation and Drainage Paper No. 56[1] along with correction procedures. The main variable needing correction to accurately compute the hourly ETo is solar radiation. However, relative humidity was also examined using the procedures described in Allen et al (1998). Figure 4 contains a graph of the corrected solar radiation for the Los Banos CIMIS station for 2015 through half of 2017. This weather parameter is often in error if a pyranometer becomes covered with dust or debris, or if it loses calibration. This can be identified by comparing the daily incoming solar radiation with the maximum potential solar radiation (computed based on elevation, latitude, and time of year). If the measured value does not approach or become equal to the maximum potential over a time frame of several weeks, this could indicate an error in the measurement. Day-to-day variability is expected, but during a clear day, the measured should approach the potential. High values of solar radiation can be caused by incorrect sensor calibration.

[1] Allen, R.G.; Pereira, L.S.; Raes, D. & Smith, M. (1998). Crop evapotranspiration – Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper, No. 56, FAO, Rome

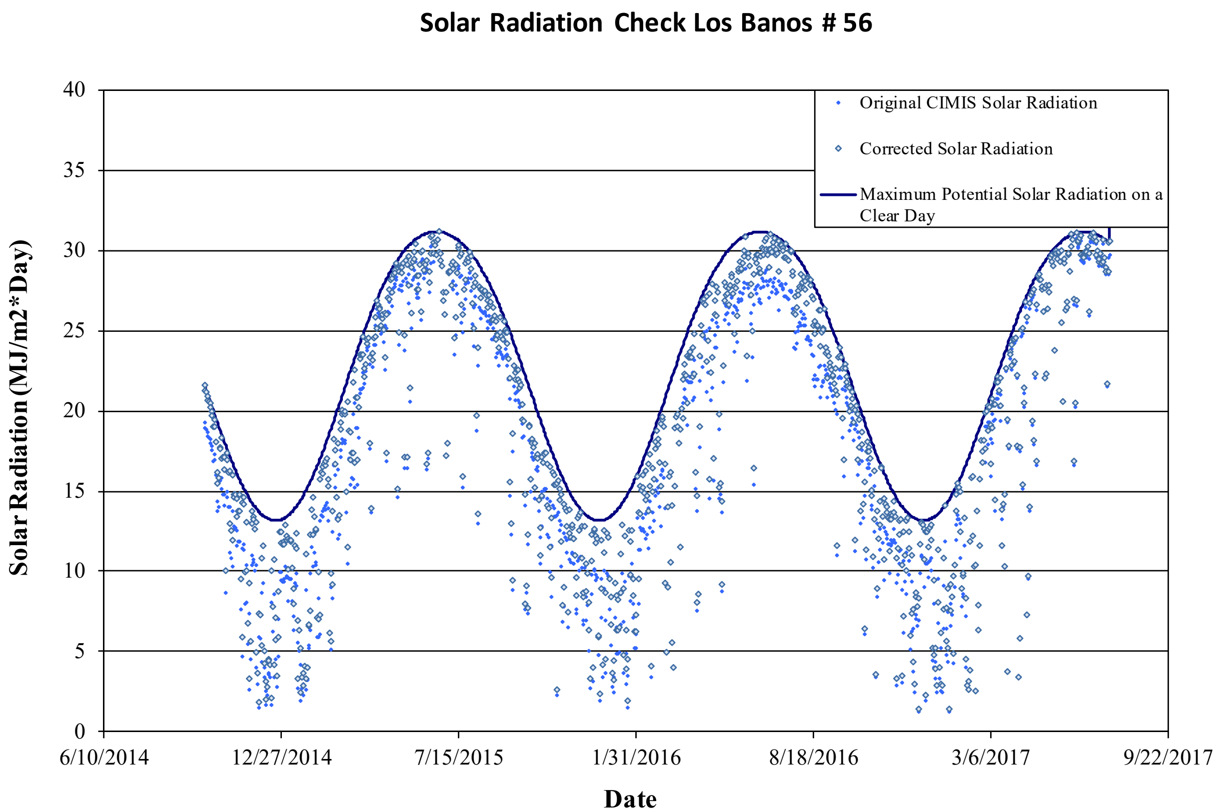


Figure 4. Example of solar adjustments made on Los Banos CIMIS Station for 2015-2017. The same analysis was conducted for all weather stations in the project area.

For missing data, or if an error was flagged on the CIMIS station signifying missing, incomplete, or odd data results, data were examined for general consistency. Missing data and data believed to be in error were corrected. The correction procedure used in this analysis replaced the missing or flawed data with the averages from nearby weather stations. Once all hourly data was corrected, the data was input into REF-ET^{TM} (Dr. Richard Allen, University of Idaho) to compute the corrected hourly ASCE Standardized ETo that was used in this study.

ETo and individual weather data are used within the ITRC-METRIC process to compute inputs into the software. METRIC computes the instantaneous ETc for every pixel within the LandSAT image at the instant the image is taken. Knowing the ETo at that instant from the local weather station, a **crop coefficient (Kc)** can be computed (Kc = ETc/ETo). It has been shown that this instantaneous actual Kc at the time of image acquisition (approximately 11 a.m.) is a very good representation of the Kc for that entire day. These instantaneous Kc results are interpolated using a cubic spline procedure between image dates. The interpolated pixel Kc for each day is then multiplied by the daily corrected spatial ETo discussed in the next section.

Corrected Spatial ETo

Spatial CIMIS ETo is a relatively new resource available through the DWR. A specialized algorithm uses weather station data, elevations and other inputs to interpolate ETo between stations. However, Spatial

CIMIS ETo rasters rely on CIMIS weather data that could have errors. In order to improve accuracy, ITRC incorporated the corrected CIMIS weather data into the Spatial CIMIS ETo raster images using a model we developed for ArcGIS 10.1.

The basic correction procedure first included adding the locations of all the CIMIS stations listed in Table 3 into GIS. The uncorrected Spatial ETo at the weather station location was extracted for each day over the time frame investigated. The difference between the corrected daily ETo for each station and the uncorrected Spatial ETo was computed. These differences were used to generate a difference raster using Inverse Distance Weighting (IDW) interpolation. The difference raster was combined with the uncorrected Spatial ETo to generate the corrected Spatial ETo image.

Figure 5 shows a comparison of the uncorrected Spatial CIMIS ETo and the corrected Spatial ETo for July 15, 2015. The corrected Spatial ETo represents the combination of our corrected ETo data blended with the original Spatial CIMIS ETo.

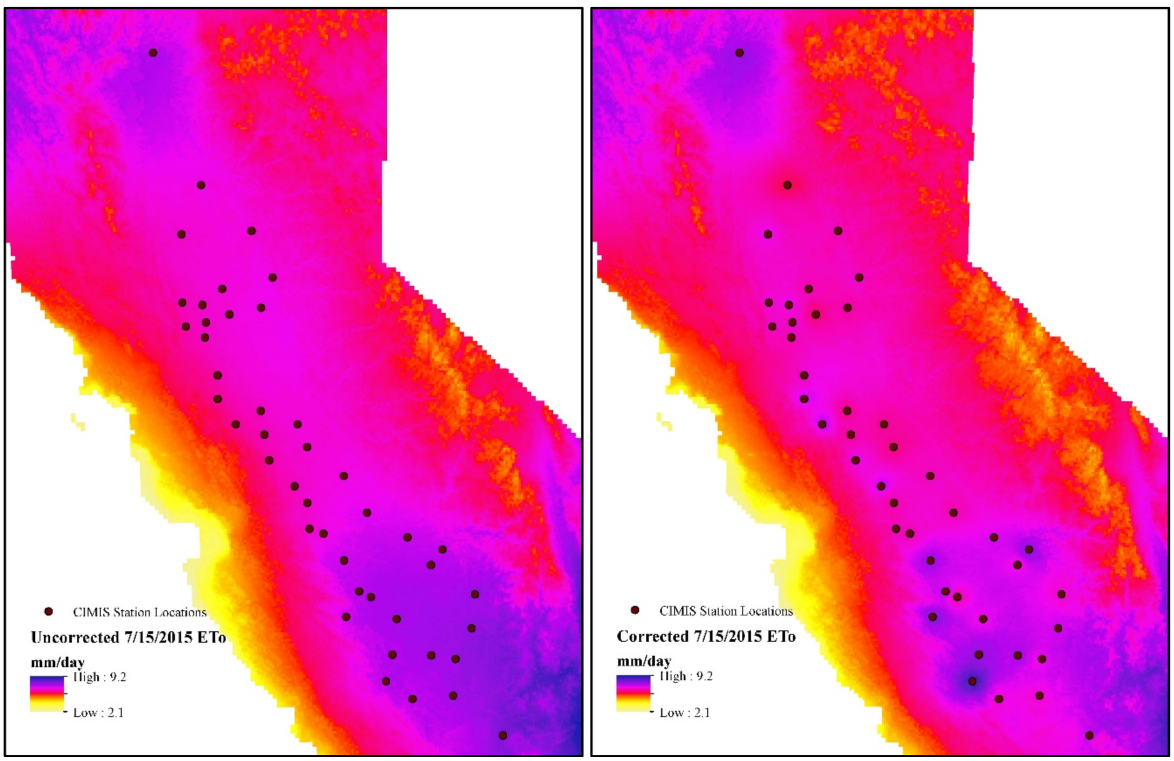


Figure 5. Example of uncorrected Spatial CIMIS ETo compared to corrected Spatial ETo for July 15, 2015

Elevation Data

A Digital Elevation Model (DEM) obtained from the USGS was used to adjust the model outputs based on the surface elevation throughout the area of interest. The DEM used had a resolution of 10m (1/3 arc second) which was then re-projected into a 30m × 30m pixel size to match the resolution of the LandSAT images.

Land Use Map

The ITRC-METRIC process requires land use information to help estimate ETc. Annual land use rasters were created from data provided from the National Agricultural Statistics Service (NASS). Figure 6 shows an example of the 2016 land use raster used in the modeling process. Each color identifies a different land use type (i.e., almonds, alfalfa, developed, etc.). The land use data provided by NASS underwent a control process so that only one land use type was uniform across the entire designated agricultural field. The agricultural field boundaries were provided by shapefiles produces by the DWR's land use surveys of the counties in California. Figure 7 shows an example of the original uncorrected NASS land use compared to the land use used in this analysis, which is much more consistent. The inconsistent "pixelated" areas in the corrected land use were identified as non-cropped areas in the DWR land use survey. Therefore, these non-ag areas use the original NASS data.

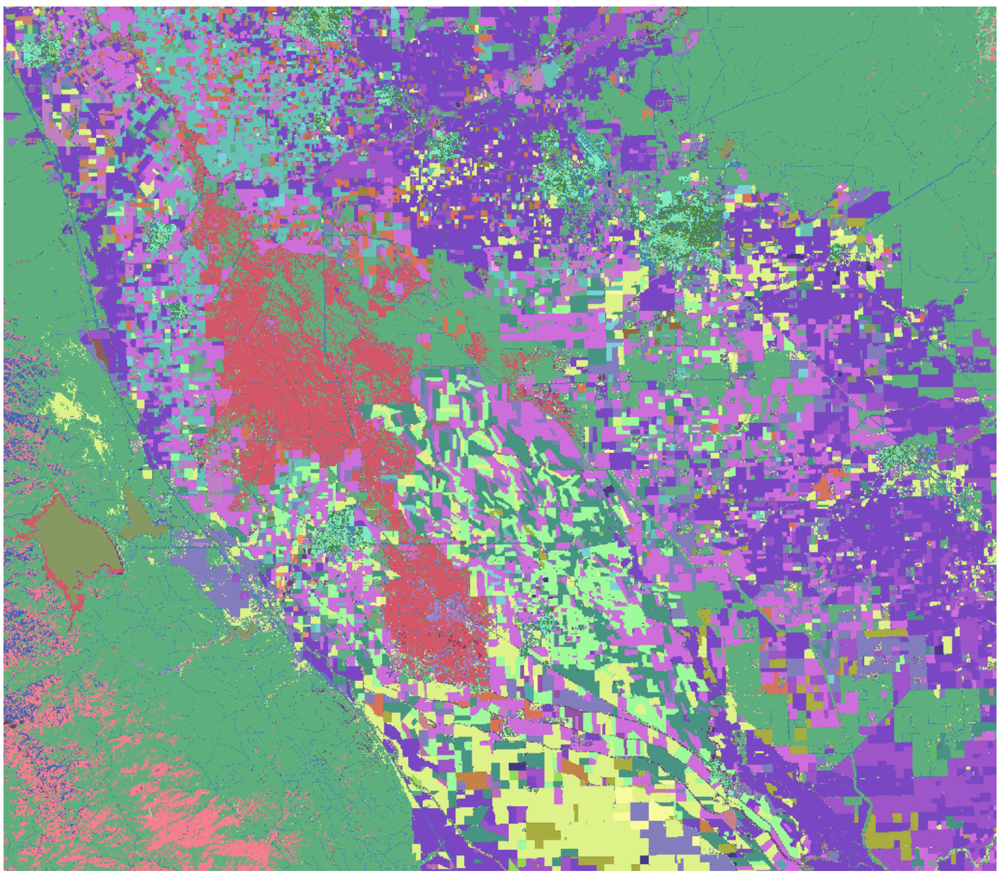


Figure 6. Example of the 2016 NASS land use raster used for this project. Each color identifies a different land use type (i.e., almonds, alfalfa, developed, etc.)

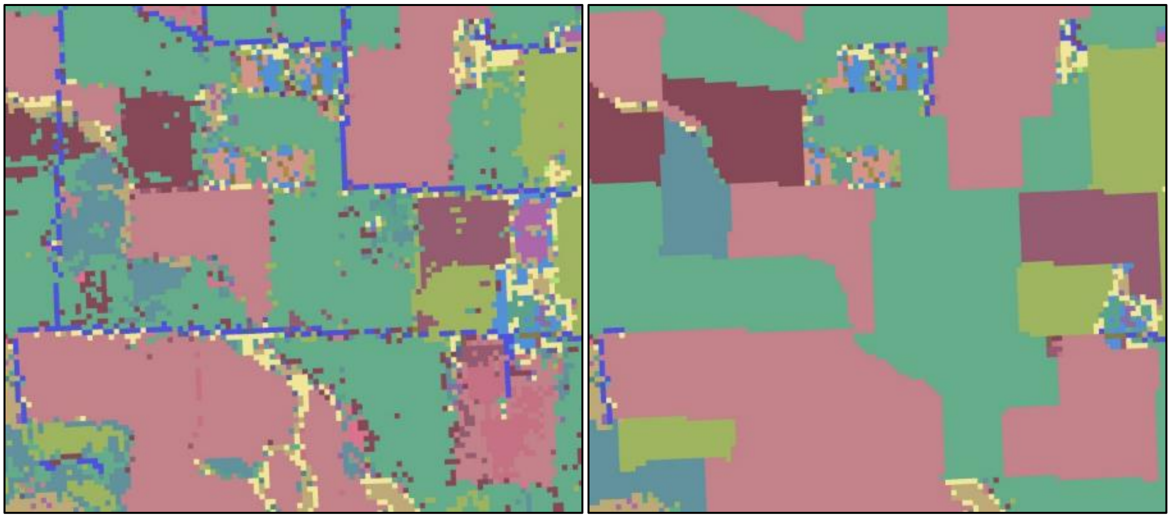


Figure 7. Example original NASS land use (left) compared to corrected land use based on the majority crop type within each agricultural field (right). Each color identifies a different land use type.

Interpolation between Image Dates

The selected images were processed, resulting in instantaneous actual crop coefficients (Actual Kc) on those dates for each pixel. The crop coefficient has been shown to remain constant during the majority of the daylight hours. Therefore, the instantaneous actual Kc was used as a surrogate for the daily actual Kc. In order to estimate the actual ETc between dates that images are available, actual Kc's are interpolated between image dates. A modified cubic spline approach is used to examine images within the month to be computed, prior to that month, and after that month. For example, to interpolate the ETc in the month of July, the July image(s) would be used along with May and June, and August and September. Cubic spline interpolation provides a smooth, non-linear interpolation between image dates. The interpolation takes place for every pixel in the image and the results are temporary Kc images for every day in the month. The daily pixel actual Kc values are then multiplied by the daily corrected Spatial ETo previously discussed to compute the daily actual ETc for each pixel. These daily ETc images are summed together for each month. Finally, the corrected Spatial ETo is summed for each month and the monthly ETc is divided by the ETo to generate the final monthly Kc image.

Results

The results will be first discussed by field and year. Fields in Figure 8 have been numbered and colored to identify the property (color) and specific field (number). Fields 16 and 17 will not be utilized, because information from these fields was not provided. The Dos Rios fields are shown for reference purposes, tabular ETc for fields 7 and 8 will not be included unless requested by River Partners.

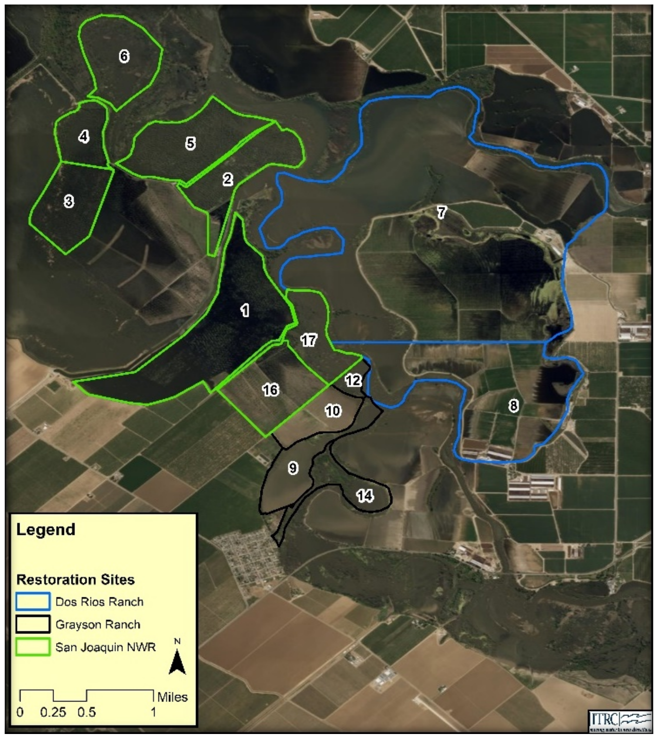


Figure 8. Map identifying field locations

Example evapotranspiration maps are shown in Figure 9 for 2009 and 2016 calendar years. The maps for all years can be found in **Appendix A**. The ETc variability is shown as color variation, where blues and reds have higher ET and yellow is lower. Low vegetative areas have lower ETc than open water and dense vegetation. Annual ETc variability will be influenced by several factors. In the agricultural fields on Grayson, the crop types will have the most significant influence, while in the natural vegetation areas (Grayson and SJNWR), precipitation and vegetation maturity will have the most significant influence. Figure 10 shows the annual precipitation for the study years.

Table 4 shows the annual ITRC-METRIC ETc depth averaged over each field. The Field ID's at the top coincide with Figure 8. Clearly there are some areas that consistently have higher ETc than others, especially in the non-irrigated areas. The irrigated Grayson fields (9, 10) tend to have consistent ETc during the same years but variations between years, which is common when different crops are grown.

To simplify the analysis, the fields were grouped by vegetation type and the ETc was averaged (weighted based on field acreage) within those groups. It is clear that the ETc is lower in the SJNWR and Native areas compared to the irrigated and non-ag areas in Grayson. The difference is even greater if we eliminate 2011 from the analysis. The fall 2010 to winter 2011 was very wet. It is likely that crop plantings were delayed or a different crop was chosen in the ag areas, which resulted in the lower ETc value. The high ET in SJNWR and Native is due to the heavy rains causing flooding and heavy weed grown, which resulted in unusually high ET. The 2011 data was not used for the prediction of future ETc.

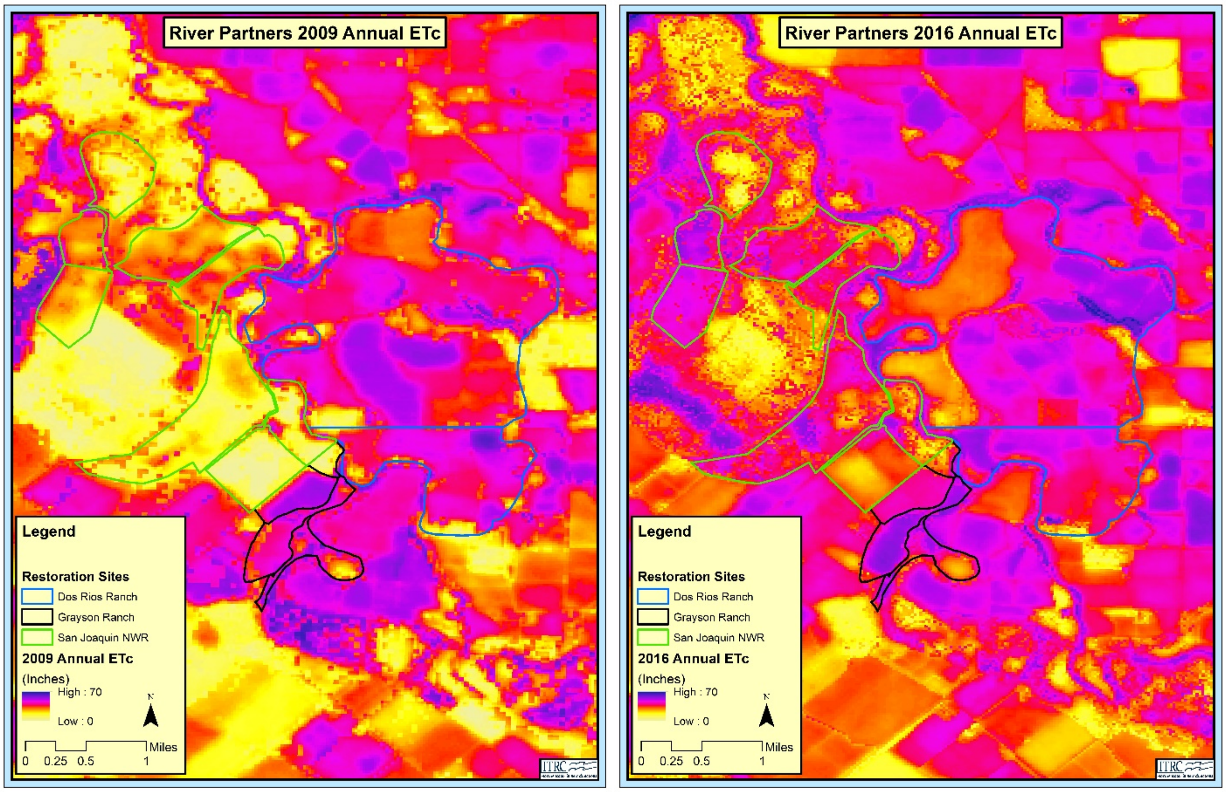


Figure 9. Example ITRC-METRIC ETc maps for 2009 and 2016

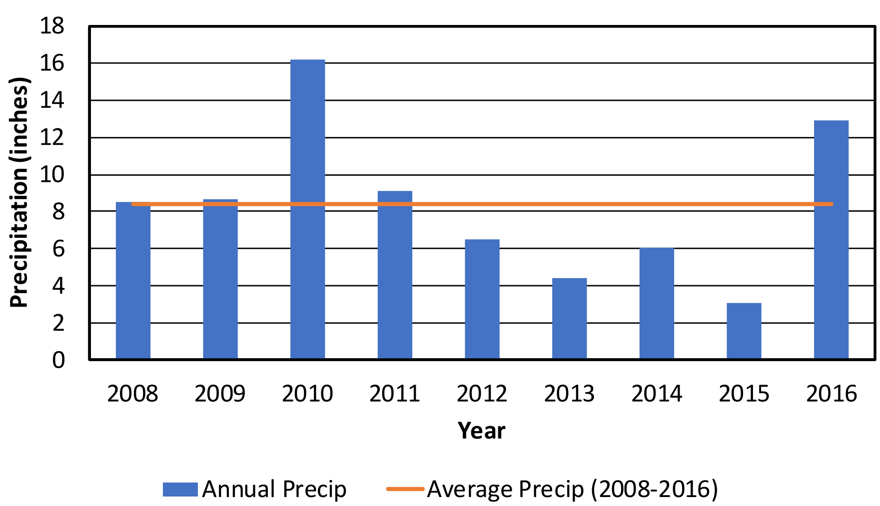


Figure 10. Local annual precipitation from Modesto CIMIS station

Table 4. Annual ITRC-METRIC ETc depth (inches) for evaluated fields

ETc (inches/year)										
Field ID	**1**	**2**	**3**	**4**	**5**	**6**	**9**	**10**	**12**	**14**
Acreage	366	144	134	78	184	152	105	81	22	77
Year	SJNWR	SJNWR	SJNWR	SJNWR	SJNWR	Native	Grayson	Grayson	Grayson	Grayson
2009	16.8	26.3	22.5	30.2	26.9	20.5	41.9	45.5	14.4	39.4
2010	26.2	32.9	25.2	35.9	35.1	28.4	41.9	39.4	34.9	38.5
2011	46.9	49.0	49.3	50.9	52.3	50.3	34.6	38.3	44.7	48.4
2013	44.6	38.5	41.4	50.6	43.9	34.7	54.8	50.6	44.5	50.7
2014	36.3	32.9	36.4	42.3	37.0	27.3	51.6	48.3	33.9	42.0
2015	35.1	32.1	34.4	40.7	35.8	22.5	47.3	44.5	31.0	36.2
2016	39.0	35.2	45.3	47.0	38.6	29.0	50.4	41.7	31.1	40.0

Table 5. Summary of average ETc depth weighted by field acreage shown for different land use category

Field IDs *Acreage*	**1-5** *905*	**6** *152*	**9, 10** *186*	**12, 14** *100*
Year	SJNWR	Native	Grayson Ag	Grayson Non-Ag
2009	22.3	20.5	43.5	33.8
2010	29.8	28.4	40.8	37.7
2011	49.0	50.3	36.2	47.6
2013	43.5	34.7	53.0	49.3
2014	36.4	27.3	50.2	40.2
2015	35.1	22.5	46.1	35.0
2016	39.9	29.0	46.6	38.0
Average	**36.6**	**30.4**	**45.2**	**40.2**

To develop the 10- to 15-year prediction, the ITRC-METRIC data was examined in the SJNWR restored habitat (Hagemann and Lara Tracts specifically). The ETc depths in SJNWR Fields 1, 2, 3, 4, and 5 were used to predict the future water use in the next 10-20 years by transposing this water use into the Grayson agricultural fields. The ETc depths for each year were converted to feet and multiplied by the Grayson ag field acreage to compute the volume of ETc in acre-feet. Table 6 shows the predicted water use 10-20 years into the future in the table on the left.

Just north of the Hagemann and Lara Tracts is an area that has never been developed (identified as Field 6). The area has been subject to flooding, fires, regrowth, etc. In the distant future, it is probable that vegetation in restored areas would be similar to the area that was never developed. The ETc is lower in the non-developed location because of vegetation missing in areas that are prone to flooding and fires. The long-term predicted ETc volume on the Grayson ag fields is shown in the right table of Table 6. The volume ETc in the future is computed as the depth of Native field ETc converted to feet and multiplied by the Grayson ag field acreages.

Table 6. Predicted future ETc on Grayson ag fields in 10-20 years after restoration (left) and in the predicted long-term (right), compared to current ETc

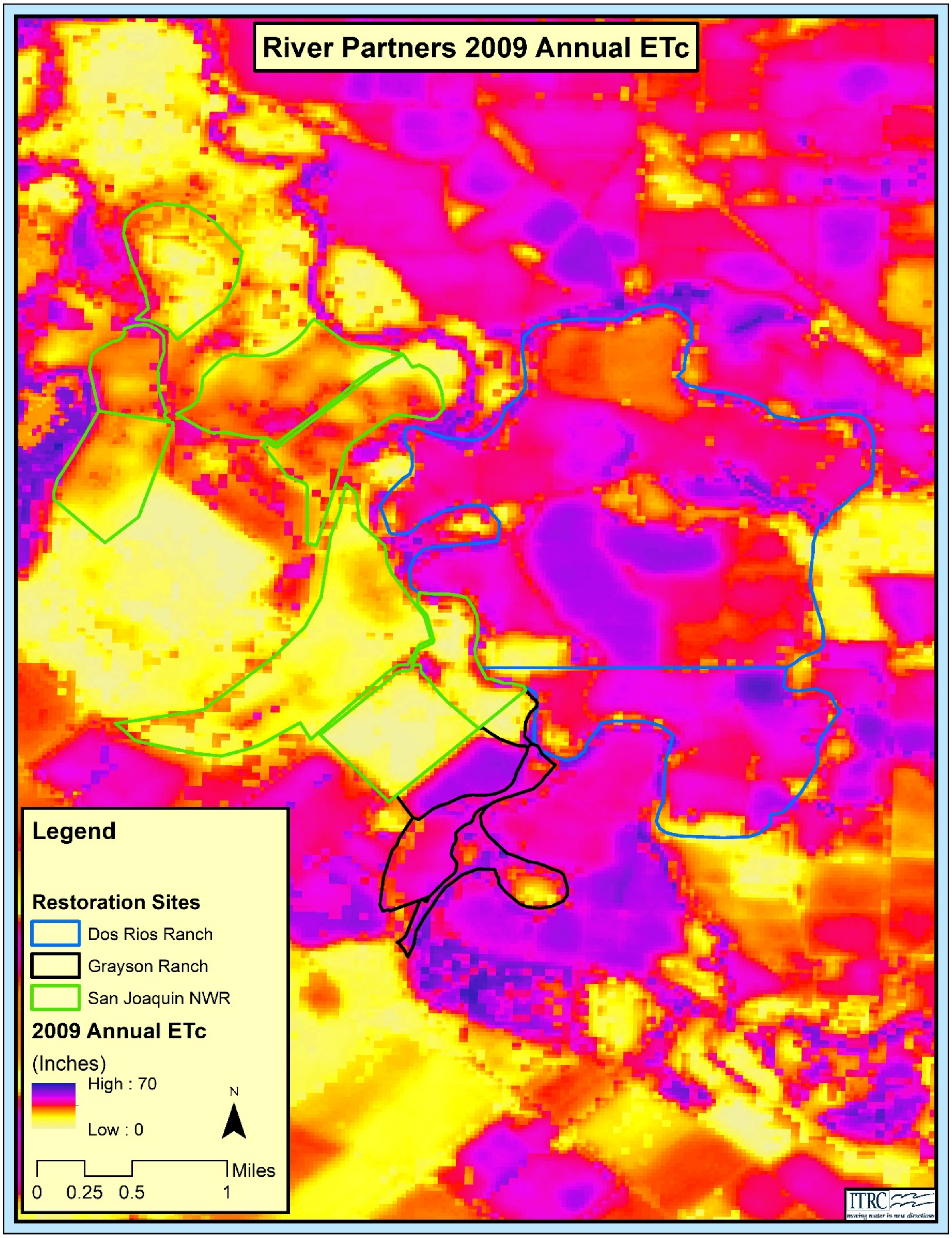
	Grayson Ag Fields ETc (Acre-Feet)	
Year	**Predicted 10-20 years in Future**	**Current**
2009	347	676
2010	462	634
2013	676	823
2014	566	779
2015	546	716
2016	620	723
Average	**536**	**725**
	Difference	**189**

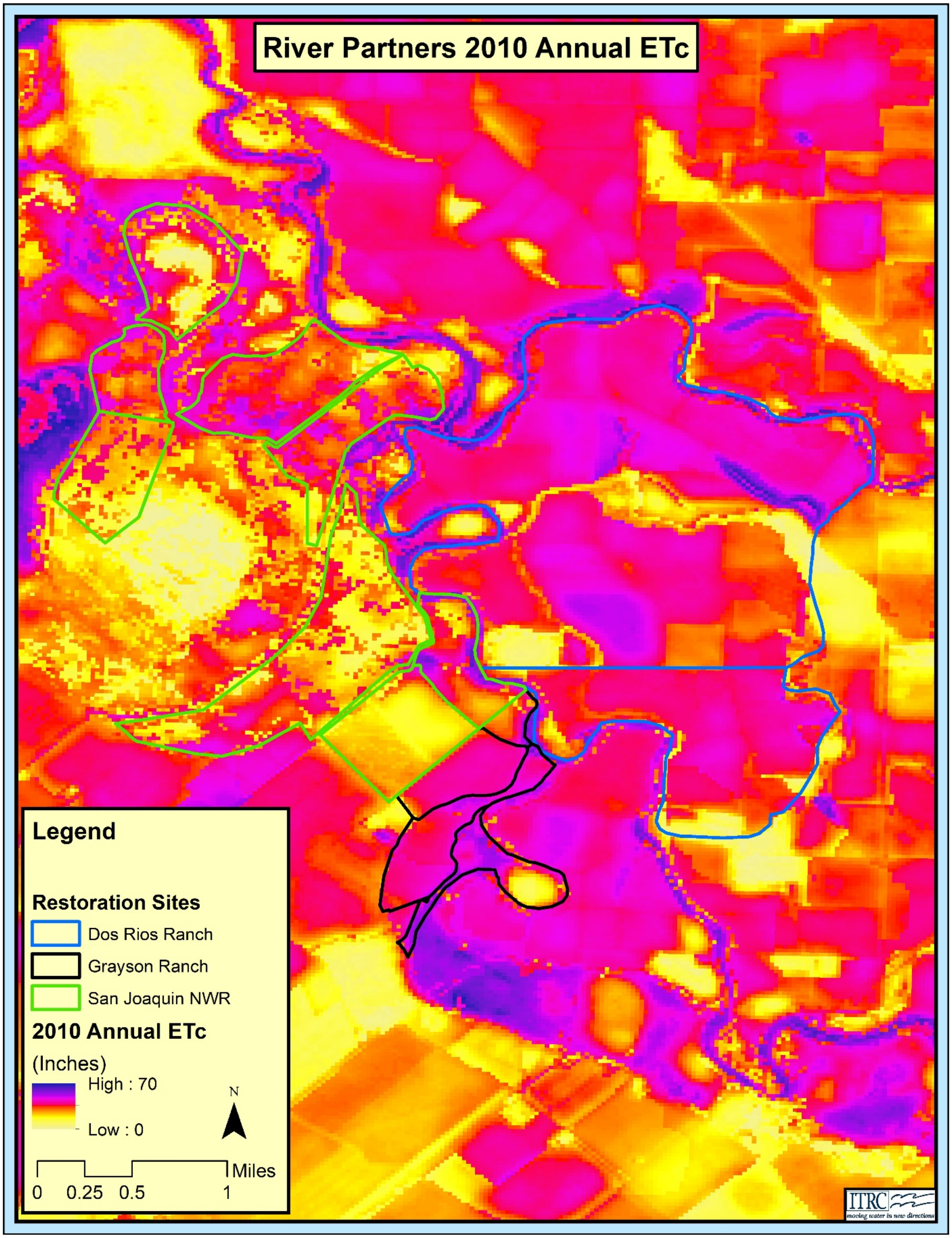
	Grayson Ag Fields ETc (Acre-Feet)	
Year	**Predicted Long-Term Future**	**Current**
2009	318	676
2010	442	634
2013	539	823
2014	424	779
2015	350	716
2016	450	723
Average	**421**	**725**
	Difference	**305**

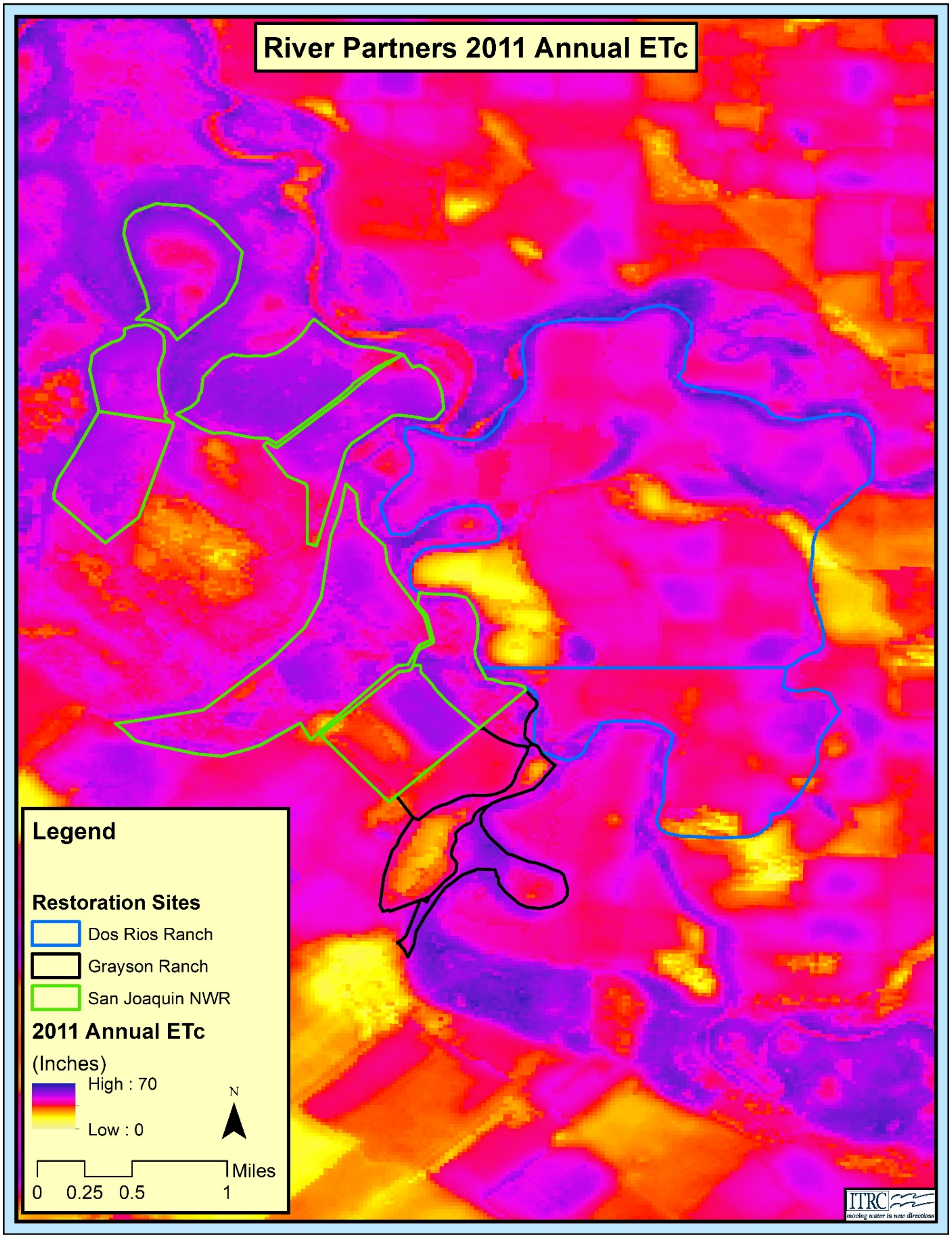
The difference between the current and future ETc in both scenarios (10-20 years and long-term) is significantly different. In reality, the long-term ETc is likely between these values. However, in 10-20 years it will likely be between 180-200 AF. The Grayson non-ag areas (fields 12 and 14) are assumed to stay the same, so the ETc will likely remain consistent.

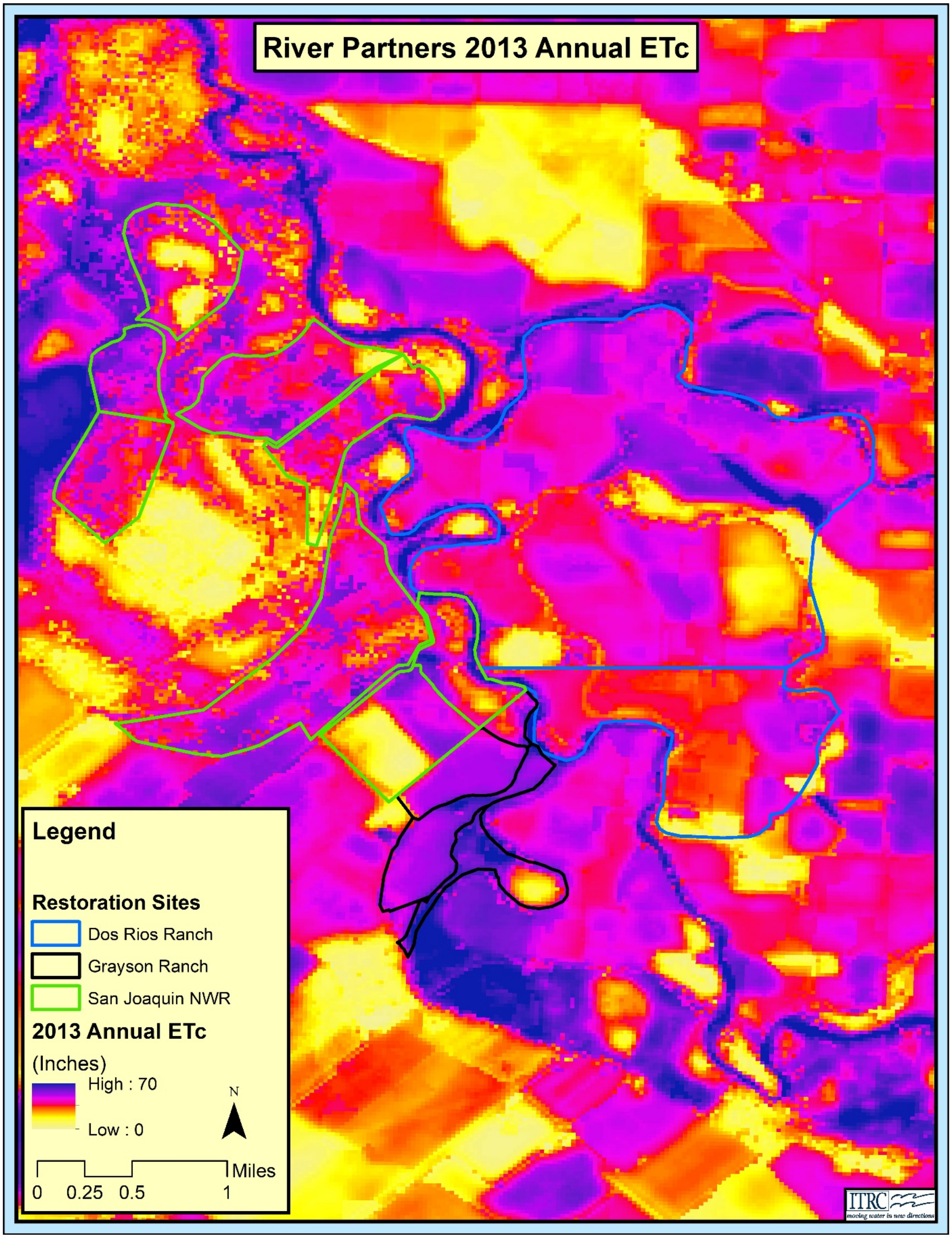
Attachment A

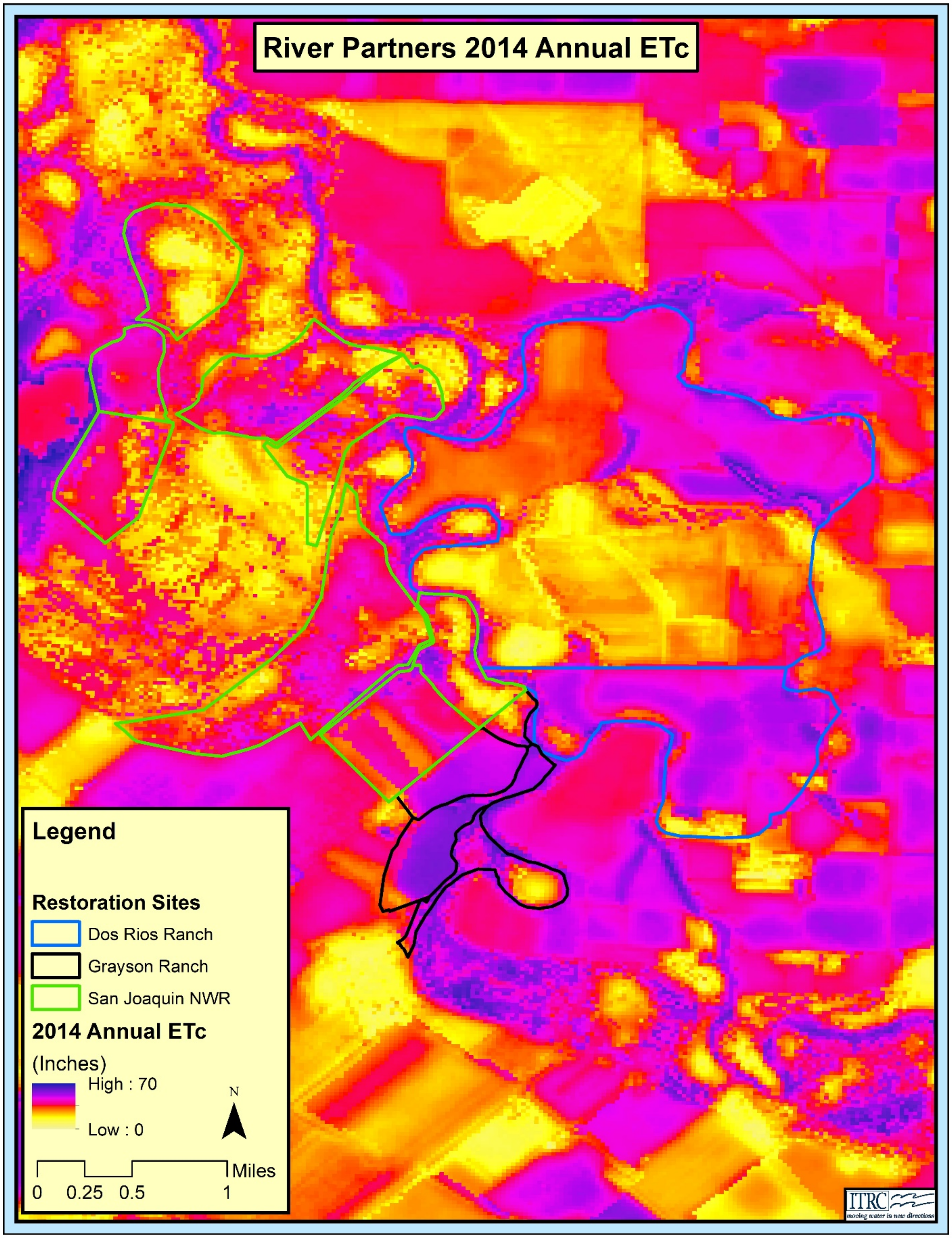
Annual ITRC-METRIC ETc Maps

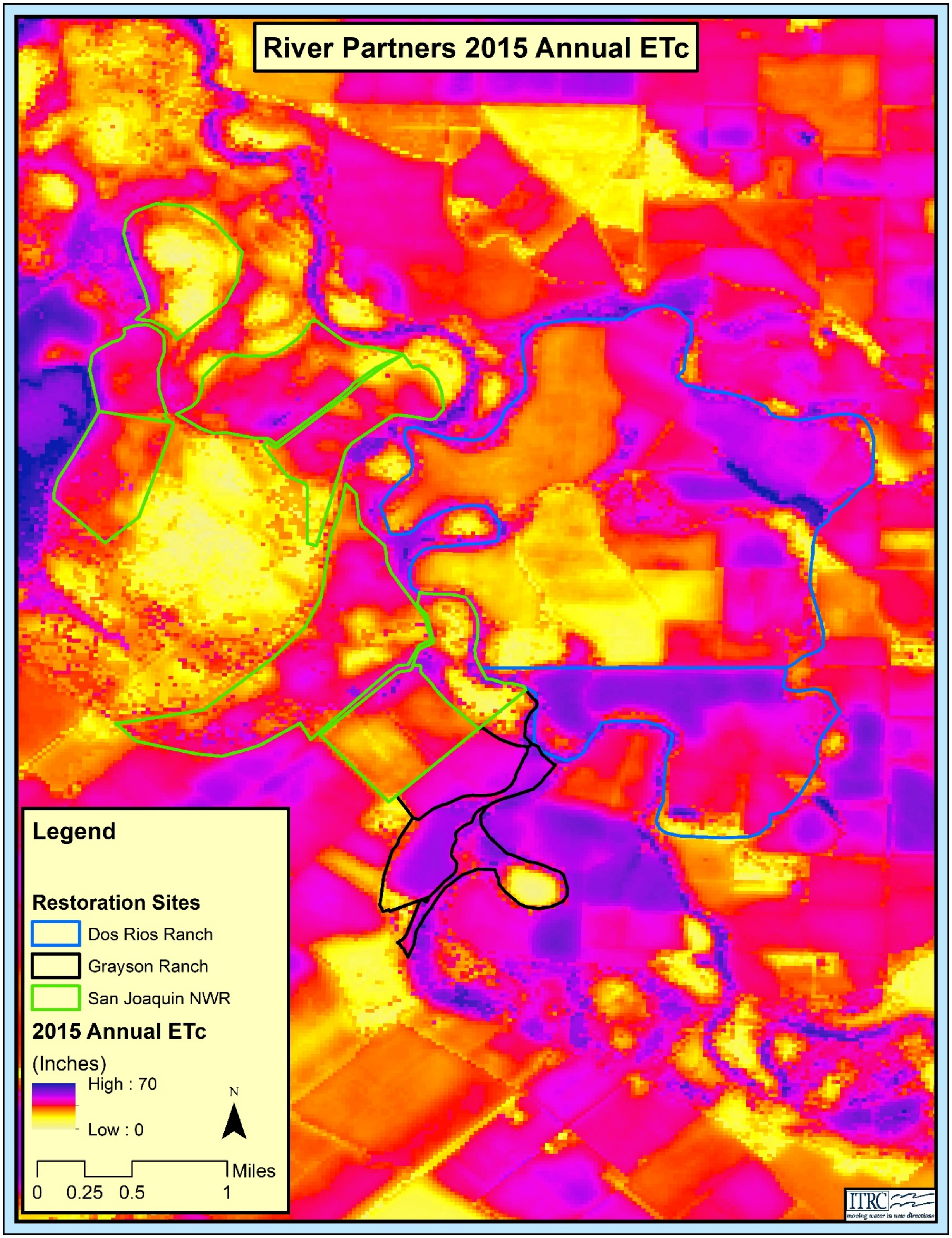


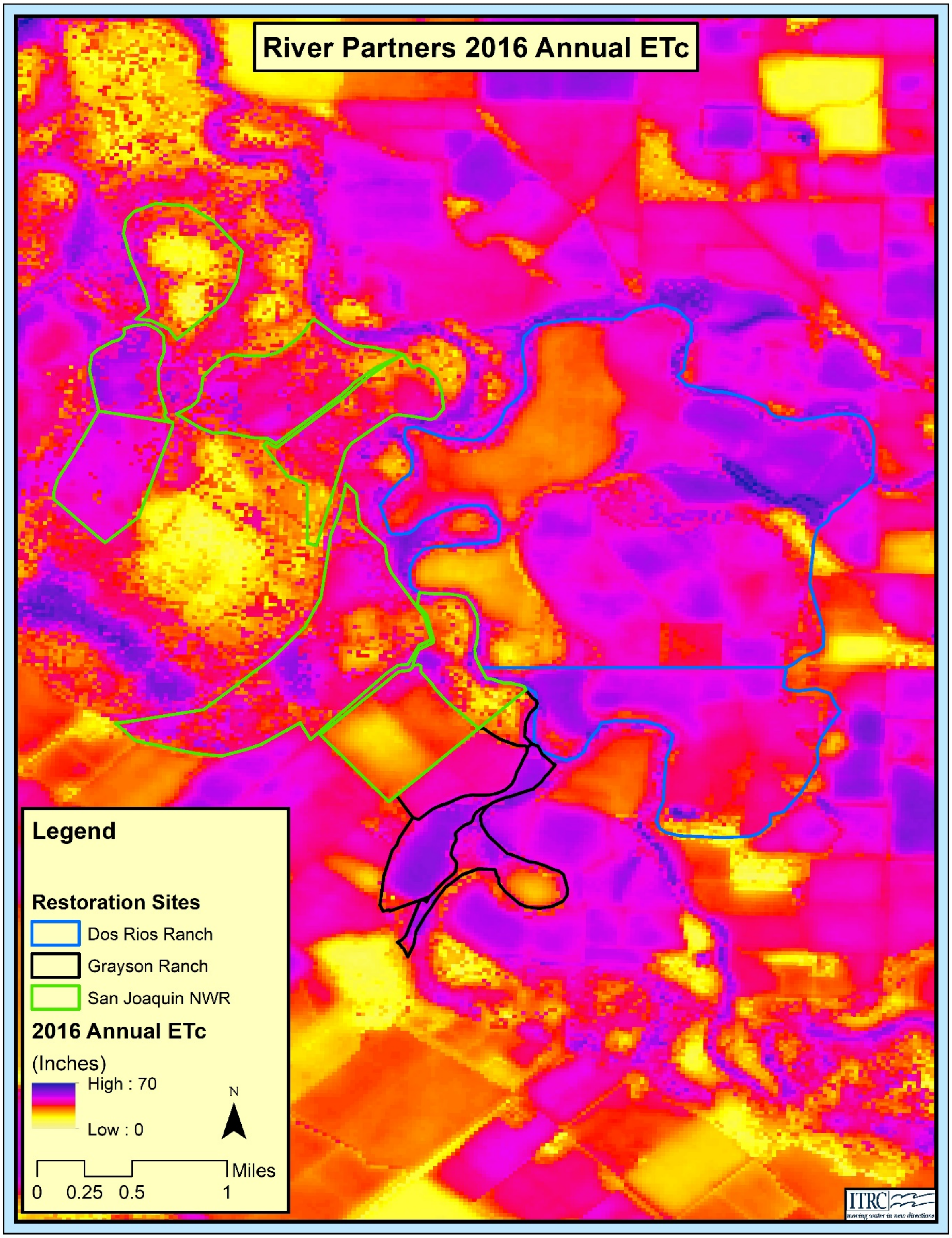

River Partners 2010 Annual ETc
Legend
Restoration Sites
Dos Rios Ranch
Grayson Ranch
San Joaquin NWR
2010 Annual ETc
(Inches)
High : 70
Low : 0
N
0 0.25 0.5 1 Miles
ITRC


River Partners 2011 Annual ETc
Legend
Restoration Sites
Dos Rios Ranch
Grayson Ranch
San Joaquin NWR
2011 Annual ETc
(Inches)
High : 70
Low : 0
N
0
0.25
0.5
1
Miles
ITRC
moving water in new directions


River Partners 2013 Annual ETc
Legend
Restoration Sites
Dos Rios Ranch
Grayson Ranch
San Joaquin NWR
2013 Annual ETc
(Inches)
High : 70
Low : 0
N
0
0.25
0.5
1
Miles
ITRC
moving water in new directions


River Partners 2014 Annual ETc
Legend
Restoration Sites
Dos Rios Ranch
Grayson Ranch
San Joaquin NWR
2014 Annual ETc
(Inches)
High : 70
Low : 0
N
0 0.25 0.5 1 Miles
ITRC
moving water in new directions


River Partners 2015 Annual ETc
Legend
Restoration Sites
Dos Rios Ranch
Grayson Ranch
San Joaquin NWR
2015 Annual ETc
(Inches)
High : 70
Low : 0
N
0 0.25 0.5 1
Miles
ITRC
moving water in new directions


River Partners 2016 Annual ETc
Legend
Restoration Sites
Dos Rios Ranch
Grayson Ranch
San Joaquin NWR
2016 Annual ETc
(Inches)
High : 70
Low : 0
N
0
0.25
0.5
1
Miles
ITRC