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Vegetation Response to Interim Flows in the San Joaquin River

Annual Report 2011

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

February 2012

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Vegetation Response to Interim Flows in the San Joaquin River

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Background

In 2006, the Department of the Interior entered into the San Joaquin River Settlement (Settlement) in *NRDC et al., v. Kirk Rodgers et al*. The Settlement was subsequently approved by the Court in October 2006 and the San Joaquin River Restoration Settlement Act (Act), Public Law 111-11, authorizes and directs the Secretary of the Interior to implement the Settlement. The San Joaquin River Restoration Project (SJRRP) is a comprehensive long-term effort to restore flows and a self-sustaining Chinook salmon fishery to the San Joaquin River from Friant Dam to the confluence of Merced River, while reducing or avoiding adverse water supply impacts.

Historically, riparian vegetation in California's Central Valley was typical of a dynamic system largely driven by annual flooding and a long summer drought (Thompson 1961 as cited in Stillwater Sciences 2003). Vegetation recruitment and survival were maintained through annual flooding via floodplain inundation, scour, and sediment deposition. Water availability during summer drought was the primary factor structuring vegetation establishment and distribution. This cycle of flooding and drought was – and still is – important to pioneer woody plant species, primarily willows (*Salix* spp.) and cottonwoods (*Populus* spp.), which rely on floods for bare seed beds, water, and nutrients, and which grow roots quickly to reach permanent water tables and a secure bank footing to resist subsequent floods (Braatne et al. 1996 as cited in Stillwater Sciences 2003).

Riparian forests require periodic seedling recruitment and subsequent establishment to maintain the stand through time (Stillwater Sciences 2003). A mature riparian zone typically consists of a mosaic of vegetation types of various ages and species. Commonly, mixed riparian forests occupy mid-elevation floodplain sites, and valley oak woodland and savannah occupy the oldest and driest floodplain sites such as high terraces and cut banks. Riparian vegetation dynamics are tightly coupled with river processes. Along geomorphically active streams, cottonwoods and willows are typically among the first species to colonize bare stream banks and bars. These species, with traits such as high seed output and rapid growth rates, tend to establish in bands parallel to the channel, with the youngest stands occurring closest to the active channel (Gregory et al. 1991, McBride and Strahan 1984, Walker and Chapin 1986 as cited in Stillwater Sciences 2003). Each band of vegetation represents a separate recruitment event. Over time, pioneer vegetation traps sediment and adds litter and nutrient inputs to floodplain soils (Walker and Chapin 1986 as cited in Stillwater Sciences 2003). As the floodplain develops and the riparian stand ages, changes in microclimate

(shade, temperature, relative humidity) occur which often facilitates establishment of other riparian species such as Oregon ash (*Fraxinus latifolia*), box elder (*Acer negundo*), and valley oak (*Quercus lobata*). These "later successional" species typically produce larger seeds and are more shade-tolerant than the early pioneers, allowing them to persist in the seedbank and germinate under the forest canopy when soil temperature and moisture conditions are adequate. Recruitment of these species is not as dependent on flow and sediment conditions as willows and cottonwoods.

Riparian vegetation along the San Joaquin between Friant Dam and Mendota has been significantly modified by agricultural development, hydrologic changes from operations of Friant Dam and the construction and operation of the flood control levees and bypass system. River regulation has created artificial hydrologic conditions, resulting in decreased peak flows, increased summer base flows, and reduction of physical processes such as scour and sediment deposition compared with historical conditions (Stillwater Sciences 2003). Riparian pioneer tree populations that evolved with pre-regulation cycles of flooding and drought have decreased recruitment and altered topographic distributions relative to bank elevation and proximity to the channel (Strahan 1984, McBain and Trush 2000, Stillwater Sciences 2001 as cited in Stillwater Sciences 2003). The reduction in riparian tree recruitment is compounded by human development on floodplains that has simultaneously removed over 90 percent of the historical riparian forests for fuel wood, agricultural and urban expansion, and floodplain mining (Katibah 1984 as cited in Stillwater Sciences 2003). The San Joaquin River historically supported a much wider riparian corridor than is present under current conditions. Reduced riparian vegetation along streambanks has decreased shaded riverine cover, organic inputs, water temperature control, and habitat structure (including inputs of large woody debris to aquatic habitats in the river), thus degrading aquatic habitat and fishery health. Important functions of the floodplain have also been reduced or eliminated, including flood flow retention and the ability for the channel to meander, which in turn increases both the risk of flooding and the amount of sediment deposited by flood flows.

In order to evaluate the establishment and development of riparian vegetation in response to restoration flows, Reclamation's Technical Service Center (TSC) in Denver, CO and Mid-Pacific Region in Sacramento, CA established monitoring transects in river reaches 1A through 4B2 and including the East Side and Mariposa Bypasses. Monitoring began in August 2011 and will be conducted annually for comparison over time. Hydrologic variables, including discharge and depth to groundwater as they relate to vegetation, will also be incorporated in the monitoring program. Interim flows were implemented in Water Year 2010; changes over the monitoring period beginning in 2011 will be evaluated.

Project Area

Vegetation transects were located in several reaches of the SJRRP Restoration Area (reach descriptions from CDWR 2002):

Reach 1A – River mile (RM) 267-243; Friant Dam to Highway 99 bridge at Herndon. This reach has the greatest diversity of vegetation types and the highest overall diversity of plant species. It is also the most urbanized region of the project area, and has more gravel extraction and the least number of confining levees of any of the reaches. Riparian oak forest and mixed riparian forest are more commonly encountered in Reach 1A than downstream. Herbaceous and exotic vegetation types account for two-thirds (66.8 percent) of the total natural vegetation mapped, while approximately one-quarter (26.8 percent) is riparian forest. Woody scrub makes up less than seven percent (6.5 percent) of the total natural vegetation. The most common natural habitat types found here are: herbaceous (2701 acres), mixed riparian forest (526 acres), riparian oak forest (289 acres), willow scrub (290 acres), wetland/marsh (247 acres), and willow riparian (233 acres). The ratio of habitat per river mile is 194.2 acres/mi. In addition to woody exotic trees and giant reed (*Arundo donax*), scarlet wisteria (*Sesbania punicea*) is widespread in portions of Reach 1A. It has invaded wide areas of the floodplain in this and the subsequent Reach 1B, displacing willow scrub along the edge of the low-flow channel.

Reach 1B – RM 243-229; Highway 99 bridge to Gravelly Ford. This reach is more narrowly confined by levees than the upper section. The proportion of herbaceous and exotic vegetation is closer to one half of the total natural vegetation (55 percent), while the proportion of woody riparian vegetation is closer to one-third (30.6 percent) of the total and occurs mainly in narrow strips immediately adjacent to the river channel. Willow scrub is more abundant (14.3 percent) than in Reach 1A. Outside the levees and steep bluffs, the land use is nearly all agricultural. Scarlet wisteria was observed as far downstream as river mile 240. Giant reed patches are commonly encountered. The most abundant habitat types are herbaceous (300 acres) and mixed riparian (280 acres), followed by cottonwood riparian (193 acres), willow scrub (155 acres) and willow riparian (120 acres). This reach has the second lowest ratio of natural vegetation per mile—in 14 miles of channel, there is a little over one square mile of natural habitat (48 acres/mile).

Reach 2 (2A and 2B) – RM 229-205; Gravelly Ford to Mendota Pool. This reach is characterized by seasonal drying in the late summer and fall. The water table recedes into the porous substrate, creating a pronounced riparian drought nearly every year. There is about half as much riparian forest, proportionally, as in Reach 1 (15 percent of natural and naturalized vegetation), about the same proportion of woody scrub communities (13.5 percent) as Reach 1B, and more herbaceous vegetation (71 percent) than in Reach 1 overall. The most abundant habitat type by far is herbaceous (718.7 acres), followed by riparian scrub (302.8 acres),

willow scrub (254.2 acres), riverwash (173.8 acres), willow riparian (165.4 acres), and cottonwood riparian forest (124.5 acres). The ratio of natural vegetation/river mile is 79.0 acres/mi., about 60 percent higher than in Reach 1B, but 40 percent of that in Reach 1A. Cultivated lands occupy nearly all the lands outside the river bottom. The character of the reach changes somewhat near Mendota Pool (RM 216-204). Downstream of the bifurcation structure at RM 216 (SW of which is found the large elderberry savanna), the riparian zone is very narrowly confined to a thin strip 3-10 meters wide bordering the channel. The herbaceous understory is however, very rich in native species and a high proportion of the total vegetative cover is native plants, possibly due to the exclusion of cattle and other domestic stock from these thin habitat strips.

Reach 3 – RM 205-182; Mendota Pool to Sack Dam. The reach is characterized by a continuous flow within a very confined channel, seasonally low water (although not as dry as Reach 2), and narrow strips of riparian habitat along the river's edge. Adjacent lands are mostly under cultivation, although the city of Firebaugh borders the river's west edge for 3 miles. This reach has the smallest proportion of herbaceous habitat (25.2 percent) and the highest proportion of riparian forest (53.7 percent). Willow scrub occupies 21 percent of the total extent of natural vegetation. The most common habitats are cottonwood riparian (460.8 acres), willow scrub (230.5 acres), herbaceous (174.4 acres), and willow riparian (124.8 acres). Forty-seven and one-half acres of natural vegetation were mapped for every river mile in this reach, equivalent to the ratio found for Reach 1B.

Reach 4A – RM 182-148; Sack Dam to southern portions of the San Luis National Wildlife Refuge. This reach begins in cultivated and ends in public lands. Access for field verification and transects was denied in about half of this stretch. Reach 4A has the fewest habitat types and the lowest ratio of natural vegetation per river mile of any of the segments—only 502 acres of vegetation in this 34-mile segment (14.8 acres/mi.). The proportion of herbaceous habitats is typical of the San Joaquin River as a whole—about two-thirds (67.7 percent), while the proportion of forest is 22.4 percent and the proportion of woody scrub is 5 percent. The most common habitats are herbaceous (177.2 acres), willow riparian forest (89.1 acres), riverwash (65.2 acres), and riparian scrub (56.7 acres).

Reach 4B – RM 136 to 148; continues through public lands to the confluence with Bear Creek. Cultivated fields border approximately nine miles of the river's eastern bank. The floodplain is broad between widely spaced levees and the water table is nearer the surface than in some of the other reaches. These factors, along with a much lower level of disturbance to the native landscape on the public lands, create vast areas of natural habitat, compared to the upstream reaches. The ratio of natural habitat per river mile increases thirty-five-fold over that of Reach 4A, with a similar ratio continuing to the Merced River confluence (512.8 acres/mi. in Reach 4B). The most common vegetation type by far in this reach is herbaceous vegetation (4175 acres), followed by willow riparian forest (701.2

acres), wetland/marsh (377.7 acres), and willow scrub (132.1 acres). Giant reed was not seen in this reach.

Methods

Vegetation Transects

Twenty permanent vegetation transects were established within river reaches 1A, 1B, 2A, 2B, 3, 4A, 4B2 (*i.e.* San Luis National Wildlife Refuge (NWR)), and the East Side and Mariposa Bypasses (Figures 1 and 2). Due to the large project area (over 150 RM), it was feasible to locate and monitor two transects within each reach with the exception of the East Side Bypass, where four transects were placed, two of which were in the Merced NWR. Transects were placed in areas adjacent to the river channel within the active floodplain. These sites are subsequently subject to seasonal changes in water and nutrient input and scour and sediment deposition. These transects are not representative of vegetation types across entire reaches, but are illustrative of vegetation change over time resulting from Interim Flows. Maps of vegetation transects by river reach are shown in Figures A-1 to A-11 in Appendix A.

Plant cover, composition, and overstory height and stem density were collected along each transect. Habitat variable ratings were determined for the area encompassing the transect. The length of each transect was determined by the extent of the floodplain and varied from 35 to 100 meters (m). Waypoints for each end of transects are listed in Appendix B. Forms used to collect data are included in Appendix C.

Timing

Monitoring will be conducted annually during spring or summer months depending on flow levels with the objective of collecting data at similar river phases and when vegetation is at comparable stages of development each year.

Herbaceous vegetation

For herbaceous understory measurements, cover and species composition were measured either every 0.5 or 1 m along the transect depending on the length of the transect. The point-intercept method was used, which entailed recording the first "hit" for herbaceous plants by species and for woody species under 1 m tall (Figure 3). If a plant was not intercepted, then bare soil, litter, rock, or water were recorded. The location and extent of invasive weed species were documented when encountered.

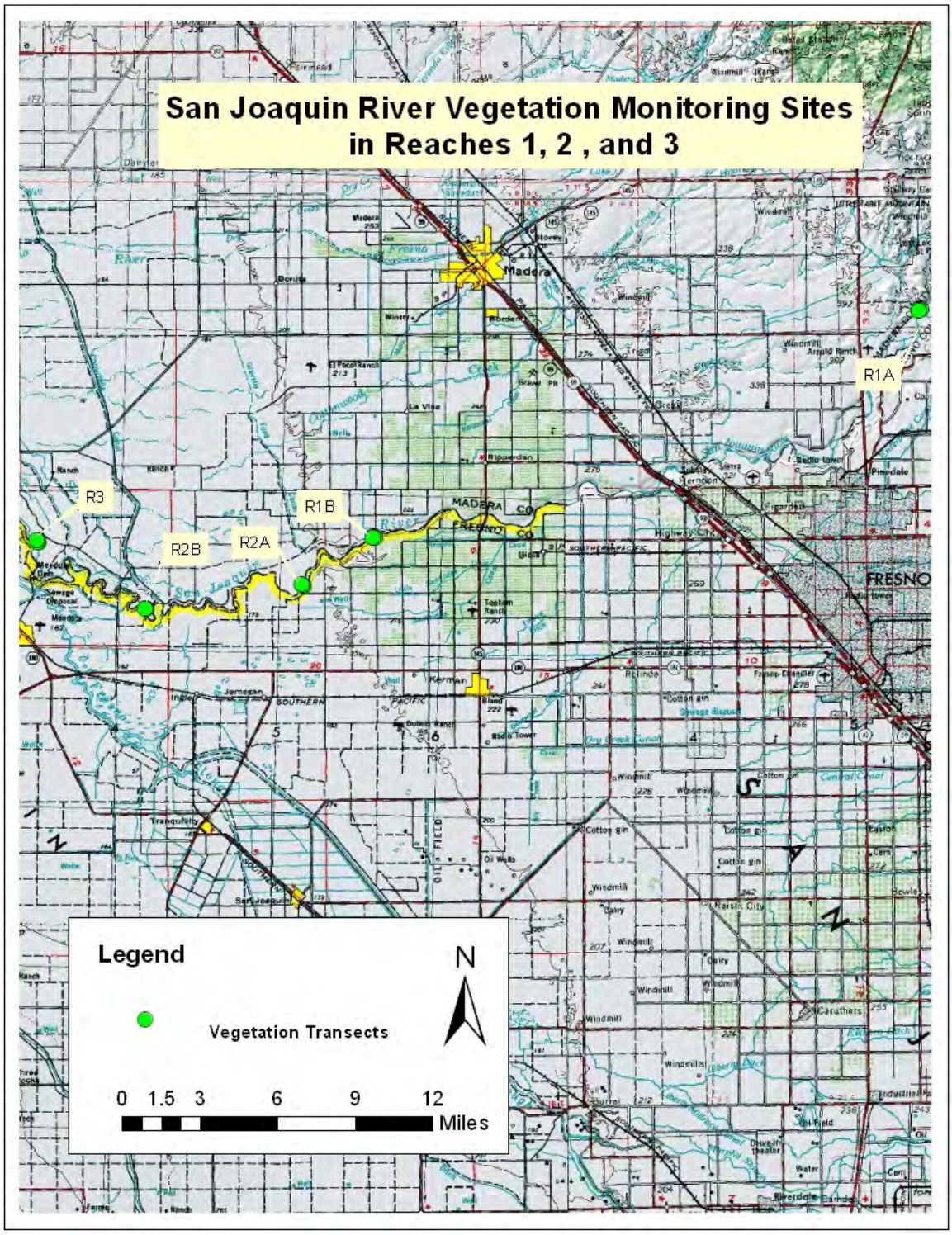

Figure 1.—Location of upstream vegetation transects in Reaches 1, 2, and 3 along the San Joaquin River.

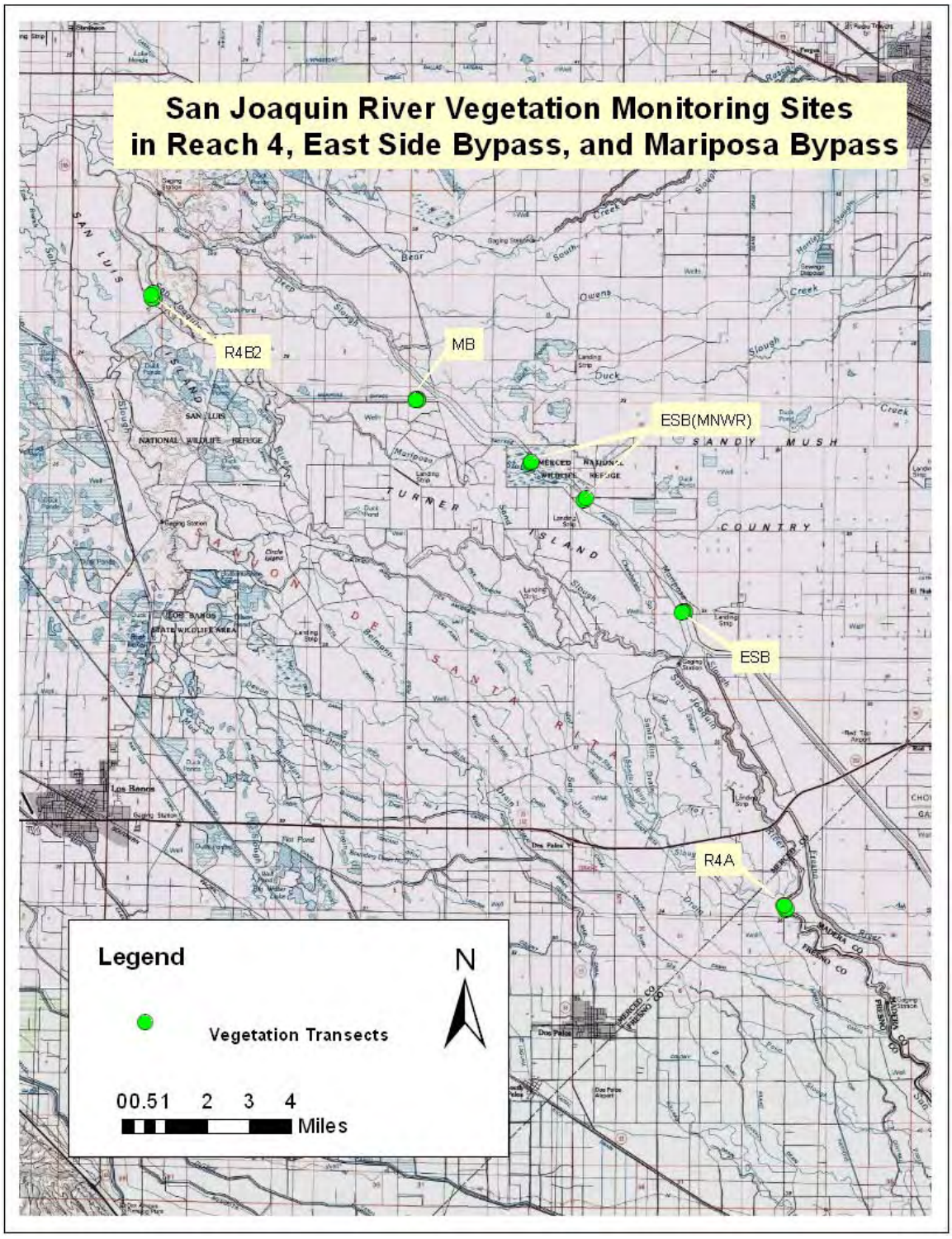

Figure 2.—Location of downstream vegetation transects in Reach 4, East Side Bypass, and Mariposa Bypass along the San Joaquin River.

Figure 3—Measuring herbaceous cover along transect.

Overstory vegetation

The line-intercept method was used for measuring woody overstory cover. Overstory cover was measured along the transect by noting the point along the tape where the canopy began and the point at which it ended for each woody species over 1 m tall. Because species overlapped in some cases, the sum of the cover for all species did not necessarily reflect the actual percentage of overstory cover along the tape. The percentage of the tape covered by overstory was also calculated. The height of the tallest vegetation within each continuous stretch of the same species was measured.

Stem Density

Woody stem density was determined by using a meter stick to measure one meter outward on one side of the transect. All woody stems within the one meter belt transect were counted and recorded by size into 4 classes by species (see Figure C-3 in Appendix C for descriptions of size classes).

Habitat Variables

A riparian systems model (Stein et al., 2000) was used to rank riparian condition. This qualitative model (riparian rank) includes spatial and structural diversity of native woody plants, contiguity of dominant vegetation, invasive vegetation, hydrology, topographic complexity, characteristics of flood-prone areas, and

biogeochemical processing. These criteria consider the interaction between geology, hydrology, and organic and inorganic inputs to the system. Each criterion is scored between 0 and 1.0 and scores are added so that the "best" rank is an 8. See Figure C-4 in Appendix C for a listing of the variables and descriptions.

Statistical Analysis

Vegetation monitoring data will be statistically compared over time to evaluate any significant changes in vegetation transects. Total percent cover (*i.e.* actual cover estimate) will be statistically analyzed for herbaceous and overstory vegetation. Relative percent cover was determined for herbaceous life-forms (*i.e.* native or introduced shrubs <1 m in height, grasses and grass-like species, and forbs). Relative cover is cover of a species or life-form expressed as a percent of total vegetation. Because this was the first year of monitoring, no comparison analysis was conducted.

Photo Stations

Two digital photographs were taken at each end of the transect – one toward the transect and one facing outward. These photos will provide visual documentation of vegetation height, density, species composition, and general site development for comparison over time.

Groundwater Monitoring

Reclamation anticipates improving the groundwater monitoring network where possible within the vicinity of vegetation transects. Groundwater recession rates have been closely tied to riparian vegetation establishment and survival in the San Joaquin Valley and elsewhere (reference). Groundwater data from wells installed near transects can be used to determine if any correlations are observed between growth and development of vegetation and water table levels. No analysis was conducted for this report since ground water wells associated with transects were not yet established as of 2011.

Results

Vegetation Transects

Timing

Vegetation transects were monitored August 1-4, 2011. Because 2011 was a wet year, interim releases were supplemented with flood releases and monitoring was

not feasible until relatively late in the summer due to high river levels and inundated sites. The large drop in river levels in late July, prior to monitoring in 2011, can be seen in Figure 4, which shows the hydrograph for Water Year 2011 along the San Joaquin River approximately 3.7 kilometers (2.3 miles) downstream of Friant Dam.

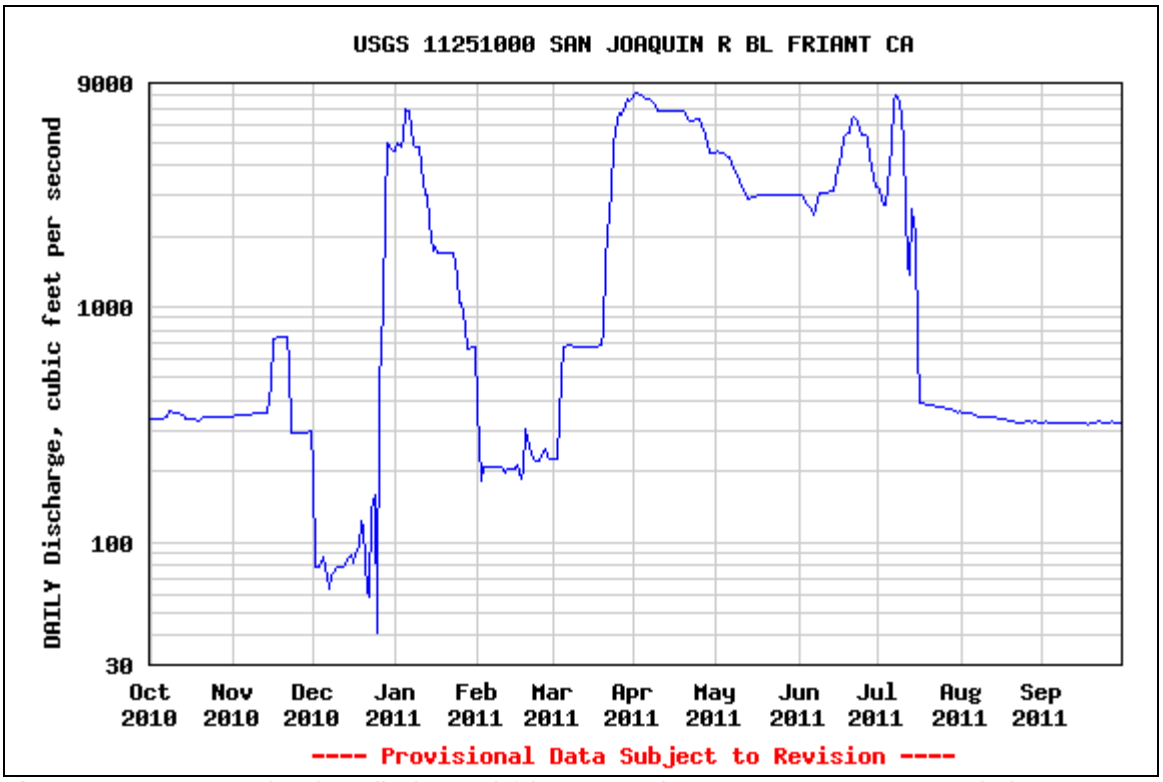

Figure 4.—San Joaquin River discharge (cfs) measured at USGS gage 11251000 below Friant, California for Water Year 2011. Source: United States Geological Survey.

Herbaceous vegetation

The average total percent cover by individual species, life-form (*i.e.* native or introduced shrubs < 1m, grasses, and forbs) and cover type (*i.e.* plants, litter, bare ground, rock, water) found in the herbaceous layer (*i.e.* understory) are shown in Table 1. Forty-six annual and perennial species were detected in the herbaceous measurements of vegetation transects in all river reaches combined.

Total percent herbaceous plant cover was highest (>70 percent) in Reaches 3 and Mariposa Bypass, where native forbs were the dominant lifeform, and in Reach 4B2, where introduced grasses were the dominant lifeform. Total percent herbaceous plant cover was lowest (<20 percent) in Reaches 1B and 2A, where bare ground dominated transects. Regeneration of woody species, as represented by herbaceous shrub cover (<1m in height), was highest in Reach 1B (4.5 percent), followed by Reach 4A (1.5 percent). The highest plant diversity in the

Table 1.— Total percent herbaceous cover of individual species, life-form, and cover type in vegetation transects by reach in August 2011 along the San Joaquin River.

Average Total Percent Herbaceous Cover									
	River Reach								
Species	**1A**	**1B**	**2A**	**2B**	**3**	**4A**	**ESB**	**MB**	**4B2**
Button bush	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandbar willow	0.5	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Goodding's willow	0.0	0.0	0.0	0.5	0.3	1.5	0.0	0.0	0.0
Native trees/shrubs	0.5	4.5	0.0	0.5	0.3	1.5	0.0	0.0	0.0
Pacific foxtail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	1.0
Redroot flatsedge	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Yellow nutgrass	0.0	5.0	0.0	0.0	3.5	1.4	1.0	0.5	0.0
Flatsedge	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salt grass	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4
Common spikerush	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0
Baltic rush	1.5	0.0	0.0	0.0	0.0	0.0	0.7	6.5	5.2
Mexican sprangletop	0.5	0.0	1.5	2.2	1.6	2.2	0.2	0.0	0.0
Unidentified grasses*	0.5	0.0	1.0	0.0	0.0	0.0	6.5	0.0	0.0
Native graminoids	4.0	5.0	2.5	2.2	5.1	3.6	20.4	12.5	20.6
Ripgut brome	0.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Bermuda grass	1.0	2.0	0.0	0.0	4.1	1.2	2.7	3.0	2.0
Barnyard grass	0.5	0.0	0.5	0.0	0.6	1.7	0.3	0.0	26.1
Mediterranean barley	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1.0
Rice	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Bahia grass	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0
Rat-tail fescue	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Introduced graminoids	2.0	2.0	6.0	0.0	4.7	2.9	8.3	8.0	29.1
California mugwort	8.0	0.0	0.0	1.4	10.5	0.0	0.0	0.0	0.0
Pappose tarweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.0	1.3
Pitseed goosefoot	0.0	0.0	0.0	0.0	3.3	0.0	0.0	1.5	3.5
Doveweed	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Wright's buckwheat	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Delta button celery	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Threepetal bedstraw	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0
Sunflower	0.0	0.0	1.0	0.0	0.0	0.0	0.0	3.0	7.1
American bird's-foot trefoil	0.0	0.0	3.5	9.3	0.0	0.0	0.0	0.0	0.0
Field mint	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pale smartweed	0.0	0.0	0.0	0.0	12.4	0.0	0.0	0.0	0.0
Yellow cress	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0
American black nightshade	0.0	0.0	0.5	4.3	2.8	0.0	0.0	0.0	1.9
Cocklebur	1.0	0.0	0.5	0.0	20.6	4.2	7.3	12.0	7.1
Unidentified forbs*	0.5	0.0	0.0	1.4	0.7	2.0	6.0	1.5	0.0
Native forbs	10.0	0.0	7.5	16.4	55.0	6.2	13.8	51.0	20.9
Common mugwort	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0
Black mustard	1.0	0.0	2.0	4.1	0.0	0.0	0.0	9.0	5.8
Prickly lettuce	0.0	0.0	0.5	0.0	0.8	0.0	0.0	1.0	1.0
Alkali mallow	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.6
Common knotweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	2.1
Curly dock	0.0	0.0	0.0	0.0	0.0	0.7	0.5	3.0	1.3
Himalayan blackberry	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Russian thistle	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Saltwort	0.0	0.0	0.0	0.0	7.5	0.5	0.0	0.0	0.0
Clover	0.0	0.0	0.0	2.1	0.0	0.0	3.3	0.0	0.0
Stinging nettle	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Water speedwell	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Introduced forbs	6.5	0.5	3.0	6.7	8.3	4.1	4.8	22.5	10.8
Total Plant Cover	23.0	12.0	19.0	25.8	73.4	18.3	47.3	94.0	81.4
Litter	33.5	20.0	16.5	22.9	16.0	7.5	22.7	4.5	11.8
Bare	37.0	55.0	45.0	51.3	10.6	74.2	30.0	1.5	6.8
Rock	6.0	13.0	19.5	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cover	100	100	100	100	100	100	100	100	100
Total No. Species Detected	15	5	15	9	15	10	15	14	16

herbaceous layer was found in transects in Reach 4B2 in the San Luis NWR, where 16 different species were detected (Table 1); however only 8 of these were native species. Transects in Reaches 1A, 2A, 3, and in the East Side Bypass followed in diversity levels, with 15 species detected in each. The greatest native plant diversity was measured in transects in Reaches 3 (11 native out of 15 species) and in Reach 1A (10 native out of 15 species).

Relative percent herbaceous cover of lifeforms by reach is shown in Figure 5. Native forbs and grasses were typically the most common lifeforms detected. Native species were dominant relative to introduced species among herbaceous plants in all reaches, although relative cover of native and introduced species was very close in Reaches 2A and 4B2 due to a fairly high percentage of introduced grasses (Figure 5 and Table 2).

Overstory vegetation

A total of 11 woody species was detected in the overstory layer of all transects combined (Table 3). No overstory woody species were recorded along transects within Reach 4A and the Mariposa Bypass. Total percent overstory cover was highest in the uppermost reaches 1A and 1B, with estimates of 45.2 and 54.9 percent, respectively, followed by Reach 3 (17.4 percent). There was less than 10 percent total cover in all other reaches where overstory species were present. In general, overstory species diversity was directly related to proximity to Friant Dam, with only upstream Reaches 1A and 1B having more than 2 species in the overstory composition. Gooding's willow was the most frequently documented overstory species, detected in 6 of the 9 river reaches monitored. The average height of the tallest overstory shrubs within each stretch by species is also shown in Table 3.

The vast majority of overstory trees and shrubs were comprised of native species relative to introduced (Table 2). The only overstory introduced species recorded were giant reed (technically a grass but also categorized as a shrub; USDA - NRCS 2012) and scarlet wisteria, both found only in transects in Reach 1B (although the species' were observed in other reaches but did not fall within transects). Both are classified as a noxious weed in California.

Stem Density

Density of woody plants by size class and species is listed in Table 4. No stems were detected in the one meter belt associated with transects in Reach 4B2 and the East Side and Mariposa Bypasses. Highest densities were found in upstream Reaches 1A, 1B, and 2B. Reach 2B had the greatest density by far (4.44 stems/m^2 in all size classes) with stems dominantly sandbar willow in size class 2. A relatively high number of stems in size classes 1 and/or 2 indicate potential for regeneration of woody species in Reaches 1A, 1B, 2A, 2B, and 4A.

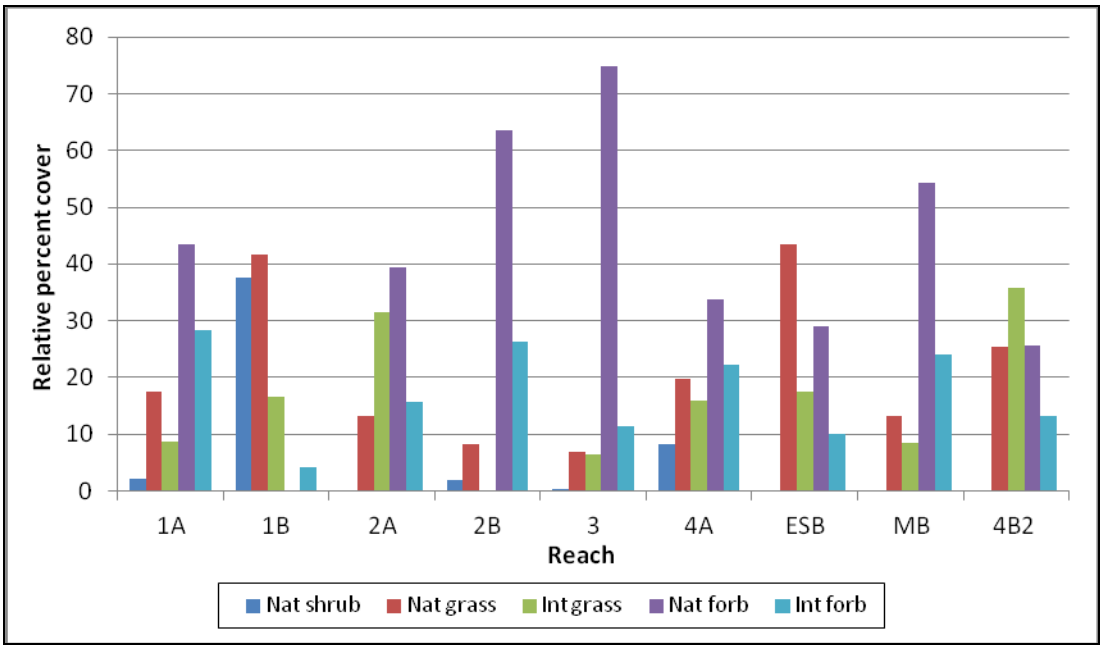

Figure 5.—Relative percent herbaceous cover of lifeforms in vegetation transects by reach in August 2011 along the San Joaquin River.

Table 2.— Proportion of native and introduced species in the herbaceous and overstory layers by reach in August 2011 along the San Joaquin River.

	Relative Percent Cover			
	Herbaceous cover		Overstory cover	
Reach	**Native spp**	**Introduced spp**	**Native spp**	**Introduced spp**
1A	63.0	37.0	100.0	0.0
1B	79.2	20.8	81.8	18.2
2A	52.6	47.4	100.0	0.0
2B	73.8	26.2	100.0	0.0
3	82.3	17.7	100.0	0.0
4A	61.9	38.1	No overstory	
ESB	72.5	27.5	100.0	0.0
MB	67.5	32.5	No overstory	
4B2	51.0	49.0	100.0	0.0

Table 3.— Total percent cover and average height of woody overstory species (>1 m) detected in vegetation transects by reach in August 2011 along the San Joaquin River. No overstory species were documented in transects within Reaches 4A and Mariposa Bypass.

Average Total Percent Overstory Cover														
	1A		1B		2A		2B		3		ESB		4B2	
Species	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)	Tot % cov	Avg. Ht. (m)
White alder	0.6	4.3	0.0		0.0		0.0		0.0		0.0		0.0	
Button bush	7.1	2.2	7.6	2.4	0.0		0.0		0.0		0.0		0.0	
Oregon ash	8.9	10.3	0.0		0.0		0.0		0.0		0.0		0.0	
Fremont cottonwood	0.0		4.1	2.0	0.0		0.0		16.7	15.0	0.0		0.0	
Valley oak	21.1	12.1	0.0		0.0		0.0		0.0		0.0		0.0	
Sandbar willow	5.7	2.2	22.1	2.8	0.0		0.0		0.0		0.0		0.0	
Gooding's willow	0.0		11.8	3.5	1.1	3.9	4.4	5.9	0.8	3.0	0.2	not avail	8.7	8.6
Arroyo willow	4.7	4.9	0.0		0.0		0.0		0.0		0.0		0.0	
Black elderberry	0.0		0.0		0.0		2.8	4.2	0.0		0.0		0.0	
Total native	48.0		45.5		1.1		7.2		17.4		0.2		8.7	
Giant reed	0.0		9.8	4.4	0.0		0.0		0.0		0.0		0.0	
Scarlet wisteria	0.0		0.3	1.3	0.0		0.0		0.0		0.0		0.0	
Total introduced	0.0		10.1		0.0		0.0		0.0		0.0		0.0	
Total canopy*	45.2		54.9		1.1		7.2		17.4		0.2		9.3	

*Total canopy may not equal sum of all species due to overlap

Table 4.—Density of woody plant species by size class and species in river reaches along the San Joaquin River.

		Average # stems/m^2											
Reach	Size class*	Giant Reed	Button bush	Oregon Ash	Fremont cottonwood	Valley oak	Sandbar willow	Goodding willow	Willow sp.	Black elderberry	Scarlet wisteria	By size class	All size classes
1A	1	0	0.01	0.04	0	0.01	0.01	0	0.04	0	0	0.10	
	2	0	0.07	0	0	0	0.14	0	0.22	0	0	0.43	
	3	0	0.18	0.01	0	0.01	0.31	0	0	0	0	0.50	
	4	0	0.02	0.01	0	0.01	0.02	0	0	0	0	0.06	1.08
1B	1	0	0.01	0	0	0	0	0	0	0	0	0.01	
	2	0	0.22	0	0	0	2.49	0	0	0	0.02	2.73	
	3	0.22	0.28	0	0	0	1.14	0.05	0	0	0	1.69	
	4	0	0	0	0	0	0.01	0	0	0	0	0.01	4.44
2A	1	0	0	0	0	0	0.19	0	0	0	0.02	0.21	
	2	0	0	0	0	0	0.04	0	0	0	0	0.04	
	3	0	0	0	0	0	0	0	0	0	0	0.00	
	4	0	0	0	0	0	0	0	0	0	0	0.00	0.25
2B	1	0	0	0	0	0	0.01	1.56	0	0	0	1.57	
	2	0	0	0	0	0	0	0	0	0	0	0.00	
	3	0	0	0	0	0	0	0.06	0	0.32	0	0.38	
	4	0	0	0	0	0	0	0	0	0	0	0.00	1.95
3	1	0	0	0	0	0	0	0	0	0	0	0.00	
	2	0	0	0	0.07	0	0	0	0	0	0	0.07	
	3	0	0	0	0	0	0	0.04	0	0	0	0.04	
	4	0	0	0	0	0	0	0	0	0	0	0.00	0.11
4A	1	0	0	0	0	0	0	0.02	0	0	0	0.02	
	2	0	0	0	0	0	0	0.41	0	0	0	0.41	
	3	0	0	0	0	0	0	0	0	0	0	0.00	
	4	0	0	0	0	0	0	0	0	0	0	0.00	0.43
ESB	1	0	0	0	0	0	0	0	0	0	0	0.00	
	2	0	0	0	0	0	0	0	0	0	0	0.00	
	3	0	0	0	0	0	0	0	0	0	0	0.00	
	4	0	0	0	0	0	0	0	0	0	0	0.00	0.00
MB	1	0	0	0	0	0	0	0	0	0	0	0.00	
	2	0	0	0	0	0	0	0	0	0	0	0.00	
	3	0	0	0	0	0	0	0	0	0	0	0.00	
	4	0	0	0	0	0	0	0	0	0	0	0.00	0.00
4B2	1	0	0	0	0	0	0	0	0	0	0	0.00	
	2	0	0	0	0	0	0	0	0	0	0	0.00	
	3	0	0	0	0	0	0	0	0	0	0	0.00	
	4	0	0	0	0	0	0	0	0	0	0	0.00	0.00

Size classes: 1= current year's seedling; 2= <1 m in ht; 3= >1 m in ht and <10 cm DBH; 4= >10 cm DBH

Habitat Variables

The highest ranking habitat variables (>7) were found in the uppermost reaches 1A and 1B (Table 5). These sites were rated relatively close to the highest possible ranking of 8.0, which indicates excellent riparian condition. Reaches with a moderate ranking (between 5.0 and 6.0) were 2A, 2B, 3, and 4B2. All other reaches ranked between 3.65 and 4.75. These sites similarly ranked relatively low in variables "Coverage and Spatial Diversity", "Stuctural Diversity", "Micro- and Macrotopographic Complexity", and "Biogeochemical Processes".

Table 5.—Ranking of habitat variables as an indicator of riparian condition.

Habitat Variable	1A	1B	2A	2B	3	4A	ESB	MB	4B2
Coverage & Spatial Diversity	1.00	1.00	0.25	0.25	0.45	0.20	0.18	0.20	0.40
Structural Diversity	0.70	0.75	0.25	0.40	0.60	0.20	0.18	0.25	0.40
Contiguity of Habitats	1.00	0.80	0.80	0.90	0.65	0.80	0.90	1.00	0.80
% Invasive Woody Vegetation	1.00	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hydrology	1.00	1.00	1.00	1.00	0.80	1.00	0.50	0.30	0.70
Micro- & Macrotopographic Complexity	1.00	0.85	0.80	0.35	0.70	0.35	0.28	0.20	0.50
Characteristics of Flood-prone Area	1.00	1.00	0.90	0.90	0.80	1.00	0.83	0.30	0.80
Biogeochemical Processes	0.80	0.80	0.35	0.30	0.60	0.20	0.40	0.40	0.60
Total Score*	7.60	7.10	5.35	5.10	5.60	4.75	4.25	3.65	5.20

* Possible score 0 (Poor) to 8 (Excellent)

Photo Stations

Photographs taken from the end of vegetation transects the first year of monitoring are shown in Appendix D. The 2011 photos will provide a record for future comparison.

Discussion

Because this was the first year of vegetation monitoring, no statistical comparisons were conducted. Data collected within transects showed similarities to vegetation types described by reach in 2000 (CDWR 2002). These descriptions are included in the Project Area section above.

Reach 1A – In 2000, this reach was described as having the highest diversity of vegetation types and of vegetative species of all reaches. This diversity was captured in data from transects, particularly in the overstory, where the greatest number of woody species in all reaches was detected. Although plant diversity in the herbaceous layer of transects in Reach 1A was not the highest compared to other reaches, it did show a relatively high diversity of native plants. The exotic species giant reed and scarlet wisteria were not detected in transects but were noted to be widespread in portions of Reach 1A in 2000. This reach received the highest ranking for riparian condition, almost meeting the highest possible score of 8.

Reach 1B – Transects within this reach fall within the "willow scrub" vegetation type (dominated by sandbar and Goodding's willows), which was noted to be more prevalent in this reach than in Reach 1A. Both giant reed and scarlet wisteria were detected in transects and were observed to displace willow scrub in 2000. Transects in Reach 1B were found to have the lowest herbaceous cover compared to all other sites. This reach was estimated to have the second highest rating in riparian condition of all reaches monitored.

Reach 2 (2A and 2B) – This reach was described as being heavily dominated by herbaceous vegetation cover and frequently experiencing drought conditions as a result of porous soils. Transects were representative of an herbaceous vegetation type, with an average of only 4.2 percent overstory cover for the entire reach (average of 2A and 2B; Table 3). Woody stem density was relatively high in Reach 2B due to numerous Goodding's willow seedlings. Future monitoring will determine if interim flows are capable of sustaining a "willow riparian" vegetation type within Reach 2. Riparian condition was ranked moderately, with lowest scores in the variables coverage and spatial diversity (i.e. cover and diversity of native riparian species), structural diversity (i.e. different size- and age- classes of riparian vegetation), and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel).

Reach 3 – The most common habitat type described in Reach 3 in 2000 was the "cottonwood riparian." Vegetation transects were representative of this type and were the only transects to include mature cottonwoods. Although Reach 3 had one of the lowest ratios of natural habitat in 2000 (47.5 acres per mile), transects within this reach indicated the highest native herbaceous plant species diversity of all the sites included in this study as well as the highest proportion of native cover relative to introduced species. Reach 3 received a moderately high ranking in riparian condition with improvement most needed in the coverage and spatial diversity (i.e. cover and diversity of native riparian species) variable.

Reach 4A – Reach 4A was described as having the fewest habitat types and the lowest ratio of natural vegetation per river mile of any reach and was dominated by herbaceous vegetation. Transects within this reach were indicative of an herbaceous vegetation type (albeit very low plant cover and high cover of bare

ground), with no overstory species recorded. Goodding's willow < 1m in height was, however, detected in both cover (1.5 percent) and density (0.44 stems/m^2) measurements, indicating potential for willow riparian habitat if river conditions can sustain woody species along this reach. Riparian condition was ranked moderately, with lowest scores in the variables coverage and spatial diversity (i.e. cover and diversity of native riparian species), structural diversity (i.e. different size- and age- classes of riparian vegetation), micro- and macrotopographic complexity (mixture of topographic features) and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel).

Reach 4B2 – The vast majority of this reach is covered by herbaceous vegetation, which was typified by vegetation within transects. Average overstory cover was 8.7 percent but transects within Reach 4B2 were among the highest in herbaceous cover at 81.4 percent. Transects also showed the highest herbaceous plant species diversity, although half of species detected were exotics. While mature Goodding's willow were included in transects, no woody species were detected in herbaceous cover or stem density measurements, indicating that recruitment is potentially low. Reach 4B2 received a moderate ranking in riparian condition with improvement most needed in the coverage and spatial diversity (i.e. cover and diversity of native riparian species) and structural diversity (i.e. different size- and age- classes of riparian vegetation) variables. This reach is located in the San Luis NWR, which has been supplied with year-round water; therefore hydrologic conditions may not change considerably and effects from interim flows may be difficult to determine.

Previous descriptions of vegetation types along the East Side and Mariposa Bypasses were not available. Existing conditions as characterized by transects follow.

East Side Bypass – Transects in this reach fell within almost exclusively herbaceous habitat, with only 0.2 percent average overstory cover and no woody species detected in herbaceous or stem density measurements. The proportion of native plant species relative to introduced was comparatively high, as was native herbaceous plant species diversity. Riparian condition was ranked moderately low, with relatively low scores in the variables coverage and spatial diversity (i.e. cover and diversity of native riparian species), structural diversity (i.e. different size- and age- classes of riparian vegetation), micro- and macrotopographic complexity (mixture of topographic features), and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel). Two of four transects were located within the Merced NWR and, like the San Luis NWR in Reach 4B2, have a year-round water supply which could make it difficult to identify changes in vegetation from interim flows.

Mariposa Bypass – Vegetation was strictly herbaceous with no woody species of any size detected in transects within the Mariposa Bypass. Transects in this reach

had the highest average herbaceous total cover (94.0 percent) of any included in this study. Mariposa Bypass received the lowest ranking in riparian condition of all reaches studied. Low scores were given for the variables coverage and spatial diversity (i.e. cover and diversity of native riparian species), structural diversity (i.e. different size- and age- classes of riparian vegetation), hydrology (i.e. proximity to natural water source), micro- and macrotopographic complexity (mixture of topographic features), and biogeochemical processes (i.e. vegetation with woody debris, leaf litter, detritus in channel).

Groundwater wells were not yet installed; therefore no correlations between groundwater levels and vegetation were analyzed in 2011. A wide range of hydrologic regimes have been observed from year to year on the San Joaquin River, which is expected to be captured in groundwater well data. In turn, the effects of varying hydrology should be apparent in vegetation development.

Conclusions

Generally, upstream reaches (*i.e.* 1A through 3, but particularly 1A and 1B) exhibited healthier riparian condition than downstream reaches, with greater cover, diversity, and density of woody species and higher habitat variable rankings. Subsequently, downstream reaches – with the exception of the wildlife refuges – are likely to have a greater potential for showing effects from interim flows. Continued monitoring will determine if vegetative conditions have improved in transects along all reaches of the San Joaquin River included in this study.

Summary

The SJRRP Vegetation Monitoring Study evaluates the response of riparian vegetation to Interim Flows through comparison of transect data over time. Changes in vegetation may have implications for Friant Dam flow scheduling, habitat establishment supporting fish, and maintenance needs to convey flows. In 2011 SJRRP established transects, collected the first year of data, and ranked transects for riparian condition. SJRRP will continue to monitor these transects during 2012.

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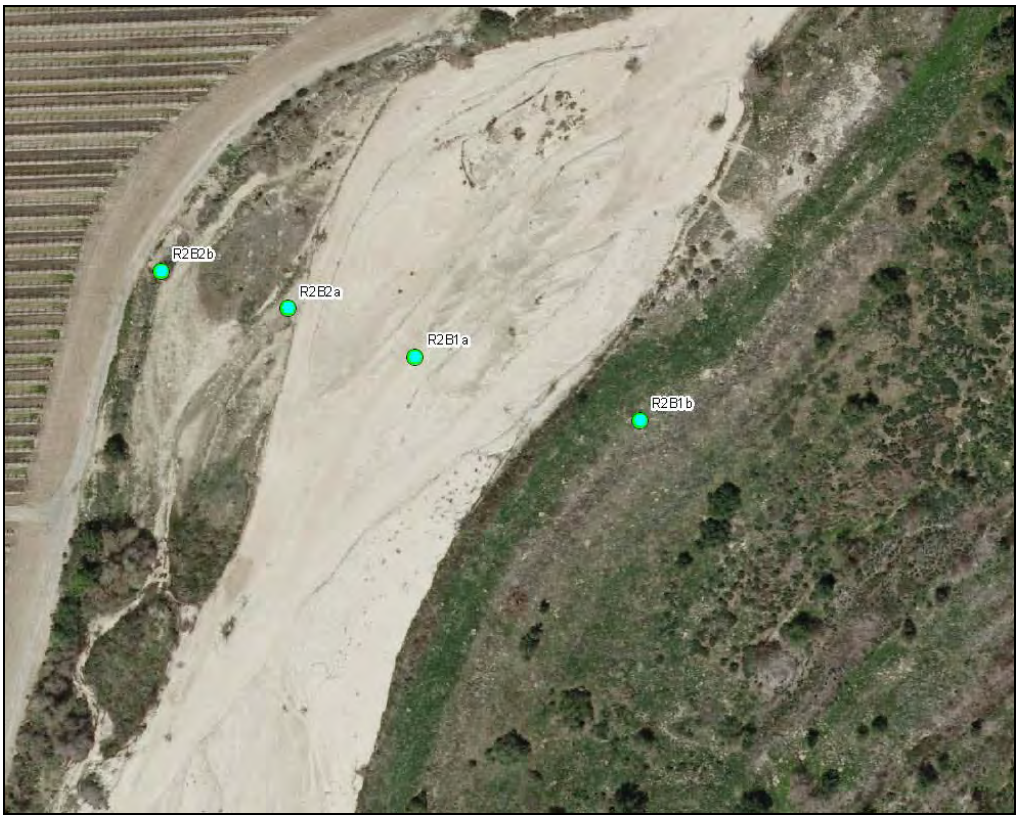
Appendix A

Maps of Vegetation Transects by River Reach

Reach 1A

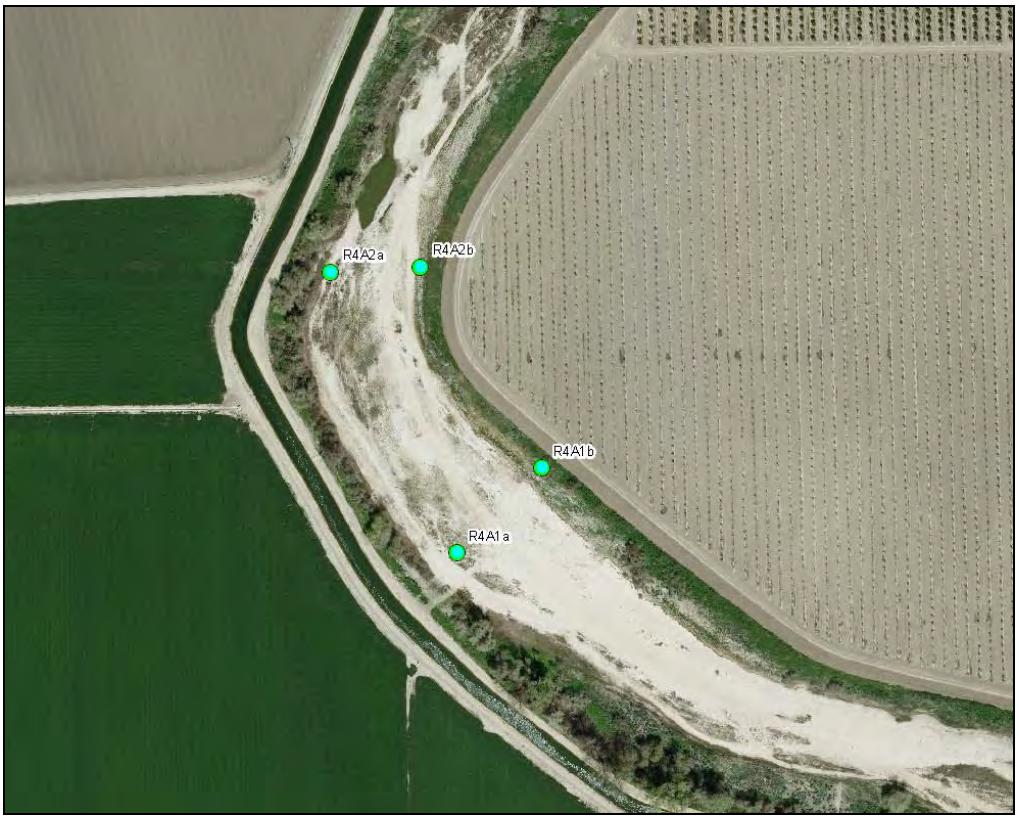
Reach 1B

Reach 2A



Reach 2B

Reach 3

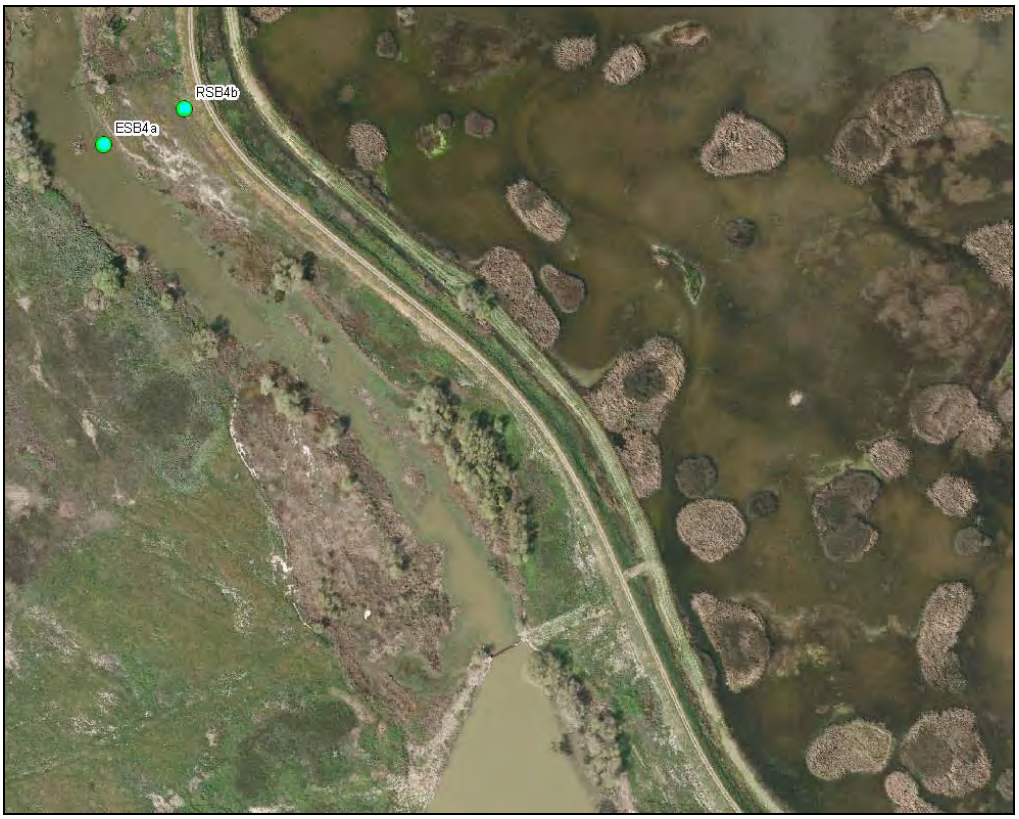


Reach 4A

Reach 4B2 (San Luis NWR)

Reach East Side Bypass

Reach East Side Bypass (Merced NWR), Transect 3



Reach East Side Bypass (Merced NWR), Transect 3

Reach Mariposa Bypass

Appendix B

Vegetation transect waypoints

All datum in NAD83.

Reach	Transect	Endpoint A		Endpoint B		Zone
		x	y	x	y	
R1A	1	255049	4091361	255081	4091315	11S
	2	254888	4091300	254940	4091218	11S
R1B	1	755779	4077621	755782	4077561	10S
	2	755580	4077600	755592	4077546	10S
R2A	1	751417	4074422	751327	4074469	10S
	2	751327	4074470	751230	4074504	10S
R2B	1	741586	4072746	741646	4072729	10S
	2	741552	4072759	741518	4072769	10S
R3	1	734778	4076749	734732	4076729	10S
	2	734713	4076882	734652	4076833	10S
R4A	1	718414	4100615	718463	4100664	10S
	2	718341	4100777	718393	4100780	10S
MB	1	703911	4119706	703910	4119656	10S
	2	703797	4119712	703795	4119662	10S
ESB	1	714230	4111882	714285	4111905	10S
	2	714194	4111872	714145	4111861	10S
	3	710325	4116027	710390	4116107	10S
	4	708217	4117404	708262	4117424	10S
R4B2	1	693717	4123312	693634	4123287	10S
	2	693670	4123484	693583	4123432	10S

Appendix C

Data collection forms

San Joaquin Restoration Flows
Vegetation Monitoring
Herbaceous Cover

Date: ____________________ **Transect #:** ____________________

Observers: ____

Photo #s: A Toward transect: ____________ B Toward transect: ____________
Away from transect: ____________ Away from transect: ____________

Notes:

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

Figure C-1.—Herbaceous cover data form.

San Joaquin Restoration Flows
Vegetation Monitoring
Overstory Cover

Date: _____ Observers: _____

Transect: _____

Species	Start	Stop	Height	Start	Stop	Height	Start	Stop	Height	Start	Stop	Height

Figure C-2.—Overstory cover data form

San Joaquin Restoration Flows
Vegetation Monitoring
Tree Density
Site Characterization

Date: _____

Transect: _____

Observers: _____

Density

Size class	Description	Species				
1	Current year seedling					
2	< 1 m (3 ft) in height					
3	> 1 m (3 ft) in height and < 10 cm (4 in) DBH					
4	>10 cm (4 in) DBH					

Site Characterization

Elevational differences along transect (e.g. terraces, gradual change):

General composition of bed material in river:

Multiple channels or single channel:

Active erosion or protection on banks:

Figure C-3.—Density and Site Characterization data form

Variable	Rankings-written description and numeric score											
	Poor ═══ ═══Excellent											
Coverage and Spatial Diversity	Site permanently converted to land use not able to support native riparian vegetation, such as housing, agriculture, or concrete channel	0	No existing riparian vegetation (e.g., covered with grasses and scrub, bare ground).	0.2	Patches of monotypic woody riparian vegetation covering up to 50% of the site, interspersed among herbaceous species or bare ground.	0.4	Patches of diverse riparian vegetation (e.g., at least two different genera of woody riparian vegetation present) covering up to 30% of the site, interspersed among grasses, invasive plants, or bare ground; and/or greater than 50% of the site covered with monotypic patches of riparian vegetation, interspersed among herbaceous species or bare ground.	0.6	Diverse woody riparian vegetation (at least three genera) covering between 30% and 75% of the site, e.g., strips or islands of riparian habitat interspersed in open space.	0.8	Diverse riparian vegetation (e.g., at least three different genera of native riparian vegetation present) covering between 75% and 100% of the site, interspersed in open space or herbaceous plant communities.	1.0
Structural Diversity	Site permanently converted to land use not able to support native riparian vegetation, such as housing, agriculture, or concrete channel	0	No existing riparian vegetation (e.g., covered with grasses and scrub, bare ground).	0.2	Vegetated areas of the site contain sparse, scattered, patchy, or remnant riparian vegetation that is immature and/or lacks structural (vertical) diversity.	0.4	Patches of riparian vegetation contain riparian trees and/or saplings(i.e., perennial dicots), but contain none or poorly developed shrub understory.	0.6	Riparian vegetation patches contain cottonwood trees and saplings, with well-developed native shrub understory, or shrub understory, but few riparian trees.	0.8	Patches of diverse riparian vegetation. They contain cottonwood trees, saplings, and seedlings (or evidence of seedling establishment), as well as developed native shrub understory and herbaceous layer.	1.0

Contiguity of Habitats	No linear contiguity or transitional upland habitat; surrounded by or isolated within an anthropogenic modified setting.	0	No linear contiguity upstream or downstream, but isolated within upland open space habitat.	0.2	Contiguous with comparable habitat on one end of the site, but surrounded with urban/suburban or other non-open space lands adjacent (lateral to) to the site on at least one side.	0.4	Contiguous with comparable habitat on one end of the site and surrounded by transitional upland habitat which is at least twice the width of the riparian zone.	0.6	Contiguous with comparable habitat on both ends of the site, but surrounded with anthropogenically modified lands adjacent (lateral to) to the site on at least one side.	0.8	Contiguous with comparable habitat on both ends of the site and surrounded by transitional upland habitat on both sides which is at least twice the width of the riparian zones.	1.0
Percent of Invasive Woody Vegetation (please note other invasive herbaceous vegetation)	Site is covered by pure stands of invasive vegetation or lacks any riparian vegetation	0	70-99% invasive vegetation.	0.2	40-69% invasive vegetation.	0.4	10-39% invasive vegetation.	0.6	4-9% invasive vegetation	0.8	Site is covered by less than 5% invasive vegetation.	1.0
Hydrology	No regular supply of water to the site. Site not associated with any water source, surface drainage, impoundment, or groundwater discharge.	0	Water supply to the site is solely from artificial irrigation. No natural supply.	0.2	Site is sustained by source of water not associated with water way. For example, the site is sustained by groundwater or urban runoff. There is no evidence of riparian processes.	0.4	Site is sustained by natural source, but no evidence of riparian processes, such as overbank flow or scour or deposition. Cut banks.	0.6	Site is within or adjacent to an impoundment on a natural waterway which is subject to fluctuations in flow or hydroperiod.	0.8	Site is within or adjacent to a waterway that provides the primary source of water to the site. The site contains evidence of riparian processes where water flows into the riparian vegetation zone.	1.0
Micro- and Macrotopographic Complexity	Flood-prone area contained in a concrete-lined channel.	0	Flood-prone area is characterized by a homogenous, flat earthen surface with little to no micro- and macro-topographic features.	0.2	Flood-prone area contains micro- and/or macro-topographic features such as pits, ponds, hummocks, bars, but is predominantly homogenous or flat surface	0.5	Flood plain mostly hetero-geneous, characterized by micro-topo-graphic features ie pits, ponds, hummocks,bars. However, there are no macro-topographic features, such as braiding, 2° channels, backwaters.	0.8	Flood-prone area is characterized by micro- and macro-topographic complexity, such as meanders, bars, braiding, 2°channels, backwaters, terraces, pits, ponds, hummocks, etc.	1.0		

Characteristics of Flood-prone Area	All flows are contained in a concrete-lined channel, culvert, etc.	0	Channel has an earthen bottom; however, it is structurally confined (e.g., riprap or concrete sideslopes) such that the flood-prone area is wholly contained within the channel, except in extreme events.	0.2	Channel has an earthen bottom and earthen sideslopes; however, it is incised or confined such that the flood-prone area is wholly contained within the channel and there is no opportunity for overbank flow, except in extreme events.	0.3	Site is part of a flood plain, which provides an opportunity for overbank flow during moderate flow events (i.e., during a 2- to 10-year-flood event). However, the flood-prone area is confined by levees, berms, dikes, cut banks, or other obstructions or barriers such that the area available for overbank flow is less than twice the width of the channel at bankful conditions.	0.6	Site is part of a flood plain, which provides an opportunity for overbank flow during moderate flow events. The flood-prone area is confined by levees, berms, dikes, cut banks, or other obstructions or barriers; however, the area available for overbank flow is equal to or greater than twice the width of the channel at bankfull conditions.	0.8	Site is part of an unconfined natural floodplain at least twice the width of the channel at bankfull conditions and there is evidence of overbank flow.	1.0
Biogeochemical Processes	Flood-prone area contained in a concrete-lined channel, culvert, etc., with little to no vegetation or detritus.	0	Site can support grasses, forbs, or other herbaceous vegetation, and there is woody debris, leaf litter, or detritus present in the channel.	0.2	Site supports at least 25% relative cover of grasses, forbs, herbaceous, or riparian vegetation, and there is at least 10% relative cover of woody debris, leaf litter, or detritus in the channel.	0.4	Site contains between 25% and 50% relative cover of any strata of riparian vegetation and between 10% and 40% relative cover with woody debris, leaf litter, or detritus.	0.6	Site contains between 50% and 75% relative cover of any strata of riparian vegetation and between 40% and 60% relative cover with woody debris, leaf litter, or detritus.	0.8	Site contains greater than 75% relative cover of any strata of riparian vegetation (native or non-native) and greater than 60% relative cover with woody debris, leaf litter, or detritus.	1.0

Figure C-4.—Habitat variables data form.

Appendix D

Scientific Names and Locations of Plants Detected in Vegetation Transects

CODE	SCIENTIFIC NAME	COMMON NAME	LIFEFORM	REACH								
				1A	1B	2A	2B	3	4A	ESB	MB	4B2
Tree/shrub												
ALRH	*Alnus rhombifolia*	White alder	NT	X								
CEOC	*Cephalanthus occidentalis*	Button bush	NS	X	X							
FRLA	*Fraxinus latifolia*	Oregon ash	NT	X								
POFR	*Populus fremontii*	Fremont cottonwood	NT		X			X				
QULO	*Quercus lobata*	Valley oak	NT	X								
SAEX	*Salix exigua*	Sandbar willow	NS	X	X							
SAGO	*Salix gooddingii*	Gooding's willow	NT		X	X	X	X	X	X		X
SALA	*Salix lasiolepis*	Arroyo willow	NT	X								
SASP2	*Salix sp.*	Willow	NT	X								
SANI	*Sambucus nigra*	Black elderberry	NT				X					
SEPU	*Sesbania pungens*	Scarlet wisteria	IS		X							
Graminoid												
ALSA	*Alopecurus saccatus*	Pacific foxtail	NG								X	X
ARDO2	*Arundo donax*	Giant reed	IG		X							
BRDI	*Bromus diandrus*	Ripgut brome	IG	X		X						
CYDA	*Cynodon dactylon*	Bermuda grass	IG	X	X			X	X	X	X	X
CYER	*Cyperus erythrorhizos*	Redroot flatsedge	NG							X		
CYES	*Cyperus esculentus*	Yellow nutgrass	NG		X			X	X	X	X	
CYSP	*Cyperus sp.*	Flatsedge		X								
DISP	*Distichlis spicata*	Salt grass	NG	X								X
ECCR	*Echinochloa crus-galli*	Barnyard grass	IG	X		X		X	X	X		X
ELMA	*Eleocharis macrostachya*	Common spikerush	NG							X		
HOMA	*Hordeum marinum ssp gussoneanum*	Mediterranean barley	IG								X	X
JUBA	*Juncus balticus*	Baltic rush	NG	X						X	X	X
LEUN	*Leptochloa uninervia*	Mexican sprangletop	NG	X		X	X	X	X	X		
ORSA	*Oryza sativa*	Rice	IG			X						
PANO	*Paspalum notatum*	Bahia grass	IG							X		
VUMY	*Vulpia myuros*	Rat-tail fescue	IG			X						
Forb												
ARDO	*Artemisia douglasiana*	California mugwort	NF	X			X	X				
ARVU	*Artemisia vulgare*	Common mugwort	IF						X			
BRNI	*Brassica nigra*	Black mustard	IF	X		X	X				X	X
CEPA	*Centromadia parryii ssp rudis*	Pappose tarweed	NF								X	X
CHBE	*Chenopodium berlandieri*	Pitseed goosefoot	NF					X			X	X
ERSE	*Eremocarpus setigerus*	Doveweed	NF			X						
ERWR	*Eriogonum wrightii*	Wright's buckwheat	NF			X						
ERRA	*Eryngium racemosum*	Delta button celery	NF							X		
GATR	*Gallium trifudum*	Threepetal bedstraw	NF					X				
HEAN	*Helianthus annuus*	Sunflower	NF			X					X	X
LASE	*Lactuca serriola*	Prickly lettuce	IF			X		X			X	X
LOUN	*Lotus unifoliolatus*	American bird's-foot trefoil	NF			X	X					
MALE	*Malvella leprosa*	Alkali mallow	IF							X		X
MEAR	*Mentha arvensis*	Field mint	NF									
POAR	*Polygonum arenastrum*	Common knotweed	IF								X	X
POLA	*Polygonum lapathifolium*	Pale smartweed	NF					X				
ROPA	*Rorippa palustris*	Yellow cress	NF					X				
RUCR	*Rumex crispus*	Curly dock	IF						X	X	X	X
RUDI	*Rubus discolor*	Himalayan blackberry	IF	X								
SATR	*Salsola tragus*	Russian thistle	IF			X						
SASP	*Salsola sp.*	Saltwort	IF					X	X			
SOAM	*Solanum americanum*	American black nightshade	NF			X	X					X

TRSP	*Trifolium sp.*	Clover					X			X		
URDI	*Urtica dioica*	Stinging nettle	IF				X					
VEAN	*Veronica anagallis-aquatica*	Water speedwell	IF		X							
XAST	*Xanthium strumarium*	Cocklebur	NF	X		X		X	X	X	X	X

Appendix E

Photo Stations 2011

Reach 1A, Transect 1

1A – Toward transect

1A – Away from transect

1B – Toward transect

1B – Away from transect

Reach 1A, Transect 2

2A – Toward transect

2A – Away from transect

2B – Toward transect

2B – Away from transect

Reach 1B, Transect 1

1A – Toward transect

1A – Away from transect

1B – Toward transect

1B – Away from transect

Reach 1B, Transect 2

2A – Toward transect

2A – Away from transect

2B – Toward transect

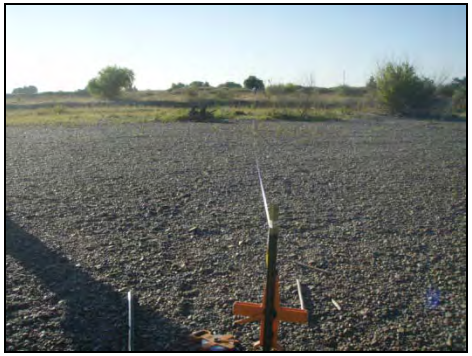
2B – Away from transect

Reach 2A, Transect 1

1A – Toward transect

1A – Away from transect

1B – Toward transect

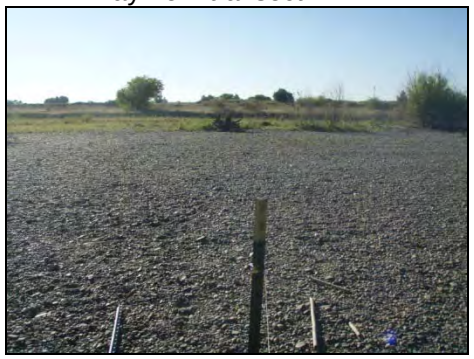


1B – Away from transect

Reach 2A, Transect 2

2A – Toward transect

2A – Away from transect



2B – Toward transect

2B – Away from transect

Reach 2B, Transect 1

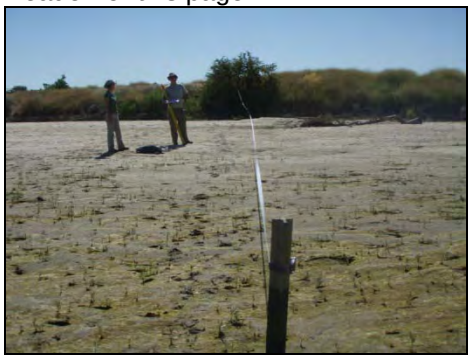
1A – Toward transect

1A – Away from transect

1B – Toward transect

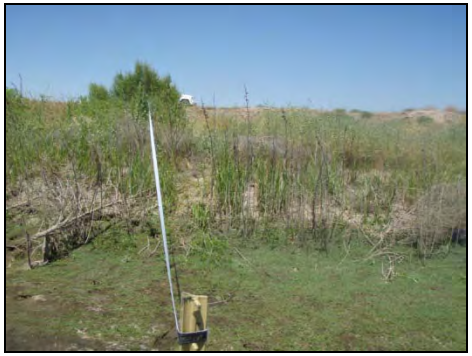
1B – Away from transect

Header for this page




Reach 2B, Transect 2

2A – Toward transect | 2A – Away from transect | 2B – Toward transect | 2B – Away from transect




Reach 3, Transect 1

1A – Toward transect | 1A – Away from transect | 1B – Toward transect | 1B – Away from transect

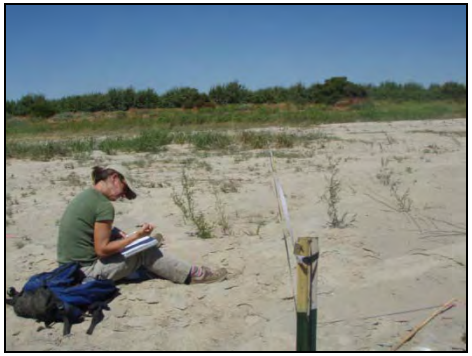



Reach 3, Transect 2

2A – Toward transect | 2A – Away from transect | 2B – Toward transect | 2B – Away from transect

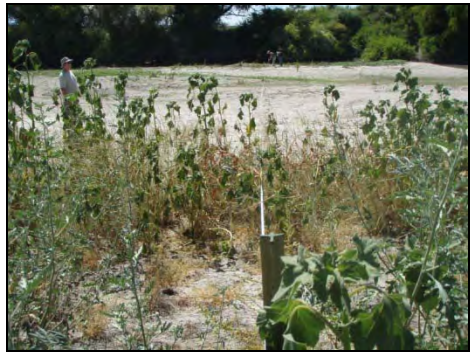



Reach 4A, Transect 1
1A – Toward transect | 1A – Away from transect | 1B – Toward transect | 1B – Away from transect



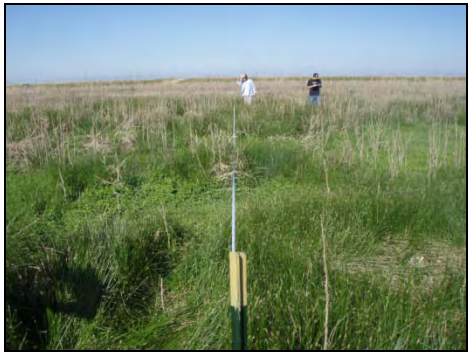
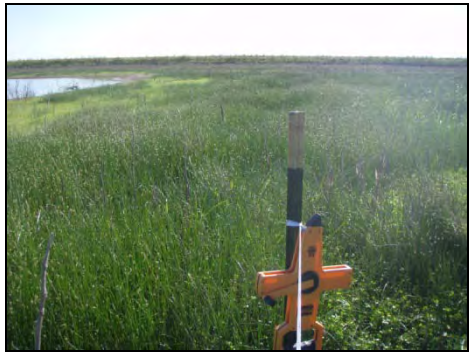

Reach 4A, Transect 2
2A – Toward transect | 2A – Away from transect | 2B – Toward transect | 2B – Away from transect






East Side Bypass, Transect 1
1A – Toward transect | 1A – Away from transect | 1B – Toward transect | 1B – Away from transect

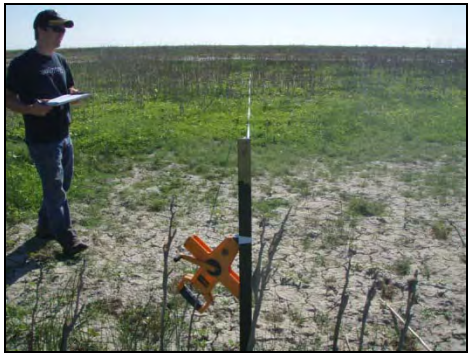


East Side Bypass, Transect 2

2A – Toward transect | 2A – Away from transect | 2B – Toward transect | 2B – Away from transect

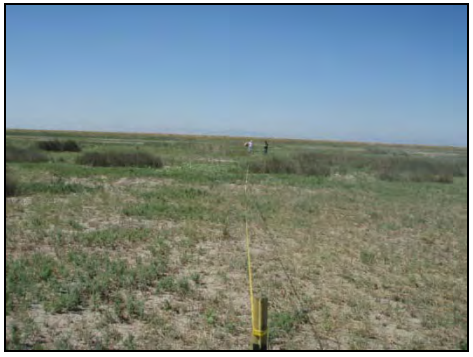





East Side Bypass (Merced NWR), Transect 3

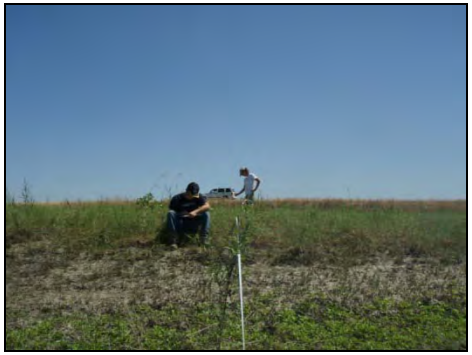
3A – Toward transect | 3A – Away from transect | 3B – Toward transect | 3B – Away from transect





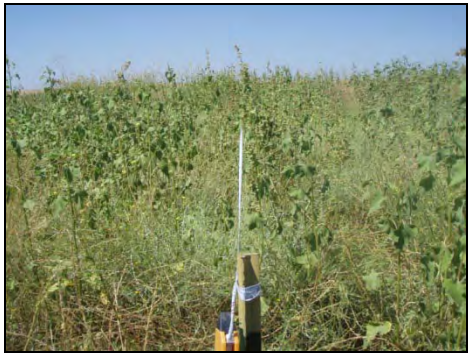

East Side Bypass (Merced NWR), Transect 4

4A – Toward transect | 4A – Away from transect | 4B – Toward transect | 4B – Away from transect




Mariposa Bypass
1A – Toward transect | 1A – Away from transect | 1B – Toward transect | 1B – Away from transect



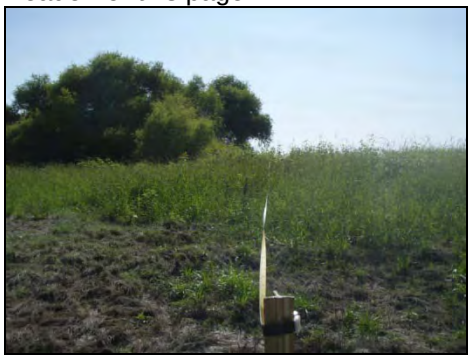



Mariposa Bypass
2A – Toward transect | 2A – Away from transect | 2B – Toward transect | 2B – Away from transect




Reach 4B2 (San Luis NWR), Transect 1
1A – Toward transect | 1A – Away from transect | 1B – Toward transect | 1B – Away from transect

Header for this page




Reach 4B2 (San Luis NWR), Transect 2

2A – Toward transect

2A – Away from transect

2B – Toward transect

2B – Away from transect