Appendix H3. CNDDB Figures

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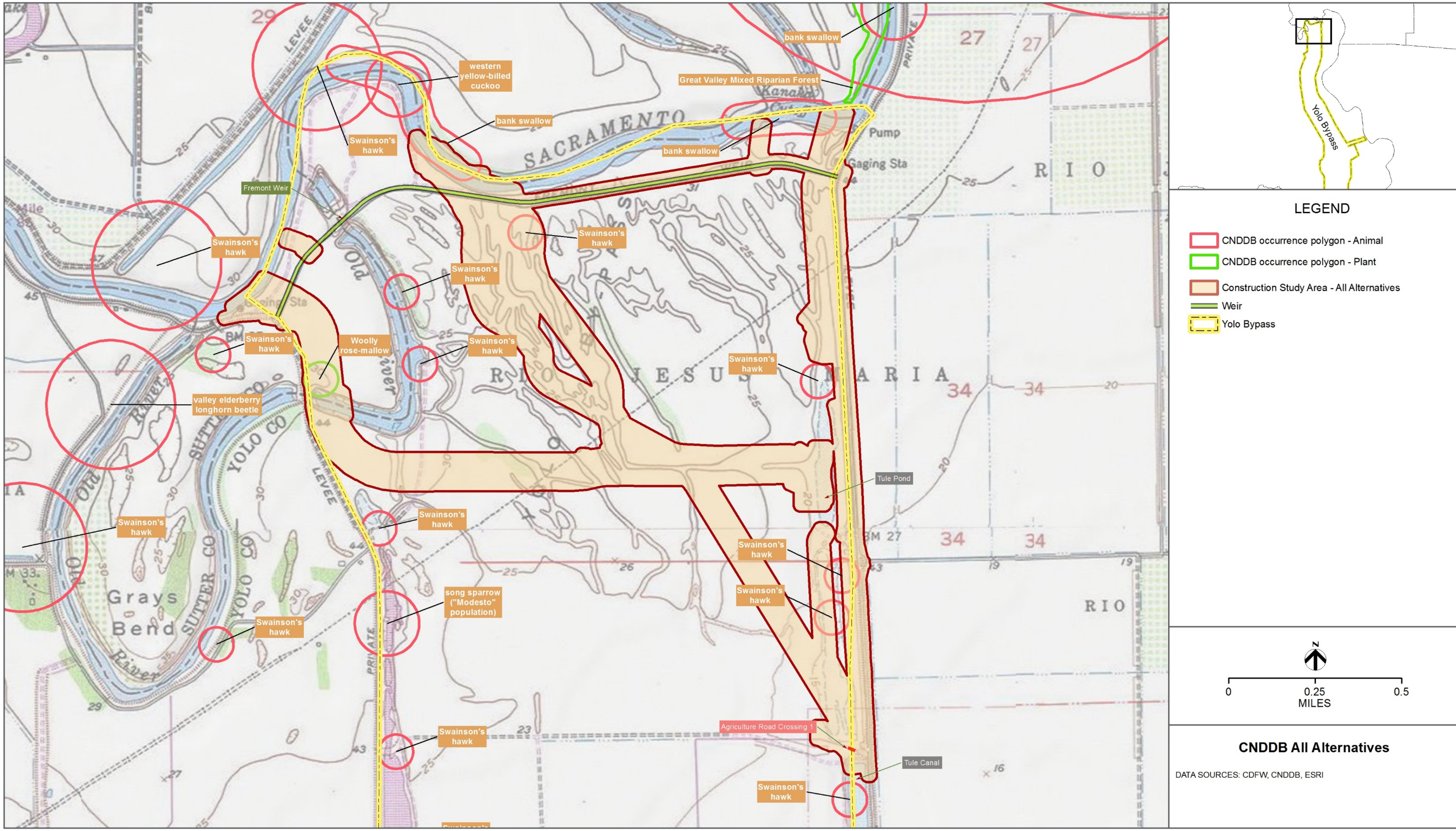

Figure H3-1.
CNDDB Occurrences within the Project Vicinity

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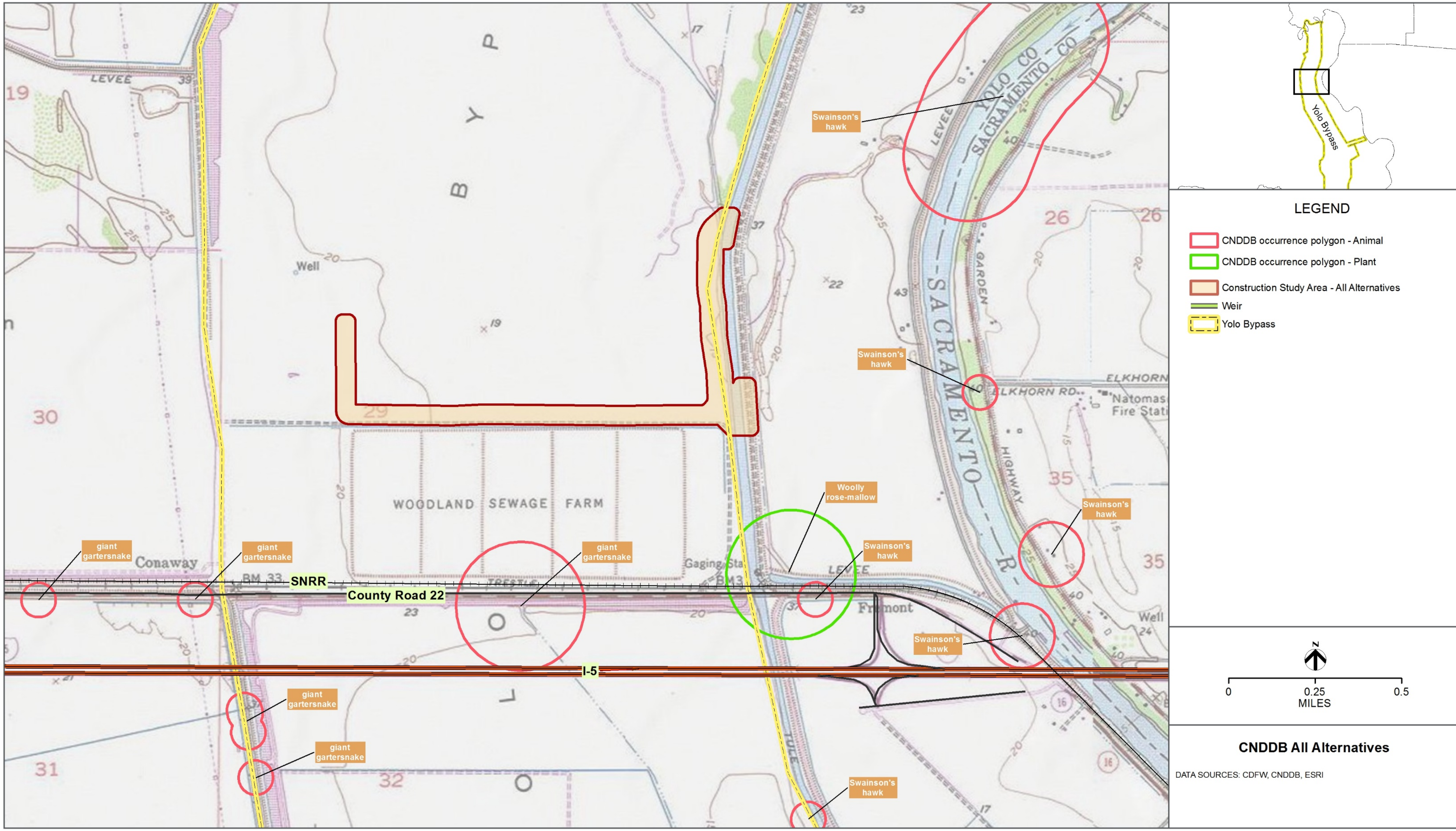

Figure H3-2.
CNDDB Occurrences within the Project Vicinity

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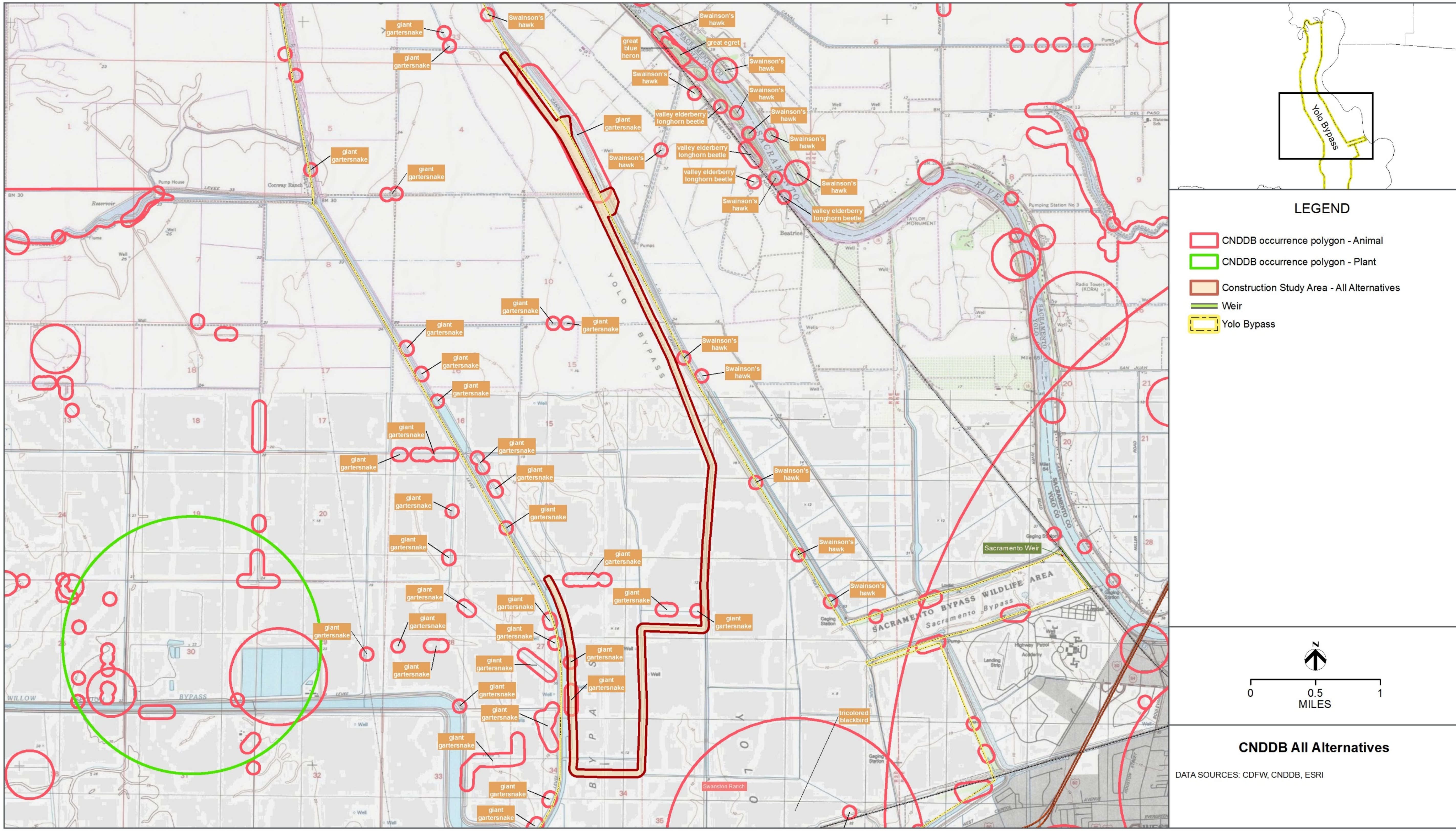

Figure H3-3.
CNDDB Occurrences within the Project Vicinity

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REFERENCES

California Department of Fish and Wildlife. 2016. California Natural Diversity Database (CNDDB). Available from: www.map.dfg.ca.gov/rarefind. Accessed on: October 1, 2016.

Appendix H4. Special-Status Species Tables

Table H4-1. Special-Status Plant Species and their Potential for Occurrence in the Construction Study Area[1]

Scientific Name **Common Name**	**Status Federal/State/ CRPR[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Astragalus pauperculus Depauperate milkvetch	–/–/4.3	Annual herb. Vernally mesic (wet) and volcanic soils in chaparral, cismontane woodland, and valley and foothill grassland from 200 to 4,000 feet (60 to 1,215 meters) above mean sea level (amsl). Blooms March through June.	**Not Expected.** Annual nonnative grassland may provide suitable habitat, but the study area is located below the species' known elevation range.
Astragalus tener var. *ferrisiae* Ferris' milkvetch	–/–/1B.1	Annual herb. Vernally mesic meadows and seeps, and subalkaline flats in valley and foothill grassland from 7 to 245 feet (2 to 75 meters) amsl. Known from only six sites in the Sacramento Valley, one of which is the Tule Ranch in the YBWA (CDFG 2008). Blooms April through May.	**Not Expected.** Seasonally wet areas with alkaline soils are not present in the study area. This species was not observed during botanical surveys.
Astragalus tener var. *tener* Alkali milkvetch	–/–/1B.2	Annual herb. Alkaline soils in playas, vernal pools, and adobe clay valley and foothill grasslands from 3 to 200 feet (1 to 60 meters) amsl. Blooms March through June.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys. This species is known from the Tule Ranch Unit of the YBWA.
Atriplex cordulata var. *cordulata* Heartscale	–/–/1B.2	Annual herb. Saline or alkaline soils in chenopod scrub, meadows and seeps, and sandy areas of valley and foothill grassland below 1,837 feet (560 meters) amsl. Blooms April through October.	**Potential.** Sandy, alkaline soils in grassland provide suitable habitat in the study area for Alternatives 2 through 6. This species was not observed during botanical surveys. However, such surveys did not cover the area with suitable soils and habitat.
Atriplex depressa Brittlescale	–/–/1B.2	Annual herb. Alkaline clay soils in chenopod scrub, meadows and seeps, playas, valley and foothill grassland, and vernal pools from 3 to 1,050 feet (1 to 320 meters) amsl. This plant has similar habitat requirements as heartscale and San Joaquin spearscale and is frequently found growing in association with these species. Blooms April through October.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys.

Scientific Name Common Name	Status Federal/State/ CRPR[2]	General Habitat Description	Potential for Occurrence[3]
Atriplex persistens Vernal pool smallscale	–/–/1B.2	Annual herb. Drying bottoms of large, alkaline vernal pools from 33 to 377 feet (10 to 115 meters) amsl. Blooms June through October.	**Not Expected.** Vernal pools are not present in the study area, which is below the known elevation range for this species. The nearest suitable habitat for this species is at the Tule Ranch Unit of the YBWA (CDFG 2008).
Carex comosa Bristly sedge	–/–/2B.1	Perennial rhizomatous herb. Coastal prairie, marshes and swamps (lake margins), and valley and foothill grassland below 2,050 feet (625 meters) amsl. Blooms May through September.	**Potential.** Marshes and grasslands provide suitable habitat in the study area for all alternatives. This species was not observed during botanical surveys.
Centromadia parryi ssp. *rudis* Parry's rough tarplant	–/–/4.2	Annual herb. Alkaline, vernally mesic soils, seeps, and sometimes roadsides in valley and foothill grasslands and vernal pools below 328 feet (100 meters) amsl. Blooms May through October.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys. Suitable habitat is present at the Tule Ranch Unit of the YBWA.
Chloropyron palmatum Palmate salty bird's-beak	FE/SE/1B.1	Hemiparasitic annual herb. Saline-alkaline soils in seasonally flooded wetlands in chenopod scrub and valley and foothill grasslands from 16 to 508 feet (5 to 155 meters) amsl. This species grows in scattered localities in the Sacramento and San Joaquin Valleys and at Livermore in the Bay Area. Locally, it is frequently found growing on Pescedaro saline-alkaline silty clay soils in association with salt grass, tarplant (*Hemizonia* spp.), Parish's glasswort (*Arthrocnemum subterminale*), and alkali heath (*Frankenia salina*) near Woodland, California. Blooms May through October.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys. The nearest CNDDB occurrence was observed in 2012 approximately 2.1 miles west of the Yolo Bypass, just outside of the City of Woodland.
Cuscuta obtusiflora var. *glandulosa* Peruvian dodder	–/–/2B.2	Parasitic annual vine. Freshwater marshes from 50 to 920 feet (15 to 280 meters) amsl. Blooms July through October.	**Potential.** Freshwater marshes provide suitable habitat in the study area. This species was not observed during botanical surveys.
Downingia pusilla Dwarf downingia	–/–/2B.2	Annual herb. Vernal pools or other seasonal wetlands in annual grasslands from 3 to 1,500 feet (1 to 445 meters) amsl. Blooms March through May.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys. However, the entirety of the grasslands in the study area was not surveyed. Suitable habitat is present at the Tule Ranch Unit of the YBWA.

Scientific Name **Common Name**	**Status Federal/State/ CRPR**[2]	**General Habitat Description**	**Potential for Occurrence**[3]
Eryngium jepsonii *Jepson's coyote-thistle*	--/--/1B.2	Perennial herb. Clay soils in valley and foothill grassland and vernal pools from 10 to 985 feet (3 to 300 meters) amsl. Blooms April through August.	**Not Expected.** Suitable combination of habitat and soils is not present in the study area. This species was not observed during botanical surveys. This species is known from the Tule Ranch Unit of the YBWA.
Extriplex joaquinana San Joaquin spearscale	--/--/1B.2	Annual herb. Alkaline soils in chenopod scrub, meadows and seeps, playas, and valley and foothill grassland from 3 to 2,740 feet (1 to 835 meters) amsl. Blooms April through October.	**Potential.** Alkaline soils in grasslands and seeps provide suitable habitat in the study area. This species was not observed during botanical surveys. There are two CNDDB occurrences of this species within the Yolo Bypass, south of I-80.
Fritillaria agrestis Stinkbells	–/–/4.2	Perennial bulbiferous herb. Clay, sometimes serpentine soils in chaparral, cismontane woodland, pinyon and juniper woodland, and valley and foothill grassland from 33 to 5,100 feet (10 to 1,555 meters) amsl. Blooms March through June.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area, which occurs below the known elevation range for this species.
Fritillaria liliacea Fragrant fritillary	–/–/1B.2	Perennial bulbiferous herb. Often on serpentine soils in coastal scrub, coastal prairie, cismontane woodland, and clay soils in valley and foothill grassland from 1 to 1,345 feet (3 to 410 meters) amsl. Locally, this species is usually found growing on the tops of mima-mounds or other upland areas within vernal pool grasslands. Blooms February through April.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys.
Gratiola heterosepala Boggs Lake hedge-hyssop	–/SE/1B.2	Annual herb. Clay soils in margins of lakes, marshes, or swamps and deeper vernal pools from 33 to 7,800 feet (10 to 2,375 meters) amsl. Found at scattered locations in the Central Valley, northern Coast Ranges, central Sierra Foothills, and Modoc Plateau. Blooms April through August.	**Not Expected.** Clay soils are not present in the margins of marshes in the study area. This species was not observed during botanical surveys. Suitable habitat is present at the Tule Ranch Unit of the YBWA.
Hesperevax caulescens Hogwallow starfish	–/–/4.2	Annual herb. Found in mesic, clay soils in valley and foothill grassland and shallow vernal pools below 1,660 feet (505 meters) amsl. Blooms March through June.	**Not Expected.** Suitable combination of habitat and soils is not present in the study area. This species was not observed during botanical surveys. This species is known from the Tule Ranch Unit of the YBWA.

Scientific Name **Common Name**	**Status Federal/State/ CRPR[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Hibiscus lasiocarpus var. *occidentalis* Woolly rose-mallow	–/–/1B.2	Perennial rhizomatous herb. Often in riprap on sides of levees, margins of freshwater marshes, wet riverbanks, and on low, peat islands below 400 feet (120 meters) amsl. Blooms June through September.	**Known.** The banks of the Sacramento River provide potential habitat for this species. This species was observed during botanical surveys of the FWWA – three individuals were found along the old river oxbow, a fourth plant was found south of Fremont Weir near a scour pond, and a fifth plant was found by Agricultural Road Crossing 1 (DWR 2014a, 2015a) (See Figure 9-1 for locations). Suitable habitat for this species is present in the study area for all alternatives. There is also a CNDDB occurrence outside of the construction study area near the north water control structure (See Appendix G2).
Juglans hindsii Northern California black walnut	–/–/1B.1	Perennial deciduous tree. Streams and disturbed slopes in the San Francisco Bay Area, inner North Coast ranges, and the Sacramento and San Joaquin valleys below 1,445 feet (440 meters) amsl. This species was formerly found throughout riparian areas in northern California and has served as rootstock for cultivated English walnuts. Northern California black walnut readily hybridizes with other walnuts, including other rootstock and English walnut; this propensity has reduced the genetic purity of extant native walnut stands and contributed to the increasing rarity of genetically pure individuals. Blooms April through May.	**Known.** There is suitable habitat for this species in the study area for all alternatives. One black walnut was documented within the FWWA in 2013 (Calflora 2016).
Lathyrus jepsonii var. *jepsonii* Delta tule pea	–/–/1B.2	Perennial herb. Freshwater and brackish marshes, usually on marsh/slough edges, generally restricted to the Sacramento-San Joaquin Delta below 16 feet (5 meters) amsl. This species is found only in the Sacramento-San Joaquin Delta where it grows within and above the upper tidal zone, frequently mixed among shrubby vegetation such as California rose, Himalayan blackberry, or sandbar willow (*Salix exigua*). Blooms May through September.	**Potential.** Freshwater marshes provide suitable habitat in the study area for all alternatives. This species was not observed during botanical surveys. This species is known from the YBWA, south of I-80.

Scientific Name **Common Name**	**Status Federal/State/ CRPR[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Legenere limosa Legenere	–/–/1B.1	Annual herb. Vernal pools from 3 to 2,890 feet (1 to 880 meters) amsl. This species grows in the bottoms of larger vernal pools, frequently with species such as pale spikerush (*Eleocharis macrostachya*) and rayless goldfields (*Lasthenia glaberrima*). It may also be found with the related dwarf downingia. Blooms April through June.	**Not Expected.** Vernal pools are not present in the study area. This species is known from the Tule Ranch Unit of the YBWA.
Lepidium latipes Heckard's pepper grass	–/–/1B.2	Annual herb. Alkaline flats in annual grasslands and edges of vernal pools from 6 to 660 feet (2 to 200 meters) amsl. This species typically co-occurs with plants such as rye grass, dwarf pepperweed (*Lepidium latipes*), smooth goldfields (*Lasthenia glabrata* ssp*. glabrata*), and annual hairgrass (*Deschampsia danthonioides*). Blooms March through May.	**Potential.** Grasslands with alkaline soils provide suitable habitat in the study area for Alternatives 2 through 6. This species was not observed during botanical surveys, although surveys were not conducted during this species' blooming period. This species has been documented at the Tule Ranch Unit of the YBWA.
Lessingia hololeuca Woolly-headed lessingia	–/–/3	Annual herb. Sometimes restricted to clay or serpentine soils in broadleafed upland forest, coastal scrub, lower montane coniferous forest, and valley and foothill grassland (sometimes roadsides) from 50 to 1,000 feet (15 to 305 meters) amsl. Blooms June through October.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys.
Lilaeopsis masonii Mason's lilaeopsis	–/SR/1B.1	Perennial rhizomatous herb. Flooded tidal zones on mud banks and flats along erosional creek banks, sloughs, and rivers with freshwater marsh, brackish marsh, or riparian scrub influenced by saline water below 33 feet (10 meters) amsl. Blooms April through November.	**Not Expected.** Tidally influenced habitat is not present in the study area. This species was not observed during botanical surveys.

Scientific Name Common Name	Status Federal/State/ CRPR[2]	General Habitat Description	Potential for Occurrence[3]
Limosella australis Delta mudwort	–/–/2B.1	Perennial stoloniferous herb. Usually found on mud banks of both freshwater and brackish marshes and riparian scrub areas below 10 feet (3 meters) amsl. Similar to Masons' lilaeopsis, this plant is frequently found in microhabitats where bank sloughing and other similar disturbances have created localized areas of saturated fine sediment (clay and silty clay) deposition below the average high tide level (CDFG 2008). Blooms May through August.	**Not Expected.** Suitable microhabitat (saturated fine sediment in mud banks of marshes and riparian scrub) is not present in the study area. This species was not observed during botanical surveys. The nearest known CNDDB occurrences are south of Sacramento.
Myosurus minimus Little mousetail	–/–/3.1	Annual herb. Valley and foothill grasslands and alkaline vernal pools from 66 to 2,100 feet (20 to 640 meters) amsl. Central Valley populations are thought to be hybrids of M. minimus and M. sessilis. Blooms March through June.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys. Known from the Tule Ranch Unit of the YBWA.
Navarretia leucocephala ssp. *bakeri* Baker's navarretia	–/–/1B.1	Annual herb. Mesic, alkaline clay soils in vernal pools and swales in cismontane woodlands, lower montane coniferous forest, meadows and seeps, and valley and foothill grasslands from 16 to 5,710 feet (5 to 1,740 meters) amsl. Blooms April through July.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys. The closest CNDDB occurrence of this species is at the Tule Ranch Unit of the YBWA.
Neostapfia colusana Colusa grass	FT/SE/1B.1	Annual herb. Found in large adobe vernal pools, usually in alkaline basins as well as acidic soils from 16 to 656 feet (5 to 200 meters) amsl. This species tends to be found in larger, deeper vernal pools where it grows on the drying pool bottoms, frequently later into the summer than many other vernal pool plants. It is widely distributed throughout suitable habitats within the Central Valley, although it is uncommon wherever found. Blooms May through August.	**Not Expected.** Vernal pools are not present in the study area. This species was not observed during botanical surveys. Suitable habitat for this species may be present at the Tule Ranch Unit of the YBWA.
Plagiobothrys hystriculus Bearded popcornflower	–/–/1B.1	Annual herb. Found in vernal swales, vernal pool margins, and mesic valley and foothill grasslands below 900 feet (274 meters) amsl. Blooms April through May.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. Known from the Tule Ranch Unit of the YBWA and locations further south in Solano County.

Scientific Name Common Name	Status Federal/State/ CRPR[2]	General Habitat Description	Potential for Occurrence[3]
Puccinellia simplex California alkali grass	–/–/1B.2	Annual herb. Alkaline flats in valley and foothill grasslands from 6 to 3,050 feet (2 to 930 meters) amsl. Blooms March through May.	**Potential.** Alkaline grasslands provide suitable habitat in the study area for Alternatives 2 through 6. This species was not observed during botanical surveys, although surveys were not conducted during this species' blooming period. Suitable habitat for this species may also be present at the Tule Ranch Unit of the YBWA.
Sagittaria sanfordii Sanford's arrowhead	–/–/1B.2	Perennial rhizomatous herb. Found in shallow freshwater marshes and swamps below 2,130 feet (650 meters) amsl. Blooms May through November.	**Potential.** Freshwater marshes provide suitable habitat in the study area for all alternatives. This species was not observed during botanical surveys.
Symphyotrichum lentum Suisun Marsh aster	–/–/1B.2	Perennial rhizomatous herb. Found in brackish and freshwater marshes along the banks of sloughs and other waterways below 985 feet (300 meters) amsl. This species grows in marshes along tidal streams in the Sacramento-San Joaquin Delta, frequently at or very near the water line mixed with tules, cattails, and other emergent vegetation. Blooms April through November.	**Potential.** Freshwater marsh provides suitable habitat in the study area for all alternatives. This species was not observed during botanical surveys. There are two CNDDB occurrences of this species within the Yolo Bypass south of I-80.
Trichocoronis wrightii var. *wrightii* Wright's trichocoronis	–/–/2B.1	Annual herb. Alkaline soils in meadows and seeps, marshes and swamps, riparian forests, and vernal pools from 16 to 1,430 feet (5 to 435 meters) amsl. Blooms May through September.	**Not Expected.** Suitable combination of soils and habitat is not present in the study area. This species was not observed during botanical surveys. Suitable habitat for this species may be present at the Tule Ranch Unit of the YBWA.
Trifolium hydrophilum Saline clover	–/–/1B.2	Annual herb. Salt marshes and alkaline soils in moist valley and foothill grasslands and vernal pools below 1,050 feet (320 meters) amsl. Blooms April through June.	**Potential.** Alkaline grasslands provide suitable habitat in the study area for Alternatives 2 through 6. This species was not observed during botanical surveys, although surveys were not conducted during the blooming period for this species.

Scientific Name **Common Name**	**Status Federal/State/ CRPR[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Tuctoria mucronata Solano grass [also called Crampton's tuctoria]	FE/SE/1B.1	Annual herb. Found in valley and foothill mesic grassland and in vernal pools from 16 to 32 feet (5 to 10 meters) amsl. This species tends to be found in larger, deeper vernal pools where it grows on the drying pool bottoms, frequently later into the summer than many other vernal pool plants. It is widely distributed throughout suitable habitats within the Central Valley, although it is uncommon wherever found. Blooms April through August.	**Not Expected.** Vernal pools and appropriate seasonal wetland conditions suitable for this species are not present in the study area. This species was not observed during botanical surveys. This species is known from the vicinity of the Yolo Bypass and it could occur in suitable habitat at the Tule Ranch unit (CDFG 2008) of the YBWA.

Sources: CDFG 2008, CNDDB 2016; USFWS 2016, DWR 2014a, DWR 2015a

[1] For the purposes of this analysis, the study area includes the construction footprint plus a 100-foot buffer. If operations impacts are expected on any species potentially occurring within the Yolo Bypass, those are discussed separately in Chapter 9 of the EIS/EIR.

[2] Status:

FE Federally Endangered
FT Federally Threatened
FC Federal Candidate for Listing
SE Endangered in California
ST Threatened in California
SR Rare in California

*CNPS Rare Plant Ranks (California Rare Plant Ranks are assigned by a committee of government agency and non-governmental botanical experts and are not official State designations of rarity status):

1A Presumed extinct in CA
1B Rare, threatened, or endangered in CA and elsewhere
2B Rare, threatened, or endangered in CA but more common elsewhere
3 Plants about which more information is needed - A Review List
4 Plants of limited distribution - A Watch List

Threat Ranks

- 0.1-Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat)
- 0.2-Moderately threatened in California (20-80% occurrences threatened / moderate degree and immediacy of threat)
- 0.3-Not very threatened in California (less than 20% of occurrences threatened / low degree and immediacy of threat or no current threats known)

[3] Life history information included when necessary to determine the potential for occurrence within the study area or to support the associated impact analysis.

Not Expected: Not expected to occur: Species is unlikely to be present in the study area due to poor habitat quality, lack of suitable habitat features (vegetation communities and/or soils), or restricted current distribution of the species.

Potential: A suitable combination of soils and habitat is present in the study area. This species may also be known from the project vicinity, but not within the study area.

Known: The species, or evidence of its presence, was observed in the study area during reconnaissance surveys, or was reported by others.

Table H4-2. Special-Status Wildlife Species and their Potential for Occurrence in the Construction Study Area[1]

Scientific Name Common Name	Status Federal/State/ Other[2]	General Habitat Description	Potential for Occurrence[3]
INVERTEBRATES			
Anthicus antiochensis *Antioch Dunes anthicid beetle*	--/--/--	Found along rivers in interior sand dunes and sand bars, and in dredge spoil heaps.	Suitable soils and habitat area not present in the study area. Known from south of the Yolo Bypass.
Anthicus sacramento *Sacramento anthicid beetle*	--/--/--	Found along rivers in interior sand dunes and sand bars, and in dredge spoil heaps.	Suitable soils and habitat area not present in the study area. Known from south of the Yolo Bypass.
Branchinecta conservatio Conservancy fairy shrimp	FE/--/--	Endemic to the grasslands of the northern two-thirds of the Central Valley; found in large turbid vernal pools. Large pools are filled by winter and spring rains and usually last into June.	**Not Expected.** Vernal pools and suitable grasslands are not present in the study area. Nearest known occurrence of this species is in vernal pools at the Tule Ranch Unit of the YBWA.
Branchinecta lynchi Vernal pool fairy shrimp	FT/--/--	Vernal pools and other seasonal wetlands in valley and foothill grasslands.	**Not Expected.** Vernal pools and suitable seasonal wetlands are not present in the study area. Nearest known occurrence of this species is in vernal pools at the Tule Ranch Unit of the YBWA.
Branchinecta mesovallensis Midvalley fairy shrimp	--/--/--	Small vernal pools and seasonal wetlands less than 202 m^2 in area (average area 67 m^2), with average depth of 10 cm (range 5-15 cm).	**Not Expected.** Vernal pools and suitable seasonal wetlands are not present in the study area. Nearest known occurrence of this species is in vernal pools at the Tule Ranch Unit of the YBWA.
Desmocerus californicus dimorphus Valley elderberry longhorn beetle	FT/--/--	Elderberry shrubs (*Sambucus* spp.) below 3,000 feet in elevation, typically in riparian habitats.	**Known.** Assumed present because elderberry shrubs, its host plant, occur in the study area for Alternatives 3, 4, and 6. Twenty-two elderberry shrubs have been mapped within the FWWA, 2 along the old river oxbow and 20 at the north end of the survey area adjacent to the Sacramento River. Only 3 of these plants are located within the study area for Alternatives 3, 4, and 6 (See Figure 9-1 for locations). There are CNDDB occurrences of this species just outside of the FWWA, along the old river oxbow, and along the Sacramento River east of the south water control structure (See Appendix G2). Known from the Yolo Bypass.

Scientific Name Common Name	Status Federal/State/ Other[2]	General Habitat Description	Potential for Occurrence[3]
Elaphrus viridis Delta green ground beetle	FT/--/--	Lives in areas of grassland interspersed with vernal pools including several larger vernal pools.	**Not Expected**. Suitable grassland habitat interspersed with vernal pools is not present in the study area**.** This species has only been found in the greater Jepson Prairie in south-central Solano County.
Lepidurus packardi Vernal pool tadpole shrimp	FE/--/--	Vernal pools and other seasonal wetlands in valley and foothill grasslands.	**Not Expected.** Vernal pools and suitable seasonal wetlands are not present in the study area. Nearest known occurrence of this species is in vernal pools at the Tule Ranch Unit of the YBWA.
Linderiella occidentalis California linderiella	--/--/--	Vernal pools and seasonal wetlands from 1 to 52,500 m^2 in area (average area 1,283 m^2), with average depth of 19 cm (range 3–151 cm).	**Not Expected.** Vernal pools and suitable seasonal wetlands are not present in the study area. Nearest known occurrence of this species is in vernal pools at the Tule Ranch Unit of the YBWA.
AMPHIBIANS			
Ambystoma californiense California tiger salamander	FT/ST/SSC	Grassland habitats of the valleys and foothills. Vernal pools and seasonal wetlands with a minimum 10-week inundation period and surrounding uplands. Requires burrows for aestivation and standing water until late spring for larvae to metamorphose. Most of the habitat for this species has been eliminated from the Central Valley lowlands, and remaining localities are largely clustered in a ring around the Central Valley foothills.	**Not Expected.** Suitable vernal pool and seasonal wetland habitat is not present in the study area. Nearest known location of suitable habitat for this species is in vernal pools at the Tule Ranch Unit of the YBWA.
Rana draytonii California red-legged frog	FT/--/SSC	Aquatic habitats including pools and backwaters within streams and creeks, ponds, marshes, springs, sag ponds, dune ponds, and lagoons.	**Not Expected.** The study area is outside the known geographic range for this species.
Spea hammondii Western spadefoot toad	--/--/SSC	In winter, breeds in vernal pools and seasonal wetlands with a minimum 3-week inundation period. In summer, aestivates in grassland habitat, soil crevices, and rodent burrows.	**Not Expected.** Suitable vernal pool and seasonal wetland habitat is not present in the study area. The Tule Ranch Unit of the YBWA provides suitable habitat.

Scientific Name **Common Name**	**Status Federal/State/ Other**[2]	**General Habitat Description**	**Potential for Occurrence**[3]
REPTILES			
Emys marmorata Western pond turtle	--/--/SSC	Found in ponds, lakes, rivers, streams, creeks, marshes, and irrigation ditches with abundant vegetation, and either rocky or muddy bottoms in woodland, forest, and grassland. In streams, prefers pools to shallower areas. Logs, rocks, cattail mats, and exposed banks are required for basking.	**Known.** Assumed present in agricultural ditches and slow-moving watercourses in the study area for all alternatives. Adjacent upland areas provide suitable basking habitat. Based on surveys, habitat quality within the study area is high. This species was observed near Wallace Weir during surveys.
Thamnophis gigas Giant garter snake	FT/ST/--	This species in endemic to California Central Valley wetlands. Requires sufficient water during the active summer season; emergent, herbaceous aquatic vegetation accompanied by vegetated banks to provide basking and foraging habitat; bankside burrows, holes, and crevices; and high ground or upland habitat above the annual high water mark to provide cover and refugia from floodwaters.	**Known.** Assumed present in agricultural ditches and slow-moving watercourses in the study area for all alternatives. Giant garter snakes are known to occur in the project vicinity. Based on surveys, habitat quality within the study area ranges from moderate to good. A garter snake not identified to species was observed during surveys. There are CNDDB occurrences of this species outside the north water control structure, along the Sacramento River levee toe drains, along the south water control structure in the agricultural fields, along the levee, and in the Tule Canal (See Appendix G2).
BIRDS			
Accipiter striatus Sharp-shinned hawk	--/--/SSC	Winter visitor to the Central Valley floor. Forages primarily in riparian woodlands and other wooded habitats, where it preys primarily on small birds.	**Potential.** Suitable foraging habitat is present in woodland habitats in the study area for all alternatives. This species is known to forage in riparian habitat along Putah Creek and Sacramento River levee toe drains; these areas provide suitable winter foraging habitat.
Accipiter cooperii Cooper's hawk	--/--/SSC	Nests and forages primarily in riparian woodlands and other wooded habitats, where it preys primarily on birds and, to a lesser extent, small mammals.	**Known.** Riparian woodlands provide suitable nesting and foraging habitat in the study area for all alternatives. One Cooper's hawk pair was observed foraging and exhibiting courtship behavior (and was presumed nesting) within the FWWA during surveys. This species is known to forage in riparian habitat throughout the Yolo Bypass during fall and winter.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Agelaius tricolor Tricolored blackbird	UR/--/SSC	Breeds in freshwater marshes with tall emergent vegetation, in upland habitats, and in silage fields. Forages in agricultural areas, particularly where livestock is present. Typically nests from mid-April to late July.	**Known.** Agricultural fields provide suitable foraging habitat and freshwater emergent wetlands provide suitable nesting habitat in the study area for all alternatives. This species was observed during surveys, but no nests or nesting behavior were documented. The nearest CNDDB occurrence of this species is north of I-80.
Ammodramus savannarum Grasshopper sparrow (nesting)	--/--/SSC	Grasshopper sparrows prefer open grasslands with bare ground for foraging and habitat with shrub cover and heavy vegetation for nesting. This species typically nests from early April to mid-July, with a peak in May and June.	**Potential.** Grasslands and scrub habitats provide suitable foraging and nesting habitat in the study area for all alternatives. This species was not observed during surveys. It is known to breed in the YBWA.
Antigone canadensis tabida Greater sandhill crane	--/ST/FP	Winter visitor to the Central Valley. Forages primarily in moist croplands with rice or corn stubble; also frequents grasslands and emergent wetlands. In winter, this species is most densely concentrated in counties south of Yolo County, in agricultural regions and large preserves that support vast fields of suitable habitat.	**Potential.** Agricultural fields, grasslands, and wetlands provide suitable winter foraging habitat in the study area for all alternatives. This species was not observed during surveys. Water levels in the agricultural fields and wetlands in the northern management units of the YBWA are managed to provide high-quality foraging habitat for cranes and similar species.
Aquila chrysaetos Golden eagle	--/--/FP	Nests and forages in a variety of open habitats, including grassland and cropland, but most common in foothill and shrub-steppe habitats, where it preys on jackrabbits, other mid-sized mammals, and upland game birds. Rare breeder in the Central Valley foothills; breeds in cliffs, rock outcrops, and large trees.	**Potential.** Grasslands and agricultural fields in the study area for all alternatives provide suitable foraging habitat, but the study area is not suitable for nesting. This species was not observed during surveys, but is known to occasionally forage in upland habitats throughout the Yolo Bypass during winter.
Ardea alba Great egret	--/--/--	Nests colonially in tall trees. Forages in fresh and saline marshes, shallow open water, and occasionally cropland or low, open upland habitats.	**Known.** Known to forage in wetlands, uplands, and agricultural fields in the study area for all alternatives. Breeding colonies were documented adjacent to the FWWA during surveys. There is a CNDDB occurrence that was observed in 2016 along the Sacramento River, south of I-80.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Ardea herodias Great blue heron	--/--/--	Nests colonially in tall trees. Forages in fresh and saline marshes, shallow open water, and occasionally cropland or low, open, upland habitats.	**Known.** Known to forage in wetlands, uplands, and agricultural fields in the study area for all alternatives; suitable nesting habitat is also present in the study area for all alternatives. Breeding colonies were documented adjacent to the FWWA during surveys. Known to breed and forage in the Yolo Bypass, with CNDDB occurrences along the Sacramento River east of the south water control structure (See Appendix G2).
Asio flammeus Short-eared owl	--/--/SSC	Winter visitor to and rare nesting species in Yolo County. Forages in open habitats, including emergent wetlands, grasslands, shrublands, and agricultural fields. Typically nests on the ground in prairies and agricultural areas from early March through July.	**Potential.** Grasslands, emergent wetlands, and agricultural fields provide suitable foraging and nesting habitat in the study area for all alternatives. This species was not observed during surveys, but is known to occur in the Yolo Bypass (Brice 2016).
Athene cunicularia Burrowing owl	--/--/SSC	Prefers open, dry annual or perennial grasslands, deserts, and scrublands characterized by low-growing vegetation. In agricultural environments, burrowing owls nest along roadsides and water conveyance structures surrounded by crops. Nests and roost burrows are commonly dug by ground squirrels. Nests from February through August, with peak nesting occurring in April and May.	**Potential.** Grasslands and agricultural fields provide suitable habitat, although the tall vegetation and regular flooding within the study area for all alternatives is not optimal. This species was not observed during surveys and very few suitable burrows were observed. There are 13 CNDDB occurrences of this species in the Yolo Bypass south of I-80.
Aythya americana Redhead	--/--/SSC	Nests in freshwater emergent wetlands where dense stands of cattails and tules are interspersed with areas of deep, open water. In winter and during migration, forages and rests on large, deep bodies of water and feeds on submergent aquatic plants and insects.	**Potential.** Freshwater emergent wetlands provide suitable nesting and foraging habitat in the study area for all alternatives. This species was not observed during surveys, but is known to occur in the Yolo Bypass (Brice 2016).
Buteo regalis Ferruginous hawk	--/--/SSC	Winter visitor to the Central Valley. Forages most commonly in grasslands and shrub-steppe; also forages in agricultural fields. Preys primarily on rabbits as well as other small mammals and birds.	**Potential.** Grasslands and agricultural fields provide suitable winter foraging habitat in the study area for all alternatives when not flooded.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Buteo swainsoni Swainson's hawk	--/ST/--	Forages in grasslands with scattered trees, juniper sage flats, riparian areas, savannahs, and agricultural or ranch habitats. Nests from late March through late August, with peak nesting activity occurring late May through July.	**Known.** Trees in riparian forest and riparian scrub provide suitable nesting habitat in the study area for all alternatives. Grasslands and agricultural fields in the study area for all alternatives provide suitable foraging habitat. At least eight pairs were observed foraging and nesting within the FWWA during surveys. This species was also observed at Agricultural Road Crossing 1, but no nests were found there. There are numerous CNDDB occurrences of this species within and adjacent to the FWWA, outside the north water control structure along the Sacramento River and levee toe drains, and along Tule Canal near the south water control structure (See Appendix G2).
Charadrius alexandrinus nivosus Western snowy plover	FT/--/SSC	A small shorebird, this species inhabits beaches, dry mud or salt flats, and sandy shores of rivers, lakes, and ponds. Nests on the ground on broad, open beaches or salt or dry mud flats, where vegetation is sparse or absent (small clumps of vegetation are used for cover by chicks).	**Not Expected.** Salt and dry mud flats do not occur in the study area.
Charadrius montanus Mountain plover	--/--/SSC	Nests exclusively in flat, arid, sparsely vegetated areas, permitting a full view of its surroundings. Short-grass prairies are preferred. Where grasses are taller, plovers stick to areas that have been heavily grazed or recently burned. Winters in short-grass plains and fields, plowed fields, and sandy deserts. This species only overwinters in California, typically from September to mid-March.	**Potential.** Grasslands and agricultural fields provide suitable wintering habitat in the study area for all alternatives. Sparsely vegetated areas provide potential nesting habitat. This species was not observed during surveys.
Chlidonias niger Black tern	--/--/SSC	Nests in freshwater marsh and rice habitats, forages for fish and insects in open water, rice, and marsh. Inhabits inland California and the Delta during summer, and forages primarily in marine habitats in winter. This species is present in Yolo County primarily during migration.	**Potential.** Freshwater marsh and open water habitats provide suitable habitat in the study area for all alternatives during spring migration. This species was not observed during surveys.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Circus cyaneus Northern harrier	--/--/SSC	Nests and forages in open habitats including marshes, grasslands, shrublands, and agricultural fields. Nests from April to September, with peak activity from June through July.	**Known.** Open grassland habitats and marshes provide suitable nesting and foraging habitat in the study area for all alternatives. This species was observed at Agricultural Road Crossing 1 during surveys, although no nests were found. The nearest CNDDB occurrence was observed in 2015 approximately 5.7 miles northwest of the project area, north of Davis.
Coccyzus americanus occidentalis Western yellow-billed cuckoo	FC/SE/--	Breeding habitat primarily consists of large blocks or contiguous areas of riparian habitat, particularly cottonwood-willow riparian woodlands. Prefers dense riparian thickets with dense, low-level foliage near slow-moving water sources. This species nests from mid-June through August, with most eggs laid from mid-June through mid-July.	**Known.** Dense riparian areas in the northwestern part of the study area for all alternatives provide suitable nesting and foraging habitat, although the quality of the habitat is not high due to a lack of preferred mid-successional forest structure. This species was not observed and did not respond to recorded calls during surveys. Two records of this species from within the FWWA are from June and July 2006; these individuals were presumed to be migrants based on the timing and lack of subsequent observations (Brice 2016). There are CNDDB occurrences of this species outside of the FWWA along the Sacramento River (See Appendix G2).
Dendroica petechia brewsteri California yellow warbler	--/--/SSC	Nests in riparian woodland and riparian scrub habitat, where it gleans insects from foliage. Forages in a variety of wooded and shrubland habitats during migration. This species is currently present in Yolo County only during migration. Yellow warbler has declined dramatically in California's Central Valley with the loss of riparian habitat, and this species has not been known to breed in Yolo County since 1974 (Gaines 1974).	**Potential.** Riparian woodland and scrub provide suitable nesting and foraging habitat in the study area for all alternatives. This species is known to forage in low numbers in riparian habitats along Putah Creek and the Sacramento River levee toe drains; these areas provide suitable foraging habitat during migration.

Scientific Name Common Name	Status Federal/State/ Other[2]	General Habitat Description	Potential for Occurrence[3]
Egretta thula Snowy egret	--/--/--	Nests colonially in tall trees. Forages in fresh and saline marshes, shallow open water, and occasionally irrigated cropland or wet upland habitats.	**Known.** Marshes in the study area for all alternatives provide suitable foraging habitat. No breeding colonies are present onsite, but suitable nesting habitat is present. This species was observed at the FWWA and Agricultural Road Crossing 1 during surveys, but no nests or nesting behavior were evident.
Elanus leucurus White-tailed kite	--/--/FP	Forages in grasslands and agricultural fields; nests in riparian zones, oak woodlands, and isolated trees. Nests from February to October, with peak nesting activity from May to August.	**Known.** Trees in riparian forest and scrub provide suitable nesting and foraging habitat in the study area. This species was observed at the FWWA during surveys, but no nests were found.
Empidonax traillii brewsteri Little willow flycatcher	--/SE/--	Migrates through the Central Valley during spring and fall. Forages in riparian willow scrub and nests in montane riparian willows.	**Potential.** Riparian willow scrub provides suitable foraging habitat in the study area for all alternatives. This species was not observed during surveys. It is known to forage in low numbers in riparian habitats along Putah Creek and the Sacramento River levee toe drains; these areas provide suitable foraging habitat during migration.
Eremophila alpestris actia California horned lark	--/--/SSC	Nests and forages in open habitats with short vegetation (often less than four inches high) or bare ground, including grasslands and fallow agricultural fields.	**Potential.** Grasslands provide suitable foraging habitat, although the availability of short vegetation and bare ground is limited in the study area for all alternatives. This species was not observed during surveys, but is known to be a year-round resident in the Yolo Bypass.
Falco columbarius Merlin	--/--/SSC	Winter visitor to California. Forages in a wide variety of habitats, but in the Central Valley it is most commonly found around agricultural fields and in grasslands. Feeds primarily on small shorebirds and passerines.	**Potential.** Grasslands and agricultural fields provide suitable foraging habitat in the study area for all alternatives during winter when they are not flooded.
Falco mexicanus Prairie falcon	--/--/SSC	Currently presumed to be a non-breeding winter visitor to Yolo County. Forages most commonly in grasslands and shrub-steppe; also forages in agricultural fields. Preys on small mammals and less frequently on birds.	**Potential.** Grasslands and agricultural fields provide suitable foraging habitat in the study area for all alternatives. This species was not observed during surveys.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Falco peregrinus anatum American peregrine falcon	--/SE/FP	Nonbreeding visitor to the Central Valley. Forages in a wide variety of habitats, but is most common in mudflats near water, where shorebirds and waterfowl are abundant.	**Potential.** Open areas provide suitable foraging habitat in the study area for all alternatives. This species was not observed during surveys. It is known to hunt abundant shorebirds and waterfowl present from mid-summer to late winter in the YBWA and has become more common in that area since the initiation of shorebird management activities in 2002.
Grus canadensis tabida Greater sandhill crane	--/ST/FP	Winter visitor to the Central Valley. Forages primarily in moist croplands with rice or corn stubble; also frequents grasslands and emergent wetlands. In winter, this species is most densely concentrated in counties south of Yolo County, in agricultural regions and large preserves that support vast fields of suitable habitat.	**Potential.** Agricultural fields, grasslands, and wetlands provide suitable winter foraging habitat in the study area for all alternatives. This species was not observed during surveys. Water levels in the agricultural fields and wetlands in the northern management units of the YBWA are managed to provide high-quality foraging habitat for cranes and similar species.
Haliaeetus leucocephalus Bald eagle	FD/SE/BCC, FP	Winter visitor to the Central Valley floor. Forages primarily in fish-bearing waters, but also in open terrestrial habitats.	**Potential.** Open areas provide suitable winter foraging habitat in the study area for all alternatives.
Icteria virens Yellow-breasted chat	--/--/SSC	Breeds in areas of dense shrubs, including abandoned farm fields, forest edges and openings, swamps, and edges of rivers, streams, and ponds. Its habitat often includes blackberry bushes. During migration, stays in low, dense vegetation. Nests from early May through early August, with peak breeding activity in June.	**Potential.** Riparian scrub provides suitable nesting habitat in the study area for all alternatives. This species was not observed during surveys, but is known to occur in the Yolo Bypass (Brice 2016).
Ixobrychus exilis Least bittern	--/--/SSC	Suitable breeding habitat includes freshwater and brackish marshes with tall, dense emergent vegetation and clumps of woody plants over deep water. Primarily forages from emergent vegetation on prey such as catfish, minnows, eels, sunfish, killifish, perch, amphibians, small snakes, and mammals. Based on limited data, this species arrives on California nesting grounds around late March to May, and lays eggs from mid-April through early July.	**Potential.** Freshwater marshes and emergent wetlands provide suitable breeding and foraging in the study area for all alternatives. This species was not observed during surveys. It is known to breed in the YBWA (Brice 2016).

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Lanius ludovicianus Loggerhead shrike	--/--/SSC	Nests and forages in grasslands, agricultural fields, open woodlands, and shrublands. Northern and central California provide year-round habitat for this species. In California, this bird lays eggs from March to May, and young become independent in July or August.	**Known.** Grasslands, woodlands, scrub, and agricultural fields provide suitable nesting and foraging habitat in the study area for all alternatives. This species was observed in the FWWA during surveys, but no nests were found. It is known to nest and forage at the Tule Ranch Unit of the YBWA.
Larus californicus California gull	--/--/SSC	Forages in open water, wetland, and cropland habitats, as well as landfills. Although individuals may be present year-round, this species does not breed in the Central Valley.	**Potential.** Open water, wetlands, and agricultural fields provide suitable foraging habitat in the study area for all alternatives, especially during winter flooding. This species was not observed during surveys. It is known to forage in the Yolo Bypass year-round and especially during winter floods.
Laterallus jamaicensis coturniculus California black rail	--/ST/FP	Nests in high portions of salt marshes, shallow freshwater marshes, wet meadows, and flooded grassy vegetation.	**Not Expected**. There is one CNDDB occurrence of this species in a salt marsh east of the Yolo Bypass and west of the Yolo Bypass at the CDFW Calhoun Cut Ecological Reserve.
Melospiza melodia Song sparrow (Modesto population)	--/--/SSC	Affinity for emergent freshwater marshes dominated by tules and cattails as well as riparian willow (*Salix* spp.) thickets. These song sparrows also nest in riparian forests of valley oak with a sufficient understory of blackberry, along vegetated irrigation canals and levees, and in recently planted valley oak restoration sites. Nesting usually begins in April.	**Known.** Valley oak woodlands along Sacramento River levees provide potential nesting habitat. In addition, freshwater emergent wetland, riparian forest, and riparian scrub provide suitable foraging and nesting habitat in the study area for all alternatives. This species was observed exhibiting territorial behavior in the FWWA and at Agricultural Road Crossing 1 during surveys, but nests were not found. There are CNDDB occurrences adjacent to the FWWA (See Appendix G2).
Nemenius americanus Long-billed curlew	--/--/SSC	Forages in cropland, grassland, wetland, and mudflat habitats. Although individuals may be present throughout the year, this species does not breed on the Central Valley floor.	**Potential.** Agricultural fields, grasslands, and wetlands provide suitable foraging habitat in the study area for all alternatives. This species was not observed during surveys.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Nycticorax nycticorax Black-crowned night-heron	--/--/--	Nests colonially in dense marshes, groves of low willow trees, and dense shrubs. Forages in fresh and saline marshes, including cattail marshes, and in shallow open water at the edges of marsh vegetation.	**Known.** Wetlands and marshes provide suitable nesting and foraging habitat in the study area for all alternatives. This species was observed during surveys, but no nests or nesting behavior were evident.
Pandion haliaetus Osprey	--/--/SSC	Forages exclusively in fish-bearing waters.	**Known.** Known to forage in the study area for all alternatives during winter floods, which provide suitable foraging habitat. Osprey are unlikely to nest in the study area because foraging habitat is marginal during the dry summer breeding season. This species was observed during surveys.
Pelecanus erythrorhynchos American white pelican	--/--/SSC	Forages in open water. Although individuals may be present year-round, this species does not breed in the Central Valley.	**Known.** Known to forage in the study area for all alternatives throughout the year, especially in mid-summer when birds from distant breeding colonies and non-breeding birds arrive in the Central Valley, occasionally in numbers significant to the nation-wide population. This species was observed during surveys.
Plegadis chihi White-faced ibis	--/--/SSC	Forages in wetlands and irrigated or flooded croplands and pastures. Breeds colonially in dense, freshwater marsh.	**Known.** Wetlands, agricultural fields, and marshes provide suitable foraging and nesting habitat in the study area for all alternatives, especially in cattail marshes during summer months. No known breeding colonies are present in the study area. This species was observed in the FWWA and at Agricultural Road Crossing 1 during surveys, but no nests or nesting behavior were evident.
Phalacrocorax auritus Double-crested cormorant	--/--/SSC	Forages for fish in open water. Breeds colonially in rock ledges or groves of trees.	**Known.** Open water provides suitable foraging habitat in the study area for all alternatives. More limited fish resources during the summer make the study area unlikely to support a breeding colony. This species was observed in the FWWA and Agricultural Road Crossing 1 during surveys, but nests and nesting behavior were not evident.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Progne subis Purple martin	--/--/SSC	Habitat is widely but locally distributed in forested and woodland areas at low to intermediate elevations throughout California. Nests in buildings and riparian habitats and has persisted by nesting in hollow-box bridges.	**Potential.** Riparian areas provide potential foraging and nesting habitat in the study area for all alternatives. This species was not observed during surveys.
Riparia riparia Bank swallow	--/ST/--	Breeding habitat in California is extremely consistent with regard to the microsite. Nesting colonies only occur in vertical banks or bluffs of friable soils suitable for burrowing by these small birds. Nests from early May through July, with peak activity from mid-April through mid-May. Most juveniles fledge by mid-July (CNDDB 2016).	**Known.** Vertical banks and bluffs that provide suitable nesting habitat occur near Fremont Weir along Sacramento River adjacent to the study area for all alternatives. During surveys, a bank swallow colony was observed on the bank of the Sacramento River, opposite Fremont Weir, approximately 0.5 mile west of the existing fish ladder. Approximately 50 individuals and 75 burrows, several with chicks, were observed at this colony (DWR 2015d). There are CNDDB occurrences of this species along the Sacramento River (See Appendix G2).
Rallus longirostris obsoletus California clapper rail	FE/SE/FP	Glasswort (*Salicornia pacifica*) and California cord grass (*Spartina foliosa*) needed during winter flood tides. Nests in marshlands (cord grass, glasswort, gum-plant, salt grass) near tidal ponds, arranging plants or drift material over the nest as a canopy.	**Not Expected.** Glasswort and cord grass do not occur in the study area.
Vireo bellii pusillus Least Bell's vireo	FE/SE/--	Structurally diverse woodlands along watercourses, including cottonwood-willow forests, oak woodlands, and mule fat scrub.	**Potential.** Structurally diverse woodlands along watercourses provide suitable habitat in the study area for all alternatives. However, the study area is outside of this species' current known breeding geographic range. This species was not observed during surveys. The closest location for this species is along the South Fork of Putah Creek.
Xanthocephalus xanthocephalus Yellow-headed blackbird	--/--/SSC	During the breeding season, nests in freshwater emergent wetlands with dense vegetation. Nests from mid-April through late July.	**Potential.** Agricultural ditches and emergent wetlands provide suitable nesting and foraging habitat in the study area for all alternatives. This species was not observed during surveys.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Mammals			
Antrozous pallidus Pallid bat	--/--/SSC	Roosts alone, in small groups (2 to 20 bats), or gregariously (100s of individuals). Day roosts in caves, crevices, mines, and occasionally in hollow trees and buildings. Roosts must protect bats from high temperatures. Bats move deeper into cover if temperatures rise. Night roosts may be in more open sites, such as porches and open buildings. Maternity colonies are typically active May through October.	**Potential.** Riparian areas along Sacramento River provide suitable day roost habitat in the study area for all alternatives. Open grasslands, snags, and trees provide suitable roosting and maternity colony habitat in the study area for all alternatives. This species was not observed during daytime surveys; however, highly suitable features for roosting and foraging were identified during surveys.
Corynorhinus townsendii Townsend's big-eared bat	--/--/SSC	Typically roosts in caves; however, colonies of <100 individuals occasionally roost in buildings. Forages in all but alpine and subalpine habitats, but prefers mesic forests.	**Not Expected.** Unlikely to breed in the study area due to marginal habitat quality, but may forage on site.
Lasionycteris noctivagans Silver-haired bat	--/--/--	Habitat is primarily forested (frequently coniferous) areas adjacent to lakes, ponds, or streams, including areas that have been altered by humans. Prefers to roost in tree hollows and snags. During migration, these bats sometimes occur in xeric (dry) areas.	**Potential.** Riparian forest and open water provide suitable roosting and foraging habitat in the study area for all alternatives. This species was not observed during daytime surveys; however, highly suitable features for roosting and foraging were identified during surveys.
Lasiurus blossevillii Western red bat	--/--/SSC	Roosts primarily in trees (especially mature cottonwoods and sycamores), less often in shrubs. Roost sites often are in edge habitats adjacent to streams, fields, or urban areas. Preferred roost sites are protected from above, open below, and located above dark ground cover. Mates in August and September; young are typically born in late May and are able to fly by September.	**Potential.** Riparian areas along Sacramento River provide suitable day roosting and foraging habitat in the study area for all alternatives. This species was not observed during daytime surveys; however, highly suitable features for roosting and foraging were identified during surveys.

Scientific Name **Common Name**	**Status Federal/State/ Other[2]**	**General Habitat Description**	**Potential for Occurrence[3]**
Lasiurus cinereus Hoary bat	--/--/--	Habitat includes primarily deciduous and coniferous forests and woodlands, including areas altered by humans. Foraging habitat includes various open areas, including spaces over water and along riparian corridors. Roost sites are usually in foliage of large deciduous or coniferous trees near the ends of branches from 10 to 62 feet (3 to 19 meters) above ground, with dense foliage above and open flying room below, often at the edge of a clearing and commonly in hedgerow trees. Feeds primarily on moths, although it eats a variety of flying insects. Populations in the Central Valley are most likely migratory, not reproductive.	**Potential.** Open areas and riparian corridors provide suitable foraging habitat in the study area for all alternatives. Large deciduous trees provide suitable roosting habitat in the study area for all alternatives. This species was not observed during daytime surveys; however, highly suitable features for roosting and foraging were identified.
Taxidea taxus American badger	--/--/SSC	Primarily found in drier open stages of most shrub, forest, and herbaceous habitats with friable soils. Mates in summer and early fall, and young are born in March and April.	**Potential.** Dry, open areas provide suitable burrowing and foraging habitat in the study area for all alternatives. This species was not observed during surveys.

Sources: CDFG 2008, CNDDB 2016; USFWS 2016, DWR 2014 b and c, DWR 2015b, c, and d.

[1] For the purposes of this analysis, the study area includes the construction footprint plus a 500-foot buffer. If operations impacts are expected on any species potentially occurring within the Yolo Bypass, those are discussed separately in Chapter 9 of the EIS/EIR.

[2] Status:

Federal: FE = listed as Endangered under the federal Endangered Species Act, FT = listed as Threatened under the federal Endangered Species Act, FD = federally delisted, FC = Candidate Species under the federal Endangered Species Act, BCC = Federal Bird of Conservation Concern (BCC), UR = Under Review for listing

State: SE = listed as Endangered under the California Endangered Species Act, ST = listed as threatened under the California Endangered Species Act, FP = Listed as Fully Protected under the California Fish and Game Code, SSC = Listed as Species of Special Concern by CDFW

[3] Life history information included when necessary to determine the potential for occurrence within the study area or to support the associated impact analysis.

Not Expected: Not expected to occur: Species is unlikely to be present in the study area due to poor habitat quality, lack of suitable habitat features (vegetation communities, vegetation structure, presence of burrows, etc.), or restricted current distribution of the species.

Potential: Suitable habitat is present in the study area. This species may also be known from the project vicinity, but not within the study area.

Known: The species, or evidence of its presence, was observed in the study area during reconnaissance surveys, or was reported by others.

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Appendix H5

Inundation Analysis for EIS/EIR Alternatives

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Draft Technical Memorandum

Inundation Analysis for EIS/EIR Alternatives

Yolo Bypass Salmonid Habitat Restoration & Fish Passage Project – Ten Percent Design

Yolo County, CA
May 9, 2017

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YOLO BYPASS SALMONID HABITAT RESTORATION & FISH PASSAGE PROJECT – TEN PERCENT DESIGN

Inundation Analysis for EIS/EIR Alternatives

MAY 9, 2017

1. PURPOSE AND BACKGROUND

All six of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) alternatives involve creating a channel to connect the Sacramento River to the Yolo Bypass, which will pass through or around the Fremont Weir. A multiple bay, gated structure will provide the ability to control flows through the transport channel. A previously developed TUFLOW model was updated to represent the EIS/EIR alternatives (Department of Water Resources [DWR] 2017). Model simulations extended from October 2nd through at least May 30th to capture daily inundation footprints for 16 water years from 1997-2012. The TUFLOW results are used as inputs for a number of other analyses including agricultural economic impacts, mercury modeling, and others to assess the range of project impacts.

This report describes the hydrodynamic modeling of EIR/EIS alternatives in TUFLOW, the model results, and post-processing performed to extract and format the results for use by other analyses. The results of these analyses will be used to help assess the impacts of the alternatives selected by the Bureau of Reclamation (Reclamation) and DWR, herein referred to as the Lead Agencies.

The six project alternatives that were selected through the plan formulation process are listed below. The associated key project components are summarized in Table 1 and the location of the components used in the alternatives are presented in Figure 1.

Six project alternatives have been developed:

- Alternative 1 – East Side Small Gated Notch, 6,000 cubic feet per second (cfs) Design Flow
- Alternative 2 – Central Small Gated Notch, 6,000 cfs Design Flow
- Alternative 3 – West Side Small Gated Notch, 6,000 cfs Design Flow
- Alternative 4 – West Side Small Gated Notch – Managed Flow, 3,000 cfs Design Flow and Managed Floodplain
- Alternative 5 – Central Multiple Gated Notches, 3,400 cfs Design Flow and Managed Floodplain
- Alternative 6 – West Side Large Gated Notch, 12,000 cfs Design Flow and Managed Floodplain

All of the elevations presented in this memorandum are reported in the North American Vertical Datum of 1988 (NAVD 88).

Table 1. Alternative Components

Components	Alt 1 East	Alt 2 Center	Alt 3 West	Alt 4 West	Alt 5 Multiple	Alt 6 West
Peak Design Flow (cfs)	**6,000**	**6,000**	**6,000**	**3,000**	**3,400**	**12,000**
East Channel (Intake Channel, Headworks, & Outlet Channel)	**X**					
Central Channel (Intake Channel, Headworks, & Outlet Channel)		**X**			**X**	
West Channel (Intake Channel, Headworks, & Outlet Channel)			**X**	**X**		**X**
Excavated Fremont Weir Floodplain (Wildlife Area)					**X**	
Supplemental Fish Passage West	**X**	**X**			**X**	
Supplemental Fish Passage East			**X**	**X**		**X**
Downstream Channel	**X**	**X**	**X**	**X**		**X**
Ag Crossing #1	**X**	**X**	**X**	**X**	**X**	**X**
Knaggs Area Improvements				**X**		
Conaway Area Improvements				**X**		
Swanston Area Improvements					**X**	

1.1 TUFLOW MODEL

This section includes a brief description of the TUFLOW model used to evaluate the EIS/EIR alternatives. The report "Yolo Bypass Salmonid Habitat Restoration and Fish Passage Hydrodynamic Modeling Report" contains detailed descriptions of the model development; boundary conditions, calibration, alternatives modeled, results, and post-processing performed (DWR 2017).

Figure 2 shows the TUFLOW model domain and boundary condition locations. The model domain includes the Yolo Bypass, the southern portion of the Sutter Bypass, the Sacramento River from Rio Vista to near the Tisdale Weir, a portion of the Feather River, the portion of the American River through Sacramento, as well as a number of sloughs and creeks in or near the Yolo or Sutter Bypasses. Some of the sloughs and creeks represented include Putah Creek, Cache Creek, Cache Slough, and Sutter Slough. The model contains a combination of one-dimensional (1D) channels and two-dimensional (2D) grids (with square cells). The 1D channels are more computationally efficient and are used for streams outside and inside the bypass. The 2D grids model areas where flow is not 1D including the floodplain areas and the confluence of the Sutter Bypass, Sacramento River, and Feather Rivers. The cells sizes for the three 2D grids comprising the model are 100 feet, 200 feet, and 400 feet and their respective locations are highlighted in Figure 2.

The elevation data used in the model came from a variety of sources including LiDAR, single-beam bathymetry surveys, multi-beam bathymetry surveys, and other models. Cross-sections for the 1D channels within the Yolo and Sutter Bypasses were extracted from this data. Cross-sections outside of the Yolo Bypass were trimmed versions of cross-sections obtained from a draft Central Valley Floodplain Evaluation and Delineation (CVFED) HEC-RAS model (CVFED 2013). Extensive use of breaklines and other elevation modifications ensure that the modeled grid matched the terrain.

Individual simulations modeled from October 2nd through May 30th, and sometimes longer to capture late season flooding, for each water year from 1997 through 2012. The inflow boundaries used average daily discharges based upon the best available data. The downstream boundary used stages from the gage at Rio Vista collected on a 15-minute timestep in order to capture tidal effects.

The model contains several hydraulic structures within the bypass including the Fremont Weir, the Sacramento Weir, the Lisbon Weir, agriculture crossings and culverts along Willow Slough.

Detailed medium scale vegetation mapping (scale of 1:2000) provided the basis for Manning's Roughness Coefficients. The modeling team adjusted the coefficients within reasonable ranges for each category to improve calibration.

The model was calibrated to three separate time intervals to capture specific types of conditions:

1. High flow condition – Calibrated to the 1997 event using gaged data, including both Water Surface Elevation (WSE) and discharge measurements and high water marks

2. Low flow condition – Calibrated to a period in February 2010 focusing on the Tule Canal/Toe Drain channel during low flow conditions based on direct measurements collected by cbec

3. Flood recession – Calibrated to a receding flood event during March and April 2011 using gage data, a series of aerial photos, high water marks, and limited flow measurements

2. MODEL DEVELOPMENT

Alternatives 1, 4, 5, and 6 were modeled in TUFLOW. Alternatives 2 and 3 were not modeled because they are similar to Alternative 1. Each of the alternatives includes an intake gate structure and downstream transport channels connecting the Sacramento River to the Tule Canal. The TUFLOW model represents the proposed channels and gates as 1D features. Alternative 5 includes additional grading to increase the inundated area north of Agricultural Crossing #1.

Each of the alternatives included the same modifications to the four agricultural crossings. The changes at Agricultural Crossing #1 are being designed as part of the proposed project. The changes at crossings #2 and #3 are being constructed as part of the Fremont Weir Adult Fish Passage Modification Project. The changes at Agricultural Crossing #4 will be implemented as a separate project.

The modeled operational timeframe for each water year extends from November 1 to March 15. The gates are closed before and after the operational timeframe. An alternative end date of March 7 was also evaluated for Alternative 4.

2.1 AGRICULTURAL CROSSING CHANGES (COMMON TO ALL ALTERNATIVES)

The proposed alternatives include changes to increase conveyance at four agricultural crossings. The changes to Agricultural Crossing #1 are being designed as part of the project and can be found in the Description of Alternatives – Draft Technical Memorandum presented in Volume I, 10% Design Appendices. DWR provided design information for modeling purposes for the other agricultural crossings which will be implemented as parts of separate projects. The locations of the agricultural crossings are shown in Figure 1. The proposed changes include replacing Agricultural Crossing #1 with a bridge, replacing crossings #2 and #4 with box culverts, and completely removing crossing #3. Table 2 identifies the setup of the agricultural crossings in the existing conditions and proposed alternative models.

Table 2 Agricultural crossing definitions for existing condition model and proposed models

Components	Existing Conditions	Proposed Conditions
Ag Crossing #1	Variable height weir elevations: 20.2+ feet	Rail car bridge width: 60 feet (48 feet effective) invert: 12.4 feet Variable height weir elevations: 20.0+ feet
Ag Crossing #2	Circular culvert diameter: 2.7 feet invert: 12 feet Variable height weir elevations: 17.2+ feet	Rectangular culverts number: 6 width: 24 feet (each) height: 7.2 feet invert: 12 feet Variable height weir elevations: 21.5+ feet
Ag Crossing #3	Circular culverts number: 3 diameter: 2 feet invert: 11.7 feet Variable height weir elevations: 16.5+ feet	Completely removed Uses interpolated cross-section based on upstream and downstream cross-sections
Ag Crossing #4	Variable height weir elevations: 8.3+ feet	Rectangular culverts Number: 7 width: 12 feet height: 10 feet invert: 3 feet Variable height weir elevations: 14+ feet

2.2 ALTERNATIVE 1

Alternative 1 (presented in Description of Alternatives – Draft Technical Memorandum, Volume I – 10% Design Appendices) includes a channel with three gates along the eastern alignment to bring in a target flow of 6,000 cfs into the Bypass to the north of Tule Pond as shown in Figure 3. One of the proposed gates is 34 feet wide and the other two are each 27 feet wide. The larger gate has an invert elevation of 14.0 feet (NAVD 88) and the smaller gates have an invert elevation of 18.0 feet (NAVD 88). The smaller gates are actively opened and closed as needed to limit the discharge to the 6,000 cfs target when the weir is not overtopping. After the weir overtops, the larger gate is kept open to maintain connectivity. The channel downstream from the gates connects to the north end of the Tule Pond.

2.2.1 Operations

All gates are opened once the upstream water surface elevation is one foot above the lowest gate invert (14.0 + 1.0 = 15.0 feet). Once the design flow of 6,000 cfs is reached, which occurs at an upstream river stage of approximately 27.5 feet, the two smaller gates would be programmed to start closing such that 6,000 cfs isn't exceeded. Gate closures are controlled so that there isn't a sudden reduction in flow. Gate 1, the larger gate, would remain fully open throughout operations. Once Fremont Weir begins to overtop, gates 2 and 3 would remain in their last position prior to the weir overtopping (generally both are closed at this point). After the overtopping event is over, gates 2 and 3 open and close as needed to keep the discharge below but as close as possible to 6,000 cfs. If the upstream river stage drops below the gate lowest gate invert (14.0 feet) or the end of the operational period (generally March 15th) is reached all of the gates are closed.

2.3 ALTERNATIVE 4

Alternative 4 (presented in Description of Alternatives – Draft Technical Memorandum, Volume I – 10% Design Appendices) includes a channel with three gates along the western alignment to bring a target flow of 3,000 cfs into the Bypass along with managed floodplain modifications as shown in Figure 4. One of the proposed gates is 40 feet wide and each of the others are 27 feet wide. The 40-foot wide gate and one of the 27-foot long gates are actively opened and closed to limit the discharge to the 3,000 cfs target when the weir is not overtopping. One of the 27-foot wide gates is kept open during overtopping events to maintain connectivity. The channel flows into the Tule Pond from the west.

The managed floodplains unique to Alternative 4 use water control structures and berms to increase inundation in specific areas at lower discharges than the other alternatives. The lower discharges decrease the flooding in areas outside of the managed floodplains. The berms are designed to help maintain a target WSE in each floodplain area, but not significantly impede large flood events.

The Knaggs managed floodplain north of Interstate 5 (see Figure 5) attempts to maintain a WSE of 21.5. A proposed berm on the south and east sides of the area detain water on the floodplain. Notches in the berm at 21.5 feet allow water to move through the floodplain while maintaining the target WSE. The proposed inflatable dam in the Tule Canal is raised to back water up in the canal and onto the floodplain but is lowered if the floodplain WSE exceeds the target which would happen during flood events. The discharge in the bypass channel (for salmon and sturgeon passage) is around 300 cfs at the target WSE. A proposed drainage channel prevents large amounts of water from being trapped in the floodplain.

The Conaway managed floodplain south of Interstate 5 (see Figure 6) attempts to maintain a WSE of 17.5 feet. The proposed berm, inflatable dam, bypass channel, and drainage channel function like those in the Knaggs managed floodplain. The Conaway area also includes an additional outflow weir that helps to drain the much larger floodplain area to meet the target WSE or at the end of the inundation period.

2.3.1 Operations

All gates are opened once the upstream water surface elevation is one foot above the lowest gate invert (16.1 + 1.0 = 17.1 feet). Once the design flow of 3,000 cfs is reached, which occurs at an upstream river stage of approximately 26.6 feet, the two smaller gates would be programmed to start closing such that 3,000 cfs isn't exceeded. Gate closures are controlled so that there isn't a sudden reduction in flow. Gate 1, the larger gate, would remain fully open throughout operations. Once Fremont Weir begins to overtop, gates 2 and 3 would remain in their last position prior to the weir overtopping (generally both are closed at this point). After the overtopping event is over, gates 2 and 3 open and close as needed to keep the discharge below but as close as possible to 3,000 cfs. If the upstream river stage drops below the gate lowest gate invert (16.1 feet) or the end of the operational period (generally March 15th) is reached all of the gates are closed.

2.4 ALTERNATIVE 5

Alternative 5 (presented in Description of Alternatives – Draft Technical Memorandum, Volume I – 10% Design Appendices) has three separate gated channels and a target discharge of 3,400 cfs. It includes additional grading around existing and proposed channels to increase the frequently inundated area. Figure 7 shows the Alternative 5 components. Three gated channels convey Sacramento River water into the Bypass. Each channel has a different slope and gates with different invert elevations. During a flood event the gates are opened and closed to regulate the discharges in each of the channels based upon the Sacramento River WSE to help maintain target fish passage criteria. Some of the gates are kept open throughout a flood event to maintain connectivity. The design includes 17 proposed gates 10 feet wide at invert elevations between 14 and 23 feet (NAVD88). The wide floodplain channel merges with the Tule Canal near the south end of Tule Pond. The design for Alternative #5 changed after the TUFLOW modeling was completed. The reader is referred to the above-mentioned TM for a detailed rationale regarding the reasons that the modeling conclusions would not change as a result of the design modifications.

2.5 ALTERNATIVE 6

Alternative 6 (presented in Description of Alternatives – Draft Technical Memorandum, Volume I – 10% Design Appendices) includes a channel with five gates along the western alignment to bring a target flow of 12,000 cfs into the Bypass as shown in Figure 8. Each gate is 40 feet wide and has an invert elevation of 16.1 feet (NAVD88). Up to four of the gates are actively opened and closed to limit the discharge to the 12,000 cfs target when the weir is not overtopping. One gate remains open to maintain connectivity. The channel downstream from the gates crosses the Yolo Bypass and flows into the west side of the Tule Pond.

2.5.1 Operations

All gates are opened once the upstream water surface elevation is one foot above the lowest gate invert (16.1 + 1.0 = 17.1 feet). Once the design flow of 12,000 cfs is reached, which occurs at an upstream river stage of approximately 29.8 feet, three of the gates are programmed to start closing such that 12,000 cfs isn't exceeded. Gate closures are controlled so that there isn't a sudden reduction in flow. Two of the gates would remain fully open throughout operations. Once Fremont Weir begins to overtop, the three gates being operated would remain in their last position prior to the weir overtopping (generally all are closed at this point). After the overtopping event is over, the three operating gates open and close as needed to keep the discharge below but as close as possible to 12,000 cfs. If the upstream river stage drops below the gate lowest gate invert (16.1 feet) or the end of the operational period (generally March 15th) is reached all of the gates are closed.

3. RESULTS AND POST-PROCESSING

A number of follow-on analyses use the TUFLOW results. Scripts were used to extract, process, and format the raw results as needed to meet the needs of the technical teams using the results.

3.1 BYPASS DISCHARGES AND WET AREA THROUGH TIME

Figures 9 through 24 plot discharges into the Yolo Bypass and wet area through time for existing conditions and the alternatives by water year. The Fremont Weir discharge is based upon existing conditions. During high flow events in the alternative models, the Fremont Weir discharge is reduced because of the discharge through the proposed channels. During large events, the total discharge into the Bypass for the alternatives (including gate discharges) is only slightly higher than existing conditions, but the relative difference is much lower than the discharge through the proposed gates.

Alternative 6 has the highest target discharge and generally has the largest wetted area through time. During some periods, the managed floodplains in Alternative 4 create more inundated area for longer over the managed floodplains than the other alternatives.

3.2 CHANGE IN INUNDATION ANALYSIS

To understand and quantify the increased inundation provided by each alternative, expected annual inundation was computed directly from the wetted-area time-series following the recently published methods by Matella & Jagt (2013). To streamline the analysis, the wetted- area time-series outputs for the 16 water years were used directly in the analysis. The wetted area time-series were imported into HEC-EFM and statistical queries were generated for the period of November 1 to May 30 to populate area-duration-frequency (ADF) curves for durations of 2, 3, 7, 14, 21, 28, and 60 days. The wetted-area time-series considers all wet areas within the previously defined Yolo Bypass extents, and were not further screened for suitable depths or velocities for a specific fish species nor refined for shorter periods of time corresponding to specific fish life history needs; otherwise this may have been stated as expected annual habitat, but this determination is outside the scope of this modeling effort.

The ADF curves were then used in two ways. First, the curves were used to identify inundation acreages at flow frequencies of 1 in 3 years (33 percent exceedance), 1 in 2 years (50 percent exceedance), and 2 in 3 years (67 percent exceedance).Table 3, Table 4, and Table 5 presents the inundation acreages for 33 percent, 50 percent, and 67 percent exceedances, respectively. These tables generally demonstrate that: 1) longer duration events (i.e., > 4 weeks) are inundated longer in 1 out of 3 years; 2) medium duration events (i.e., 2 to 4 weeks) are inundated longer in 1 out of 2 years; and 3) shorter duration events (i.e., < 3 weeks) are inundated longer in 2 out of 3 years. The Alternative 6 provides the greatest inundation increase ranging from 9,000 acres in 2 out of 3 years to 10,000 acres in 1 out of 2 years. Additionally, Table 5 results demonstrate that the alternatives are exceeding the inundation objective of >17,000 acres for 14 consecutive days in 2 out of 3 years.

Second, the area under the ADF curves were integrated to compute expected annual inundation based on the 16 years of model outputs (see Table 6 and Figure 25). Expected annual inundation relative to existing conditions predicted to be 2,700 ±600 acres for Alternative 1, 3,200 ±500 acres for Alternative 4, 3,000 ±500 acres for Alt04_Mar7, 2,300 ±500 acres for Alternative 5, and 3,900 ±700 acres for Alternative 6. As shown by Figure 25, expected annual inundation benefits generally increase with increasing notch inflow whereby a 12,000 cfs notch (Alternative 6) yields greater inundated acres than a 6,000 cfs notch (Alternative 1), and similarly, a 6,000 cfs notch yields greater inundated acres than a 3,400 cfs notch (Alternative 5). However, a 3,000 cfs notch coupled with managed floodplain (Alternative 4) yields greater inundated acres than a 6,000 cfs notch for events greater than 1 week in duration and a 12,000 cfs notch for events greater than 3 weeks in duration. It is noted that the ADF curves and expected annual inundation results are based on an annual maxima approach per Matella & Jagt (2013) for a relatively short 16-year period. Given that there can be multiple discrete inundation events in the Bypass, a partial duration series approach could be considered, and would likely better capture the benefits of managed floodplain in Alternative 4.

Table 3 Inundated area in 33% of years between November 1 and May 30

Duration (Days)		Expected Annual Inundation (acres)					Expected Annual Benefit (acres)				
	Existing	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06
2	47535	47572	47471	47470	47365	47508	37	-64	-65	-170	-26
3	47185	47228	47115	47114	47012	47156	43	-70	-70	-173	-29
7	45947	45998	45891	45890	45807	45930	51	-56	-57	-140	-18
14	44530	44611	44497	44472	44275	44492	81	-32	-58	-254	-37
21	35365	35438	35376	35347	35318	35500	73	11	-19	-47	134
28	28137	30000	29732	29718	29591	31068	1863	1595	1581	1454	2932
60	2001	7585	8645	8481	7592	8367	5584	6644	6480	5591	6366

Table 4 Inundated area in 50% of years between November 1 and May 30

Duration (Days)		Expected Annual Inundation (acres)					Expected Annual Benefit (acres)				
	Existing	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06
2	35381	35763	35461	35445	35429	36108	382	80	64	48	727
3	33325	35367	34882	34874	33894	36101	2042	1557	1549	569	2776
7	26483	30743	29503	29482	29000	32937	4260	3020	2999	2517	6454
14	18958	25541	24218	24198	23725	28440	6583	5260	5240	4767	9482

Duration (Days)		Expected Annual Inundation (acres)					Expected Annual Benefit (acres)				
	Existing	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06
21	15464	22798	22072	22052	22236	25663	7334	6608	6588	6772	10199
28	15205	18469	19355	17323	18076	19329	3264	4150	2118	2871	4124
60	1439	3738	6712	6591	3815	5251	2299	5273	5152	2376	3812

Table 5 Inundated area in 67% of years between November 1 and May 30

Duration (Days)		Expected Annual Inundation (acres)					Expected Annual Benefit (acres)				
	Existing	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06
2	25113	30140	28416	28396	28397	31987	5028	3304	3284	3284	6874
3	23545	28167	26819	26799	26804	29717	4622	3274	3254	3259	6172
7	19046	25811	24547	24528	24341	27835	6766	5501	5482	5296	8790
14	15883	21725	21818	21798	21708	24028	5842	5935	5915	5826	8145
21	8937	14096	15867	15850	14954	17618	5159	6930	6912	6017	8681
28	5959	8069	10547	10529	8581	10627	2110	4588	4570	2623	4668
60	1372	1527	6201	6172	1645	2015	155	4829	4800	273	643

Table 6 Expected annual inundation

Duration (Days)		Expected Annual Inundation (acres)					Expected Annual Benefit (acres)				
	Existing	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06	Alt01	Alt04	Alt04 Mar7	Alt05	Alt06
2	34079	37104	36814	36574	36465	38207	3025	2736	2495	2387	4128
3	33425	36409	36108	35879	35822	37698	2985	2683	2454	2397	4273
7	30144	33625	33384	33050	33091	35000	3481	3240	2906	2946	4856
14	26906	29719	30232	30125	29552	31122	2813	3327	3219	2646	4217
21	22727	25059	26052	25628	24992	26587	2332	3325	2901	2265	3860
28	18578	20079	21732	21290	19984	21140	1501	3154	2713	1406	2563
60	6414	8917	10690	10407	8564	9974	2502	4276	3992	2149	3560

3.3 LAST DAY WET FOR AGRICULTURE ECONOMICS ANALYSIS

A GIS script processed the TUFLOW results to determine the Last Day Wet (LDW) for individual field units within the Bypass for use in the Yolo Bypass Agricultural Impact Analysis. Yolo County performed landowner outreach to gather additional information to use in the Yolo Bypass Agricultural Impact Analysis. During those discussions with landowners, the agriculture economics team learned that farmers are likely to begin planting their fields when at least 70 percent of their fields were dry (or conversely, the last day when more than 30 percent of the area is wet). Based on this information and discussions with the lead modeler of the Yolo Bypass Agricultural Impact Analysis, it was agreed upon to use this assumption as the ratio for last day wet (LDW) calculations. The agriculture economics team provided the field units used in this analysis.

The script analyzes the raster results for each day to determine LDW. To capture features smaller than the TUFLOW grid cells (100-400 foot cell size) the script subtracts the 25-foot base DEM from the TUFLOW water surface elevation outputs to create 25-foot depth rasters. The percent dry for each field unit is computed by dividing the number of dry raster cells by the total number of raster cells. The last day in the simulation where less than 70 percent of the raster cells are dry is assigned to the LDW attribute. Figures 26 through 105 show the LDW for existing conditions, for the proposed conditions, and the difference between the two for each alternative and water year combination. The final determination of the impact on LDW will be evaluated by the agriculture economics team but some observations can be made from looking at the LDW results. The change to LDW varied considerably year to year but was quite similar between alternatives. The change to LDW was small most years with few fields showing a difference greater than a couple weeks. Occasionally the LDW for the alternative solution was earlier than existing conditions. This is likely due to faster drain times because of the changes to the agricultural crossings.

3.4 DISCHARGE VS DISCHARGE RATING CURVES FOR WATER RIGHTS ANALYSIS

The CALSIM modeling group requested flow vs flow rating curves at the Fremont Weir. The rating curves provide an estimate of the discharge into the Yolo Bypass (over the Fremont Weir or through any proposed intake structures) based upon the total discharge between the Sutter Bypass, Feather River and Sacramento River for existing conditions and each of the alternatives. This rating curve is used by the CALSIM model to partition flows between the Yolo Bypass and the Sacramento River past Verona. Figure 106 shows scatterplots of the discharge into the Yolo Bypass (including any proposed gate/channels) vs the discharge in the Sacramento at Verona for existing conditions and each of the alternatives. Figure 107 is a zoomed in view of the same data. The CALSIM group converted the scatterplots into a rating curve formatted as required for their analysis.

3.5 DATA FOR FISHERIES ANALYSIS

The fisheries team requested depth and velocity magnitude raster datasets for the bypass as well as time-series of discharges at specific locations based on the 1D and 2D model results. The raster datasets were provided in NetCDF format. The time-series discharge data was averaged on a daily basis and provided in csv format as requested.

3.6 MERCURY MODELING TEAM DATA REQUESTED

The TUFLOW results provide the input hydraulics for a model that predicts concentrations and mass balances of inorganic and methylmercury in the Yolo Bypass. The mercury model uses a much coarser grid than the TUFLOW model using 40 cells to simulate the entire bypass as shown in Figure 108.

The mercury model requires flow data between cells as well as spatial data on a sub-grid (relative to mercury grid cells) level that includes mercury cell, sub-cell id, area, wet area, Manning Roughness Coefficient (mean), mean depth, max depth, mean velocity, mean WSE, and water volume. The TUFLOW model does not directly output the required mercury model inputs. A series of scripts extracted, computed, and aggregated the TUFLOW results to get the input data required for the mercury model. The scripts handled the 1D and 2D results differently because the information available differs.

All of the files provided to the mercury modeling team were in comma delimited ASCII files for ease of use and readability.

3.6.1 Discharge extraction

Discharges passed from the TUFLOW model to the mercury model describe the flows to and from individual cells. For 1D, discharges are extracted at the channel crossing the mercury model grid's cell boundary. For 2D, the TUFLOW model provides discharges at polylines that were created along mercury model grid cell boundaries. Multiple polylines were created along mercury cell boundaries allowing discharges across different portions of the boundary to record flows in opposite directions. For the same timestep, there may be a discharge from cell 1 to cell 2 and a separate discharge from cell 2 to cell 1. The mercury model uses both discharges to compute the effects of mixing between the two cells.

3.6.2 Spatial data 2D

For the 2D areas, the scripts aggregated data to 500 foot by 500 foot mercury sub-grid cells. The native TUFLOW outputs have a native resolution of 50 feet by 50 feet giving 100 TUFLOW cells per mercury sub-grid cell. Because the sub-grid cells are Cartesian cells and the mercury cells are polygons, one sub-grid cell can include multiple mercury grid cells. When this occurs the sub-grid cell has an entry for each of the spanned mercury cells in the output files.

The scripts aggregated spatial data in the 2D portions including model elevations, Manning N inputs, depths and velocities. The model elevation data is not dependent upon the results and was extracted separately. For the result-dependent data, sub-grid cells with an average depth of less than 0.1 feet were considered dry and no values are reported for that timestep.

3.6.3 Spatial data 1D

The 1D channel geometry is based upon cross-sections associated with the channel. Cross-sections provide higher resolution in the direction of the cross-section but are often spaced further apart than 2D cells. Some of the information needed is directly available and is computed by the scripts. Data is reported for each TUFLOW channel within a mercury cell.

3.6.4 Reconciling discharge and volume data

Based upon the initial extracted data, the discharges in and out of individual cells do not correlate with the volumes reported in the 1D and 2D spatial results. There are several potential reasons for the discrepancy: the precision of the model results, errors related to the extraction process (particularly the 1D spatial data), discharges represent snapshots rather than average over a time, infiltration impacts the spatial data but is not accounted for in the discharge data, and mass errors within the TUFLOW model. A reconciliation algorithm adjusts the discharges to match the spatial data because the mercury model requires consistent results.

The reconciliation algorithm is an iterative approach adjusting the discharge data to match the extracted spatial data. For each iteration, the algorithm processes each cell:

1. Sum the discharges in and out of the cell for each timestep to get the "Net Flow."
2. Compute the "Expected Net Flow" based on the change in volume of water in the cell based upon the spatial data (combined 1D and 2D).
3. Compute the "Cell Flow Adjustment" by subtracting "Net Flow" from the "Expected Net Flow" which represents how much the discharges have to change to make the results consistent.
4. Adjust each of the flows in and out of the cell proportional to its magnitude relative to the total absolute flow in and out of the cell to make the percent change of discharge across each face equal.

Adjusting a cell forces the discharge data and spatial data to reconcile but will also change the discharges for neighboring cells invalidating any previous reconciliation for the neighbor cell. The process is repeated for 200 iterations which provides a good fit between the spatial and discharge data for all of the cells.

4. CONCLUSIONS

The TUFLOW model previously developed for the Yolo Bypass (DWR 2017) was modified to represent the EIS/EIR alternatives. Model simulations were executed for 16 water years from 1997 through 2012. The model results suggest each of the alternatives would provide an increase in inundated area over existing conditions. The relative increase in inundated acres generally corresponds to the target structure discharge. However, the managed floodplains in Alternative 4 provide more inundated acres for longer periods using a smaller discharge. The model results were post-processed and formatted for use in other analyses including Agriculture Economics, Fisheries, CALSIM, and Mercury modeling.

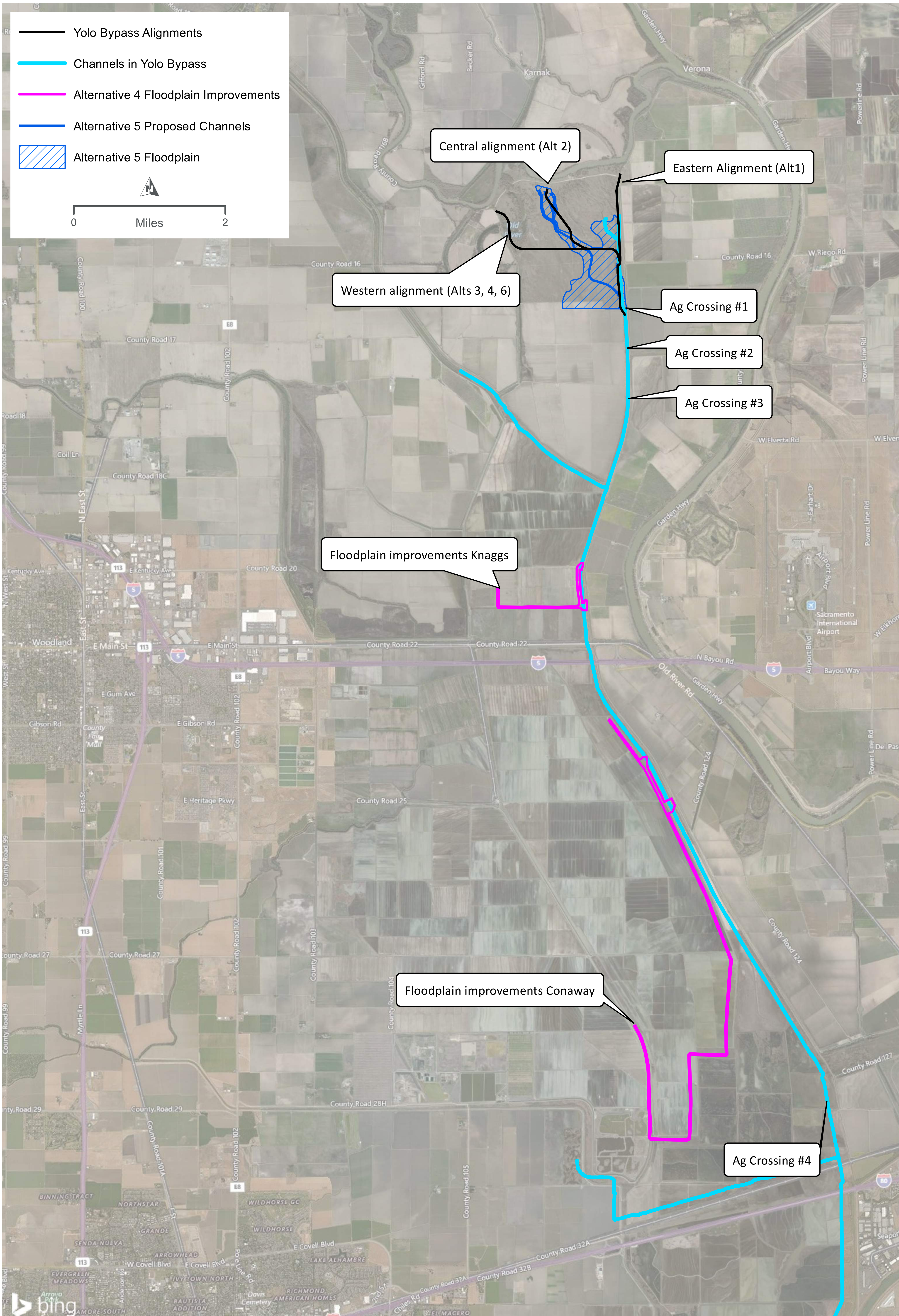
5. REFERENCES

California Department of Water Resources (DWR). 2017. *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Hydrodynamic Modeling Draft Report*. June. Prepared by HDR and cbec.

CVFED. 2013. Central Valley Floodplain Evaluation and Delineation Program. HEC-RAS models for 1997 and 2006 Events. HEC-RAS simulation files.

Matella & Jagt. 2013. Integrative method for quantifying floodplain habitat. Journal of Water Resources Planning Management. Technical Notes.

6. FIGURES



ALTERNATIVES OVERVIEW

LOCATIONS OF FEATURES CREATED OR MODIFIED FOR THE ALTERNATIVE MODELS

FIGURE 1