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Final

Caltrans Bat Mitigation:
A Guide to Developing Feasible and Effective Solutions

Prepared for:

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Executive Summary

The California Department of Transportation (Caltrans) manages over 50,000 miles of state and interstate highways, and these facilities overlap with myriad habitat types and natural areas in California. Maintenance, rehabilitation, and improvement activities on California's State Highway System and its associated infrastructure are ongoing. Bridges, culverts, viaducts, and other infrastructure components provide habitat for multiple bat species in California. Caltrans' goal is to maintain and operate structures for the purposes of transportation without adversely affecting bat populations, while also balancing the needs of bats with the safety of transportation workers.

This guidance document was developed to update the *California Bat Mitigation Techniques, Solutions, and Effectiveness* report that was prepared for Caltrans in 2004. It describes bat habitat relative to transportation structures, discusses bats' conservation status, details the pertinent regulatory framework, and provides guidance for assessing bat habitat on highway infrastructure. This document describes how to identify and characterize potential temporary and permanent impacts on bats related to bridge and culvert projects, discusses mitigation strategies, and provides mitigation case studies and recommendations based on field assessments by expert bat biologists at 39 bridges and culverts. These structures were identified by Caltrans and other biologists as having bat mitigation habitat incorporated into their designs.

Bridges, culverts, and other transportation structures have provided bats with modified types of habitat that have supported their populations throughout all 12 Caltrans Districts. In many cases, bats have adapted to roosting in transportation structures as a result of lost or degraded habitats.

There are 25 species of bats in California, and 16 use bridges and/or culverts. Because relatively high percentages of the populations of Mexican free-tailed bats (*Tadarida brasiliensis mexicanus*), Yuma bats (*Myotis yumanensis*), and pallid bats (*Antrozous pallidus*) roost in bridges and culverts, these species are the most susceptible to adverse effects if bridges or culverts are replaced or retrofitted. Thus, transportation structures provide important resources for bats, but activities associated with their rehabilitation, improvement, or replacement also put bat populations at risk.

The California Department of Fish and Wildlife (CDFW) is the primary agency responsible for the conservation of bats in California, and 12 species of bats are designated as Species of Special Concern by CDFW. The primary regulatory mechanism applicable to bats is the California Environmental Quality Act (CEQA), which requires an analysis of a project's effects on the environment, including biological resources such as bats. Depending on a project's potential effects, Caltrans may develop appropriate avoidance, minimization, and mitigation measures to

reduce the impacts of the project on biological resources to less-than-significant levels through coordination with CDFW. CDFW also issues Lake and Streambed Alteration Agreements (LSAAs) under Section 1600 et al. of the California Fish and Game Code. This permitting process can provide CDFW with a means of further reducing impacts on bats beyond the mitigation measures in the project's environmental document.

If potential bat habitat is present at a bridge or culvert project site, it should be evaluated at least 2 years before the construction phase begins. If the evaluation of potential habitat indicates that bats or their habitat are present on or in the transportation structures that would be affected during project implementation, an impact analysis and avoidance, minimization, and mitigation measures will be developed.

The avoidance and minimization measures for impacts on night roosting and day roosting habitat are similar, and may include: (1) limiting project activities to daytime hours and the winter; (2) avoiding the use of lights under the bridge during nighttime hours; (3) not operating or parking vehicles and equipment with internal combustion engines under the bridge if bats are present; (4) planning work to avoid restricting bats' airspace access to roost sites; (5) using exclusion devices when bats are absent to prevent them from occupying the work areas; and (6) using fencing or flagging to identify buffer zones around roosting bats as environmentally sensitive areas (ESAs) where work activities and construction personnel are prohibited.

The development of a project-specific bat mitigation plan is one of the best ways to ensure the measures developed in the planning process are completed during construction. There is no "one size fits all" solution to achieve effective mitigation. Rather, each bridge or culvert is different and bats occupying these structures may use them for different parts of their life cycle, the requirements of which vary among species. A mitigation and monitoring plan should be developed in coordination with CDFW and describe monitoring methods and frequency, mitigation success criteria, and provisions for adaptive management if unforeseen circumstances arise.

To evaluate the effectiveness of completed bat roosting habitat mitigation strategies for bridge and culvert projects, H. T. Harvey & Associates wildlife ecologists Dr. Dave Johnston and Kim Briones, M.S., conducted focused field assessments between late spring and summer in 2017 and 2018 at 39 structures, many of which had undergone relatively recent construction. The mitigation approaches for the 39 bridge and culvert projects were divided into three categories: original habitat retained; original habitat lost and new on-site habitat provided; and original habitat lost and new off-site habitat provided.

Mitigation that retained the original habitat was effective for all applicable species except pallid bats; they did not always return to their original roost sites after being disturbed. Many project sites where new on-site habitat was provided were determined to have effective mitigation, and some bridges exhibited increased populations post-construction. Cast-in-place bat boxes were successful when installed in concrete slab bridges, but not when built in the soffits of closed box girder bridges. Add-on replacement roosting habitat using Oregon wedges, panels, and bat boxes were successful. Concrete add-on replacement habitat structures were more durable than their wooden counterparts, which tended to warp over time. Replacement habitat structures that had crevices widths of 1.5 inches and larger were not occupied by bats and therefore ineffective. Hanging concrete bar bat boxes had mixed results for efficacy, possibly because crevice gaps were too wide in some cases. Culverts with bat boxes or panels were usually recolonized with bats and considered effective mitigation. The findings of the focused field evaluation indicated that Oregon wedges, panels, add-on collars, bat boxes, capped drains on bridges, and small bat boxes on culverts can provide effective mitigation.

Recommendations that could greatly improve both the accuracy of the scientific data collected regarding the use of transportation structures by bats in California and help advance the development of future avoidance, minimization, and mitigation measures for bats include: (1) creating standardized data sheets for the various types of bat surveys in coordination with CDFW and the California Bat Working Group; (2) providing incentives for research to improve off-site bat mitigation habitat, such as stand-alone bat boxes and bat condominiums, whose current designs and use are ineffective and an inefficient use of resources; and (3) providing incentives for research on the ultrasonic noise generated by the construction equipment that is used for transportation projects, the attenuation of these ultrasonic noises, and whether the estimated buffer zone distances are sufficient to reduce or eliminate their effects on bats.

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Glossary

Add-on habitat: Any mitigation habitat feature, such as a bat box, that is installed on a transportation structure.

Alternative roost: Secondary roosts used by individual bats or small numbers of bats.

Ambient: Conditions in the surrounding or immediate environment.

Anthropogenic: Of, related to, caused by, or created by humans.

Attenuate: To decrease or weaken in amount, degree, or intensity.

Autoclassifier: Automated software that uses a variety of algorithms to classify bat acoustic calls to species.

Bachelor colony: Congregation of male bats that roost separately from female bats during the maternity season.

Bat detector: An electronic device used to detect or record ultrasonic vocalizations of bats that are inaudible to humans.

Creation habitat: New habitat that is provided where none previously existed.

Day roost: A roost that is occupied by reproductive and non-reproductive bats during the day, and provides a place for bats to rest, enter daily torpor, rear young, or communicate. Bats choose their day roosts based on their seasonal life cycle requirements.

Decibel (dB): The measure of the relative loudness of a sound based on a logarithmic scale that reflects the ratio of actual sound pressure to a reference level of sound pressure for human hearing.

Echolocation: The emission of vocalizations and the subsequent analysis of the echoes of those vocalizations to create a "picture" of the environment. The primary function of echolocation in bats is for locating prey and for spatial orientation. Most North American bat species use high frequency, ultrasonic vocalizations for echolocation, which are inaudible to humans; however, some species such as the western mastiff bat (*Eumops perotis*) echolocate using lower frequency vocalizations audible to humans.

Exclusion: The temporary or permanent removal of bats from a roost by passive means.

Frequency: In sound, frequency is the number of oscillations, vibrations, or cycles, of a sound wave that pass a fixed point in a unit of time. The units of measurement for frequency are Hertz (Hz) or kilohertz (kHz).

Heterothermic: Physiological term for animals that can maintain a high body temperature through metabolism (i.e., warm-blooded) and when needed, lower their metabolism so that their body temperature is reduced or at the ambient temperature (cold-blooded).

Hibernaculum: A location where bats roost during the winter; the plural form is hibernacula.

Kilohertz: The unit of measurement of frequency equal to 1,000 cycles per second.

Maternity colony: A temporary association of reproductive female bats for giving birth to, nursing, and weaning their pups.

Maternity roost: A roost where reproductive females give birth to and raise their young.

Maternity season: The time period when pregnant females congregate at a day roost to give birth and raise their young. The maternity season is generally over when the year's young are flying and begin foraging on their own. The specific timing of a given maternity season varies among different climatic regimes, with the earliest maternity seasons occurring from early March through June in the hottest desert areas in California and the latest maternity seasons occurring from May to the end of August in the coldest climates of California. The timing of a maternity season is also dependent upon a given year's weather conditions. A late winter can postpone parturition and extend the maternity season to the end of August.

Migratory stopover: A temporary roost site used by migratory bats en route to their summer or winter roost sites.

NABat: The North American Bat Monitoring Program, which is designed for long-term monitoring of bat populations at the continental scale. The program's website is: https://www.nabatmonitoring.org/

Night roost: A roost that is occupied primarily at night and serves as a place where bats can rest between foraging bouts, consume or digest food, maintain social interactions, and be protected from predators or inclement weather. Night roosts are typically situated in a protected but open structure that is normally less cryptic than day roosts. Bridge girders and closure pours provide night roost habitat. Day roosts (defined above) can sometimes function as night roosts.

Oregon wedge: A plywood or concrete day roost box that is installed on the exterior of a transportation structure.

Permanent loss of roosting habitat: Occurs when roost habitat is removed, such as when a bridge that serves as a roost is demolished.

Replacement habitat: Anthropogenic habitat such as a bat box that is created to take the place of roost habitat that is removed or lost.

Search call: Echolocation call pulses that are used by bats when they are searching for prey. Search calls from individuals of the same species are usually consistent in their structure such as frequency, duration, and call shape, which enables them to be used for species identification in acoustic surveys.

Self-mitigating: When roost habitat is incidentally replaced by virtue of the transportation structure design, as with a bridge that incorporates expansion joints, which are typically used by bats, or other replacement habitat.

Shifting baseline syndrome: The gradual change in how an environmental system is compared to or assessed due to the change or shift in the baseline reference data. From one generation of observers to the next, the reference of baseline observations changes so it is difficult to assess changes in habitat structure and populations of plants and animals.

Social call: Low-frequency vocalizations used by bats for social communications that are often audible to humans.

Sonogram: A graph that illustrates a bat call, typically with frequency on the y-axis and time on the x-axis.

Swarming: Behavior where male and female bats congregate around hibernacula, and is believed to be associated with mating, social communication, and awareness of the winter habitat for that year's young.

Swarming season: The swarming season is known to occur from midsummer to early fall.

Target species: The species present in a transportation structure pre-construction, and for which mitigation habitat is created or mitigation measures are intended.

Temporary loss of roosting habitat: Occurs when roost habitat is physically inaccessible to bats on a temporary basis, such as when improvements are made to a transportation structure.

Thermodynamics: The branch of physics that deals with the transfer of energy or heat from one place to another or from one form to another, such as when a bridge deck heats up from solar radiation and transfers the heat to the bridge soffit where bats roost.

Thermoregulation: The ability to regulate heat and metabolism through internal or external mechanisms.

Torpor: A voluntary physiological state in which a heterothermic animal is able to lower its body temperature, heart rate, and respiration to reduce energy requirements.

Vespertilionid: Of the family Vespertilionidae, known as the evening bats or vesper bats. This is the largest family of bats (Order Chiroptera).

Volant: Capable of flight.

Section 1. Introduction and Project Goals

The California Department of Transportation (Caltrans) is responsible for the ongoing maintenance, rehabilitation, and improvements of the State Highway System (SHS). The SHS is composed of over 50,000 miles of state and interstate highways in California and its associated infrastructure, including over 24,000 bridges and culverts. About 1 in every 6 transportation bridges in California is used in some capacity by bats (Erickson et al. 2003). Bridges and culverts provide roosting habitat for 16 of the 25 bat species that occur in California. These roosting features are analogous to naturally occurring roosts, many of which have been degraded or lost due to disturbance and other anthropogenic influences. In many cases the large mass of these human-made structures replaces some of the lost natural roosting habitat resources for bats and provides them with stable thermal conditions that bats require throughout their lifecycle. Over the past several decades, the importance of bridges and culverts as roosting habitat has become increasingly apparent.

Caltrans' goal is to maintain and operate bridge structures for the purposes of transportation without adversely affecting bat populations, while also prioritizing the safety of transportation workers. Along with the responsibility for planning, designing, building, and maintaining California's many state transportation structures, Caltrans biologists, planners, engineers, maintenance workers, and contractors have a responsibility to ensure the protection and conservation of bat populations that occupy these structures. As part of its commitment to environmental stewardship, Caltrans has sought guidance from bat specialists and directed the formation of this document and several other important guidance documents on bat ecology, surveys, impact assessments, and mitigation strategies. This guidance document serves to update and expand on the *California Bat Mitigation Techniques, Solutions and Effectiveness* report prepared by H. T. Harvey & Associates, Wildlife Associates, Elizabeth Pierson, and Caltrans (Johnston et al. 2004), which is subsequently referred to as the 2004 Guidance Manual.

Ongoing research continues to improve our understanding of bat biology and ecology. This allows researchers and transportation practitioners to make more informed assessments of bridges as bat habitat and decisions on developing recommendations to avoid, minimize, or mitigate adverse effects on bats from transportation projects. These research-based recommendations will continue to increase the likelihood of bat conservation effort success and the probability that bat species and populations will persist in California well into the future. The purpose of this guidance document is to provide Caltrans and practitioners with a standardized and consistent approach for developing avoidance, minimization, and mitigation efforts that can be implemented for bat species throughout California. H. T. Harvey & Associates and Caltrans personnel coordinated with the CDFW and expert bat biologists throughout the state on the development of this guidance.

This guidance document is intended to assist biologists and transportation decision-makers, and there is an emphasis on early agency coordination and planning. The completion of surveys for bat species that would potentially be affected by implementation of a transportation project during the planning and environmental review process can inform project design and increase the likelihood that appropriate replacement habitat features will be incorporated into the project. Agencies such as CDFW should be consulted early in the project schedule so they can contribute to the development of avoidance, minimization, and mitigation plans for bats.

The approach for the 2004 Guidance Manual consisted of four goals:

1. Provide a synthesis of existing information regarding bats and mitigation efforts worldwide and throughout the United States, but with a particular focus on transportation issues in California.

2. Evaluate a range of mitigation alternatives and their relative effectiveness in California.

3. Provide mitigation guidelines for bats as they apply to Caltrans projects.

4. Develop the transportation-related components of the California Bat Conservation Plan (CBCP).

The 2004 Guidance Manual addressed the first three goals. At the time of preparation of the 2004 Guidance Manual, the CBCP was in the early stages of development. As of July 2019, the CBCP was still in progress; however, work will be reinitiated in fall 2019 and completion is anticipated by the end of 2020 (Osborn pers. comm. 2019).

Project Objectives for the 2019 Caltrans Bat Mitigation Report

This guidance document was developed to update the 2004 Guidance Manual and will serve to facilitate Caltrans' internal review and approval of proposed updates to its guidance on bats. This update is meant to assist Caltrans personnel tasked with conserving bat populations that occupy transportation structures.

This project included statewide data collection that was conducted to determine the efficacy of mitigation completed to offset temporary and permanent habitat loss associated with bridge and culvert projects. H. T. Harvey & Associates conducted a statewide survey of 87 bridges and culverts where bat mitigation had been implemented. H. T. Harvey & Associates visited nearly half of these sites to collect data to determine the efficacy of implemented mitigation. This document also includes representative photos and design plans for several effective roost habitat designs that were observed in the field. These examples of bridge and culvert bat mitigation projects are not meant to be replicated exactly as "off-the-shelf designs and mitigation plans" for use on any project; they are meant to showcase successful bat mitigation plans and replacement bat habitat designs. A single roost design cannot accommodate all bat species, roost types, site conditions, or types of impacts.

In support of the primary goal of updating the 2004 Guidance Manual, this guidance document incorporates the best available science on bat ecology and provides information on the following topics:

- Bat habitat in and around transportation–related structures
- Conservation status of bats
- California regulations relevant to bats and transportation projects
- Assessing potential bat habitat with recommendations for bat survey protocols and biologist qualifications
- Determining the potential impacts
- Mitigation Strategies
- Case studies for bridge and culvert projects completed by Caltrans and other transportation agencies that have implemented on-site and off-site bat roost mitigation designs
- Bat mitigation recommendations

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Section 2. Bat Habitat in and Around Transportation–Related Structures

2.1 Overview

This section discusses the aspects of bat biology, roosting ecology, and foraging ecology that are relevant to transportation structures and projects. The transportation structures most commonly associated with bat species are bridges. In addition to bats roosting inside or on bridge structures, bats can roost in culverts, on rocky banks, or in nearby trees such as those in adjacent riparian habitat. These trees represent potential roosting sites for foliage roosting bats (e.g., hoary bats and western red bats), as well as for many species of crevice roosting bats. Buildings that are adjacent to a transportation project may also provide potential habitat for crevice or cavern roosting species. All 25 bat species that occur in California use one or more natural features or anthropogenic structures for roosting (Table 2-1) and 16 species are known to use bridges. Of these 16 bat species, 4 species commonly use bridges, 8 species occasionally use bridges, and 4 species rarely use bridges. Bats also forage in habitats near bridges such as riparian communities, open water, and tree canopies along transportation corridors.

2.2 Bat Biology

Aspects of bat biology that are the most relevant to transportation structures and projects are species' tendency to form colonies, reproductive biology, roosting ecology, and foraging ecology. Roosting ecology and foraging ecology are discussed in Sections 2.3 and 2.4, respectively.

Many species of bats, especially those often associated with bridges, tend to aggregate in colonies that vary in typical size among species. Several species, such as the long–eared myotis (*Myotis evotis*) form small colonies or are non-colonial like hoary bats and western red bats, but most aggregate. A few species, such as Yuma myotis (*Myotis yumanensis*) and Mexican free-tailed bats (*Tadarida brasiliensis mexicanus*), form large colonies of several hundred to many thousand individuals. Hibernating colonies form during the winter, and maternity colonies, which are composed of adult females and their young, occur from spring through early fall. Bats have complex social systems (Kerth 2008), and maternity colonies are often matrilineal, with females returning to their natal roosts throughout their lives (Lewis 1995). For many species, the maternity colonies show high fidelity to their chosen roost sites, particularly for sites such as caves, which typically have high structural stability. The temporal and spatial patterns of colony formation should be considered when evaluating the potential impacts of transportation projects, particularly those involving bridges; a species' entire regional population may be concentrated within a single bridge roost.

Bats are unusual among small mammals because they are long-lived. An individual bat living up to 15 years is not uncommon and the little brown myotis (*Myotis lucifugus*) is known to live over 30 years. In general, bats also have a low reproductive rate. Most species have only one young per year. A few species such as the pallid bat, hoary bat, and western red bat have twins or multiple births. Females are often 2 years old before they reach reproductive maturity and breeding females are usually behaviorally sensitive to disturbance. As a result of low reproductive rates, maternity colonies that are affected by temporarily-reduced fecundity or mortality, including transportation project activities, may require multiple years to recover following a disturbance event (See case studies in Section 8).

2.3 Roosting Ecology

Bats use multiple roost types and the inhabitation of each type varies temporally and seasonally. Common characteristics to all roosts include an appropriate temperature regime, protection from predators and inclement weather, and proximity to foraging sites. By roosting in a colony, bats conserve energy through thermoregulation, have increased mating opportunities and maternal care, have greater numbers of communication with other bats, and are likely to have less competition for food from other vertebrate species (Altringham 2011). These roost sites may occur in crevices, cavities, and foliage. The roosting patterns for California bat species are provided in Table 2-1. Roost site selection and use, structural features of roosts, and the importance of bridges as roosting habitat for bats are discussed below.

Table 2-1. Roosting Patterns for California Bat Species

Species Name	Common Name	Status	Bridge	Cave/ Mine	Building	Cliff/ Rock Crevice	Tree Bark/ Hollow	Tree Foliage	Riprap/ Dry Rock Wall
Family Phyllostomidae (leaf-nosed bats)									
Choeronycteris mexicana	Mexican long-tongued bat	SSC, WBWG:H		1	2				
Leptonycteris yerbabuena	Lesser long-nosed bat	WBWG:H		1					
Macrotus californicus	California leaf-nosed bat	SSC, BLMS, WBWG:H	3	1					
Family Molossidae (free-tailed bats)									
Eumops perotis	Western mastiff bat	SSC, BLMS, WBWG:H			3	1			
Nyctinomops femorosaccus	Pocketed free-tailed bat	SSC, WBWG:M				1			
Nyctinomops macrotis	Big free-tailed bat	SSC, WBWG:MH				1			
Tadarida brasiliensis mexicanus	Mexican free-tailed bat		1	2	1	1	3		
Family Vespertilionidae (mouse-eared bats)									
Antrozous pallidus	Pallid bat	FSS, SSC, BLMS, WBWG:H	1	2	1	2	1		

Species Name	Common Name	Status	Bridge	Cave/ Mine	Building	Cliff/ Rock Crevice	Tree Bark/ Hollow	Tree Foliage	Riprap/ Dry Rock Wall
Corynorhinus townsendii	Townsend's big-eared bat	FSS, SSC, BLMS, WBWG:H	2	1	2		3		
Eptesicus fuscus	Big brown bat		1	2	1	2	1		
Euderma maculatum	Spotted bat	SSC, BLMS, WBWG:H				1			
Lasionycteris noctivagans	Silver-haired bat	WBWG:M	3				1		
Lasiurus blossevillii	Western red bat	FSS, SSC, WBWG:H						1	
Aeorestes cinereus	Hoary bat	WBWG:M						1	
Lasiurus xanthinus	Western yellow bat	WBWG:H						1	
Myotis californicus	California myotis		2	2	1	1	2		3
Myotis ciliolabrum	Small-footed myotis	BLMS, WBWG:M	2	2		1			
Myotis evotis	Long-eared myotis	BLMS, WBWG:M	2	2	2	2	1		2
Myotis lucifugus	Little brown myotis	WBWG:M,	2	2	1	2	2		
Myotis occultus	Arizona myotis	SSC, WBWG:H	2		2		1		

Species Name	Common Name	Status	Bridge	Cave/ Mine	Building	Cliff/ Rock Crevice	Tree Bark/ Hollow	Tree Foliage	Riprap/ Dry Rock Wall
Myotis thysanodes	Fringed myotis	BLMS, WBWG:H	2	1	2	2	1		
Myotis velifer	Cave myotis	SSC, BLMS, WBWG:M	2	1	3				
Myotis volans	Long-legged myotis	WBWG:H	2	2	2		1		
Myotis yumanensis	Yuma myotis	BLMS, WBWG:LM	1	2	1	3	2		3
Parastrellus hesperus	Canyon bat		3	2	3	1			

Notes: Adapted from Johnston et al. [2004]

* 1 = use frequently; 2 = use sometimes; 3 = use rarely; Blank = not known to use

Status:

BLMS = Bureau of Land Management Sensitive

FSS = U.S. Forest Service Sensitive

SSC = California Department of Fish and Wildlife, Mammal Species of Special Concern

WBWG:H = Western Bat Working Group High Conservation Priority

WBWG:MH = Western Bat Working Group Medium-High Conservation High Priority

WBWG:M = Western Bat Working Group Medium Conservation Priority

WBWG:ML= Western Bat Working Group Medium-Low Conservation Priority

Roost site selection and use. The primary criteria for roost site selection are diurnal and seasonal temperature patterns. Bats are unusual among mammals because they are heterothermic, meaning their body temperature is variable. Although they are capable of thermoregulating like other mammals, bats also have the capacity to allow their body temperatures to follow ambient temperatures in a manner similar to many cold-blooded animals. In general, bats seek thermally-buffered roost sites with stable temperatures over time and a lower range in temperature fluctuation throughout the day and night when compared to the surrounding environment. In the summer while raising young, bats often seek warm, but thermally-buffered, environments. These settings provide enough thermal diversity for bats to maintain a fairly constant body temperature regime by simply moving to areas with different temperatures. In the winter, especially in areas where temperatures frequently drop below freezing, bats seek thermally stable roosts that are ideally just a couple of degrees above freezing in which to hibernate. In most regions of California, where temperatures rarely drop below freezing, bats typically seek cool roosts that do not substantially fluctuate in temperature. This behavior enables bats to save energy by using torpor, which allows their body temperatures to drop below their normal temperatures when active (Salinas et al. 2014).

Bats change roosts seasonally. Although the timing of roost changes varies with species and geographic location, bats generally form maternity colonies in the spring. These aggregations are maintained until the young are independent, which usually occurs in the late summer or early fall. During this maternity season, adult males typically roost alone or less commonly in bachelor colonies.

In the fall, some California species, such as the Mexican free-tailed bat and the western red bat, migrate regionally—often less than 200 miles—to milder climates, and use roosts for short periods as migratory stop-over sites (Johnston 1998, Johnston and Whitford 2009). Hoary bats, however, migrate long distances between their summer pupping areas and their wintering areas along the California coast; these migrations may exceed 1,000 miles. Other species, such as the pallid bat, remain within the same general area year-round, hibernate or lower their body temperature by entering shallow torpor, and maintain a low level of activity throughout the winter (Johnston et al. 2018). For most species, little is known about their migratory movements.

Although large hibernating aggregations are common in some parts of the United States, they are relatively rare in California. The largest hibernating aggregations have been found only in caves and mines. However, aggregations of more than 1,000 non-hibernating Mexican free-tailed bats have been observed overwintering in bridges along the California Coast and in portions of the Central Valley (Johnston 1998). For example, the Alameda Creek Bridge on Interstate 880 (I-880) in Alameda County provides overwintering habitat for approximately 1,000 Mexican free-tailed bats, most of which leave in late February or early March. This bridge is close enough to the San

Francisco Bay that winter temperatures remain relatively cool with little fluctuation. These bats likely fly to the Central Valley, where summer nights are warm and there are presumably high concentrations of insects as prey (Johnston 1998). Most California bat species roost singly or in small groups when hibernating during the winter. During the summer months maternity colonies roost in conditions that are very warm and thermally stable. Roosts typically receive solar radiation that warms the roost for crevice-roosting bats. In the winter, bats seek conditions which remain cool and do not warm up during the day (Altringham 2011). For the State Route (SR) 91 Santa Ana River Bridge Widening Project in Riverside County, LSA bat specialist Jill Carpenter reported that bats roosted in the bat boxes that were situated on the outer concrete I-beams and usually received solar radiation during part of each day (Carpenter pers. comm. 2018). During the winter months, the bats used bat boxes located centrally under the bridge where temperatures were cooler and more constant.

Bats are most active and raise their young during the summer. During this season bats frequently use one roost during the day where they sleep and rear their young and another roost at night for resting, digesting, and socializing. Occasionally bats will day roost outside of a crevice in an area more typical of a night roost; however, this is uncommon and makes bats more vulnerable to predation. Day roosts tend to be cryptic, concealed, and not always "predictable" in their location. When crevice roosting bats choose a tree for day roosting, the tree is usually greater than 12 inches diameter at breast height and more than 40 feet tall (Rancourt et al. 2007). However, bats can exhibit a certain amount of flexibility, and in Plumas National Forest, a small maternity colony of five female pallid bats used a small sugar pine (*Pinus lambertiana*) cavity only 5 feet above the ground as a day roost (Johnston and Gworek 2006). In contrast, night roosts tend to be more open or exposed, are relatively easier for bat biologists to locate, and are typically close to foraging habitat.

Little is known about roost requirements specific to mating. Some winter day roosts are used specifically for the purposes of mating, as in the case of the cave-dwelling California leaf-nosed bat (*Macrotus californicus*) (Brown and Berry 1994), but it is generally assumed that most other California bats, such as the pallid bat, mate primarily in their unspecialized fall and winter roosts (Johnston et al. 2006). Additionally, some night roosts are used as swarming areas where bats may investigate the suitability of overwintering sites, give that year's offspring information about the locations of overwintering sites, and bring males and females from multiple colonies together to increase genetic diversity (Altringham 2011). All the vespertilionids (i.e., mouse-eared bats) and the California leaf-nosed bat mate during fall and winter but females do not become pregnant until the spring as these bats exhibit a delayed fetal development. Molossids (i.e., free-tailed bats), such as the Mexican free-tailed bat, usually mate in late winter or early spring. All California bats give birth to babies sometime from mid-spring to mid-summer, depending upon the local climate.

Structural features of roosts. North American bat species use three general categories of roost structures: crevices, caverns, and foliage. Table 2-1 lists the roosting patterns of California bat species. Although some bat species appear to be obligate cavern or crevice dwellers, there is a continuum between crevices and caverns, and many species use a range of roosts. In natural settings, cavernous roosting species aggregate on open surfaces inside dark chambers, such as caves or large tree hollows. Crevice roosting species occupy a variety of narrow slots (e.g., rock crevices, exfoliating tree bark, and damaged wood in snags). With the exception of a few foliage roosting species, North American bats also roost in cave-like spaces and/or crevices in anthropogenic structures, including occupied or abandoned buildings, old mine workings, silos, towers, tunnels, and bridges. Mines and caves are especially important for several special-status species such as the Townsend’s big-eared bat, California leaf-nosed bat, fringed myotis, and less frequently, pallid bat.

Species that roost in cliff faces and rock crevices are often found along highway corridors and rocky banks near bridges in the Sierra Nevada and the Coast Ranges, particularly on highways that follow major rivers. Several bat species roost in tree cavities or under flaking bark, in structural flaws that are commonly found in conifer snags, and in live, mature cottonwoods (*Populus* spp.), sycamores (*Platanus racemosa*), and oaks (*Quercus* spp.). These tree roosts can occur within the road right-of-way, particularly along stream and river corridors. Foliage roosting species are often concentrated in stands of mature riparian trees such as cottonwoods and sycamores. The long-eared myotis has been detected roosting in crevices among rock slope protection material used for rock revetment at bridges that span streams (Rainey and Pierson 1996). California myotis and Yuma myotis have also been observed roosting in the rock revetment that surrounds a rock bridge in the East San Jose hills (Dave Johnston pers. obs. 2011).

2.4 Foraging Ecology

Twenty-three of the 25 bat species found in California are predominantly insectivorous. A few of these species also consume arthropods such as scorpions and spiders. The two remaining species, the Mexican long-tongued bat (*Choeronycteris mexicana*) and lesser long-nosed bat (*Leptonycteris yerbabuenae*), are primarily nectarivorous and confined to southern California. The Mexican long-tongued bat occurs only seasonally in California and the lesser long-nosed bat is known only from a few specimens likely to have been vagrants (Constantine 1998).

Although bat species show some specialization for particular foraging styles and habitats, they also will opportunistically exploit locally abundant prey (Johnston and Fenton 2001, Whitaker 1994). Diet studies conducted along the upper Sacramento River showed that while there were marked differences in average diet composition across species, several species took advantage of substantial hatches of particular insects, such as winged termites and caddisflies (Rainey and Pierson 1996).

Studies in Canada (Grindal et al. 1999) and the Sierra Nevada (Pierson et al. 2001) found that bat activity was concentrated over water in forested areas of western North America. The Yuma myotis feeds largely on emergent aquatic insects by skimming near the surface of lacustrine (e.g., lakes or ponds with still water) or slow-moving waters; the little brown myotis also forages over lacustrine waters but at slightly greater distances above the surface (Herd and Fenton 1983). These two myotis species forage over small creeks and large, open lakes. Bat species divide potential foraging space in ways that can be partially predicted from their wing size and shape, which determine flight speed and maneuverability (Fenton and Bogdanowicz 2002). The Mexican free-tailed bat, which has long, narrow wings, typically forages at slightly greater heights and much faster speeds than the Yuma myotis, which gleans prey off the water's surface and can also forage in much smaller spaces (D. Johnston, unpublished data). Multiple bat species forage primarily along the water's edge and in adjacent riparian vegetation. However, some species such as the western small-footed bat (*Myotis ciliolabrum*) are also known to forage exclusively away from water, including along dry creek channels, within forest canopies, or in oak savanna. All of these foraging habitats may occur near bridges and other transportation structures.

2.5 The Importance of Bridges to Bats

The relative importance of bridges to bats can be attributed to a combination of factors. Bridges frequently have structural features that are analogous to natural roosts. The large mass of concrete provides bats with a thermally buffered environment that enables regulation of their body temperature (Smith and Stevenson 2013). Bridges over water and natural habitat are more likely to be used by bats than bridges that span roadways and other developed areas. However, when present, bats roosting over roadways or development are typically less sensitive to issues relating to urbanization, such as the Mexican free-tailed bat and to a lesser degree, Yuma myotis. Some southern California bridges that span other roadways, such as the West Prado Overhead Bridge on SR 91 in Riverside County, have very large Mexican free-tailed bat colonies.

Keeley and Tuttle (1999) conducted an extensive investigation of bat species' use of bridges throughout 25 states in the continental United States and found that only 1% of surveyed structures had ideal conditions for day roosting habitat. This study also concluded that a much higher percentage of bridges could provide habitat for bats with relatively little or no extra cost for a given project. The results of the study suggested that most species chose to roost in concrete crevices that were sealed at the top, at least 6–12 inches deep, 0.5–1.25 inches wide, 10 feet or more above ground, and typically not located over busy roadways (Keeley and Tuttle 1999).

Bridges have become important roosting habitat for Mexican free-tailed bats and other bat species (Bennett et al. 2008). Because bridges have provided bats with a new roosting habitat where insect prey are typically plentiful along water courses, bridges are likely responsible for greatly increasing populations of Mexican free-tailed bats and Yuma myotis (Johnston 2012). In many cases, when surveys are conducted within a 9–15-mile radius of a bridge roost, the bridge supports the most significant, and in some cases the only, population of a particular species in the area. Several colonies have resided in the same bridges for many years and have come to depend on these structures as the only suitable habitat available to them in a particular area. This is particularly true in areas where surrounding natural habitats have been degraded or eliminated, such as the loss of riparian forests in the Central Valley.

Bridges and culverts have structural features that provide roosting sites for both crevice and cavern dwelling bats (Table 2-2). Crevice roosts, which are suitable for day roosting maternity colonies, are most frequently found in expansion and hinge joints, in abutment crevices, and in spaces formed at the junction between old and new portions of a widened bridge. Less commonly, crevices occur where a bridge, or more typically a viaduct, interfaces with rock features in the road cut. Anomalous features, such as crevices behind signs on bridges, can also provide roosting habitat. Bats that typically use crevices in bridges are listed in Table 2-1. Cave dwelling species can also use bridges as day roosts. The most commonly occurring cavernous habitat on bridges can be found in abutments, particularly where the slope meets the abutment in a configuration that provides a cave-like space. For example, the abutment spaces on each end of the Sweetwater River Bridge on SR 79 in San Diego County had a roosting Townsend's big-eared bat, which is an obligate cave roosting species.

Unscreened weep holes can become access points to cavernous habitat that is created in bridges with closed box girder type construction. At the time that the 2004 Guidance Manual was prepared, bat species were known to only occasionally access these large cavities in bridges. These species included the Townsend's big-eared bat, big brown bat, and Yuma myotis (Erickson et al. 2003). During the surveys for this project, ecologists Dr. Dave Johnston and Kim Briones, M.S., observed many hundreds of Mexican free-tailed bats pouring out of weep holes in the Lake Hodges Bridge on I-15 in San Diego County (Photo 2-1). The Mexican free-tailed bat has shown evidence of social learning (Kerth 2008) and in California has demonstrated seasonal movements among regions within the state (Johnston 1998). This roosting behavior could spread throughout this species' range to bridges where the thermodynamics are conducive to roosting. The Mexican free-tailed bat has also been observed accessing weep holes to roost in closed box girder bridge cavities in Monterey County (Tatarian pers. comm. 2019), albeit in lesser numbers. Many older bridges have hollow piers with openings to their interiors, and these cavities could accommodate large numbers of bats.

Photo 2-1. Roosting habitat at Lake Hodges Bridge with a weep hole access to cavern habitat for day roosting inside the box girder construction, a closure pour used for night roosting, and an add-on panel for day roosting habitat for crevice roosting bats.

Night roosts are most commonly found in concrete girder bridges in areas where the girders create warm air pockets and where the temperature under the bridge deck is typically warmer, and more stable, than the ambient temperature (Perlmeter 1996, 2004; Pierson et al. 1996). These sites generally offer bats protection from weather and predators. Additionally, because bats forage most frequently in association with water, and many bridges span water bodies, these sites have the distinct advantage of offering proximity to foraging areas.

Table 2-2. Bridge and Culvert Features that Provide Roosting Habitat for Maternity Colonies and Individual Bats.

Bridge or Culvert Feature	Habitat Type	Bat Purpose
Hinge/expansion joint	Crevice	Day roost
Abutment	Cavern	Day roost mostly
Hollow piers	Cavern	Day roost
Weep holes	Open cavity	Night roost
Pier to soffit interface	Cavity	Day roost
Open box girder	Open large cavity	Night roost
Closed box girder*	Cavern	Day roost
Closure pour	Open large cavity	Night roost
Culvert manhole access	Open cavity	Day roost or night roost
Culvert steel overlap	Crevice	Day roost
Recessed pockets	Crevice	Day roost

*Accessed through weep holes

Additional information regarding bats and bridges for California can be found in *The Bats and Bridges Technical Bulletin* (Erickson et al. 2003), and for the southern United States, *In America's Bridges* (Keeley and Tuttle 1999).

Section 3. Conservation Status of Bats

This section describes the conservation issues affecting bat species as they relate to California transportation projects and discusses prioritization of species for conservation. There are 25 bat species in California, 18 of which are rare and/or considered Species of Special Concern (SSC) by CDFW, species of concern by the U.S. Fish and Wildlife Service (USFWS), or sensitive species by the U.S. Forest Service (USFS). All 25 of these bat species are known to have behavioral and ecological interactions with transportation structures, and can potentially be affected by transportation projects, especially those involving bridges. Bats, like other wildlife, respond at the population and individual levels to large-scale anthropogenic changes in ecosystems and landscapes. Each bat species responds differently to anthropogenic stressors; some species respond positively, but many respond negatively (Altringham 2011). California bat populations face many challenges and the primary issues for bat conservation include: (1) loss, fragmentation, and degradation of habitat; (2) pollution from chemicals, light, and noise; (3) predation and interspecific competition; (4) introduced diseases, particularly White-nose Syndrome; (5) climate change; (6) vehicular collisions; and (7) human disturbance, which includes many of the aforementioned issues. The discussion presented below will focus on the conservation issues most relevant to bridge and culvert projects and will briefly review the other issues.

3.1 Loss, Fragmentation, and Degradation of Habitat

Bridge replacement, new bridge construction, highway realignments, and new highway corridors have the potential to contribute to the loss, fragmentation, and degradation of bats' roosting and foraging habitats. These impacts present the most serious threats to bat populations from transportation projects, particularly when the affected habitat is used for roosting; bat roosting habitat is considered a relatively scarce resource (Fenton 1997). Transportation projects can also eliminate foraging areas (e.g., removal of riparian vegetation) or fragment foraging habitat (e.g., routing a road through a line of trees where bats concentrate their foraging). Transportation projects can also change the hydrology of nearby water bodies by converting areas of a fast-moving stream that provides specific emergent insect prey to slow-moving flat water that provides for a whole different set of emergent insect prey (or vice-versa), and therefore change the bat species foraging at these habitats. Studies in forest habitats suggest that bat species diversity (the abundance of each species represented) drops substantially when habitats are disturbed, while species richness (actual number of species represented) may stay the same (Fenton et al. 1992, Medellin et al. 2000). In central California, both species diversity and species richness declined as the density of roads increased; the density is a metric of human density and the fragmentation and degradation of bat habitat (Whitford 2008). Habitat complexity and species richness have declined over time, which results in humans accepting certain levels of habitat degradation during their lifetime as normal conditions (e.g., lower background levels of bats). This acceptance of changes to intact habitats is repeated in successive generations and is a sociological phenomenon termed shifting baseline syndrome (Soga and Gaston 2018). Most of California's natural environment has long been in decline, with much of the state no longer supporting habitat for many sensitive bat species.

3.2 Pollution from Chemicals, Light, and Noise

3.2.1 Chemicals

Pollutants from construction waste that are introduced into drinking water sources for roosting bats, as well as exhaust emissions from construction equipment and vehicles, can result in adverse effects on bats during the implementation of transportation projects. Although both of these effects are generally considered temporary because they are associated with the construction phase, they are sometimes overlooked.

3.2.2 Light

Light pollution on a regional scale can be defined as the changing of natural light levels in the nocturnal landscape as a result of artificial lighting (Falchi et al. 2011). Thus, light pollution on a landscape scale is mostly the result of urbanization and is increasing by 6% per year (Holker et al. 2010). Artificial lighting was found to extend the foraging period of diurnal insectivorous birds by a few hours, which created interspecific competition with several insectivorous bats (Rich and Longcore 2006). Although some bat species are attracted to lights, many species are repelled by them (Rowse et al. 2016). Additionally, nearly all California bats are insectivorous, and insects are strongly influenced by artificial lighting. There is substantial variation among artificial lighting types regarding the compounds or technologies used and the ranges of wavelengths emitted. Common types of artificial lighting include incandescent, mercury vapor, low pressure sodium, high pressure sodium, metal halide, and light-emitting diode (LED). Partly because insects respond very differently to each kind of lighting, bats' attraction to different lighting types also varies. Thus, the effects of artificial lighting on bats are species-specific and highly dependent on the type of lighting.

In addition to the brightness of light, its wavelength also affects bats' behavior. Humans see wavelengths between 400 and 700 nanometers (nm) (i.e., visible light spectrum), while many insects can see in the ultraviolet range of 10 to 400 nm and most bats likely see ultraviolet light between 335 and 395 nm (Gorresen et al. 2015). Therefore, bats perceive light differently than humans. Because there has been relatively little research on the effects of different types of lighting on North American bats, it remains difficult to ascertain how much a bat or bat colony might be affected by artificial lighting.

Light pollution at a microhabitat level, such as on a bridge structure, usually involves specific light sources that can potentially result in direct impacts on bats and their roosting habitat. Most lighting on bridges is confined to the top deck and lamp posts are typically located along its edges. The lighting is directed on the road and is also angled away from the bridge on both sides. In some settings, the areas below the bridge are illuminated to provide visibility along pedestrian pathways or for vehicular traffic if the bridge spans another road. Although uncommon, lighting from a bridge deck may also shine directly on the soffits (undersides) of an adjacent bridge where bats could potentially emerge from expansion joints. Any direct or indirect artificial lighting has the potential to degrade or eliminate roosts or potential roosting habitat.

3.2.3 Noise

Bats are acutely sensitive to changes in their sound environment and can react to even relatively quiet noise if it is foreign to them and stimulates a stress response (Altringham and Kerth 2016). Additionally, the frequency of the noise is also important because individual species of bats have different sensitivities to various noise frequencies. Nearly all of California's bats are insectivorous, and with the exception of a few species, such as the pallid bat (*Antrozous pallidus*), use high-frequency echolocation to detect prey and orient themselves within the landscape. Bats also use sound to communicate, especially while flying. Different species of bats will respond differently to human-induced noise and noise will affect certain bat behaviors differently, such as foraging versus roosting (Caltrans 2016).

Although traffic along a bridge may generate enough noise to disrupt bats' foraging ability adjacent to the bridge, much of their foraging will typically be far enough away from an occupied bridge roost that traffic noise is not a disruption. Further, most of the sounds generated from traffic tend to be low frequency, which except for the pallid bat, should not affect bats' abilities to locate prey. Pallid bats detect prey by passively listening to low frequency sounds generated by the prey (Bell 1982, Johnston and Fenton 2001) so traffic may affect this species' ability to forage near noise pollution. Allen et al. (2010) measured cortisol levels in roosting Brazilian free-tailed bats (*Tadarida brasiliensis brasiliensis*) in very noisy bridges and in remote caves without much human disturbance and found that bats roosting in noisy bridges had similar cortisol levels to their counterparts in quiet caves. Bats in noisy bridges did not show elevated levels of cortisol, suggesting that these bats didn't experience additional stress from the noise. Thus, these bats seemed to be unaffected by the noise from traffic activity on bridges. However, noise from construction activities can potentially disturb roosting bats to the point that they abandon their roost. Townsend's big-eared bats (*Corynorhinus townsendii*) are so sensitive to noise disturbance that they are known to abandon their young when disturbed (Pierson and Rainey 1994).

At a construction project in a large urban park, a maternity colony of big brown bats (*Eptesicus fuscus*) tolerated high decibel (dB) levels of low frequency sounds (audible to humans) generated by chain saws (75–86 dB) and large graders (85–89 dB) within 100 feet of their maternity roost, but the colony abandoned their roost when workers used a high-frequency (19–28 kilohertz [kHz]) laser surveying instrument, inaudible to the human ear (Johnston et al. 2018). Although high frequencies attenuate to ambient sound in shorter distances than lower frequencies, the noise from equipment should be measured for corresponding frequencies to which the bat species involved are most sensitive. For example, in order to determine appropriate buffer zones for operating equipment near an active big brown bat roost, the dB of the 20 kHz frequency (the frequency that the big brown bat is most sensitive to) of noise and distance needed before the noise attenuated to ambient sound would need to be measured. See Sections 6 and 7 for more discussion on determining impacts and developing mitigation. Caltrans (2016) also provides guidance and good discussions about noise impacts to bats at transportation projects.

Most construction noise is low frequency and within a range of low auditory sensitivity for many bat species. However, potential adverse effects on bats from construction noise include roost abandonment and the interruption or impediment of bats' abilities to use echolocation for foraging or navigation around bridges. Noise disturbance and displacement of bats from roosts or important foraging areas can potentially result in reduced survivability of individuals from increased susceptibility to predation, reduced quality of thermal and social environments, and decreased foraging efficiencies. During the development of impact assessments and avoidance and minimization measures for the effects of construction noise on bats, the frequency of noise generated and the hearing sensitivity of the bat species at risk should be considered.

3.3 Predation and Interspecific Competition

Bats roosting on and emerging from bridges may be susceptible to predation due to their large concentrations. In California, bats have few predators, but may be susceptible to owls, hawks, snakes, and domestic cats (Lefevre 2005, Sommer et al. 2009, Mikula et al. 2016). Peregrine falcons (*Falco peregrinus*) in particular hunt bats in flight in California (Peeters and Peeters 2005). Other raptor species such as the American kestrel (*Falco sparverius*) and barn owl (*Tyto alba*) have been observed roosting on California bridges and are known to capture Mexican free-tailed bats as they leave their bridge roosts (Dave Johnston, pers. obs. 2001). Nonnative rats (*Rattus rattus*) are also known to prey on bats in roosts in cavernous habitat (Fellers 2000), which sometimes occurs in the space between the abutments and the bank slopes of bridges. Other species, such as American crows (*Corvus brachyrhynchos*), have been known to capture bats but these observations are relatively rare. Additionally, bridges that provide nesting habitat for raptors and ravens (*Corvus corax*) can lead to an increase in predation on bats from predatory birds.

Interspecific competition among bats is not well understood in North America. However, habitat use studies of bats in northern Monterey County suggest that species which are more sensitive to disturbance, including the hairy-winged bat (*Myotis volans*), are replaced by more tolerant species such as Yuma myotis (*Myotis yumanensis*) or Mexican free-tailed bat (Whitford 2008).

3.4 White-Nose Syndrome

The primary introduced disease that exhibits the greatest risk to bats is White-nose Syndrome (WNS), which is caused by a fungus (*Pseudogymnoascus destructans*) and infects bats in hibernation. This disease has spread rapidly from the state of New York, where it was first reported in North America, to the state of Washington within 12 years. Genetic data suggests this disease is widespread but uncommon in Europe, the likely source of the pathogen in North America. The WNS fungus was detected in Chester, California in the spring of 2019 although as of July 2019 the WNS disease had not yet been detected in bats of California (CDFW 2019a). It is anticipated that bats afflicted with WNS will soon be found in California; however, bats in most parts of California do not enter the long periods of hibernation in cold (0–10°C), damp conditions associated with the disease (Frick et al. 2010). The exceptions are bats that inhabit the high elevations of the Sierra Nevada and northern high plateau areas, such as the caves in Lava Beds National Monument. Species such as the little brown myotis (*Myotis lucifugus*), which is especially susceptible to the disease, hibernate in these cold, damp caves during winter months. Bridges built in these and other geographic areas with cold winters (Building Climate Zone 16 of the California Energy Commission[1]) could help incubate the WNS fungus, which would put overwintering bats in these areas at risk of infection.

[1] https://www.researchgate.net/figure/California-Energy-Commission-building-climate-zones_fig1_242224522

3.5 Climate Change

The effects of climate change on bat populations is an emerging topic in bat conservation. Because many of their life history traits (e.g., seasonal migration, distribution, hibernation, and reproduction) are closely tied to local and regional temperature patterns, a changing climate is expected to have important implications for many bat species. Effects of climate change on bats may include shifts in regional distribution, changes in reproductive patterns such as the timing of mating and delayed fertilization, declined reproductive success in semiarid regions where water may be increasingly scarce, direct mortality from extreme weather events, reduced insect prey base, and reduced biodiversity; only the most flexible species may be able to adjust to changing conditions (Adams and Hayes 2008; Hughes et al. 2012; Loeb and Winters 2012; Aguiar et al. 2016; Grider et al. 2016; Stepanian and Wainwright 2018). Some effects of climate change on bats have already been observed; shifts in seasonal migration times have been documented in an Indiana bat (*Myotis sodalis*) colony in Indiana (Pettit and O'Keefe 2017), and one of the nation's largest Mexican free-tailed bat colonies at Bracken Cave in Texas (Stepanian and Wainwright 2018). If or how climate change could affect bats in California, particularly bridge-dwelling bats, is difficult to predict. In California, bridges primarily support bats during the maternity season but spring, fall, and winter bridge roosting habitats are also important. The maternity season can be defined as when pregnant females congregate at a roost to give birth and raise their young. The maternity season is generally over when the year's young are flying and begin foraging on their own. Shifts in local migratory patterns and seasonal use of bridges could change the patterns of bat use.

3.6 Vehicular Collisions

Transportation infrastructure such as roads and highways has substantially affected wildlife through the direct casualties associated with vehicle collisions. Most research on vehicle-related fatalities has focused on non-flying mammals, birds, and herptiles. However, with an increased awareness of vehicular collisions with bats, more research is needed to understand this threat (Lesinski 2007, Russel et al. 2009, Medinas et al. 2013). Vehicle-related bat casualties have been linked to the proximity of roadways relative to commuting or foraging flyways (e.g., roads through or alongside tree stands, riparian corridors), nearness to important roost sites such as maternity roosts, time of year, species-specific flight behavior pattern (e.g., low-flying versus high-flying pattern), age, and sex (Lesinski 2007, Gaisler et al. 2009, Medinas et al. 2013, Novaes et al. 2018). Russell et al. (2009) examined the incidence of roadway bat casualties between a known little brown myotis and Indiana bat roost site and associated foraging areas; the researchers estimated that annual highway mortality accounted for as much as 5% mortality of the combined colonies.

Other studies have found a higher incidence of collision-related bat casualties in the late summer, which may be attributed to the time when young of the year become volant (Gaisler et al. 2009).

Given that bridges provide important roost habitat for bats, and are thus an attractant for bats, bridges could represent a casualty risk for bats that occupy these structures. This may be especially true when vegetative growth blocks the aerial passage under the bridge, forcing bats to fly over the bridge to access areas on the opposite side of the bridge as their roosts. Although not well-studied, many transportation projects in Europe have developed mitigation for bats comprising crossing structures, such as overpasses (e.g., bat gantries) or underpasses where known commuting routes intersect roadways, in an attempt to safely guide bats over or under roadways (Berthinussen and Altringham 2012, Elmeros et al. 2016). While underpasses appear to be more widely-used by bats and thus, generally more effective, research results are inconsistent. More research and monitoring are needed to fully assess the effectiveness of these mitigation structures.

3.7 Human Disturbance

Human disturbance is an important threat to bat conservation and can lead to roost abandonment, or in the case of active maternity colonies of Townsend's big-eared bats, direct mortality of young. Though direct forms of human disturbance are a threat to bat populations, impacts associated with indirect forms of human disturbance may represent a greater overall threat. Human disturbance during critical periods, namely winter hibernation and maternity seasons, can have detrimental effects on bat populations. For example, frequent arousals caused by cave visitations during the winter hibernation season can result in reduced energy reserves and survival rates of hibernating bats (Boyles and Brack Jr. 2009). During the maternity season, an increase in even a low level of human disturbance can cause sensitive species, particularly the Townsend's big-eared bat and sometimes the pallid bat, to move to different roost sites or abandon roost sites altogether (Beck and Rudd 1960, Pierson et al. 1988). In urban areas, bridge-roosting bats are especially vulnerable to human disturbance because urban bridges are often an attractant for regular human activity, including homeless encampments and vandalism. Common species, such as the Yuma myotis and Mexican free-tailed bat, generally adapt to regularly occurring disturbance. However, bat colonies that roost within the physical reach of humans become vulnerable to damage and possible destruction.

3.8 Species Priorities for Conservation

Because bridge-roosting bat species have different sensitivities to disturbance and use bridges to varying degrees, the following list identifies the levels of risk to these species. This list was developed by the California Bat Working Group in 2007. The Highest Risk, Medium Risk, and Lowest Risk categories indicate the level of risk to populations of these species as a result of roosting in bridges. For example, the long-eared bat (*Myotis evotis*) is included in the Lowest Risk category because a very low percentage of this species' populations in California use bridges as habitat. Thus, there is a very low likelihood that transportation projects will affect long-eared bat populations. In contrast, the commonly occurring Yuma myotis is a riparian and waterway obligate and a very high percentage of the species' population uses bridges for maternity roosting habitat. Therefore, populations of this species have been designated as being at the highest risk of impacts due to transportation projects.

Highest Risk:

- **Pallid bats** — Impacts on day roosts and maternity roosts of this species in and on bridges are fairly well-documented. In Johnston et al.'s 2004 study of three bridge projects with pre-construction maternity colonies of pallid bats, none of the mitigation worked; after pallid bats were excluded, no pallid bats returned to the new or retrofitted bridges with replacement habitat. In this 2019 study, mitigation for lost habitat for pallid bats for 10 bridges and one culvert was provided through replacement habitat; however, post-construction surveys suggest only four of the bridges and the culvert now have pallid bat colonies. The pallid bat is a CDFW SSC, and both subspecies (*A. p. pacificus* and *A. p. pallidus*) appear to be declining in California and adjacent states (Johnston and Stokes 2007; Johnston 2017). In addition to the loss of day roosting habitat for maternity colonies, the loss of night roosting habitat could also pose a substantial threat to bat populations in certain situations as the result of bridge replacement and retrofitting activities. An example situation involving night roosts is discussed in Section 8 for Uvas Creek Bridge Project on SR 152 in Santa Clara County.

- **Yuma myotis** — This species occurs in colonies of up to 100 or more individuals on many bridges near water throughout the state. The Yuma myotis is often considered an obligate riparian species (Johnston et al. 2002) because it forages primarily on the surface, very near the surface of water bodies, or within the riparian habitat on aquatic emergent insects (Brigham et al. 1992). This species forages preferentially over still, open bodies of water, and thus may benefit from reservoirs and slow-moving water associated with bridge projects (Herd and Fenton 1983). At lower elevations this species frequently forms large colonies in culverts and bridges over water, which exposes them to disturbances from bridge or culvert maintenance, improvement, or replacement projects. Yuma myotis are increasing their populations because of water management projects and because bridges often span watercourses and provide maternity roosting habitat (Johnston 2012). Yuma myotis are considered at high risk because a large percentage of their population occurs in bridges and culverts, which makes them susceptible to habitat loss when bridges are retrofitted or replaced.

- **Mexican free-tailed bats** — This species is by far the most common and abundant species in transportation structures, especially in bridges and causeways over or adjacent to waterways. It is partly because of bridges that this species has been able to increase in numbers since the beginning of the European colonization of California (Johnston 2012). Because of their affinity to roost in anthropogenic structures, this species is also exposed to issues relating to bridge replacement projects, bridge retrofits, and poor water quality associated with urban areas. For example, when the Franklin Boulevard Causeway Bridge in Sacramento County was rebuilt, 40,000 bats had to be excluded from the structure (Johnston 2005). This colony represented a very high percentage of the regional population. The project involved installing seven bat condominiums that were intended to provide replacement maternity roosting habitat; however, there were only 2,000 bats total at the peak occupancy for all seven bat condominiums combined. Four years passed between the bats' exclusion and when they had access to the new bridge, suggesting that the majority of this large population was at risk in the interim. In addition to bridge projects, natural disasters such as flooding or fires can also put these large concentrated populations at risk when they roost in bridges.

Medium Risk:

- **Townsend's big-eared bats** — This species occasionally day roosts in bridges with partially-open abutments or open-ended box beams (Dave Johnston, and Kim Briones pers. obs., 2018; Pierson and Fellers 1998). Maternity colonies of this species have long been known to be extremely sensitive to increases in disturbance, and females have been documented abandoning their young when disturbed (Humphrey and Kunz 1976). Some research suggests that the species is reasonably tolerant of disturbance when no increase in the ambient levels of noise disturbance occur, but more studies are needed to better understand tolerance levels and the conditions of these disturbances and how they affect this species (CDFW 2016, Freeman 2012). The Townsend's big-eared bat is a CDFW SSC.

- **Big brown bats** — This species occasionally uses expansion joints for day roosts in bridges, and data from this study determined that big brown bat individuals will typically return to mitigation roost habitat or retained roost habitat following disturbance (See Section 8). Big brown bats are known to abandon roosts when construction activities include high frequency noises between 20 and 30 kHz (H. T. Harvey & Associates 2006).

- **Long-eared myotis (*Myotis evotis*), fringed myotis (*Myotis thysanodes*), California myotis (*Myotis californicus*), and long-legged myotis (*Myotis volans*), little brown myotis (*Myotis lucifugus*), Canyon bat (*Parastrellus hesperus*)** — These species night roost in small numbers in bridges that often include closure pours or concrete girders which trap warm air at night (typical night roosting habitat). However, they occasionally day roost on transportation structures and their populations can be adversely affected through retrofitting or replacement. Because they day roost only infrequently on these transportation structures, populations of these species are considered at a medium risk of impacts associated with bridge and culvert projects.

- **Western mastiff bat (*Eumops perotis*)** — This species occasionally roosts on bridges, although it is more commonly found roosting on cliff faces. Road building along cliff faces, as well as bridge construction or replacement, are considered a medium risk to this species because there are relatively few roosts in California.

Lowest Risk:

- **California leaf-nosed bats (*Macrotus californicus*)** — A small maternity colony of this cavernous roosting species was observed roosting on the California side of a bridge crossing the Colorado River in 2016 (Brown pers. comm. 2018). Because of the rarity of this species using bridges, risks to California leaf-nosed bats from implementation of bridge projects are considered minimal.

- **Western red bats (*Lasiurus blossevillii*)** — This species day roosts in the foliage of trees. Threats to this species from bridge and culvert projects are not well understood. However, bridges are frequently situated across riparian areas and likely migratory routes for this species. If these bridges are retrofitted or replaced, impacts on the trees adjacent to the bridge could affect individuals of this species.

- **Northern yellow bats (*Lasiurus xanthinus*)** — Because this species typically roosts in palms in the southernmost areas of the state, the likelihood of impacts on the species from implementation of bridge projects is anticipated to be relatively low. If implementation of a bridge project entails the removal of fan palms (*Washingtonia* spp.), which are potential roosting habitat, there is a potential for direct impacts to individuals of this species.

- **Silver-haired bats (*Lasionycteris noctivagans*)** — This species is expected to occur in many of the coniferous forests of California, and impacts from bridge-related projects are not well understood. However, bridges are frequently situated through wooded areas and sometimes across likely migratory routes for this species. Bridge projects may require trees adjacent to the bridge to be removed, which could affect individuals of this species.

- **Hoary bats (*Lasiurus cinereus*)** — Because the hoary bat migrates vast distances from parts of Mexico in the winter to more northern latitudes including Canadian forests in the summer, this species may occur in a wide variety of landscapes and habitats. Like other foliage-roosting species, any tree removal from the implementation of transportation projects could affect individuals of this species but this is considered a low risk to its populations.

- **Small-footed myotis (*Myotis ciliolabrum*)** — This species is expected to occasionally roost in bridges, but little is known about maternity colonies using bridges. Bridges are not expected to regularly provide maternity roosting habitat for this species. Thus, populations of these species are considered at a low risk of impacts associated with implementation of bridge projects.

- **Arizona myotis (*Myotis occultus*)** — This species rarely occurs in California and is only known from along the lower Colorado River. The last known maternity colony was documented in a timber bridge prior to the bridge's removal (Stager 1943). This species roosts occasionally in bridges over watercourses in Arizona, which is in the central portion of its range; however, it is expected to occur only rarely in California bridges because of its currently retracted range. Therefore, transportation projects present only a low risk to the species in California.

- **Cave myotis (*Myotis velifer*)** — This species occasionally day roosts in bridges in Arizona but has not been detected day or night roosting on bridges in California. Therefore, any potential risks to this species as a result of transportation projects in California would be considered minimal.

- **Mexican long-tongued bat (*Choeronycteris mexicana*) and lesser long-nosed bat (*Leptonycteris yerbabuenae*)** — These nectar feeding species are considered rare in California but they are occasionally observed feeding on hummingbird feeders, ornamental plantings of agave (*Agave* spp.), and the native Shaw's agave (*Agave shawii*). Both species are cave or grotto roosting bats but are not known to roost on bridges or culverts. Therefore any transportation projects would likely be considered to have minimal impacts to this species as long as agaves are not affected.

- **Spotted bat (*Euderma maculatum*)** — This species specializes on roosting on cliff faces or caves situated on cliff faces. They are not known to roost on bridges or culverts and the potential of impacts on this species from transportation projects is mostly limited to projects involving high rocky cliffs. Thus, populations of these species are considered at a low risk of impacts associated with bridge and culvert projects.

- **Big free-tailed bat (*Nyctinomops macrotis*) and pocketed free-tailed bat (*Nyctinomops femorosaccus*)** — These cliff roosting species occasionally night roost on bridges, but they have very limited ranges in California. Potential risk from transportation projects along cliffs or night roosting on bridges is considered minimal and would be considered a low risk to these populations.

Section 4. Legal Regulations and Their Implications for Projects

Although no bat species present in California is currently designated as threatened or endangered under the Federal Endangered Species Act (FESA) or the California Endangered Species Act (CESA), 12 species of bats are designated as SSC by CDFW. The USFS includes three bat species on its sensitive animal list for the Pacific Southwest Region, and the Western Bat Working Group also identifies several species as high priority for consideration of conservation measures (Section 3). The regulatory agency most directly involved with bat conservation in California is CDFW. The primary regulatory mechanism applicable to bats is CEQA, which requires an analysis of a project's effects on the environment, including biological resources such as bats.

There are no federally listed bats present in California at the time of preparation of this guidance document (USFWS 2019a, 2019b). The lesser long-nosed bat (*Leptonycteris yerbabuenae*), which was formerly federally listed as endangered, has been infrequently reported in southern California. This species did not become part of the California fauna until nectar-producing plants were established in landscaped areas, and it was delisted by USFWS in 2018. For states where federally listed bat species regularly occur, FESA provides legislated protection against loss (take) of any individuals, or the loss of any federally designated critical habitat as published in the Federal Register. If a project has the potential to result in adverse effects to listed species, project proponents initiate Section 7 or Section 10 consultation with the USFWS. The Section 7 consultation process is used for projects that are federal actions; Section 10 consultation applies to non-federal actions. FESA provides a mechanism to mitigate the loss, or potential loss, of listed species. Because many bat species' habitats overlap, protection for federally listed bat species may indirectly benefit other non-listed bat species.

No California bat species are listed as threatened or endangered, or candidates for listing, under CESA at the time of preparation of this guidance document (CDFW 2019b). The Townsend's big-eared bat was a candidate for listing under CESA from November 9, 2012, through August 25, 2016. After a review of the best scientific information available, CDFW recommended to the California Fish and Game Commission that listing of the species was not warranted. The commission, in response to CDFW staff recommendation and after considering public comment, voted not to list the species. CDFW ultimately recommends that all Townsend's big-eared bat maternity and hibernation roosts be considered habitat essential for the continued existence of the species. This recommendation was formulated as part of its status review for the Townsend's big-eared bat and is based on the susceptibility of roost structures to disturbance, degradation, and loss.

Colonial roosting species, like many bats, also receive attention during the environmental review for CEQA compliance because of the potential for individual projects to have population-level impacts to a species, even relatively common or widespread species. The following sections provide the regulatory setting for assessing potential impacts on bats through CEQA and discusses their potential implications for Caltrans projects.

4.1 California Environmental Quality Act

CEQA serves as the regulatory framework through which California public agencies assess, disclose, and mitigate significant environmental impacts from proposed projects requiring public agency approval. Because CEQA compliance is the principal regulatory mechanism to protect bat populations in California, the primary objective of protecting bats on bridges and culverts is to avoid impacts through implementation of avoidance, minimization, and mitigation measures.

Impacts on biological resources are typically considered significant if they would substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, or substantially reduce the number or restrict the range of an endangered, rare or threatened species (Public Resources Code [PRC], Section 21083; CEQA Guidelines in Title 14, California Code of Regulations [CCR], Sections 15065[a][1] and 15206[b][5]). The CEQA Guidelines identify rare, threatened, and endangered species as plants or animals already listed by a governmental agency as being rare or endangered or that meet the definitions provided in the CEQA Guidelines (Title 14, CCR, Section 15380). For example, CDFW designates rare species, such as the pallid bat and Townsend's big-eared bat, as SSC.

Caltrans, as the lead agency under CEQA, coordinates with CDFW, as a responsible agency under CEQA, to determine if the effects of a proposed transportation project meets the criteria to be considered significant under CEQA. If a project has the potential to result in significant impacts on rare, threatened, or endangered species, the lead agency is required to prepare an Initial Study/Negative Declaration (IS/ND), Initial Study/Mitigated Negative Declaration (IS/MND), or an Environmental Impact Report (EIR) to fully analyze those impacts. The Caltrans Project Development Team (PDT) determines the type of CEQA document that will be prepared by evaluating all potential environmental impacts, including those on non-biological resources, and assessing whether mitigation is required to reduce the impacts to less-than-significant levels. The biological resources section of the CEQA document is typically developed using a project's Natural Environment Study (NES) or NES Minimal Impact (NES-MI). The NES presents the status of the regulatory agency consultation process and describes the avoidance and minimization measures for biological resources. For example, the standard project avoidance and minimization measures implemented when bat roosting habitat may be affected can vary from seasonal work restrictions, such as avoiding work during the maternity season, to the use of temporary exclusionary devices prior to and during the construction phase. If project impacts on bats are identified as potentially significant even with the implementation of avoidance and minimization measures, Caltrans may develop appropriate mitigation measures to reduce the level of the impacts. Mitigation measures are typically based on habitat criteria as it is challenging to guarantee species' responses. Unfortunately, implementing mitigation measures for wildlife does not ensure that they will be successful for the targeted wildlife. Even experienced bat biologists cannot guarantee when prescribed mitigation measures will work as intended. Therefore, it is important to clearly identify qualitative and quantitative goals and objectives in a mitigation and monitoring plan and provide an adaptive management clause.

As a CEQA responsible agency, CDFW may require additional mitigation measures for bats prior to issuing approvals such as a Lake and Streambed Alteration Agreement (LSAA), which is discussed below, or incidental take permit for the project. Caltrans will incorporate the complete set of mitigation measures into the mitigation and monitoring plan that will be implemented during project activities; these measures will also be included in the project specifications and layouts. Mitigation monitoring is intended to improve the success of mitigation, inform adaptive management to meet success criteria, and improve the development of future mitigation measures over time.

The Caltrans PDT determines if any of the project effects meet the criteria to be considered significant under CEQA and determines the type of environmental document to prepare for each project. If a project has the potential to result in significant effects on rare, threatened, or endangered species, the lead agency is required to prepare an Initial Study/ Negative Declaration (IS/ND) or if there is an actual impact resulting in mitigation an Initial Study/ Mitigated Negative Declaration (IS/MND) or an Environmental Impact Report (EIR) to fully analyze those impacts. The ultimate determination regarding the type of CEQA documentation is based on an evaluation of all potential project impacts, including impacts to non-biological resources. Because CEQA compliance is the principal regulatory mechanism to protect bat populations in California, the primary objective of protecting bats on bridges and other transportation infrastructure is to avoid significant environmental effects under CEQA. Through efforts to avoid, minimize, and mitigate for negative effects to bats from activities on the SHS, we can help avoid significant environmental effects under CEQA.

During project planning, Caltrans evaluates the potential for species and their habitats to occur within the proposed project area and subsequently assesses whether project activities would result in effects on species and/or their habitats. This evaluation may be described in the preparation of a NES or NES-MI.

For bridge projects that have the potential to affect bats, Caltrans coordinates a site visit by a qualified biologist to assess the potential habitat. Based on the findings of the site visit, additional surveys for bats may be needed to identify which species are present. If implementing the bridge project would result in adverse effects on bat species, an impact analysis would be developed, typically in a NES to support the project's environmental compliance. If mitigation is required for significant impacts to bats, Caltrans would then develop and implement a bat mitigation plan.

CEQA requires monitoring to assess the success of mitigation measures. These measures are typically based on habitat criteria as it is challenging to guarantee species' responses. Mitigation monitoring is an essential part of the CEQA process and is intended to improve the success of mitigation, inform adaptive management to meet success criteria, and improve the development of future mitigation measures over time. Unfortunately, implementing mitigation measures for wildlife does not ensure that they will be successful for the targeted wildlife. Even experienced bat biologists cannot guarantee when prescribed mitigation measures will work as intended. This makes it very important to clearly identify qualitative and quantitative goals and objectives in the mitigation plan or strategy and provide an adaptive management clause. Caltrans must ensure that all standard or mitigation measures identified in the NES and the permits are incorporated into the project specifications and layouts.

4.2 California Fish and Game Code Section 1600 Lake and Streambed Alteration Agreements

CDFW issues Lake and Streambed Alteration Agreements (LSAAs) under Section 1600 of the California Fish and Game Code. An LSAA is required if project work would interfere with the natural flow of, or substantially alter, the bed, bank, or channel of a watercourse, including disturbance or removal of riparian vegetation. This permitting process can provide CDFW with a means of further reducing impacts on bats beyond the mitigation measures in the project's environmental document. CDFW can include conditions in LSAAs to reduce project impacts on wildlife, including bats and birds. CDFW can require project applicants to mitigate for impacts on bats and bat habitat when issuing LSAAs. As part of the LSAA process, CDFW "shall determine whether the activity may substantially adversely affect an existing fish and wildlife resource" once an LSAA notification is complete (CFGC 1603).

4.3 Caltrans Guidance

In addition to compliance with federal and state regulations, Caltrans strives to provide guidance to its staff to inform transportation project planning. Caltrans' goal is to maintain and operate structures for the purposes of transportation without adversely affecting bat populations, while also balancing the needs of bats and environmental compliance of project construction with the safety of transportation workers. Caltrans will continue to explore options for accommodating bats on transportation structures, as this approach is often the most effective to reduce project impacts on bats to less-than-significant levels under CEQA. Innovative design and construction methods should be evaluated and used as practicable. Innovative and effective mitigation strategies are a priority, including off-site efforts.

Caltrans strives to avoid taking, disturbing, or harassing bats and interfering with bats' natural behaviors during project activities by implementing impact avoidance and minimization measures. For project impacts that cannot be avoided or minimized, Caltrans incorporates habitat enhancement and mitigation features for bats into the project design to reduce the levels of impacts. Caltrans supports including time during the project planning stage to plan bat surveys and develop mitigation measures. Additionally, Caltrans encourages staff biologists to receive training on bat biology, survey protocols, and development of appropriate mitigation measures.

For bridge projects that have the potential to affect bats, Caltrans coordinates a site visit by a qualified biologist to assess the potential habitat. Based on the findings of the site visit, additional surveys for bats may be needed to identify which species are present. If implementing the bridge project would result in adverse effects on bat species, an impact analysis would be developed, typically in a NES to support the project's environmental compliance. If mitigation is required for significant impacts to bats, Caltrans would then develop and implement a bat mitigation plan.

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Section 5. Assessing Potential Bat Habitat

In 2003 Caltrans published the *Bats and Bridges Technical Bulletin: A Hitchhikers Guide to Bat Roosts* (Hitchhiker's Guide) (Erickson et al. 2003). This document provides guidance for anyone involved in the design, construction, or maintenance of bridge structures and is a useful resource for Caltrans biologists. Included in the Hitchhiker's Guide is a protocol for evaluating potential habitat on bridges and other transportation facilities and assessing potential project impacts on bats.

Considerable time has passed since the Hitchhiker's Guide was published, and new research and technologies have increased knowledge and understanding of bat ecology, use of transportation structures, and effectiveness of mitigation designs. Thus an update to the Erickson et al. (2003) protocol was deemed necessary and is included in this guidance document. This update followed the same levels of impact analysis from a preliminary desk study to the field assessment of potential impacts. However, this update also includes guidance on mitigation planning and qualifications for project biologists responsible for carrying out these analyses. The following sections describe the steps for evaluating bat use of transportation structures and for Caltrans biologists or environmental consultants to perform each level of analysis.

5.1 Caltrans Protocols for Bat Surveys

5.1.1 Level 1: Preliminary Desktop Review

The preliminary desk study begins with a review of databases (e.g., CNDDB), aerial imagery (e.g., Google Earth), and other background materials such as the California Log of Bridges on State Highways, as-built reports, bridge inspection reports, habitat conservation plans, or other publicly available regional planning documents to provide context for potential habitat and bat activity in the project region. This review should also include examining maps of bat species' ranges and descriptions of species' habitat use (see Section 3). Preliminary desktop review should be initiated as early as possible to allow sufficient time to conduct seasonal surveys, design replacement habitat, and allow time for bat colonies to occupy replacement habitat. A minimum of 2 years would be an ideal amount of time to initiate the desktop review, but for projects with an expedited schedule, biologists can perform all preliminary desktop and seasonal surveys in the field within 1 year.

Existing conditions surrounding the transportation project site may contribute to its suitability to support bats. For example, nearby riparian habitat, aquatic features, cliffs or rocky outcrops, caves or mines, woodlands with snags, and agriculture increase the potential for bats to be present in bridges and adjacent habitats.

Transportation structures that have the potential to support bats based on their features include the following:

- Concrete box girder bridges (Photo 5-1)
- Arch-style bridges (Photo 5-2)
- Timber or wood bridges (Photo 5-3)
- Steel multi-beam/girder bridges (Photo 5-4)
- Concrete T-beam (Photo 5-5)
- Bridges that combine materials (e.g., junctions between wood and concrete, or steel and concrete) (Photos 5-3 and 5-4)
- Concrete box culverts or tunnels, corrugated metal culverts at least 5 feet tall (Photos 5-6 and 5-7)
- Other old bridges of various designs

Photo 5-1. Concrete box girder bridge. W54-S5 Connector OH, SR-54, San Diego County.

Photo 5-2. Arch-style bridge. Kaweah River Bridge, SR-46, Tulare County.

Photo 5-3. Timber or wood bridge. Santa Fe Railroad Bridge, National Trails Highway, Riverside County.

Photo 5-4. Steel multi-beam bridge. I-5 Interchange Bridge, SR-43, Kern County.

Photo 5-5. Concrete T-beam bridge. Salt Creek Bridge, SR-46, Tulare County.

Photo 5-6. Concrete box culvert. Santa Ana River Culvert, SR-91, Orange County.

Photo 5-7. Corrugated metal culverts. Santa Fe Railroad Culverts, near National Trails Highway, Riverside County.

Bridge or other transportation facility structural features where bats may roost include the following:

- Expansion Joints (Photo 5-8)
- Hinges (Photo 5-9)
- Open/semi-open abutments (Photo 5-10)
- Closure pours (Photo 5-11)
- Crevices (Photos 5-12 and 5-13)
- Weep holes (Photo 5-14)
- Spaces between concrete girders and diaphragms (Photos 5-9 and 5-15)
- Hollow interior of concrete box girder bridge (Photo 5-16)

Transportation structures that have a low potential to support bats based on their features include bridges made of slab concrete, continuous slab, and box girders with no interior access. Transportation structures associated with engineered concrete-lined channels or structures in urban environments also have a low potential to support roosting bats, but may be viable if suitable habitat is present in the site vicinity. Bridges situated over busy highways, such as the West Prado Overhead Bridge on SR 91 in Riverside County, in urban areas with suitable surrounding habitat should also not be discounted, as bat colonies have been detected in this situation. Furthermore, day roosting bats may also be found in abandoned swallow nests (Keeley and Tuttle 1999). Regardless of the findings of the preliminary desk study, no structure should be discounted as having potential to support bats until the preliminary field assessment has been conducted.

Photo 5-8. Expansion joints and open space between the girders and diaphragms. Sespe Creek Overflow, SR-126, Ventura County.

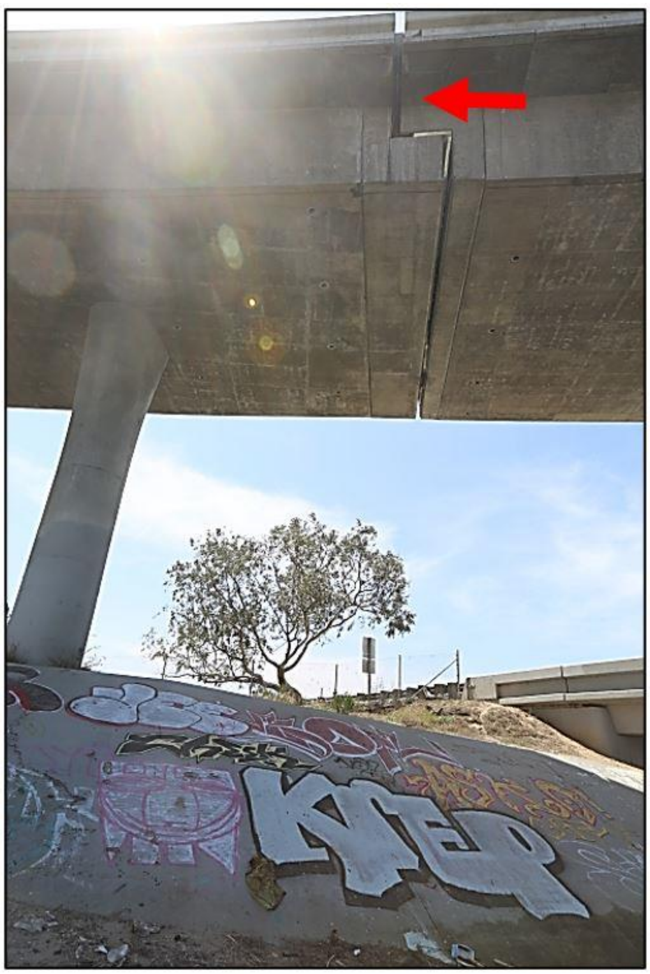

Photo 5-9. Hinge joint. W54-S5 Connector OH, SR-54, San Diego County.

Photo 5-10. Semi-open abutment. Sweetwater River, SR-79, San Diego County.

Photo 5-11. Closure pour. St. John's River, SR-216, Tulare County.

Photo 5-12. Crevice in a concrete culvert. Santa Ana River Culvert, SR-91, Orange County.

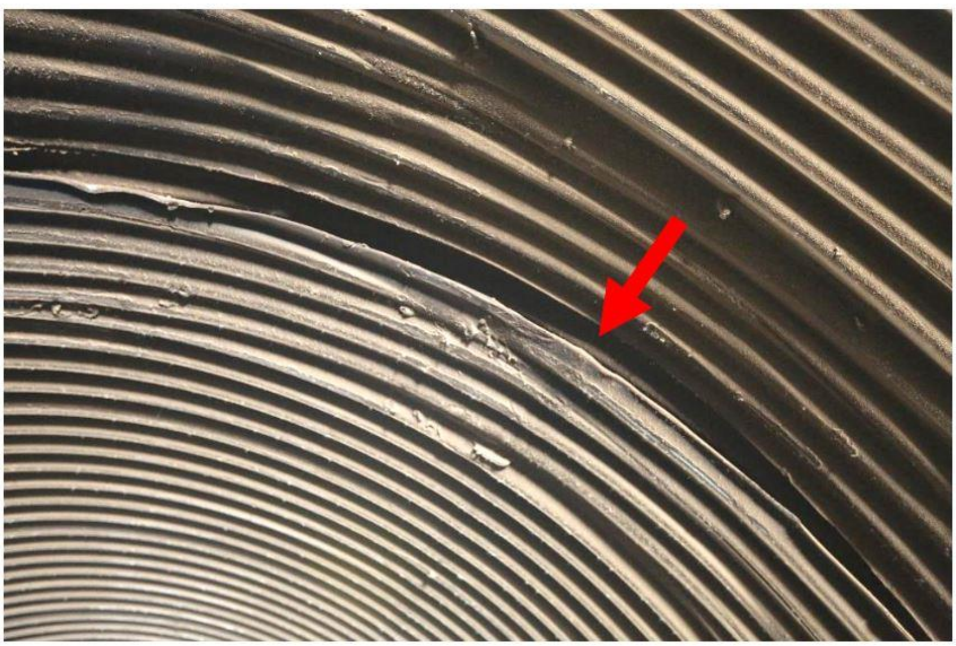

Photo 5-13. Crevice between two overlapping culvert pipes. Santa Fe Railroad Culverts, near National Trails Highway, Riverside County.

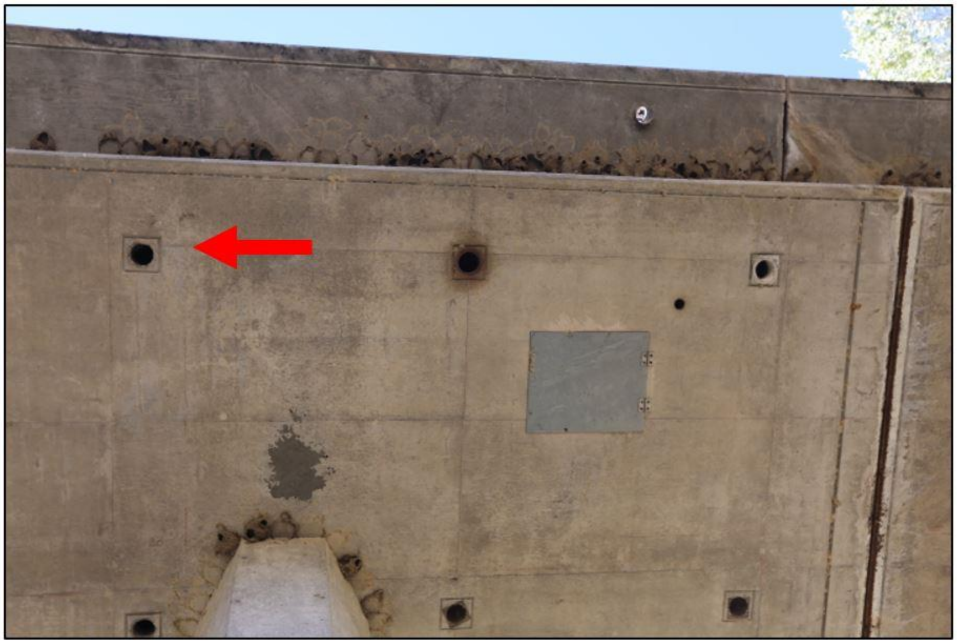

Photo 5-14. Weep holes in the soffit of a box beam bridge. John R. Trainor Memorial Bridge, SR-36, Tehama County.

Photo 5-15. Spaces between concrete girders and diaphragms. Foss Creek Bridge, Kinley Road, Sonoma County.

Photo 5-16. Hollow interior of a concrete box girder bridge. San Benito River Bridge, Nash Road, San Benito County.

Table 5-1. Summary of Field Surveys

Type of Surveys	Caltrans Project Phases*	Notes on Survey and Schedule
Level 1	Phases K and 0	
Level 2	Phases K and 0	Surveys can be conducted during any time of the year; 1–3 field surveys are required to determine types of natural communities and roosting habitat.
Level 3	Phases K, 0, 1, and 3	Focused surveys must be conducted during the maternity season. Surveys may be conducted during Phase 1 and 3 if the project schedule is expedited, but surveys should be completed at least 2 years prior to the Ready to List date.

*Phase K = Project initiation; Phase 0 = Project Approval and Environmental Document; Phase 1 = Asset Management Plan; Phase 3 = Construction Support.

5.1.2 Level 2: Preliminary Field Assessment

The preliminary field assessment should include a daytime survey to determine whether suitable habitat and/or signs of bat use are present in the biological study area of the project. Special care should be taken to ensure bats are only minimally disturbed during field assessments, especially during the maternity and hibernation seasons. As noted in Section 6.3.5, maternity colonies are known to have been disturbed to the point they abandoned their roost because of too much human disturbance by biologists and planners whose responsibility was to minimize project related disturbance. Additionally, Section 3.7 describes various human disturbances to bat colonies, including visiting colonies in hibernation, that ultimately can result in reduced energy reserves and survival rates of hibernating bats.

Suitable habitat and/or signs of bat use to look for during the daytime preliminary field assessment include guano, urine staining, and culled insect parts on or underneath the bridge. Appendix A contains representative images of these signs and observations of bats on bridge structures. Bats that are difficult to see may also be detected by audible social calls and through the use of a bat detector, which converts ultrasonic echolocation emissions into frequencies audible to humans in real-time. The preliminary field assessment can be performed during any time of the year, provided that weather conditions or local flooding do not affect the qualified biologist's ability to do a thorough evaluation. Recent rains or flooding may remove some evidence of bats under bridges. Some bridges may need only maternity season surveys, but bridges along the coast should have winter surveys and bridges in the Central Valley should include migratory spring and fall surveys in addition to maternity season surveys (see Level 3, Focused Surveys below).

The methods used and data collected during the preliminary assessment should include the following:

- Survey under the entire bridge, as feasible.
- Identify the type of habitat present (e.g., day and night roosting habitat).
- Describe the features that provide the roosting habitat (e.g., expansion joints, hinges, closure pours).
- Describe signs of bat use with respect to each habitat feature, if present.
- Include a sketch of the structure showing the locations of suitable habitat features and bat activity in each feature, based on sign or visual detection. A sketch will help in describing the habitat feature and planning for future surveys.
- The preferred method of documenting conditions in the survey area, including evidence of bats, is using a digital camera capable of capturing high-resolution images that provide scale. Take adequate photos to capture the bridge size, structural type, and all features that are relevant to bat use. At a minimum, the photographs should document the bridge signage (with identification number, post mile, and bridge name [if applicable]); a right-angle (i.e., side perspective) view showing the entire span; the abutments and any details associated with

potential roosting habitat; representative images of the soffit, expansion joints, hinges, and closure pours; how the piers support the deck; representative weep holes documenting the presence or absence of screens; and images of various bat sign such as urine staining and guano on the structure.

- Because several species may occupy a bridge, ensure that each type of guano sign is photographed. Pallid bats typically leave culled parts of arthropods such as scorpion (*Paruroctonus silvestrii*) tails and Jerusalem cricket (*Stenopelmata fuscus*) legs and heads. If bats occupy the bridge, the survey time under active roosts needs to be limited. Any use of flash photography to document roosting bats will create some level of disturbance. Many digital cameras can take images at very low light; if a flash is required, use a minimum setting such as 1/8 power or less.
- Estimate dimensions (i.e., length, width, depth) of each roost habitat type. Dimensions should be taken into consideration when designing mitigation habitat.
- Describe surrounding environmental conditions, including the dominant habitat type present, aquatic features, and other potential roost habitat (e.g., tree snags or large sycamores with cavities) on site and within the vicinity of the site. Survey the entire project site plus a 100-foot-wide buffer for potential roosting habitat.
- Describe potential alternate habitat opportunities on- and off-site.

If no habitat or sign of bats is observed, no further surveys are warranted. The project biologist should carefully document the reasons for determining that no bat habitat is present on or adjacent to a project site, and why further surveys are not merited. If habitat is present, but no sign of bats are observed, additional surveys may be necessary to support the conclusion that bats are not present, as small colonies and individuals may often not produce obvious signs of occupancy. The project biologist will determine whether additional, appropriately-timed surveys are recommended on the basis of the survey findings. If additional surveys are warranted, see Level 3 Focused Surveys below.

5.1.3 Level 3. Focused Surveys

If suitable habitat and signs of bat use are observed during the preliminary field assessment, focused surveys should be performed by a qualified biologist to determine the approximate size of the colony(s) and the species present. As noted above, caution should be taken when conducting field surveys at active roosts. While many transportation structure roosts are exposed to ongoing disturbance or noise, novel disturbance created by surveyors could result in roost abandonment during the maternity season or could be metabolically costly to bats during extended periods of torpor or hibernation (see Sections 3.7, 6.3.5, and 7.3). To ensure that disturbance is kept to a minimum, the project biologist and any field assistants should not loiter directly underneath known or suspected occupied roosts longer than is necessary to record data. Survey activities that could disturb roosting bats include loitering and or talking underneath occupied roosts, spotlighting colonies, or photographing bats in the roost. Some level of disturbance is necessary to collect evidence of bat use, but surveyors should be cognizant of the potential effects of their presence and keep their activities to a minimum.

Additionally, CDFW may require review and approval of biologists' qualifications for performing Level 3 surveys. Coordination with CDFW prior to Level 3 surveys is strongly recommended. Surveys should be performed in the summer, fall, spring, and winter to determine how the site is used by bats. As described above, novel disturbance created by surveyors could have adverse effects on roosting bats. Thus, surveys should be completed with caution and only until enough information is gathered to inform avoidance, minimization, and mitigation measures. Information collected during focused surveys should include an estimate of the number of bats and species present during the summer, fall or spring, and winter to provide an assessment of spatial and temporal use. Multiple visits during a given season may be necessary to fully describe use of the site, given variation in roost use during a season (roost-switching) and between years (interannual variation in the timing of arrival and departure). The following sections provide guidance for focused surveys to be conducted during maternity season, migratory periods, and the winter hibernation period.

- Maternity Season Surveys. In California, the maternity season generally occurs from March 1 to August 31, with maternity colonies forming earlier in the season in southern California and later in season in northern California (See Section 3). The maternity season varies from one species to another with as much as 6 weeks between the parturition times between the earlier Yuma myotis and the later Mexican free-tailed bat, even at the same bridge site (Carpenter pers. comm. 2019a). Elevation and regional climates can also affect this timing. Depending on the project region, the weather for a given year, and the species of bat, the peak of the maternity season, when maternity colonies have formed and flightless young are present, is generally between April and July. However, because weather is less predictable now, likely because of global climate change, bats can respond to strange weather patterns. For example, a colony of Yuma myotis near the Colorado River produced young in January that were flying by February (Brown pers. comm. 2018). Section 3 provides additional discussion about the timing of maternity colonies. In order to more accurately determine the maternity season for a given species, region, and year, a local bat specialist can be consulted. The following guidance is provided for maternity season surveys.

1. Conduct a daytime inspection to determine if bats are present and to identify areas of high use. Large numbers of bats in the late spring and summer months typically indicate that a maternity colony is present. Daytime inspections can be conducted during any time of day as long as weather conditions do not affect the project biologist's ability to do a thorough field assessment. While daytime inspections are usually sufficient to determine the presence of night-roosting habitat, nighttime roost inspections (2–3 hours after sunset) are recommended if special-status species are suspected to occur. The presence of large guano pellets or sizeable culled insect parts may indicate the presence of the pallid bat or Townsend's big-eared bat.

2. Conduct a follow-up dusk emergence count survey. Dusk emergence count surveys should be conducted on a warm night when nighttime lows are not less than 45°F and during dry weather conditions. Surveys should be conducted from approximately 15 minutes before sunset to 1 hour after sunset. Prior to any dusk emergence count, the lead biologist should understand the primary locations where bats are day roosting so these locations can be targeted during the emergence count. Depending on the locations and number of roost exit points, multiple surveyors may be needed. Surveyors should each be assigned a specific area that does not overlap with other surveyors' locations. Surveyors should station themselves such that roost exit points are backlit with the sky. High-quality (e.g., Generation 3+) night vision goggles can greatly increase the accuracy of some exit counts and, in many cases, aid in the identification of species as bats emerge. During tests of the precision for different methods of counting emerging bats, 20–25% more bats were counted using a Generation 3+ pair of night vision goggles compared to unaided vision (Dave Johnston, unpublished data).

3. Ideally, one maternity season survey should be conducted in the spring (April–May) and one in the late summer (July–mid-August) to obtain a pre- and post-volant count[2]. Conducting surveys according to this schedule will verify the presence of a maternity colony and provide a good estimate of the colony size once young are volant. If two surveys are not feasible, preference should be given to conducting a late summer survey.

[2] Timing may be vary by regional climate. Contact a bat specialist to ensure optimal timing for the survey.

4. Bat detectors that produce an audible sound are helpful in identifying and counting bats as they emerge from the roost. Conduct active acoustic monitoring concurrent with exit count surveys to determine species or frequency group[3] of bats (see Section 7.3 for recommended acoustic training requirements).

- Fall and Spring Migratory Period Surveys. In some cases, particularly in the Central Valley, peak roost occupancy can occur during migratory periods of about 6 weeks in the spring and several weeks in the fall (Johnston 1998). Therefore, at least one daytime site inspection and one dusk emergence count should be conducted between March and April, and between early September and mid-October, to assess if bats are present and to count individuals.

- Winter Surveys. At least one daytime site inspection should be conducted in January or February to determine if winter hibernacula or overwintering habitat for bats are present. Crevice-roosting species typically roost deep in crevices in the winter, and they may not be visible during winter inspections. Likewise, some individuals may only arouse during warm, dry periods, making winter dusk emergence count surveys unreliable. Therefore, visual surveys, in combination with the use of an extendable borescope to view inside crevices may be required for some bridges or culverts.

Additional field survey strategies are presented below for assessing tree habitat that can also be applied to bridges in Level 3 focused surveys.

Recommended Equipment for Level 2 and Level 3 Surveys (Photos 5-17 and 5-18).

1. A high-powered flashlight to examine roost habitat and count bats.
2. Binoculars with 7× to 10× magnification
3. A digital camera capable of taking pictures in very low light (e.g., standard camera without a flash or a forward-looking infrared camera [FLIR]).
4. Temperature data loggers to monitor internal temperatures inside habitat features and in some situations, light data loggers to assess existing light conditions outside habitat features.
5. An extending pole and an expandable device to insert temperature data loggers inside habitat features. The device needs to be compressible with the data logger either attached or inside in order to fit through a crevice, and able to expand within the roost

[3] Some species of bats are difficult to distinguish acoustically because they have similar call characteristics in some conditions. Thus, some calls may only be identified to frequency level (e.g., 30 kHz), rather than to species level.

to place the data logger at the desired position for collecting temperature information. The device must be able to be easily removed.

6. Tally counters, headlamp, night vision goggles, and a bat detector[4] for dusk emergence surveys. Bat detectors that produce audible sound (active detector) should be used while conducting evening exit count surveys. Active detectors help the surveyor hear/detect bats while observing them exiting a roost. Direct recording detectors (passive detector) can be programmed for long-term use and should be used for overnight or longer-term acoustic monitoring. Direct recording detectors do not produce audible sound while recording, but can record and store a large volume of high frequency calls, and digitize the calls for later analysis. For the best quality of call recordings, detector microphones should be placed at least 10 feet above the ground and away from vegetation (Photo 5-19).

7. Latex or nitrile gloves.

8. Plastic bags or vials to collect guano or insect part samples.

[4] Biologists should receive comprehensive training on the use of bat detectors and bat call data analysis. See Section 7.3 for bat acoustic training requirements.

Photo 5-17. General bat survey equipment for daytime inspections includes: (A) binoculars, (B) camera, (C) latex/nitrile gloves and plastic bag for samples, (D) tally counter, (E) temperature data loggers, and (F) high-powered flashlight.

Photo 5-18. General bat survey equipment for evening exit surveys includes: (A) passive bat detector, (B) heterodyne detector that produces audible sound, (C) night-vision goggles, (D) tally counter, and E) head lamp.

Photo 5-19. Passive acoustic detector set-up.

5.1.4 Assessing Tree Habitat within Transportation Project Sites

Transportation projects frequently involve removing trees or working near them, so effects on bat species that roost in trees (see Table 3-2) must also be considered in impact analyses. Surveys and possible exclusion approaches for foliage roosting bats should be planned well in advance to ensure that any potential impacts on bats in trees will be addressed in the project. The following stepwise approach is recommended to assess tree habitat for roosting bats in and near transportation project sites.

1. **Assess tree habitat.** Identify trees that support potential roosting habitat, such as those with cavities or sloughing bark, of sufficient height and size. Examine them for signs of active bat roosts such as the presence of guano and urine staining.
2. **Determine buffer zones commensurate with disturbance to potential roosts.** If trees with potential bat roosting habitat are present within or near the project site, acoustic surveys and possibly roost emergence counts are recommended.
3. **Survey each tree.** All trees within the buffer zones should be examined and categorized on the basis of their suitability as day or maternity roosting habitat. For example, biologists can use a habitat scoring system of 0–3 for each tree, with zero indicating the absence of suitable habitat and 3 representing trees with highly suitable habitat or the presence of bat sign. Such a scoring system is highly dependent on the bat species identified as having the potential to occur in the project site, the vegetation community, and the project region.
4. **Conduct acoustic surveys.** The length and extent of acoustic surveying depends on the time of year, spatial scale of the project, and target bat species (if any). Acoustic monitoring in the winter should encompass at least 10 days, but this period could be shortened to as few as 3 days during the summer.
5. **Analyze acoustic survey data.** Determine if the acoustic data suggests a patterns of bats leaving at the expected emergence time and returning at dawn. The timing of calls can generally help determine the distance between the acoustic detector and the roost. When analyzing acoustic data, examine the number of acoustic call files recorded per 10-minute intervals during the first hour and 15 minutes after sunset. Sites with five or more call files per 10-minute interval suggest that the monitored tree supports a bat roost. Fewer than five call files per 10-minute interval suggests that a bat was foraging or moving through the area rather than emerging from a nearby roost tree. If there are five or more calls per 10-minute intervals, there is likely an active bat roost at that tree, or from a nearby tree or roost. Bats could potentially be emerging from another tree but only passing by the bat

detector, giving a false positive. In order to confirm a roost in a monitored tree, a visual emergence count must be conducted as described below.

6. **Visually survey the tree at emergence time.** Visual surveys should be conducted at the time of emergence with high-quality night vision goggles (Generation 3+) and bat detectors. Several surveyors at multiple vantage points may be needed to ensure adequate visual coverage, especially around large trees. For a thorough count, the visual survey should start at sunset and continue for an hour and 15 minutes because roosting bats do not emerge all at once. They typically exit roosts sporadically, are very quick, and are easy to miss. If acoustic data and the presence of bat signs are too ambiguous to determine the species, particularly for species of special concern, guano samples can also be collected for genetic analysis. Walker et al. (2016) and Northern Arizona University's Bat Ecology and Genetics Lab[5] are resources for sample collection methods.

5.2 Biologist Qualifications to Perform Bat Surveys and Conduct Project Impact Assessments, Levels 1 and 2

The following guidance represents the preferred biologist qualifications for individuals tasked with leading Level 1 and Level 2 assessments of bats and their habitat:

Education:

Bachelor's degree in biology (natural sciences), ecology, zoology, or related degree or educational equivalent as demonstrated through adequate field experience and training.

Training:

One multi-day bat ecology and survey techniques workshop. The workshop should cover, but not be limited to, basic roosting and foraging ecology, reproduction, physiology (e.g., torpor, hibernation, and energetics), life histories of California bat species, echolocation, threats, survey methods in natural and anthropogenic habitats, and visual observation of live bats in their habitat.

Experience:

At least 1 year of experience conducting general biological surveys and preparing technical reports including but not limited to general biological assessments, wildlife inventories, special-status

[5] https://in.nau.edu/bat-ecology-genetics/ https://in.nau.edu/bat-ecology-genetics/

species surveys, and analyses, under the supervision of biologists qualified to conduct Level 3 bat habitat impact analyses.

If the biologist working on a project does not have the minimum experience, he/she should work with or seek guidance from a more experienced Caltrans biologist or other specialist (environmental consultant) who has the necessary level of training, as described above.

5.3 Biologist Qualifications to Perform Level 3 Focused Surveys

This section presents guidance on the preferred biologist qualifications for individuals tasked with leading Level 3 assessments of bats and their habitat. CDFW may require review and approval of biologists' qualifications for performing Level 3 surveys. Coordination with CDFW prior to Level 3 surveys is strongly recommended.

Education:

Bachelor's degree in biology (natural sciences), ecology, zoology, or related degree; and

Master of Science in biology (natural sciences), ecology, zoology, or related degree or educational equivalent as demonstrated through adequate field experience and training.

Training:

One multi-day bat ecology and survey techniques workshop. Workshops should cover, but not be limited to, basic roosting and foraging ecology, reproduction, physiology, life histories of California bat species, echolocation, threats, survey methods in natural and anthropogenic habitats, types of artificial bat habitat, designs of artificial bat habitat that work on bridges, designs of artificial habitat that work off-site, and visual observation of bats in their habitat.

One comprehensive acoustic analysis workshop. The workshop should include, but not be limited to, training in the functions of echolocation and ultrasound, programming and deploying bat detectors, identifying different species' calls, recognizing the limitations of acoustic surveys and the use of autoclassifiers, and summarizing datasets.

Experience:

In addition to the experience recommendations for Levels 1 and 2 assessments, the biologist should possess a minimum of 1 year of training with an experienced bat biologist who holds a CDFW Scientific Collecting Permit to conduct research on bats in California and 3 years of experience working on bridges with bats. Experience should include general bat roost habitat assessments at 10 bridge sites, dusk emergence counts at five bridge sites, acoustic surveys at five bridge sites, and at least three projects where type selection of artificial bat habitat for mitigation was required.

If the project biologist does not have the preferred minimum experience, then he/she should seek guidance from an experienced Caltrans biologist or bat specialist with a minimum of 5 years of experience working on bridges with bats.

Section 6. Determining the Potential Impacts

6.1 Introduction

To adequately assess potential impacts and develop appropriate bat mitigation measures for bridge and culvert projects, a detailed project description and set of design plans, description of construction methods, construction schedule, and known and potential habitat and roost locations need to be incorporated into the impact analyses for the potentially affected bat species. Because it is often difficult to assess the level of importance of roosts to bat populations, and natural roosts are becoming scarcer with expanding human development, every effort should be made to avoid the temporary or permanent loss of a roost.

Surveys by a qualified biologist for the applicable bat species are needed. Surveys conducted for a minimum of one site visit and a few nights of acoustic data collection during each of the four seasons are often required to provide detailed information on specific bat populations and their use of the project site for different life-history needs. Natural history parameters and ecological requirements vary considerably among species, making it critically important that individual species occurring at a project site be correctly identified, and that species' assemblages be adequately characterized. Additionally, scale is important when assessing the effects of a project on bats; impacts need to be considered at the site-specific, regional, and cumulative levels. Impacts are usually considered temporary when it is less than a year before ambient or baseline conditions are restored following project completion. Impacts are generally characterized as permanent when their duration is more than a year after project completion.

Some environmental documents pursuant to CEQA have identified the loss of bat roosts as a less-than-significant impact when the original roost is lost but a new roost will be built as mitigation. Although replacement roosts may mitigate the loss of the original roost, such mitigation should only be considered effective if the new roosts are used by the same species in numbers that are comparable to the original roost. Projects that are anticipated to temporarily exclude bats from a roost for a single maternity season, but result in an extended absence of bats from the roost, should be considered to have had a permanent impact on maternity roosting habitat. Constructing a replacement roost that never becomes occupied by bats or does not provide the intended habitat function (e.g., maternity roost) is not adequate mitigation. Similarly, constructing a replacement roost that is later destroyed, or installing a replacement roost and allowing it to disintegrate, is also inadequate mitigation.

6.2 Temporary Impacts

Temporary impacts from bridge and culvert projects include disturbance, short-term loss of a maternity day roost, or short-term loss of a night roost. Impacts are usually considered temporary when it is less than a year before ambient or baseline conditions are restored following project completion. Disturbance can include increased noise, vibration, and light exposure; degraded air quality; or reconfigured large objects (e.g., bridge components) compared to ambient or existing conditions. These impacts can adversely affect bats by disturbing their behavior, growth, reproduction, or survival. Human disturbance, even from qualified biologists repeatedly entering a cavernous area to survey for bats, can also lead to changes in the humidity and temperature regime within a roost, or alter the approach to a roost that causes the bats to change their modes of egress and ingress. Although temporary, such disturbance can lead to the abandonment of a maternity roost, which could be considered a significant impact under CEQA.

6.2.1 Disturbance

Although the typical noise levels generated by a variety of equipment and construction activities is well-studied (Caltrans 2016), these values are reported in decibels (dB). Decibels are units based on human hearing; 1 dB is the lowest level of sound a human can hear, and each dB unit is the smallest increment in which humans can detect a difference in loudness. Kilohertz (kHz) is a unit of measurement for the frequency of sounds; higher frequencies correspond to higher pitches.

While adult humans can detect sounds between approximately 0.015–18 kHz, most bats' hearing ranges from about 0.1–200 kHz (Altringham 2011). Because bats' hearing range is very different from that of humans, the operating noise levels for equipment that would be used to implement a bridge or culvert project should be tested to identify which bat species could be affected. Additionally, bats' sensitivity to noise is usually greatest at frequencies similar to those used for foraging. For example, the big brown bat's peak hearing sensitivity is at about 20 kHz (Figure 6- 1), which represents the frequency of search calls with the most energy (Koay et al. 1997).

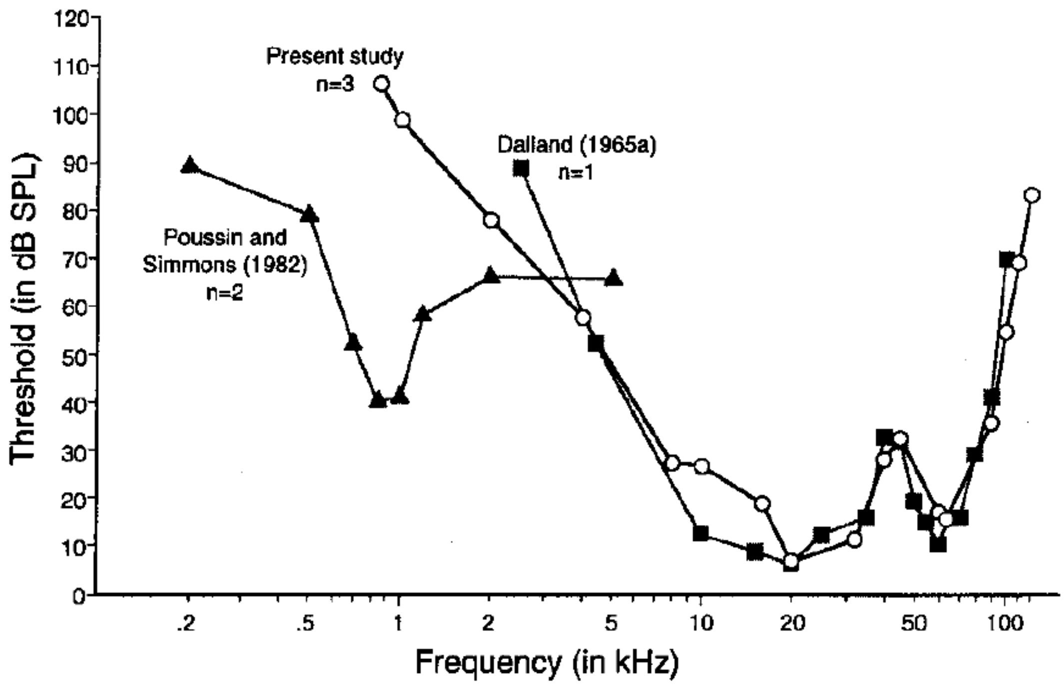

Figure 6-1. Hearing sensitivity in big brown bats (*Eptesicus fuscus*) as measured in three studies (Koay et al. 1997). Values shown depict the threshold of hearing for big brown bats for sounds up to 100 kHz.

Because bats' hearing is not as sensitive at lower frequencies compared to human hearing, the sound frequencies that disturb humans do not necessarily have a corresponding effect on most bat species, and vice versa. Humans may not be able to hear frequencies detected by bats. At a city park in Santa Clara County, an acoustic monitoring study of a maternity colony of big brown bats found that there was no difference in their egress and ingress patterns on the nights after chain saws and earthmovers were operated (H. T. Harvey & Associates 2006). The equipment was used approximately 100 feet from the roost, which was the limit of the buffer zone around the construction area. The noise levels recorded during operation of the chainsaws and earthmovers were 80 dB and 87 dB, respectively.

In contrast, acoustic monitoring data taken at this park the night after the operation of a laser-equipped surveying instrument, which was considered silent to human ears, suggested that about half of the maternity colony had abandoned the roost. According to the acoustic data, the sound frequency range emitted by the surveying instrument was 20–50 kHz, which is broadband high-frequency noise. Because the surveying instrument was used relatively close to the roost and no other equipment was operated that day, H. T. Harvey & Associates biologists determined that the surveyors' equipment likely disturbed the maternity roost and resulted in approximately half of the colony leaving (likely with their young). The observations from the city park study illustrate the implications of the differences in human and bat hearing relative to the operation of equipment. To adequately assess construction noise impacts on bat species, the noise levels emitted by the anticipated equipment to be used should be tested and compared to ambient noises. Section 7 discusses the recommended buffer distances for the operation of equipment in proximity to bat roosts.

Temporary impacts from substrate vibration, such as vibration of the roost structure, have not been studied in detail. Most references to impacts on bats from vibration during bridge and culvert projects are collectively associated with noise impacts, which infers that these two impact types are similar. Environmental documents often allude to substrate vibrations because of the assumptions that they potentially affect bats and occur concurrently with noise impacts. Substrate vibrations are usually measured by three metrics: (1) displacement (the amount of movement); (2) the velocity of the vibrations; and (3) the acceleration of the substrate movement. There are few data that suggest that substrate vibrations affect bats and little is known about this type of impact. At a bridge project in Sonoma County, pile driving within 300 feet of an active maternity colony did not disturb the roosting Yuma myotis and Mexican free-tailed bats enough to result in their departure (Tatarian pers. comm. 2018a). At another bridge site in Tulare County, the initiation of pile driving resulted in the disturbance of a maternity colony, which moved to the opposite end of a bridge; however, it is noteworthy that the bats did not leave the bridge structure (Tatarian pers. comm. 2018a).

Increased lighting as the result of bridge or culvert project implementation can affect foraging and roosting bats. The effects of increased lighting may be temporary or permanent, depending on whether novel nighttime lighting is installed on the bridge structure. Any direct or indirect artificial lighting operated during the day or night can affect bats' behavior. Section 3 discusses the types of impacts that artificial lights have on foraging and roosting bats. The type and magnitude of impacts are dependent on: (1) the lighting type (e.g., LED, incandescent) and intensity (i.e., lumens) to be used; (2) the time of day and season in which the lighting will be operated; (3) the distance from the light to the roost; (4) the location of the lighting relative any ingress and egress pathways associated with the roost; and (5) the bat species at the project site.

Air quality degradation, particularly from equipment exhaust emitted by internal combustion engines, can result in temporary impacts on bats and their roosting habitats. Equipment typically used for bridge and culvert projects includes diesel-powered generators, drill rigs, and construction vehicles. All types of equipment anticipated to be used in proximity to a roost should be considered when determining potential temporary impacts on roosting bats. Construction vehicles, particularly diesel tractors with exhaust pipes directed upwards, can adversely affect active roosts in the soffits of bridges as the vehicles move under the structure. In addition, exhaust may become trapped in adjacent riparian areas; the banks and vegetation can hold fumes along the stream channel. Exhaust from generators can be especially harmful because they are typically operated around the clock in stationary positions for many consecutive days, particularly when running pumps for coffer dams. Stationary internal combustion engines such as generators should be positioned downwind of a roost if operation is permitted while bats are roosting. In some cases, it may be better to exclude bats prior to the maternity season than allow exhaust to infiltrate an active maternity colony.

The reconfiguration of objects (e.g., construction vehicles or equipment) stationed at night near a roost, or in proximity to the ingress and egress pathways that bats use, can adversely affect bats and even contribute to roost abandonment. Bats are very sensitive to new objects in the vicinity of roosts even if the objects do not block the roost entrance. Even leaving a vehicle or large piece of equipment adjacent to a roost can have deleterious results.

6.2.2 Short-Term Loss of the Use of a Maternity Day Roost

If bats are excluded from a maternity roost site for no more than a year, the effect is generally considered a temporary loss of roosting habitat for that maternity colony as long as it does not result in displacement or harm to the bats during the maternity season. A common situation where a maternity colony can successfully be temporarily excluded is when a bridge is widened or upgraded with seismic retrofits. In these scenarios, bats are excluded only from construction areas. Other portions of the bridge structure are left available so that bats can easily move to these accessible roost sites away from the construction zone. Buffer zones around roosts should be established on the basis of construction activities. After the maternity season when pups are volant, the colony is excluded from the alternative roost site and allowed to move back to the original roost site so that construction can proceed in the area around this other area. The Alameda Creek Bridge Project on I-880 in Alameda County and the Bradley Road Bridge Project on Bradley Road in Monterey County are two good examples where bats were temporarily excluded from roosts but returned to them following project completion.

Any exclusion of an active maternity colony can potentially result in the destruction of dependent young, and even the brief loss of access to an active maternity colony roost could result in bats abandoning the roost and/or causing mortality of the young. Therefore, under no circumstances should a maternity colony be excluded during the maternity season, the timing of which varies slightly depending upon a given area's climate (See Section 3 on bat roosting ecology). Because most bridge and culvert projects, especially those entailing bridge replacement, require a construction period longer than a year, the loss of a maternity colony roost for more than a year should be considered a permanent impact in most situations (see Section 6.3 below).

6.2.3 Short-Term Loss of the Use of a Night Roost

The temporary loss of a night roost usually occurs when the level of disturbance in proximity to a bridge or culvert is high enough that bats cease to use the night roost for up to a year. The disturbance of a night roost at a bridge construction site is primarily caused by floodlights being used close to the night roost area or the ingress and egress pathways used by the bats. Daytime construction activities do not usually affect night roosting behavior as long as ingress and egress pathways are not blocked or modified. When the loss of night roosting habitat resulting from project implementation occurs for less than a year, this impact is considered temporary.

6.3 Permanent Impacts

Permanent impacts from bridge and culvert projects include post-construction disturbance from new project features, permanent loss or modification of roosts, habitat fragmentation, and increases in human activity. Impacts are usually considered permanent when it is a year or more before ambient or baseline conditions are restored following project completion or if baseline conditions cannot be restored due to new project features and permanent habitat modifications.

6.3.1 Disturbance

Disturbance caused by project implementation that results in post-construction roost abandonment is considered a permanent impact. The most common type of permanent, post-construction disturbance is from light pollution. The hinges of the West Prado Overhead Bridge on SR 91 in Riverside County supported colonies of Mexican free-tailed bats, big brown bats, and Yuma myotis that totaled approximately 2,000 individuals. The project included the creation of a new off ramp bridge structure. Although the hinges remained on the bridge post-construction, several Oregon wedges were installed on the structure in accordance with a project mitigation measure. New railroad lights were added under the bridge, but because the ensuing light shined onto the bat roosts, covers were positioned to preclude this light from the roosts. Project implementation also involved the placement of LED street lights along the Green River Road off-ramp. Light spillover from these street lights affected the north side of the bridge and the sides of the soffit. The bats altered their ingress and egress pathways and colonies returned to only the darkest areas under the bridge; the post-construction colonies were estimated to contain 500–600 total individuals that were mostly Mexican free-tailed bats.

6.3.2 Modification of Roosts

Modifications to roost sites can have substantial effects on bats' ability to use them. The increase or decrease in roost size, addition of material that partially occludes an entrance, or other modifications can change the airflow, temperature, and humidity of a roost. These environmental variables within a roost can be critical to the bats' survival and ability to reproduce (Kunz 1982). Bat species have varying habitat requirements and roosting preferences, so any changes to roosts, including their entrances and flight pathways, need to be carefully evaluated when assessing the potential impacts of bridge and culvert projects on bat populations.

6.3.3 Loss of Roosts

The permanent loss of roosting habitat is considered one of the primary conservation issues for bat populations (Fenton 1997, Pierson 1998). Roosts are focal points for conservation efforts, partially because roosting habitat is more readily defined than foraging habitat. However, the population-level impacts of the loss of a single roost are not well understood because many bat species may use several roosts within a season (Lewis 1994). Some populations may or may not have adequate alternative roosts, so it is difficult to fully understand the impacts on a specific colony. What may be a catastrophic loss for one population of bats may not be nearly as devastating to another population. The importance of colonies' alternative roosts and non-maternity roosts to fecundity and survival are not well documented or understood. For example, little is known about temporal alternate roosts, such as winter roosts, in California and their importance to bat populations. A large winter roost of about 1,000 Mexican free-tailed bats in the Alameda Creek Bridge on I-880 in Alameda County was overlooked during initial summer surveys for bats and subsequently discovered during the beginning of construction activities. Such winter roosts may serve many species from a wide geographic area.

Additionally, when a night roost is eliminated, the amount of energy required for bats to successfully utilize the surrounding foraging area may be compromised or lost because of additional flying required when night roosts are not available near foraging areas. Most bats fly from their day roost to forage in the early evening in an optimal foraging area, then roost near this foraging area at a night roost for most of the night, and forage again in the early morning in this area before flying back to their day roost to sleep for the remainder of the day. If a night roost is eliminated, bats fly from their day roost out to their foraging area and then have to commute back to their day roost to night roost for the night, and then fly out to the foraging area again in the early morning and then return back to the day roost to sleep during the day. The difference is that bats without the night roost have to commute two extra trips every night that they forage. For the Uvas

Creek Bridge on SR 152 in Santa Clara County, pallid bats had no other known night roosts in their foraging area and were expected to have to commute the 3 miles between the day roost and the foraging area four times every night instead of twice. The increased energetic needs on lactating females likely decreases the fitness of mothers and their pups. Similarly, a maternity day roost may be protected, but if nearby foraging areas are lost to development the bats will have to fly longer distances to foraging areas, which becomes more energetically expensive. As development encroaches on foraging areas, the energetic costs of the bats' commuter trips to more distant foraging areas may exceed the benefits of using the roost. The latter situation may be contributing to the continuing extirpation of pallid bats from California's coastal valleys under development (Johnston 2017).

6.3.4 Habitat Fragmentation and Isolation

Foraging areas and roosts can become isolated by large transportation projects or other major changes in the surrounding landscape, such as residential development. Radio-telemetry studies indicate that bats frequently move along linear landscape features, such as rows of trees, roads, and waterways, suggesting that bats use these features to help navigate between roosts and foraging areas (Altringham 2011). When these linear features are removed or blocked, such as when a road cuts through a long line of trees, an impact on bat populations is likely to occur (Altringham and Kerth 2016). Additionally, bats may experience increased habitat fragmentation when roads and bridges are augmented in width and/or height as careful observation has shown bats are less likely to cross wider roads with tall structures that interrupt historic flight patterns (Altringham and Kerth 2016). The amount of energy required for bats to successfully utilize the surrounding foraging area may be compromised or lost because of habitat fragmentation or loss near foraging areas, which could result in permanent impacts to individuals and bat populations.

6.3.5 Increases in Human Activity

The long-term effects of human activity (e.g., additional lighting, noise, nearby foot traffic) near a roost should be considered when analyzing impacts and developing mitigation measures for bridge and culvert projects. Multi-use paths that are designed along streams and under bridges should separate or isolate human traffic from bat roosts to the greatest extent feasible. Lighting for cars or pedestrians should be directed away from roosts or possibly shaded by trees or covers/shields.

Human activity associated with investigating roosts can also result in their abandonment. Shortly after a maternity colony of pallid bats was discovered on Little Panoche Creek Bridge on Little Panoche Creek Road in Fresno County, the roost site was visited by numerous biologists and environmental planners to assess the impacts of a proposed project at the bridge (pers. obs. Dave

Johnston, 2017). These visits occurred in June, which is shortly after pallid bat young are born. The lactating females abandoned the roost after the visits, possibly due to the frequent human disturbance. As of April 2019 pallid bats had not returned to the roost site. The area should have been fenced off as an Environmentally Sensitive Area (ESA) and signage installed to warn the project team of the sensitivity of the site to ongoing surveys.

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Section 7. Mitigation Strategies

Effective mitigation strategies can take considerable time and resources to develop, and the process to develop mitigation solutions should begin with the PDT as soon as impacts to bats are identified. The best Bat Mitigation Plans often start a minimum of 2 years before the project's Ready to List date and prior to construction. All potential on-site measures added to a bridge must be coordinated in advance with structural engineers and incorporated into the project planning process. Additionally, the lead biologist must have a good knowledge of the natural history of each species of bat that may be present. Preparing a project-specific bat mitigation plan is one of the best ways to ensure the planning process is complete. There is no "one size fits all" solution to achieve effective mitigation. Rather, each bridge or culvert is different and bats occupying these structures may use them for different parts of their life cycle, the requirements of which vary among species. For example, the Yuma myotis gives birth to pups as much as 6 weeks earlier than the Mexican free-tailed bat, which extends the maternity season considerably. In addition, regions vary both in climate and bat behavior. Bats may use cast-in-place bat condominiums in the Central Valley and in desert areas, but not along the coast because the evening temperatures are very different. Additionally, Mexican free-tailed bats in District 12 have learned to roost in closed box girder bridges by accessing their cavernous interiors through weep holes, but in most regions bats rarely use these areas. For this reason, project biologists should consider what effect their local climate region (Appendix F) will have on the type of mitigation habitat that they are considering. This section contains guidance for avoidance, minimization, and mitigation measures for different roost types, bat exclusion approaches, and monitoring recommendations. However, it does not provide specific protocols to mitigate project impacts on bats at all transportation structures.

7.1 Night Roost Avoidance, Minimization, and Mitigation Measures

Night roosts are important because they typically provide bats with a resting site close to their foraging habitat, serve as areas for socialization, and in the early fall, may offer a place for bats to swarm and mate. Night roosts are primarily utilized during nighttime hours, although bats will occasionally begin roosting earlier in the evening. In most parts of California, night roosting on bridges occurs from spring through fall, when warm daytime temperatures heat the bridge deck and create warmer-than-ambient temperatures on the structure into the nighttime hours.

7.1.1 Avoidance Measures

The following measures should be implemented for bridge projects in order to avoid affecting night roosts.

- Limit project activities to daytime hours; no work should occur under the bridge during nighttime hours.
- Establish and clearly identify the boundaries of ESAs with fencing or flagging to ensure that they are clearly visible to the contractor.
- Bats typically do not night roost during the winter months. Therefore, project activities with potential to disturb bats should occur during the winter as long as it is determined that bats are not day roosting in the bridge structures. Bridge project activities can occur outside of the winter months as long as no bats are presently roosting on the bridge.
- Bird exclusion netting must not be used because it often entangles bats, resulting in their mortality. Bat exclusion structures can be constructed from solid materials or acoustic deterrents can be used (See exclusion recommendations in Section 7.4). If it is necessary to exclude both bats and birds from the bridge, the PDT should be consulted to ensure these avoidance measures are not duplicative or result in impacts on bats or birds.
- No clearing or grubbing should occur near the bridge. Bats are sensitive to changes in the surrounding environment and the clearing of vegetation can increase the amounts of light and sound pollution in their habitat.
- Lights should not be used under the bridge structure during nighttime hours.
- Vehicles and equipment (e.g., generators, pumps) with internal combustion engines are not to be parked or operated under the bridge during nighttime hours.
- Construction personnel are not to be present under the bridge during nighttime hours.
- Work should be planned in such a way in order not to restrict bat airspace access to roost sites.

7.1.2 Minimization Measures

Minimization measures are meant to reduce impacts on a night roost. The following additional minimization measures are based on the available data regarding disturbances to roosting bats, and should be implemented during project activities to prevent night roost abandonment.

- Lighting should be directed at the portion of the bridge undergoing active work and buffer zones must be maintained.
- Internal combustion engines, such as in generators or pumps, are not to be operated under or near the bridge structure unless recommended buffer zones for the applicable bat species are maintained.
- Project fencing or flagging should be used to delineate active work areas from non-active work areas.
- Construction personnel are not to be present under the bridge during nighttime hours in non-active work areas.

In order to prevent disturbance at levels that may result in bats' abandonment of a roost, any increase in noise, light, air pollution, or human activities must be limited to the recommended protective buffer zones for each species (Table 7-1). These distances will minimize the disturbance to bats from construction activities and were identified by H. T. Harvey & Associates (2015, 2016) based on the findings of Fure (2006), who investigated the effects of nighttime lighting; the modeling of high and low frequency noises from generators and drilling rigs; and the likelihood of bat species' sensitivity to noise relative to the frequency (kHz) of their search calls (H. T. Harvey & Associates 2015, 2016). These buffer zones are recommended as guidance, however the appropriate buffer to reduce disturbances below levels at which a maternity colony may abandon its roost site is not known.

Johnston et al. (2004) recommended a generalized buffer distance of 100 feet between work activities and active roosts. However, we know now that different species of bats have different sensitivities to various sound frequencies. Caltrans (2016) indicates that a project with a noise level of 84 A-weighted dB (dBA; an expression of the relative loudness of sounds in air as perceived by the human ear) at 50 feet would attenuate to only 76 dBA at 100 feet. In order to attenuate this sound to an average ambient background traffic noise at 40 dBA, a human would have to be 2,877 feet away from the active roost to achieve the optimal noise avoidance (Caltrans 2016). However, this assumes that that noise perceived by the bats is the same as for humans. Whereas most bats hear at least some low frequency sounds down to about 4 Hz, field observations from several bat biologists (e.g., Greg Tatarian, Jill Carpenter, Stephanie Remington) suggest that bats tolerate relatively high dBA levels of low frequency sounds. It is unclear what the low frequency sounds should attenuate to and more work is needed to provide scientifically based buffer zones for these low frequency sounds.

Table 7-1. Recommended Disturbance Buffer Zones for Day and Night Roosts

Bat Species	Distance (in feet) between Activity/Equipment and Roosts					
	Construction Trucks and Heavy Equipment*	Small Vehicles	Drilling, Trenching, and Small Equipment	Light Source without Shielding	Pedestrian Traffic	Stationary Diesel/ Gasoline Exhaust Sources >2 minutes
Pallid bat, Townsend's big-eared bat	120	90	150	400	65	250
Other species of bats in California	100	65	150	300	65	250
Yuma myotis, Mexican free-tailed bat	90	65	150	250	65	250

*See Caltrans (2016) for detailed discussions of noise impacts to bats at transportation projects and specific dB levels of low frequency values for construction trucks and heavy equipment.

7.1.3 Mitigation for Night Roosting Habitat

If impacts to the bridge component that supports night roosting habitat cannot be avoided or adequately retained, mitigation options should be considered. If the night roosting component(s) of the bridge or culvert cannot be retained during construction or by the replacement structure, they should be replaced with a structure providing similar space and thermal characteristics. Project planning for bridge replacement projects should consider use of a similar bridge design, particularly if a substantial number of bats are found to be night roosting on the structure or if the bridge supports a special-status species. If an alternate design is used, consideration must be given to modifications that would provide open areas with side walls to trap heat. These areas should be at least 30 inches deep from the bottom of a side wall and the soffit (the underside of the top decking), and hang from the underside of the structure. See Section 8 and Appendix B for details for night roosting habitat structures. The longitudinal walls are most likely to provide night roosting habitat when they are approximately 3–6 feet apart. Replacement bridges that are built in stages typically have a closure pour feature. The closure pour connects the old and new bridge structures and forms an upside-down trough. The temperature of the soffit remains warmer than the ambient temperature throughout most of the night, which provides good night roosting habitat for many bat species (Photo 7-1). Although not usually implemented, another option for mitigating lost night roosting habitat would be to substantially improve a nearby potential night roosting site so that it would provide new night roosting habitat.

Photo 7-1. Closure pour used to connect old and new bridges during a replacement project.

7.2 Day Roost Avoidance, Minimization, and Mitigation Measures

Day roosts in bridges are usually occupied during the spring, summer, and fall in California, except in coastal areas, the Central Valley, and several other areas where large, non-hibernating winter colonies can be found. The avoidance, minimization, and mitigation measures presented in this section apply to those circumstances where day-roosting bats are present. The generalized guidelines are designed to control disturbances to specific levels for different groups of bats based on their generalized sensitivities. Specific avoidance, minimization, and mitigation measures for a bridge project may be less stringent after site conditions, species' sensitivity to disturbance, and the relative significance of the impacts are considered. During the late spring and summer period, day roosting females congregate and form maternity colonies.

The most sensitive time in the maternity season for disturbance occurs during the non-volant period when young are present but are not yet ready to fly. The non-volant period is generally from May through July. However, due to seasonal variation between sites, the period from April through August should be used to include the earliest non-volant period, identified in the Colorado Desert, and the latest non-volant period, observed in the High Sierra Nevada.

7.2.1 Avoidance

The following measures are recommended to avoid impacts on day roosting bats from project activities. The goal of avoidance measures is to avoid any impact or disturbance to roosting bats.

- Implement project activities when the colony is not present and retain or restore the roost characteristics after work is complete. The area around the bridge roost should be designated as an ESA.
- Airspace access to and from the bridge during project implementation should remain approximately the same as pre-construction conditions.
- Vehicles and equipment (e.g., generators, pumps) with internal combustion engines are not to be parked or operated under the bridge.
- Construction personnel should not be present under the colony, especially during the evening exodus.
- Table 7-1 lists the recommended buffer distances for roosting bats.

7.2.2 Minimization Measures

Minimization measures are usually implemented when there is a need to temporarily exclude bats from a day roost, or exclude bats from a portion of a bridge structure while retaining some of the existing roosting habitat. Excluded bats can often move to another area of the bridge that is outside both the work area and the species' recommended buffer zone. A temporary loss of day roosting habitat is usually defined as the loss of day roosting habitat for up to 1 year. The same quality and quantity of roosting habitat should be available after construction.

- For projects without special-status species issues, and most projects being implemented during daylight hours, most work should be able to occur 150 feet away from an active roost without much disturbance to the colony.
- Where work must occur in the area of a seasonal colony, work is not to occur directly under or adjacent to an active roost.
- The area under the roost within visual sight of the bats is to be designated as an ESA.
- Airspace access to and from the bridge should not be severely restricted.

- Clearing and grubbing of vegetation under and around roosts should be minimized wherever possible.
- Equipment with internal combustion engines (e.g., generators, pumps, and vehicles) should not be parked or operated underneath or adjacent to the bridge structure.
- Construction personnel should not be present directly under the day roost, especially during the evening exodus (see Table 7-1 for recommended buffer zones).
- When it is not feasible to establish the recommended buffer zones, bats should be excluded from work areas prior to April 15 of the construction year. Exclusion should be done selectively, and only to the extent necessary. See Section 7.4 below for exclusion methods and materials.

7.2.3 Mitigation for Day Roosting Habitat

Occupied roosting habitat should be replaced with habitat features that support the same species-specific physical parameters as the occupied roost when there is no alternative except to replace permanently lost day roosting habitat. If this is not feasible due to engineering or safety requirements, alternative replacement habitat may be considered. Supplemental habitat should also be considered when exclusion will occur for more than one season. However, this is rarely effective; when it does work, bats have to be excluded twice in some cases and each exclusionary event constitutes a new impact on the colony.

If at all possible, replacement roosts should support the same temperature regime, location, and search image as the occupied roosts. The need to replicate the search image is often not considered; bat house designers undervalue the importance of designing day roosting habitat that appears the same visually from a bat’s perspective. For example, if bats were roosting in the crevice of an expansion joint, then the replacement roost habitat should mimic the appearance of an expansion joint. Critical issues for replacement roost design also include access, ventilation, and protection from inclement weather and predators.

Replacement Cavernous Roosts

The most commonly used type of large cavity (cavernous) habitat occurs behind bridge abutments and the soil substrate (Johnston et al. 2004). Replacement of cavernous habitat should be closely coordinated with structural engineers and bat biologists to ensure all necessary physical and ecological parameters are incorporated into the design of a bridge. Attempts to mitigate the loss of this habitat for maternity colonies with off-site structures that mimics some of the qualities of the originally occupied habitat have not been successful; no maternity colonies have moved into the off-site mitigation habitat designed to replace cavernous habitat (Johnston et al. 2004 and the field assessments completed for this study). As described in Johnston et al. (2004), cavernous mitigation habitat was built off-site for four species of bats (pallid bats, California myotis, Yuma myotis, and Mexican free-tailed bats) as mitigation for the Pieta Creek Bridge Project on U.S. 101 in Mendocino County but no bats are known to have roosted there. However, Greg Tatarian successfully retrofitted an existing wooden structure as alternative cavity roosting habitat for Townsend's big eared bats for a non-transportation project (Tatarian pers. comm. 2016), which suggested that this approach might also be possible as bat mitigation for bridge projects. Paul Heady has also constructed off-site cavernous roosting habitat for Townsend's big-eared bats that has been occupied by several non-reproductive individuals and therefore shows some promise, but it remains to be seen if this will be occupied by a maternity colony (Heady pers. comm. 2017).

Because closed box girder bridges provide cavernous roosting habitat and Mexican free-tailed bats are beginning to more commonly access and use this habitat by way of weep holes, replacement closed box girder bridges could be considered "self-mitigating" for the cavernous habitat. It is important that the weep holes remain open for bats' ingress and egress to the large open cavities of the replacement bridge before it can be considered successfully self-mitigating.

Replacement Crevice Roosts

Crevice Modification. Within engineering limitations, minor modifications of existing or proposed expansion joints or similar crevices may provide adequate replacement habitat without compromising the structure. The following parameters should be considered when engineering crevice roosting habitat.

- The gap of the joint should be between three-quarters of an inch and 1.5 inches.
- Ideally, the size of the replacement gap should match that of the original gap.
- The larger end of the crevice width range is better for larger crevice dwellers, such as mastiff bats, pallid bats, and big brown bats.
- Smaller species, such as Mexican free-tailed bats and pocketed free-tailed bats (*Nyctinomops femorosaccus*), generally favor smaller crevices.

- The replacement crevice roost should be located near the site of the original roost, have an equivalent inner surface area, and be oriented as closely as possible to the compass direction of the opening in the original roost.
- The crevice should have good aerial access, such as a clear 6-foot drop below the roost or a lateral launching pad, where bats can drop down out of the crevice.
- The top of the crevice should be protected from sunshine, precipitation, and debris, but should have a small shelf for the bats to secure their young.
- The cover of the replacement crevice roost may be made of metal, concrete, rubber or pliable plastic gasket material, or other nontoxic substances.
- Gasket material should be omitted from the bottom 12 or more inches of the joint.
- The inside surfaces of the replacement roost should remain rough; they should not be smoothed.

Some biologists swab the insides of the replacement crevice roost with bat guano and urine collected from the original roost and sometimes they place additional guano below the new roost as an olfactory attractant. However, the efficacy of this technique needs more research.

Oregon Wedges and Other Panels. Oregon wedges and panels have been very successful in many roost replacement situations (See Photos 8-3, 8-4, 8-5, and 8-27). Since Oregon wedges were first developed, they have been extensively modified. Various wood products have been used for construction, including press board, various plywood types, pine, and redwood, but concrete Oregon wedges and panels are likely the most permanent and stable for shape retention. The disadvantages of using concrete are mostly weight and cost, but the permanent nature of these replacement materials outweighs the disadvantages. The surface should remain rough; it should not be smoothed. Any and all add-on panels need to be engineered, just as any cast-in-place roosting habitat is engineered. Concrete panels need to be reinforced with some sort of steel matrix or rebar, and require permanent attachment designed to meet engineering standards. The design and placement are extremely critical to allow proper temperature control and roost options, as well as to allow for routine bridge inspections and maintenance. Airspace access to an entrance at the bottom of the panel should also be considered. One of the common issues with concrete panels and Oregon wedges is that the crevice width is often too wide, making the crevice unattractive to crevice-roosting bats. Additionally, panels are sometimes not sealed along the top, which allows light, air, and/or rain to enter from the top and also makes the habitat less usable for crevice roosting bats. Section 8 describes the successful use of concrete Oregon wedges in the narrative for the Bi-County High-Occupancy Vehicle Lane Gap Closure Project, and for plywood Oregon wedges in the narrative for the Bear Creek Bridge Project.

Bat Houses. Off-site bat houses rarely work, as is discussed in detail in Section 8.3.3, and this discussion is limited to on-site, add-on bat roosts. Bat houses of many sizes and shapes may provide add-on roosting habitat. These houses are available as ready-made products by various manufacturers, and are also sometimes custom-fitted for a specific bridge. Bat Conservation International evaluates and approves bat houses for effectiveness and is a good source of information for approved designs[6]. Important considerations include opportunities for behavioral thermal regulation, thermal mass, interior size, ventilation, maintenance, permanency, protection from vandalism, correlation with the original structure, and effectiveness. The successful use of on-site bat houses is discussed for the Otay River Bridge Project in Section 8 and illustrated in Photo 8-27.

Add-on Collars. Collars around large piers are similar to flat panels, with a broader internal temperature range (Photo 7-2). Because their design may hamper column inspections, use of this method must be coordinated with the structural engineer to ensure accessibility. The collars should be at least 3 feet high and subdivided internally by vertical staves that extend a one-quarter of the way down the inside. Collars may be made of lightweight concrete or marine grade plywood. A limited amount of ventilation should be provided at the top to allow for temperature control (i.e., small air gaps of varying widths will ensure that different areas of the collar have different temperatures). The inside collar surface should remain rough. An interim collar roost that was installed on Cottonwood Creek Bridge on I-5 in Shasta County was successfully colonized by Mexican free-tailed bats within the same season it was installed.

[6] http://www.batcon.org/resources/getting-involved/bat-houses http://www.batcon.org/resources/getting-involved/bat-houses

Photo 7-2. Interim collar roost installed on Cottonwood Creek Bridge.
Photo by William E. Rainey.

Capped-edge Drains. Standard-edge steel drains can provide small day roosts. The 6–8-inch, cylindrical drain is capped with the bottom of a metal coffee can and paved over with asphalt. This creates a tube about 18 inches deep with a ledge at the top. The bats can use the edge to anchor themselves and the ledge to rest upon or hold their young.

7.3 Wintering and Hibernation Roosts

Wintering or hibernation roosting is a critical time for bats. Wintering usually occurs from late fall through early spring in most of California. During this period, temperatures are low and the bats are in hibernation or deep torpor. The metabolic cost of waking a bat from hibernation can be very high and could be enough to reduce their energy supply to the extent that individuals do not survive to the end of winter. It is especially costly to disturb bats during cold spells when the metabolic cost of maintaining body temperature is already high.

In many cases, the wintering and hibernation sites are used as day roosts during the rest of the year. The measures described below apply when the bats are present for wintering or hibernation purposes. Avoidance and minimization measures for the loss of wintering and hibernation roosts are essentially the same as for the loss of day roosts (see Section 7.2). The magnitude of impacts on hibernation and wintering roosts can be substantial from a regional population perspective. Therefore, substantial effects on these roost types, such as their removal, as the result of project implementation must only be considered when there are no other alternatives. In such a case, a bat expert familiar with the affected species must be consulted.

7.4 Exclusion

Planning should commence 2 years prior to the project's Ready to List date and before project construction to ensure that there is ample time to determine whether exclusion will be needed, and if so, to develop and plan exclusion approaches that can be implemented outside of the maternity season. Exclusion is very invasive to maternity colonies, even after young are volant and have started to disperse; it should never occur during the maternity season. Even when carefully done, pallid bat colonies often do not return to roosts from which they have been humanely evicted. Bats should be excluded humanely when roosting habitat is going to be lost, such as because of bridge replacement. However, they should not necessarily be excluded because of construction noise or light pollution.

For situations involving lost maternity roosting habitat, exclusion should occur after the maternity season ends and during early fall (September 1–October 15) when bats begin to disperse, but it can be done other times of the year as long as it is done outside of the maternity season. The roosting habitat should be thoroughly investigated to determine if there are any bats roosting within the expansion joints or other structures. If there are no bats in the roosting habitat, the biologists can proceed with filling the expansion joints as described below. If bats are detected in the roosting habitat, one-way doors or acoustic deterrents are recommended. For acoustic deterrents, BD100 High Power Version from Binary Acoustic Technology, Tucson, AZ (Photo 7-3), are recommended and placed at 18-foot intervals. These devices require 110-volt AC current or electricity supplied from car batteries with an inverter.

Photo 7-3. Bat deterrent example manufactured by Binary Acoustic Technology that excludes bats from an 18-foot-wide radius by emitting an omni-directional broadband signal that is set at a frequency range to which bats are sensitive.

For expansion joints and hinges, the one-way doors (Photo 7-4) can be positioned approximately every 5 feet with solid polyethylene pool noodles (Photo 7-5) between them. During installation of the one-way doors and pool noodles, the biologist should ensure that no bats are trapped or squeezed inside the expansion joints. The one-way doors can be made from three-quarter-inch plywood with plastic report covers and bent springs so that the device can easily be inserted into the expansion joint and easily removed. The pool noodles are available in different diameters; they should be wider than the diameter of the expansion joint so that moderate force is required to stuff them into the crevice (which will ensure a snug fit and make their removal slightly difficult).

Photo 7-4. One way door used as is or in conjunction with noodles (Photo 7-5).

Photo 7-5. Pool noodles of polyurethane foam that are stuffed into crevices to keep bats out once they have been excluded.

The configuration of the one-way doors and pool noodles should allow bats to crawl along the space between the noodles and the top of the expansion joint and hinge. Bats should be able to crawl inside the expansion joint space until they reach a one-way door through which they can drop and emerge. Any and all potential entrances in the expansion joint and hinge should be blocked by the pool noodles, and care should be taken to make sure that bats cannot enter the sides or at any joints of the noodles. The one-way doors and noodles should be left in place for at least 1 week. After this exclusion technique has been implemented for 1 week, the one-way doors and noodles can be removed and the expansion joints sealed. The noodles work especially well if exclusion is temporary and bats will be reentering the same crevice (or expansion joint).

For long-term exclusion (6 months or more) a combination of half-inch-square hardware cloth and expandable foam, such as Great Stuff Big Gap Filler (Dow Chemical in Midland, MI), may be a better alternative. Before initiating long-term exclusion, the biologist should ensure that no bats are present; if they are, the temporary exclusion methods described above should be used. The hardware cloth helps hold the foam in place so it does not easily fall out when it's wet, and it prevents birds and bats from digging a new cavity into the expansion joint space. The cloth should be curled into long U-shaped strips and placed into the crevice. The bottom of the U shape should be flush with the bridge soffit (bottom of the decking). The foam should be sprayed into the inserted hardware cloth so that it fills the insides of the expansion joint and is supported by the hardware cloth. Some of the wet foam material typically drips out, and it should not be allowed to enter any nearby riparian vegetation or water bodies. The foam takes up to 8 hours to dry and all excess blobs should be removed from the project site. Prior to beginning the installation of the hardware cloth and foam, Caltrans or its contractor should ensure that adequate quantities of each are available on site to completely seal off the potential roosting habitat.

7.5 Monitoring Recommendations

If required by regulatory agency permits or agreements, a project-specific mitigation and monitoring plan for bats that conforms with the goals and success criteria explicitly identified in those regulatory approvals should be developed and approved prior to the project implementation. The development of monitoring details, such as methods and frequency, should be done in coordination with the regulatory agency liaison, and should include provisions for adaptive management should unforeseen circumstances arise. If no regulatory approvals are required for aspects of the project but impacts to bats are anticipated, the biologist and PDT can determine whether the development of a mitigation and monitoring plan is necessary or if the project's avoidance, minimization, and mitigation measures can be adequately described and required through the Environmental Commitment Record (ECR) and contractor Standard Special

Provisions (SSPs) in the contract. Pre-construction monitoring is covered in Section 5; construction monitoring and post-construction monitoring are discussed below.

7.5.1 Construction Monitoring

There is no standard construction monitoring protocol, and each transportation project should have its own construction monitoring plan. Appendix E provides examples of project-specific bat mitigation plans that include construction monitoring guidelines. Construction monitoring is often limited for transportation projects involving bat mitigation because many projects do not have roosting bats during the construction period. However, if construction occurs during the maternity season or during any period when roosting bats occupy a bridge where construction is planned, monitoring for bats and their roost habitat should be conducted during the construction period.

Any roost sites should be monitored for occupancy at least once quarterly during the construction period. As part of this monitoring effort, a census of the bat population in the bridge should be performed on the same day prior to the humane eviction/exclusion by examining all roost sites and repeated immediately prior to the initiation of construction activities. A biologist familiar with bats and approved for monitoring by CDFW should be present prior to the start of any construction activities that could potentially disturb bats. One of the primary sources of disturbance to bats from construction is noise pollution, and noise monitoring is discussed below.

Noise Monitoring. To evaluate the feasibility of reducing the recommended buffer distances for bridge project-related noise, a test could be conducted to simulate the anticipated equipment to be used for high frequency noise generation and attenuation, and then modeled to determine how far buffers should be for specific frequencies of noise. There are a couple of ways to determine how far away operating equipment should be from bat roosts before the equipment noise attenuates to the ambient noise levels.

One way to assess whether high frequency noise made by a piece of operating equipment will disturb bats is to simultaneously record the ultrasonic noise produced by the equipment. H. T. Harvey & Associates used this approach for an operating Honda EU 2000 generator. The following provides the stepwise procedures we used in our assessment.

- While the generator was operating, three Song Meter SM2 bat detectors recorded ultrasounds for one minute.
- Each bat detector was set at a separate distance (approximately 30, 60, and 90 feet) from the generator.

The goal of this assessment was to determine the frequencies produced by the generator and identify at what distance the sound attenuated to the ambient level of noise or to a point where it was not expected to disturb a maternity colony. The small generator emitted a substantial amount of high frequency noise at close range; however, high frequency sounds attenuate very quickly. Figure 7-1 shows the sonograms of the generator noise at 30-, 60-, and 90-feet distances from the detectors. The sonogram at 30 feet shows quite a bit of noise, whereas the recordings at 60 and 90 feet away are minimal. At 90 feet, the sounds from bats flying near the bat detector are louder than the noises made by the generator. In the sonogram the generator noise is fairly faint and mostly at about 10 kHz. Therefore, at 60 feet, most high frequency noise is not recorded, but some of the 10 kHz noise recorded would be detected by bats and may disturb bat species, such as pallid bats that use low frequency sounds generated by prey to detect them. An approximately 100-foot-wide buffer distance should be more than adequate to avoid disturbance from a 45 kHz bat such as the California myotis (*Myotis californicus*) recorded by detectors as shown on the bottom of Figure 7- 1.

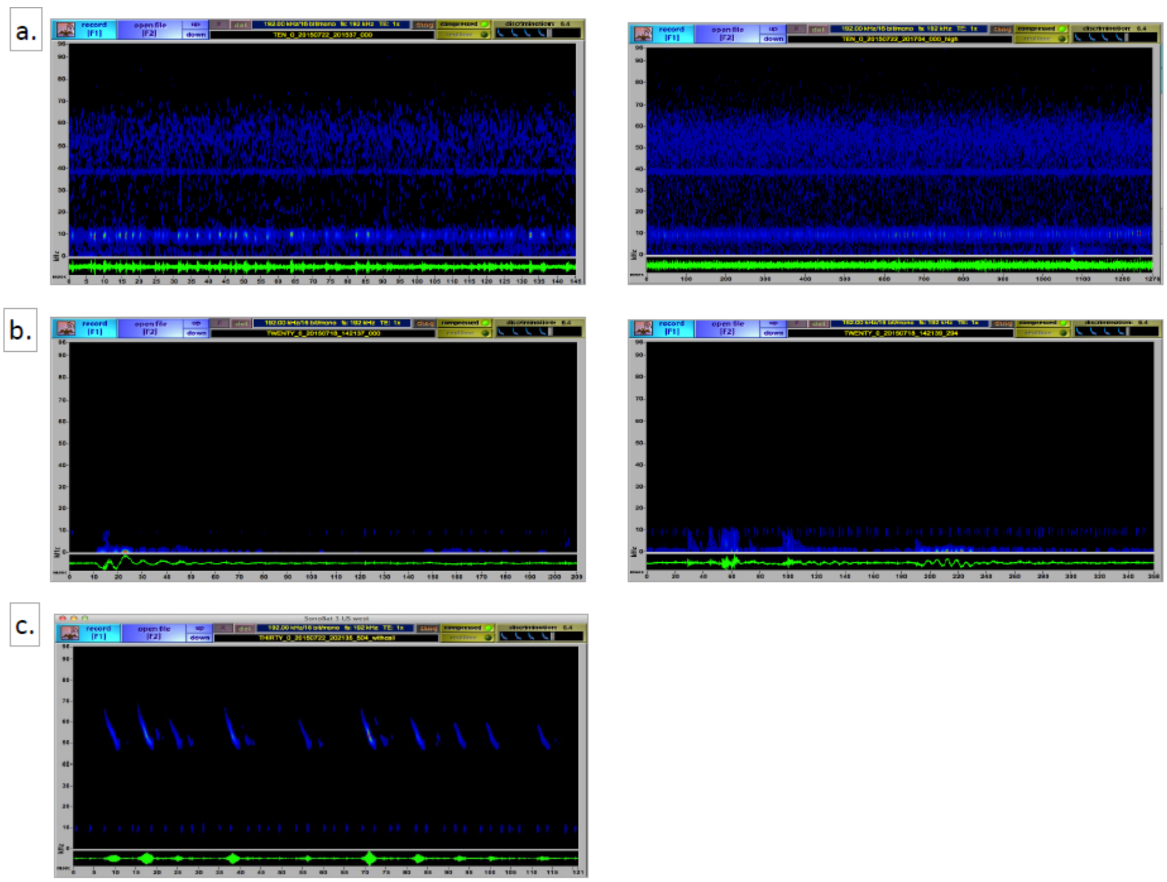

Figure 7-1. Portable generator ultrasonic sonograms.

Panels are as follows: a) ultrasonic recording output at 30 feet, b) ultrasonic recording output at 60 feet, and c) ultrasonic recording output at 90 feet.

Another way to more precisely measure attenuation in high frequency sounds is to record the operating equipment at different distances, separate the different frequencies from each detector through a sound analysis, and model the attenuation of different frequency levels, such as for 20, 30, 40, and 50 kHz levels (H. T. Harvey & Associates 2016). As an example, the high frequency sounds generated from a drilling rig were recorded at distances of 10, 30, 60, and 90 feet to determine when sounds would attenuate to ambient noise levels. As seen in Figure 7-2, the highest noise levels were measured in the human audible range (up to 10 kHz), with the second highest dB level at about 20 kHz. At the 60-foot distance, drill noise was indistinguishable from ambient conditions at frequencies of 40 kHz and higher, but ambient noise likely influenced the levels of frequencies at and above about 30 kHz. At a distance of 90 feet, drill noise was indistinguishable from ambient conditions at frequencies of 30 kHz and up, and ambient noise likely influenced the levels at frequencies above about 15 kHz. The measured levels of low frequency sounds at the 10- and 30-foot distances were consistent with the Federal Highway Administration's Roadway Construction Noise Model[7]. In addition, the drop-off rate over distance, which should be about 6 dB per doubling of distance for the overall dB level, was consistent between the 10- and 30-foot distances. Ultrasonic sounds attenuated at a much higher rate than lower frequency sounds. Based on the results at the 10- and 30-foot positions, noise levels dropped off by about 7 dB per doubling of distance at 30 kHz and by about 10 dB per doubling at the 40 kHz level. Using these drop-off rates, the sum of the frequencies between 30 and 40 kHz would be below 35 dB at a distance of about 150 feet from the drill.

[7] https://www.fhwa.dot.gov/Environment/noise/construction_noise/rcnm/rcnm03.cfm

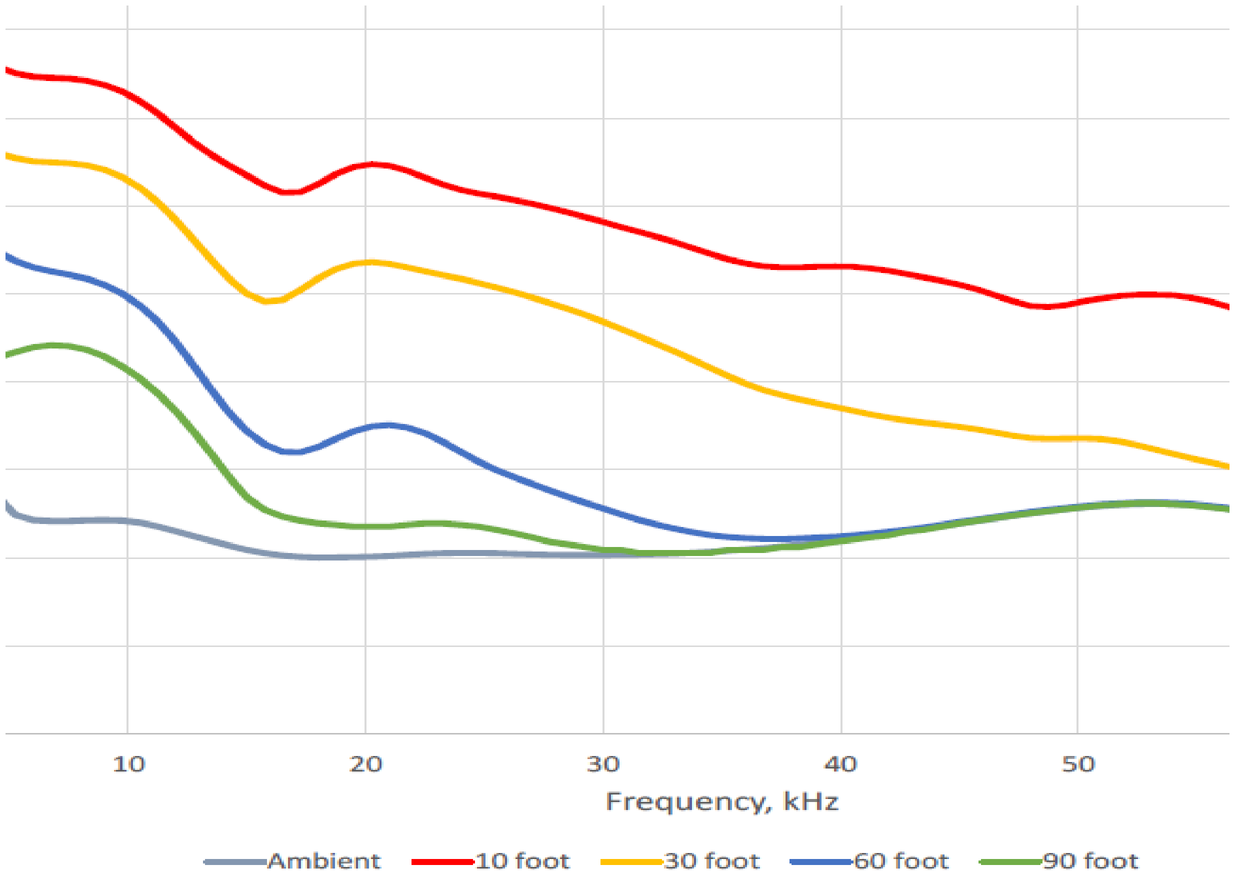

Figure 7-2. Modelling of high frequency noises.

High frequency sounds were recorded with ultrasonic bat detectors at 10 feet, 30 feet, 60 feet, and 90 feet from a drilling rig to determine needed buffer zones for special-status bat species. Using 35 dBs as an acceptable noise level for bats (Szewczak pers. comm. 2017), these models can be used to determine the drop-off rate (attenuation) needed to calculate a buffer distance for equipment to operate.

7.5.2 Post-construction Monitoring

Post-construction monitoring is essential for assessing the effectiveness of habitat mitigation, and is a requirement in CEQA documents. Success criteria of post-construction monitoring should be based upon whether the target species has occupied the mitigation habitat, if the mitigation habitat is being used as intended, and if the size of the colony or colonies is more or less similar to pre-construction conditions. For example, if a pallid bat maternity roost is lost, the expectation would be that the mitigation habitat should be occupied by an active maternity colony engaged in raising young, be present from late spring through summer, and occur in similar numbers to pre-construction counts. Similarly, for non-maternity roosts, post-construction monitoring should occur during the specific time a colony occupied a site pre-construction. For example, a bridge in the San Joaquin Valley might provide fall stopover habitat for Mexican free-tailed bats, or a bridge along the coast might provide important winter roosting habitat for this species. In these examples, monitoring should include these specific time periods to measure the success of the bats' use of the mitigation habitat.

Likewise, if a colony did not use a bridge during specific seasons before construction, there should not be a requirement to monitor the mitigation habitat during those time periods. For example, if a bridge supported a maternity colony of big brown bats, but bats did not otherwise occupy the bridge any other time of the year, then the bridge should only be monitored during the maternity season for big brown bats.

Finally, because long-term monitoring can be expensive, it does not necessarily need to occur for each successive year for the post-construction period. It would be more valuable to monitor in Years 1, 3, and 5 rather than each successive year for 3 years, as it can take several years for a population of bats to colonize or recolonize a new bridge structure. Therefore, for the same cost, information could be obtained regarding how bats have responded to bat mitigation habitat 5 years post-construction instead of only 3 years post-construction.

Post-construction monitoring requirements are typically stipulated in the CEQA document, LSAA, or project-specific bat mitigation plan. Based on our review of several CEQA documents and LSAAs for projects assessed for this guidance document, post-construction monitoring requirements tend to be inconsistent among CEQA documents and CDFW regions. Furthermore, bat mitigation plans are not consistently prepared for every project with bat-related impacts. Documenting the performance of each bat mitigation effort is important, so post-construction monitoring should be performed for all projects requiring replacement habitat. As outlined below, post-construction monitoring efforts should be conducted by a qualified biologist(s). Post-construction monitoring should include the following elements:

- Quantification of the average number of bats present by species and season.
- Comparison of replacement habitat within a structure if placement varies, or if more than one habitat type, such as Oregon wedges and hanging boxes, is provided.
- Long-term temperature monitoring from a subsample of replacement habitat features with temperature data loggers. Wireless data loggers can be used to limit the disturbance to roosting bats.

Recommended Timing and Duration of Monitoring

- Initiate post-construction monitoring within 1 year following installation of replacement habitat.

- Conduct appropriate seasonal site visits for a minimum of Years 1, 3, and 5. If success criteria (described below) have been met, the monitoring effort may be reduced or discontinued as recommended by the qualified biologist in coordination with CDFW.

Methods

- For day roost monitoring, conduct daytime inspections and evening exit counts to assess presence/absence of bats and the average number of bats, using methods described in Section 5.
- For night roost habitat monitoring, conduct nighttime inspections no less than 3 hours after sunset.
- Collect photo documentation to show use or lack of use by bats.
- Prepare a sketch of the transportation structure and indicate the locations of bat use with the numbers and species of bats, as possible, in replacement habitat.

Success Criteria

The goals of the mitigation plan and post-construction monitoring are to achieve the success criteria. The success criteria can originate from a regulatory approval, such as a LSAA, or from the environmental document. Mitigation would be considered successful when the target species has occupied the replacement habitat and when the estimated population of the target species has reached the goals set forth in the bat mitigation plan or 100% of the pre-construction population numbers. The results of each monitoring effort should be compared against the success criteria by the biologist in order to detect and correct any problems as early as possible.

If success criteria have not been met during the monitoring period, the biologist will provide recommendations for habitat modifications and additional monitoring. It is a best practice to employ adaptive management to improve mitigation success with regulatory agencies and expert bat biologists during the monitoring period and not wait until the end of the monitoring period to report that success criteria have not been met.

Reporting

- Reports should include the following elements:
- Background
- Summary of the bat mitigation plan and goals

- Survey methods
- Results and discussion
- Recommendations for adaptive management, if success criteria have not been met

If the project is working under the authorization of a LSAA, or other agency permit that directs actions for bat mitigation, the reporting requirements may be identified in that permit and must be followed. The biologist should provide reports to CDFW within 60 days following each year's monitoring site visits or within the stated report delivery requirements in any CDFW permit for the project.

Section 8. Bridge and Culvert Bat Mitigation Projects in California

8.1 Overview

This section describes the results of our evaluation of the various bat mitigation designs applied to the bridges and culverts that were visited for this project. In the 2004 Guidance Manual, nine case studies were presented as an appendix. For this Guidance Manual update, 39 projects were selected for analysis and this section provides a synthesis of the findings. Herein are examples of avoidance and minimization measures and replacement bat habitat that offsets the temporary or permanent loss of habitat. Representative plans for successful cast-in-place and add-on bat habitat features are included in Appendix B.

8.2 Methods

Between late spring and late summer in 2017 and 2018, H. T. Harvey & Associates ecologists Dr. Dave Johnston and Kim Briones, M.S., conducted field surveys of bridges and culverts to evaluate the results of bat mitigation measure implementation. The structures selected for the evaluation were based on the results of a questionnaire that was distributed to each of the 12 Caltrans Districts through the Sacramento Headquarters office. Each Caltrans District was asked to provide pre- and post-project information for bridge and culvert projects that had a bat mitigation component. The bat biologists compiled a list of 87 bridges and culverts and selected 61 bridges and culverts within each of the Caltrans Districts that provided bridge data[8] for the focused field evaluation.

Of the 61 bridges and culverts selected, 39 bridges had completed mitigation and were evaluated for their effectiveness in implementing appropriate mitigation and successfully providing roosting habitat. Surveys consisted of a combination of daytime visual inspections, colony counts, dusk flight emergence counts, acoustic monitoring, and mitigation roost temperature monitoring. In addition to the field evaluations, we also attempted to review the LSAAs and site plans for these 39 structures. However, few of these documents were available and those that were did not provide detailed mitigation information. The remaining 22 bridges and culverts did not have mitigation habitat, but were initially identified as study sites because they supported bat colonies. The following sections summarize the various types of mitigation habitat that were evaluated and the effectiveness of the mitigation. Mitigation habitat was deemed effective if there was no net loss of

[8] District 9 did not provide any bridge data.

bats and in-kind habitat type was replaced. In some cases the original roosting habitat was lost because of a bridge replacement project, but the new bridge also provided expansion joints that were colonized by bats. In cases like this, the bridge project became self-mitigating because the roosting habitat on the new bridge unintentionally provided replacement habitat for bats.

8.3 Designs for Roosting Habitat on Bridges

8.3.1 Original Habitat Retained

When feasible, retaining roost habitat is the best option for reducing impacts from bridge and culvert project implementation on roosting bats. For example, in bridge replacement projects, the alignment for the new bridge is frequently different from that of the old bridge, offering a potential mitigation opportunity through the retention of all or part of the old bridge. This option has a high probability of success because the bats do not need to accommodate to the new habitat. Sometimes safety, maintenance, and liability issues prevent retaining old bridge structures. However, this may also be the most cost-effective option for a project. Similarly, seismic retrofitting and widening projects may only involve temporary or partial loss of roost habitat, where only limited or no exclusion is needed. Below are four examples of projects that retained the original roost features.

Abutments

Auberry Bridge Project on Road 222 (Powerhouse Road) in Madera County. The original Auberry Bridge was a steel trestle bridge with concrete and wood abutments. A maternity colony of about 200 Mexican free-tailed bats and several scattered Yuma myotis occupied one of the abutments, and the bridge also supported night roosting habitat. The new bridge was constructed approximately 230 feet downstream of the original location, but installing appropriate mitigation habitat was outside the scope of the project. Therefore, instead of providing replacement roosting habitat on the new bridge, the steel trestle was removed in the fall after the colony had left and the abutments of the original bridge were left in place (Photo 8-1). The colony successfully recolonized the bridge abutment the following summer. To ensure public safety, Caltrans reinforced the abutments and added railings and other safety features to them (Photo 8-2). Additionally, the modified bridge abutments provided wheelchair-accessible fishing areas on the San Joaquin River. The post-construction survey estimated that the size of the Mexican free-tailed bat colony was roughly the same as the pre-construction estimate of 200 bats. Among the bridges surveyed for this evaluation, this was the only bridge where the abutments were left in place after project implementation.

Photo 8-1. Close-up of retained Auberry Bridge abutments and safety railings.

Photo 8-2. View from the new Auberry Bridge of the original abutments.

Hinges and Expansion Joints

Crevice-roosting bats most commonly use hinges and expansion joints for day and maternity roosting. Some projects, such as bridge retrofitting or widening, require only temporary exclusion of bats in the affected portions of the existing habitat. In these cases, bats can be temporarily excluded from the impact areas (see Sections 6 and 7) and allowed to reenter the same roosting habitat following construction. This approach is preferable to the combination of permanent exclusion and subsequent off-site mitigation or habitat replacement, and it greatly increases the chance of achieving mitigation goals. The three project examples below included temporary exclusion and were considered successful.

Bidwell Park Viaduct Project on SR 99 in Butte County. This bridge project included widening the viaduct for seismic retrofitting and closing the gap between the two viaduct structures. The project involved a two-structure viaduct that included several hinges. A few thousand Mexican free-tailed bats were counted in the bridge during pre-construction surveys (Tatarian pers. comm. 2017a). The bridge supported less habitat space post-construction, but this study's survey estimated that roughly 600 Mexican free-tailed bats had recolonized the bridge. However, some hinge space was still not occupied as of 2017, suggesting that there is room for more bats to roost on the bridge. Nonetheless, this project is worth highlighting because at least some portion of the hinge habitat was available before, during, and after construction. Although the remaining hinge crevice habitat was not likely left as mitigation habitat, these features remained to some degree and thus provided a self-mitigating bridge retrofit. Specifically, the new bridge was built with hinge crevices as structural aspects and these crevices were recolonized by the same species that were previously excluded. The population of Mexican free-tailed bats at the new bridge is expected to grow to similar numbers as observed during the pre-construction survey.

Bradley Road Bridge Project on Bradley Road in Monterey County. The goal of this project was to seismically retrofit the Bradley Road Bridge over the Salinas River. Pre-construction surveys in the summer of 1999 indicated this bridge supported maternity colonies of 220 Yuma myotis on a western span, about 3,000 Mexican free-tailed bats in various spans, and 20 pallid bats near the eastern abutment. All Yuma myotis and roughly 1,000 Mexican free-tailed bats on the western half of the bridge were humanely excluded with 10-foot-long, one-way doors after pups were volant. These bats subsequently moved their day roost to the eastern side of the bridge, which was more than 500 feet from the construction zone. During the same season and after work was finished on the western half of the bridge, the bats were excluded from the eastern half of the bridge and they returned to the western half where construction had been completed. Post-construction monitoring on the bridge during summer months in Years 3 and 5 suggested that the populations of Yuma myotis and Mexican free-tailed bats remained stable. The pallid bats were disturbed early in the construction phase before the exclusion devices were installed, and this colony had not been observed under the bridge as of 10 years after project completion. The mitigation measures for this project were mostly effective, but the early construction work started before the measures were implemented and resulted in a maternity colony of pallid bats abandoning their roost.

Alameda Creek Bridge Project on I-880 in Alameda County. This project involved a bridge deck replacement and seismic retrofit. Prior to project implementation, this bridge supported nearly 1,000 overwintering Mexican free-tailed bats and about 100 Yuma myotis. Similar to the Bradley Road Bridge Project, construction at the Alameda Creek Bridge occurred in phases, and each was initiated after bats were excluded. The bats were effectively moved from one half of the bridge at a time, with construction occurring in the half where bats were excluded. Post-construction colony size estimates of both species of bats were the same as pre-construction estimates. Thus, the avoidance, minimization, and mitigation measures implemented for this project were effective.

8.3.2 Original Habitat Lost; New On-Site Habitat Provided

Throughout the state, we found that on-site replacement habitat was designed to mitigate the loss of maternity colony roosting habitat for most bridge replacement projects that included bat mitigation. For this analysis, on-site is defined as only the bridge structure, and does not include the entire project site. The use of a variety of mitigation designs demonstrated that there was a lack of a standardized or consistent approach to designing mitigation habitat among Caltrans Districts, but within the districts there was some consistency. The sections below highlight several effective on-site mitigation habitat designs.

Oregon Wedges

The Oregon wedge is a modified bat box that can be installed on bridges and culverts post-construction. It is not incorporated into the structure, but is attached to its façade, a pier, or concrete beam. The Oregon wedge was originally designed to be constructed from exterior grade plywood panels, but these wooden bat boxes are not always resilient to weather-related warping. Oregon wedges constructed from concrete or concrete aggregate material last longer and have thermal retention characteristics more similar to other structural components used as habitat features.

While dimensions vary slightly, a typical Oregon wedge is prefabricated as one box that is 18 inches tall, 36 inches wide, and 2.25 inches thick, with a 2-inch-thick top (Appendix B-1). The width of the crevice opening at the bottom of the box varies depending on the target species. The roost interior example in Appendix B-1 is wider at the opening and narrower at the top to accommodate large and small species such as pallid bats and Mexican free-tailed bats, respectively. The prefabricated concrete piece is bolted to a predetermined location on the bridge or concrete culvert. Recent concrete Oregon wedge designs have also incorporated a small roosting ledge ("pup ledge") for juvenile bats (Appendix B-2). The ledge is located in the upper interior portion of the wedge and helps prevent non-volant young from falling. Oregon wedges have been successfully occupied by hundreds of bats post-construction for many projects, including the Bi-County High-Occupancy Vehicle Lane Gap Closure Project on SR 215 in San Bernardino County (Photo 8-3) and the Santa Ana River Bridge Widening Project on SR 91 in Orange County (Photo 8-4). Although there is variation in concrete Oregon wedge designs, this approach is considered to be one of the most effective add-on mitigation roost habitat designs.

Bi-County High-Occupancy Vehicle Lane Gap Closure Project in San Bernardino County. This project entailed the expansion of the northbound and southbound bridges over SR 215 by closing the space between the two structures. Although colony size estimates are unknown, pre-construction surveys for the bridges revealed large maternity colonies of Mexican free-tailed bats and Yuma myotis roosting in hinges and alternate roost panels that were provided from a previous project for seismic retrofitting (LSA 2018). Per the LSAA for the project, 60 Oregon wedge panels, half of which included roosting pup ledges (Photo 8-5) and half without ledges, were used to mitigate the temporary noise impacts associated with the project. The Oregon wedge panels were installed along the girders of the existing concrete tee-beam bridge and the walls of the seismic retrofit structure prior to temporary exclusion of bats from various locations on the bridge, allowing safe refuge for bats within the site during construction. During construction, the combined summer population of Mexican free-tailed bats and Yuma myotis varied from 1,615 bats in 2014 to 3,122 bats in 2016 within the entire bridge project site (LSA 2018).

An important finding was that the panel placement had a more pronounced effect on panel colonization than panel type. Both panel types placed along the girders of the concrete tee beams attracted more bats during the maternity season, and both panel types placed on the walls of the seismic retrofit structure attracted more bats during the fall and winter (LSA 2018). Based on long-term temperature data that LSA collected for the project, these differences appear to be an effect of the microclimates of the two bridge features. The girders were warmer and more thermally stable in the summer, which is beneficial for maternity colonies, and the walls were cooler during the late fall and winter, which is beneficial to bats in torpor or hibernation.

Photo 8-3. Concrete Oregon wedge style habitat at the Bi-County High-Occupancy Vehicle Lane Gap Closure Project. Note the two different box designs.

Photo 8-4. Concrete Oregon wedge style habitat at the Santa Ana River Bridge Widening Project. Note the urine staining below the boxes.

Photo 8-5. Concrete Oregon wedge panel illustrating a roosting pup ledge used for the Bi-County High-Occupancy Vehicle Lane Gap Closure Project. ***Photo taken by Jill Carpenter 2016.***

Recessed Cast-in-Place Roost Boxes

Recessed cast-in-place roost boxes are boxes that are recessed into the soffit (underside) of a bridge deck and formed during the construction of the bridge. Because the habitat is cast into the solid top deck that receives solar radiation, these cast-in-place bat boxes remain warm well after nightfall because of the thermal properties of the deck. Several designs may be used, but one of the most effective designs includes elongated roost boxes comprising long crevices that mimic expansion joints. Two bridge projects that incorporated this particular design are the Franklin Boulevard Causeway and West El Camino Avenue Bridge Projects in Sacramento County. Both of these projects demonstrated the establishment of effective mitigation roost habitat for substantial bat colonies.

The least effective design for cast-in-place roost boxes comprises a mini-condominium-style (mini-condo) bat box that is incorporated in the soffit of a closed box girder bridge. Three project examples where this design was used were the Skaggs Bridge Project on SR 145 at the Fresno – Madera County line, Dry Creek Bridge Project on SR 104 in Amador County, and the Estrella Creek Bridge Project on SR 46 in San Luis Obispo County. Although the project designs for these bridges were referred to as “bat-friendly”, bats rarely roost in this style of cast-in-place mini-condo boxes.

Franklin Boulevard Causeway Bridge Project in Sacramento County. The County of Sacramento's Franklin Boulevard Causeway Bridge Project entailed the replacement of two structures that comprised the causeway, including a steel truss portion and a timber trestle portion. Although this was not a Caltrans project, it is an excellent example of how a roost feature was incorporated into the bridge project design. The timber trestle portion of the bridge supported an estimated 40,000 Mexican free-tailed bats. The causeway was replaced with a concrete slab structure that supported five parallel rows of cast-in-place roost boxes; the boxes ran the entire 1,700-foot length of the causeway (Photo 8-6). The two outer rows consisted of three parallel 1-inch by 12-inch redwood planks that were separated by spacers which created three-quarter-inch-wide roost crevices (Photo 8-7, Appendix B-3). The roost boxes were capped with a plywood strip and cast in place during the concrete slab pour (Photo 8-8). By using the cast-in-place bat boxes, the bridge no longer required expansion joints, which resulted in a $200,000 reduction in project costs. The causeway has been monitored for many years following construction. The highest number of bats observed during the summer bat count was 68,156 bats on August 25, 2011, while only 15,823 bats were observed during a winter count on February 18, 2011. Over 99% of these bats were Mexican free-tailed bats and the remainder were Yuma myotis and big brown bats.

Photo 8-6. Recessed cast-in-place roost boxes at the Franklin Boulevard Causeway Bridge.

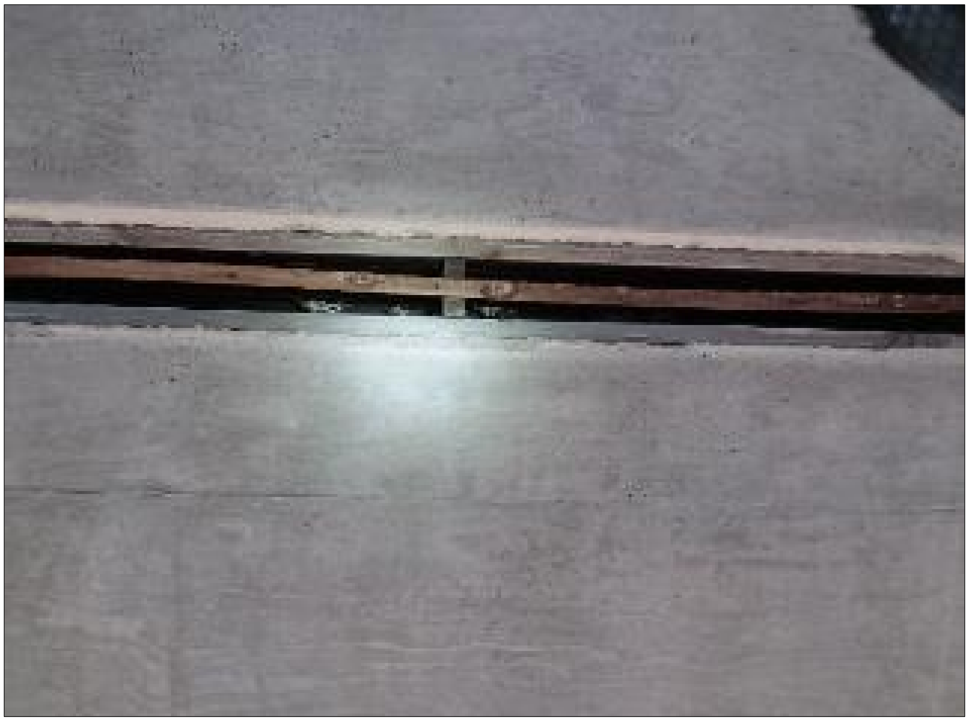

Photo 8-7. A close-up view of a two-crevice cast-in-place roost box at the Franklin Boulevard Causeway Bridge.

Photo 8-8. Recessed cast-in-place roost boxes prior to the pour at the Franklin Boulevard Causeway Bridge. *Photo courtesy of Sacramento County Public Works.*

West El Camino Avenue Bridge Project in Sacramento County. The original West El Camino Avenue Bridge was a timber structure that was constructed in 1943. In 2010, the timber bridge was replaced with a concrete slab bridge. Prior to the project, it was estimated that over 9,000 Mexican free-tailed bats used the interior of the bridge for day roosting. The amount of night roosting habitat on the bridge was likely limited to bats that night roosted in crevices. The replacement bridge was designed with 24 cast-in-place recessed roost boxes on its eastern half (Photo 8-9). The individual boxes were 12 feet long, 1 foot wide, and 1.5 feet deep. Each box supported two three-quarter-inch-wide slots and one 12-foot-long, 8-inch-wide, and 1.5-foot-deep night roost chamber between the two slots (Photo 8-10). The cast-in-place slot design mimicked the replacement habitat provided at the Franklin Boulevard Causeway Bridge; for both bridges, these slots replaced crevice roosting habitat formed between two wooden beams. At least 1,000 Mexican free-tailed bats and less than 50 Yuma myotis occupied two-thirds of the day roosting habitat of the new bridge during the field surveys for this study, which occurred 8 years post-construction. Bat counts for the middle span of the bridge were not attempted because the watercourse below the bridge limited accessibility. Furthermore, the replacement habitat closest to the abutment was near enough to areas of human disturbance that the highest density of bats likely occurred away from the abutment and over the water. The boxes designed for night roosting were not being used during the field surveys for this study. Although the bat biologists reported about 8,000 fewer bats than pre-construction estimates, they determined that the mitigation was successful because the day-roost component of the boxes appeared well-used, with many of the boxes being occupied during surveys, and only two-thirds of the potential habitat was actually counted because of access issues. Virtually all of the roost boxes that were observed were occupied by bats, although fewer bats occupied the roost boxes closest to the west abutment.

Another similarity between the West El Camino Avenue Bridge and the Franklin Boulevard Causeway Bridge was that the replacement roost habitat was cast in a top deck; this was a slab bridge that was heated by solar radiation.

Photo 8-9. Cast-in-place recessed roost boxes at the West El Camino Avenue Bridge.

Photo 8-10. Close-up of day roost slots and a night roost chamber in the recessed roost boxes at the West El Camino Avenue Bridge.

Cast-in-Place Bat Boxes (Mini-Condo Style)

Another cast-in-place mitigation habitat design feature is the fairly large recessed bat box, which is the size and shape of a mini-condo with a volume of 2 cubic feet that is cast into the soffit of a closed box girder design (Photos 8-11 and 8-12). Thus, the bat box is cast in the bridge's lower deck of the hollow box girder, which doesn't receive direct sunlight, instead of being cast in the solid deck, such as on the West El Camino Avenue Bridge. The thermal qualities of these cast-in-place bat boxes built into the bottoms of closed box girder bridges in coastal areas do not match the thermal qualities of good maternity colony habitat because the boxes quickly cool down through the evening. While the top deck absorbs sunshine, the bottom deck does not benefit much from the thermodynamics of the sun shining on the top deck because of the airspace between the top deck and the bridge soffit. Furthermore, coastal areas frequently have cool evenings, so the bottom deck of closed box girder bridges remains cooler during the day and becomes cooler quickly during nighttime. For example, Figure 8-1 shows the temperatures of the underside of the top deck of an open box girder bridge (Uvas Creek Bridge on SR 152 in Santa Clara County), and the underside of the bottom deck of a nearby closed box girder bridge at Bailey Avenue Bridge in Santa Clara County.

Photo 8-11. Recessed bat boxes at the Estrella Creek Bridge.

Photo 8-12. Close-up of recessed bat box at the Estrella Creek Bridge.

The nighttime temperatures under the open box girder bridge remained much warmer than the closed box girder bridge. In California's coastal areas where nighttime temperatures are cool, cast-in-place bat boxes in the soffit of a closed box girder bridge will not work for a maternity colony. In areas with very warm nights, such as in the San Joaquin Valley, this design has a better chance of providing maternity colony habitat.

Generally speaking, these "bat-friendly" bridge designs with cast-in-place bat boxes in the lower decks of closed box girder bridges almost never work as effective mitigation for the loss of maternity colony habitat. For example, after over 10 years of being free of bats, the recessed bat boxes at the Skaggs Bridge over the San Joaquin River are now occupied, but they support only about 100 Mexican free-tailed bats and no pallid bats, which was the target species for mitigation. Similarly, the recessed, lower deck cast-in-place bat boxes that were installed at the Estrella Creek Bridge and at the Dry Creek Bridge have not been used by day roosting bats (although the Dry Creek Bridge is occasionally used by night roosting bats).

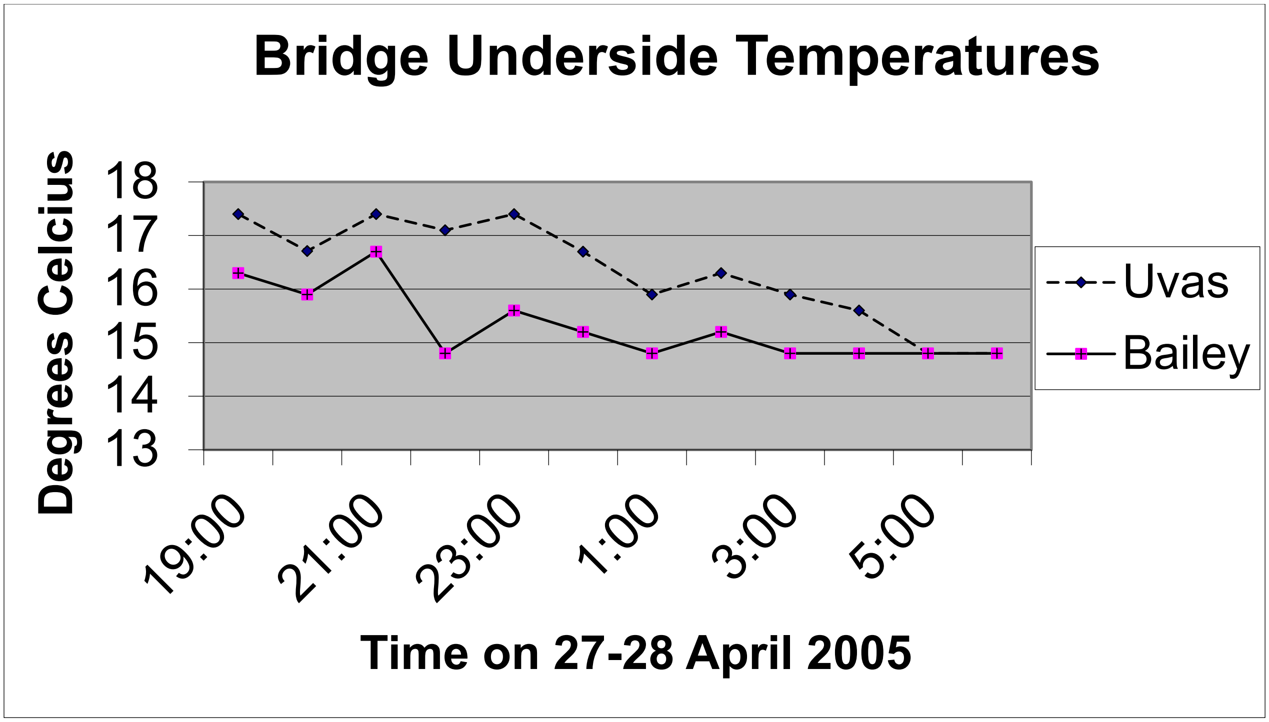

Figure 8-1. Comparison of temperatures underneath an open box girder bridge (Uvas Creek Bridge) and a nearby closed box girder bridge (Bailey Avenue Bridge).

Cast-in-Place Concrete Panels

The cast-in-place concrete panel is a unique design that is another expansion joint analog. This design includes a concrete or concrete aggregate panel that is incorporated into the soffit or underside of the bridge deck and is positioned adjacent to the inner wall(s) of a closure pour. The space between the panel and the closure pour wall provides crevice roost habitat. This design can be implemented in multiple ways, and two project examples are the St. John's River Bridge Project on SR 216 in Tulare County and the Green River Golf Club Bridge Project in Riverside County.

St. John's River Bridge Project in Tulare County. The St. John's River Bridge was an open box girder bridge that was replaced with a closed box girder bridge in 2002. This bridge was showcased in the 2004 Guidance Manual (Johnston et al. 2004) and is included in this Guidance Manual update because of its exemplary mitigation design. Prior to bridge replacement in 2002, the bridge supported day and night roosting habitat for Mexican free-tailed bats, big brown bats, Myotis species, and pallid bats. Pre-construction day roosting habitat consisted of a single expansion joint that spanned the width of the bridge. The pre-construction numbers of bats day roosting and night roosting are unknown. The mitigation habitat consisted of a single concrete panel that was incorporated into the soffit of the bridge deck along the eastern wall of the closure pour (Photos 8-13 and 8-14). The panel, which was meant to replicate the expansion joint, was nearly 225 feet long, the same depth as the closure pour, 2 inches thick, and had a 1-inch-wide crevice. It was not sealed on either of the two ends.

Post-construction, Mexican free-tailed bats have comprised the majority of bats observed. Although the big brown bat has not been observed during post-construction monitoring, over several years of time bat biologists have observed large numbers of Mexican free-tailed bats and small numbers of pallid bats, Yuma myotis, and an unidentified Myotis species (likely California myotis) occupying the bridge. In 2018, H. T. Harvey & Associates observed 1,230 Mexican free-tailed bats and 19 pallid bats day roosting in this bridge. While pre-construction numbers are not available for comparison, the panels have been well-used and support pallid bat, the target species. Further, the closure pours showed evidence of regular night use. Although the bat biologists deemed the mitigation habitat to be exemplary, and the target species recolonized the mitigation habitat, it was not considered to be 100% successful because the big brown bat has not been observed occupying the bridge.

Photo 8-13. Concrete panel at St. John's River Bridge. Note heavy urine staining along bottom crevice opening.

Green River Golf Club Bridge Project in Riverside County. The Green River Golf Club Bridge Project was not a Caltrans project. The steel girder bridge with a concrete deck was replaced with a closed concrete box girder bridge in 2012 (AECOM 2015). The bridge was relocated upstream approximately 1,000 feet east of its original position, and the stream channel spanned by the bridge was realigned as part of a larger flood control project. Prior to its removal, the bridge primarily supported day roosting big brown bats, but the pre-construction size of the colony was unknown. As part of the project, bats were temporarily excluded from the bridge. As on-site bat habitat mitigation, cast-in-place concrete panels were incorporated into the replacement bridge's design to offset the loss of bat habitat on the original bridge. The replacement bridge consisted of four, 4-inch-thick panels that were integrated into the soffit along the north and south walls of the closure pour (Photos 8-14 and 8-15) and along the exterior of the deck (Photo 8-16). Each panel extended the full length of the 130-foot-long bridge and had a 1-inch-wide crevice. Design plans for the concrete panels are found in Appendix B-4, Sheets 1 and 2. The concrete panels for this bridge differed from the St. John's River Bridge because each panel was filled with multiple vertical concrete spacers that were 1 inch thick, 5 inches wide, and 20 inches tall. These spacers created several smaller roost crevices within each panel, rather than one long crevice, and may retain warm air longer than panels without the spacers.

Mexican free-tailed bats and Yuma myotis colonized the habitat within 1 year of completion of the bridge replacement. Maternity colonies of big brown bats, California myotis, and Yuma myotis had returned to the bridge by the summer of the next year (AECOM 2015), although the actual colony sizes were not recorded to our knowledge. In 2013 Yuma myotis had colonized the exterior panels of the bridge, but the panels within the closure pour were mostly vacant of bats (Carpenter pers. comm. 2019b). A survey a few years later indicated that the exterior panels were occupied by many mud wasp nests and along with Mexican free-tailed bats, the Yuma myotis were nearly all located in the closure pour panels (Carpenter pers. comm. 2019b). During the field evaluation of this bridge in 2018, we observed approximately 500 Mexican free-tailed bats and small numbers of Myotis species, presumably Yuma myotis, day roosting almost exclusively in the panels located in the closure pour. No big brown bats were observed on the bridge although a thorough survey was not possible given view sheds of many panels are located above the river and are inaccessible. A maternity colony of big brown bats now occupies a bat house located in a concrete culvert within a half-mile of this bridge suggesting that the previous big brown bat colony moved. Heavy urine staining and scattered guano pellets inside and outside the panels in the closure pour indicated that this feature is well used for day roosting and night roosting. Although pre-construction numbers of bats roosting on the bridge are unknown, post-construction surveys indicated that all species of bats previously roosting on the bridge have returned at least to the area and the mitigation for day roosting and night roosting habitat for this project appears to have been effective.

Photo 8-14. Interior concrete panels in the closure pour of the Green River Golf Club Bridge.

Photo 8-15. Interior concrete panel in the closure pour of the Green River Golf Club Bridge.

Photo 8-16. Exterior concrete panel on the Green River Golf Club Bridge.

Add-on Hanging Roost Boxes

A variety of add-on, hanging roost boxes have been used as mitigation habitat on many bridges. Hanging roost boxes are installed on a bridge following construction. Project examples where hanging roost boxes were installed are the Cappell Creek Bridge Project on SR 169 in Humboldt County, Maacama Creek Bridge Project on SR 128 in Sonoma County and Mill Creek Bridge Project on SR 99 in Tehama County.

Cappell Creek Bridge Project in Humboldt County. The original Cappell Creek Bridge was a timber bridge that supported day and maternity roost habitat for about 300 Yuma myotis. The colony primarily occupied the spaces between the timber stringers of the bridge. The timber bridge was replaced with a concrete box beam bridge that was completed in 2012. Temporary mitigation habitat was installed during construction of the replacement bridge at two bridges, each several miles away but within the same corridor, by attaching commercially-available seven-chamber bat houses to each bridge. The permanent mitigation habitat on the new bridge consisted of four double-concrete bars which were placed side-by-side and bolted to the soffit, as well as the installation of additional commercially-available bat houses to the south side of the new bridge. Each bar consisted of two 3.2-foot-wide by 18-inch-tall concrete blocks that were 5 inches thick and attached to a 4-inch-thick roof. The close arrangement of the hanging bars created crevices (Photos 8-17 and 8-18). Design plans for the double-concrete bars are shown in Appendix B-5. Each bat box structure included an approximately 0.75-inch-wide crevice and featured a 30° roosting ledge. The length of the roost crevice for all boxes combined was approximately 13 feet. Post-construction size estimates for the Yuma myotis colony ranged from a few hundred to more than 700 bats, which was an increase of over 400 individuals. This simple mitigation habitat design proved to be very effective.

Maacama Creek Bridge Project in Sonoma County. The original Maacama Creek Bridge was a concrete arched beam bridge that supported pallid bats (Bridgehunter.com 2019). No information was available on the pre-project colony size, roosting habitat features, or temporary mitigation habitat. The original structure was replaced with a box beam bridge in 2011. The double-concrete bar design described above for the Cappell Creek Bridge was also used at the Maacama Creek Bridge, except that the width of the slots within the four hanging double-concrete bars was configured to be 1.75 inches wide to provide habitat for a pallid bat maternity colony. However, during the July 25, 2017, site visit, the bat biologists counted 131 Yuma myotis day roosting, mostly on the outsides of the double-concrete bar bat boxes, and no pallid bats had recolonized the bridge post-construction. Additionally, no guano with culled insect parts was observed below the night roosting habitat, which suggested that pallid bats did not night roost on the bridge. Although the bridge has been colonized by Yuma myotis, the mitigation habitat design for this project was not effective because the target species, the pallid bat, does not appear to have used the bridge for habitat, and roosting Yuma myotis, which had not been reported during pre-construction surveys, used little of the intended crevice habitat.

Photo 8-17. Hanging roost boxes at the Cappell Creek Bridge. Urine staining demonstrates heavy use by bats. ***Photo taken by Caltrans in 2018.***

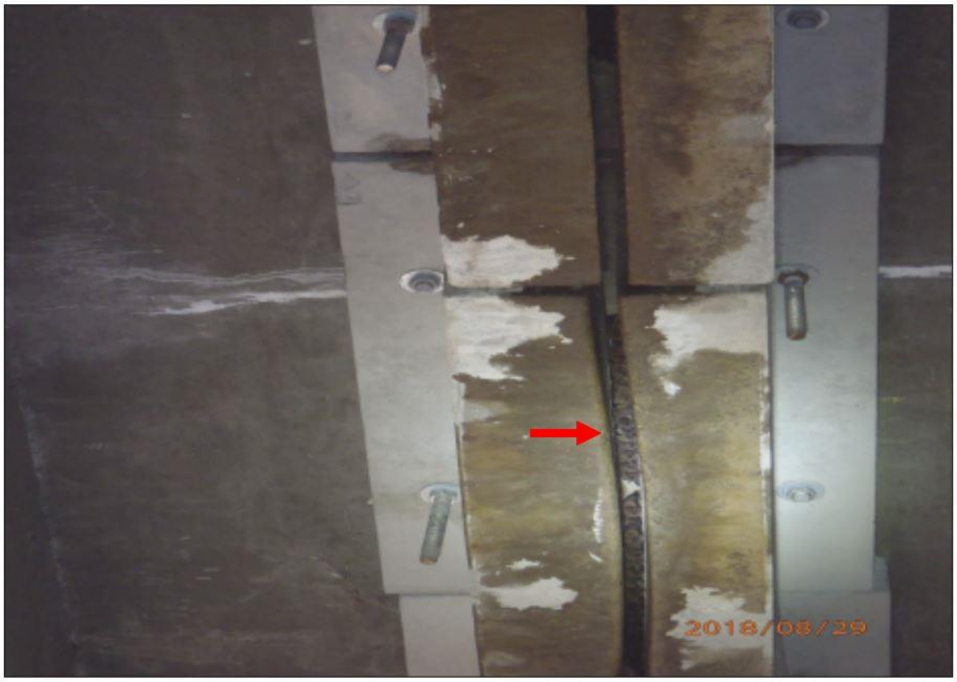

Photo 8-18. Hanging roost boxes at the Cappell Creek Bridge. Several dozen bats can be seen in lower crevice. ***Photo taken by Caltrans in 2018.***

Mill Creek Bridge Project in Tehama County. The original Mill Creek Bridge was a closed concrete spandrel-arched bridge (Bridgehunter.com 2019) that was replaced in 2004 with a closed concrete box girder bridge with a closure pour. Prior to project implementation, the bridge supported small numbers of day and night roosting pallid bats and Myotis species. Little information was available on the pre-project colony sizes, roosting habitat features, or temporary mitigation habitat.

No plans were available for the permanent roost habitat design; therefore, this description is based on H. T. Harvey & Associates field evaluation. A wooden hanging roost box comprised the replacement mitigation habitat on the new Mill Creek Bridge. The replacement habitat consisted of five wooden hanging roost boxes which were each 10 feet long, 5 feet wide, and 12 inches deep (Photos 8-19 and 8-20). Each box supported 20 vertical rows of 2-inch by 12-inch boards, which created multiple 0.75–1.5-inch-wide roost crevices. It was presumed that the variable sizes of the crevices were meant to provide habitat for the various sizes of bat species, including pallid bats and the much smaller Myotis species. The top of the box was not sealed and did not touch the soffit, creating a 0.5–1-inch-wide open gap between the box and the soffit surface within a closure pour. Each box was placed atop, and was secured to, two horizontal steel posts in the closure pour. When this site was originally monitored post-construction in 2004, no bats had day roosted in the wood boxes, but small numbers of Mexican free-tailed bats and Myotis species were night roosting in the closure pour (Johnston et al. 2004). In summer 2018, 5,025 Mexican free-tailed bats were counted day roosting in the boxes, but no pallid bats or signs of their presence have been observed at the site. Although the bridge has been colonized by a large number of Mexican free-tailed bats, this mitigation was not entirely effective because the target species, pallid bats, did not appear to use the bridge.

Photo 8-19. Hanging roost boxes in closure pour at the Mill Creek Bridge.

Photo 8-20. Close-up of hanging roost box at the Mill Creek Bridge. Note dozens of bats clustered in spotlight.

Night Roosting Habitat

As noted in Section 2, night roosting habitat provides a safe place for bats to rest and digest their food between foraging bouts. It might also be an important site for bats to socialize during the swarming season when bats mate. The loss of night roosting habitat can increase the distance a bat must travel between its day roost, foraging habitat, and night roost, thus increasing its nightly energy expenditure. Yet the loss of night roosting habitat is rarely addressed during the environmental review or design processes. While some project sites that were evaluated support night roosting habitat by virtue of the bridge design (e.g., concrete girder bridges), habitat features to replace lost night roosting habitat have only been intentionally incorporated in a few project designs. Of the 39 sites that were evaluated, night roosting habitat was incorporated into the design of only eight bridges:

1. Oakville Cross Road Bridge in Napa County
2. Kings River Bridge on Avenue 416 in Tulare County
3. West El Camino Avenue Bridge in Sacramento County
4. Estrella Creek Bridge in San Luis Obispo County
5. Skaggs Bridge at the Fresno-Madera County line
6. Dry Creek Bridge in Amador County
7. Uvas Creek Bridge in Santa Clara County
8. Cajon Creek Wash Bridge on SR 138 in San Bernardino County

Of these sites, only the Oakville Cross Road Bridge and the Kings River Bridge provided effective night roosting habitat, based on the results of the surveys. Although the Cajon Creek Wash Bridge exhibited no signs that bats used the closure pours for night roosting habitat, at the time of the field surveys the bridge had been built for less than 1 year; therefore, it may have been premature to evaluate this bridge. For night roosting habitat, bats seek open portions of bridges (e.g., between support beams or within girders) that are protected from wind (Keeley and Tuttle 1999). The Oakville Cross Road Bridge Project was an emergency bridge replacement project that was completed by the County of Napa in 2016. Although pre-project estimates of night roosting bats are unknown, the original bridge supported parallel concrete stringers that provided night roosting habitat for pallid bats, Mexican free-tailed bats, Myotis species, and possibly big brown bats (Tatarian pers. comm. 2018b). The mitigation habitat on the replacement bridge consisted of 12 perpendicular, cast-in-place diaphragms in the space between the girders (recessed boxes) (Photo 8-21). Each diaphragm measured 5.2 feet long by 3 feet wide by 2 feet deep. Based on post-construction night surveys the site was used by the same species that inhabited the bridge pre-construction (Tatarian pers. comm. 2019) (Photo 8-22). Based on observations made pre-construction and post-construction, the mitigation on this project was effective for all species, including pallid bat, the target species.

Photo 8-21. Cast-in-place diaphragm night roosting habitat at the Oakville Cross Road Bridge.

Photo 8-22. Guano accumulation under night roosting habitat at the Oakville Cross Road Bridge.

Another unique night roosting mitigation design was incorporated into the Kings River Bridge Replacement Project in Tulare County. The Kings River Bridge was a concrete girder bridge that was replaced with a cast-in-place, post-tensioned concrete box girder bridge in 2014. Prior to the bridge replacement, approximately 1,200 bats, primarily Yuma myotis and much smaller numbers of Mexican free-tailed bats, pallid bats, big brown bats, and fringed myotis, occupied day roosting habitat in the bridge expansion joints. The presence of night roosting habitat in the old bridge was undocumented. This project incorporated hanging concrete roost boxes that provided both day and night roosting habitat (Photo 8-23). This design was somewhat similar to the cast-in-place roost boxes used at the West El Camino Avenue Bridge. Each hanging box on the Kings River Bridge was 16 feet long by 4 feet wide, and supported two linear crevices along each side that varied from 0.75–1 inch wide and 1.5 feet deep. The middle of each box supports an open chamber for night roosting that is approximately 14 feet long by 2 feet wide and 1.5 feet deep. Unlike the West El Camino Avenue Bridge roost boxes, both day and night roosting features in the boxes on the Kings River Bridge appear to be well-used based on the presence of bats and bat sign during our field evaluation. Counts of as many as 4,000 bats, primarily Yuma myotis, have been observed relatively recently (Tatarian pers. comm. 2017b). Other bat species may also be present, but high water levels over the last few years have prevented thorough inspections of each of the boxes (Tatarian pers. comm. 2017b). Additionally, this project incorporated secondary recessed night roost boxes that were approximately 14 feet long by 3 feet wide and 1 foot deep (Photo 8-24). Of the recessed boxes that were not positioned over the water and could be examined, none showed evidence of bat use. Although the H. T. Harvey & Associates bat biologists could not acquire the plans for this project, it appeared that the recessed night roost boxes were shallower than the hanging boxes, and thus may not have been as thermally stable as the hanging boxes. Based on field observations, the hanging concrete boxes provided effective day and night roosting habitat; however, the recessed boxes appeared to be less effective night roosting habitat. Neither of the night roosting habitat design types provided spaces large enough for bats to fly around, such as immediately after emergence or during the fall when bats sometime use these areas for swarming behavior.

Photo 8-23. Hanging concrete roost box at the Kings River Bridge.

Photo 8-24. Recessed night roost box at the Kings River Bridge.

8.3.3 Original Habitat Lost; New “Temporary” Off-Site Habitat Provided

Few of the projects that were evaluated for this study provided permanent or temporary off-site habitat mitigation. For this analysis, off-site is defined as being off the bridge structure and either adjacent to or in the vicinity of the project site. Temporary off-site habitat is sometimes provided during the construction phase to mitigate the temporary loss of roosting habitat or the exclusion of bats from a bridge. However, when bats have been excluded for more than 1 year, the impacts are considered permanent and any temporary off-site habitat should be left in place until on-site habitat is again available. In some cases, off-site roosting habitat was provided as temporary habitat, but it became permanent when project implementation spanned multiple years or the habitat was intentionally or unintentionally left in place.

Off-Site Bat Condominiums

Franklin Boulevard Causeway Bridge in Sacramento County. At the Franklin Boulevard Causeway Bridge, seven bat condominiums (each costing $5,000) were installed as temporary surrogate day roosting habitat while the new bridge was being built. However, it was 4 years before the new replacement bridge and causeway provided potential habitat, so these bat condominiums were considered permanent. During the 4 years that the 40,000 Mexican free-tailed bats were excluded from the old bridge, the seven condominiums, which were designed to hold up to 7,000 bats each (49,000 bats total), supported a maximum of only about 2,000 bats. Within 60 days following construction of the new bridge, 16,500 Mexican free-tailed bats recolonized the new bridge. Before the old Franklin Boulevard Bridge was removed, a large population of Mexican free-tailed bats likely occupied both the Franklin Boulevard Bridge and the Yolo Causeway Bridge, which is about 30 miles to the north. When the new Franklin Boulevard Causeway Bridge opened, most of the 16,500 bats presumably came from the Yolo Causeway Bridge and other nearby bridges with Mexican free-tailed bat populations rather than the temporary off-site bat condominiums. Hence, the bat condominiums provided only a limited amount of mitigation habitat during construction.

Matadero Creek Bridge in Santa Clara County. Another example of bat condominiums used for off-site bat mitigation is the U.S. 101 North Auxiliary Lanes SR 85 to Embarcadero Road Project for the Matadero Creek Bridge in Santa Clara County. For this bridge widening project, 40 Yuma bats roosting in a seam between the middle pier and the soffit were excluded from roost sites after the maternity season. Mitigation for the temporary loss of maternity roost habitat included the installation of three bat condominiums in the vicinity of the project site. No Oregon wedges or other add-on bat habitat structures were provided because the bats would have full access to the original habitat after construction was complete. The project was expected to take no longer than 1 year. Bat biologists counted 20 Yuma myotis during a post-construction survey two years later suggesting that a half of the Yuma myotis had returned to their original roost. Although the three bat condominiums were constructed to offer alternative habitat for bats during construction, they were never occupied by day-roosting bats. It is unknown if the colony produced young at an alternative roost site during the construction year, but the 20 Yuma myotis that were observed day-roosting in early October of 2014 suggested that bats from this colony had used alternative roost sites during the construction period. The installation of the bat condominiums appeared unnecessary and not effective as mitigation for the loss of maternity roosting habitat. These structures have since been removed.

Off-Site Bat Boxes

Temporary off-site bat boxes have occasionally been used to provide off-site habitat mitigation, but these units have limited capacities for bats and are only rarely occupied. Therefore, they are largely ineffective. Off-site bat boxes support from about 50 bats in small units to roughly 300 bats in larger bat boxes. Three project examples that included bat boxes as temporary mitigation to offset the loss of day roosting habitat were the aforementioned Green River Golf Club Bridge

Project, Cappell Creek Bridge Project, and Alameda Creek Bridge Project. For these projects, the bat boxes were installed prior to exclusion but few or no bats were observed using them during or after construction. While some bats were observed using the off-site bat boxes installed along the highway corridor several miles from the Cappell Creek Bridge project during that bridge's construction, it is not clear whether these were the displaced bats. However, bats successfully recolonized all three of these bridges post-construction.

Species-Specific Bat Houses

Greg Tatarian built specialized bat houses for pallid bats (Photo 8-25) as temporary roosting habitat during implementation of a non-transportation project in the Napa Valley, and the bat house design closely mimicked the original structure (not shown). Pallid bats successfully moved into this new habitat after they were excluded from the original structure, but the colony had to be excluded from the bat houses when the construction of the replacement structure was complete. Thus, the bats had to be excluded twice, which represented major disturbances to the colony. It is unknown how the pallid bat colony would have fared if the temporary bat houses had not been installed. The bat boxes were removed post-construction, and there are several reasons why this type of temporary housing is not left in place. The temporary bat houses: (1) are typically not constructed of materials with long-term durability (e.g., concrete and steel); can become attractive nuisances if the public has easy access to them; and (3) may make an unwanted visual part of the landscape. Mr. Tatarian considers the specialized bat box design to be proprietary information; therefore, his design is not available although facsimiles of it were subsequently constructed by other individuals.

Photo 8-25. Permanent off-site bat boxes constructed for pallid bats in the Napa Valley. ***Photo by Greg Tatarian.***

8.4 Issues with Bat Mitigation Habitat

There are many potential issues associated with replacing habitat for an active bat roost. Because bats use multiple types of roosting habitats, and there are specific habitat requirements for each roost, there are many features of bat mitigation habitat that may not provide a particular function for a given population of bats. If a single critical habitat feature is missing, bats may not colonize a bat mitigation structure. For example, a maternity colony of Yuma myotis needs roosting habitat with narrow crevices about 0.5–0.75 inch wide that are dark during the day, provide 24-hour protection from predators, are close to a water feature (Fenton and Bogdanowicz 2002) and maintain a temperature of 85–100°F for a high percentage of the day and night (Tuttle et al. 2013). If only one of the above requirements is not met by replacement roosting habitat, then it will likely not be used by this species. An established colony of Yuma myotis abandoned their roost under a bridge when the associated perennial stream dried up during a drought (pers. obs. Dave Johnston, 2017). Other roost habitat requirements were met, but the loss of the critical water feature likely caused bats to abandon their roost in favor of one near water. Common issues with mitigation habitat design, unforeseen disturbances, poor construction materials, and poor habitat temperature regulation are discussed in more detail below.

8.4.1 Habitat Features are Not Species Appropriate

One of the reasons that replacement roosting habitat is ineffective as mitigation is that the dimensions of the roost features are not appropriately-sized for the target bat species. Many vespertilionids prefer day roost crevices that are about three-quarters of an inch wide, with the exception of some of the smaller crevice roosting bats, such as the canyon bat (*Parastrellus hesperus*, which prefers crevices about 0.5–0.62 inch wide. Larger species such as pallid bats often use crevices 1 – 1.5 inches wide especially along the coast where the individuals of this species are larger than their inland counterparts. Several crevice mitigation habitats used for bridge projects were considered too wide for many species. Although a small number of bats appear to occasionally use these roosts, the mitigation habitat may never be occupied by the target species or a colony of a non-target species. Crevice mitigation habitat features with variable widths offer bat species more potential options and may increase the likelihood that bats will use them.

A notable example of a project for which this issue was observed was the Airport Way Bridge Project in San Joaquin County near the city of Tracy. This bridge had four single-chambered concrete slabs mounted on two middle bent caps. Slabs were attached to the north and south sides of each bent. Each slab was 12 feet wide and crevices were formed by attaching the concrete bat boxes to the concrete bent caps. Yuma myotis and Mexican free-tailed bats are common along this reach of the San Joaquin River, yet the 50 Mexican free-tailed bats observed on the bridge were in the hinge joints, not the add-on concrete bat boxes. The space between the slabs and the bridge surfaces varied from about 1.25 – 2 inches which may be too wide for the Yuma myotis and Mexican free-tailed bat to feel comfortable. Further, these slabs were attached to the bents in such a way as they received a lot of shade from the bridge deck suggesting the slabs were cooler than the deck crevices. These characters likely contributed to the bats preferring the hinges over the replacement habitat.

Another example of mitigation roosting habitat with a crevice that was likely too wide to be effective was for the Cajon Creek Wash Bridge Project in San Bernardino County. The project was designed to incorporate a linear crevice that ran the length of the bridge and was presumably intended to mimic an expansion joint (Photo 8-26). The crevice appeared to be 2 inches wide at the opening. Night roosting habitat was also present in closure pours, though it appeared as though at least one of these was built into the bridge design for the exclusive purpose of providing night roosting habitat. This bridge was surveyed in 2018 shortly after the project was completed. No day roosting bats or signs of night roosting bats were detected, but it may have been too soon after construction to determine whether bats are going to use this bridge. However, based on other bridges where 2- inch-wide mitigation crevice habitat was installed, such as the Airport Way

Bridge, it appears unlikely that Cajon Creek Wash Bridge will provide substantial day roosting habitat unless this mitigation habitat is modified. The H. T. Harvey & Associates bat biologists were unable to review the design plans because they were not available, and it is unclear whether the crevice size was planned or if the implementation of the designs was incorrect. Nonetheless, crevice width is important and contributes to the successfulness of mitigation crevice roost habitat.

Photo 8-26. Linear crevice and closure pour in the Cajon Creek Wash Bridge.

8.4.2 Post-Construction Predator and Unanticipated Human Disturbance

In addition to providing stable thermal conditions and protection from weather, bridge and culvert roosts also need to provide protection from predators. In California, bats have relatively few predators, but they may be susceptible to owls, hawks, snakes, and domestic cats (Lefevre 2005, Sommer et al. 2009, Mikula et al. 2016). Therefore, mitigation designs should ensure that the habitat is not easily accessible to predators. The wooden bat boxes constructed for day roosting mitigation habitat at the Otay River Bridge on SR 905 in San Diego County have been successfully colonized by up to 35 Mexican free-tailed bats per box. However, predatory birds have built nests on the tops of some of the boxes. This bridge had four sets of three vertically-stacked bat boxes installed on the 160-foot-tall bridge piers. These boxes appeared to be able to hold about 300 bats per box. Because the boxes were multi-chambered, they were wide enough to provide ledges for predatory bird nests. Two red-tailed hawk (*Buteo jamaicensis*) nests and one common raven (*Corvus corax*) nest were observed on the bat boxes (Photo 8-27). Wide boxes such as these need a steeply-slanted (45°) cover to ensure that nest materials will slide off and that their tops will not provide a platform for nests large enough to support bat predators.

Additionally, bats may be vulnerable to unanticipated disturbance or injury if the mitigation roost habitat is easily accessible to people. The cast-in-place crevice-roosting habitat near the bridge abutment at the West El Camino Avenue Bridge is only about 8 feet above the ground, which is low enough that bats could easily be harassed with a stick or pole from someone standing below the roosts (Photo 8-28).

Photo 8-27. Wood bat boxes at the Otay River Bridge. Note the raptor nest on the lower box.

Photo 8-28. Recessed roost boxes at the West El Camino Avenue Bridge. Outer boxes near west abutment are easily accessible to humans. Note guano accumulation near abutment.

8.4.3 The Use of Non-Resilient Materials

Prefabricated wooden bat boxes are a seemingly simple and inexpensive mitigation habitat option. However, while many commercially-produced boxes exist, these vary greatly in materials and quality. Pressboard bat boxes warp within the first year and should never be used. Marine-grade plywood bat boxes are frequently used but are not as durable as structural-grade concrete or concrete aggregate material. Generally, wooden bat boxes are less desirable for roosting habitat mitigation because they are not usually resilient to long-term exposure and therefore do not have the same longevity as concrete-based bat boxes. Additionally, wooden bat boxes may not replicate the thermal characteristics of bridge roost features.

Although large numbers of bats were observed roosting in some plywood Oregon wedges on the Bear Creek Bridge on SR 140 in Merced County (Photo 8-29), warping of these bat boxes caused some slots to be too narrow and others to be too wide. Warping in Oregon wedges can be reduced by incorporating additional plywood vertical strips placed at intervals at least 12 inches apart for stabilization.

Photo 8-29. Plywood Oregon wedges at Bear Creek Bridge.

8.4.4 Local Climate Conditions and Temperature Regimes Not Considered

Open-topped bat boxes (i.e., bat boxes that do not have tops and allow air and light to enter) are sometimes used in box girder bridges and closure pours for mitigation crevice roosts. This design worked inordinately well at the Mill Creek Bridge for a maternity colony comprising 5,025 Mexican free-tailed bats during a 2018 survey. However, this mitigation habitat type was used in the northern Sacramento Valley climate, which has hot days and very warm nights in the summer. Having some airflow between the soffit and the bat boxes likely helped keep roosts from becoming too hot. However, open-topped boxes do not appear to be used by maternity colonies in coastal areas where the climate in early summer includes fog and frequent cool nights.

8.4.5 Inadequate Dimensions for Night Roosting Habitat

In order for night roosting habitat to be effective, it should be deep enough to trap warm air from the soffit of the top deck (which is warmed directly from solar radiation) and ideally is wide enough that flying bats can remain in the warm air (although the latter is not critical for bats to simply roost on the warm surfaces of the habitat). See Section 9 for recommendations. The night roosting habitat for the Uvas Creek Bridge was designed to be 30 inches deep, 36 inches wide, and 8 feet long through the installation of add-on panels to create the habitat below the sidewalk on the downstream side of the bridge. However, the replacement habitat is only 8 inches deep and likely does not hold enough warm air to attract night roosting bats. No bats have been observed in this feature.

8.4.6 Species-Specific Mitigation Habitat

The target species for the Maacama Creek Bridge Project mitigation habitat was the pallid bat, but this species has not been observed using the mitigation habitat. The width of the cast concrete hanging box crevices at Maacama Creek Bridge is 1.75 inches, which is too wide for pallid bats and smaller vespertilionids. It is generally believed that pallid bats prefer crevices no wider than 1.5 inches (Keeley and Tuttle 1999). While the Maacama Creek Bridge hanging boxes were occupied by a small number of Myotis species, they preferred the narrower spaces between the boxes, rather than the intended roost crevice. The hanging boxes may have been designed for 1.5-inch-wide crevices but their construction resulted in slightly wider gaps. Nonetheless, this example demonstrates why habitat designs and habitat installation must be species- and site-specific.

8.5 Bat Mitigation Field Survey Results

Table 8-1 provides a summary of results of the field surveys for bat mitigation transportation projects. Bridge and culvert projects that retained the original roosting habitat for the affected species resulted in effective mitigation with the exception of pallid bats, which did not always return to their original roost sites after being disturbed. Success criteria should be based upon post monitoring data gathered over a five-year period to determine whether the target species has occupied the mitigation habitat, if the mitigation habitat is being used as intended, and if the size of the colony or colonies is more or less similar to pre-construction conditions. In four projects where the original habitat was retained (one involving the abutments and three involving hinges or expansion joints), populations of Mexican free-tailed bats and Yuma myotis returned to roosts in similar numbers. Two of these projects had pallid bat populations prior to construction, but neither of these colonies returned to roosts after the disturbance. For the 14 bridge and culvert projects where the original roosting habitat was lost and new on-site replacement habitat was provided, the post-construction surveys suggested that the effectiveness of the mitigation was highly dependent on the structure of the replacement habitat, the type of bridge, and the climate in the project region. Recessed cast-in-place bat boxes worked well for slab concrete bridges. The Franklin Boulevard Causeway presently provides habitat for over 82,000 bats, which represents 205% of its pre-construction population of 40,000. Cast-in-place bat condominiums for closed box girder bridges were always ineffective mitigation in coastal regions and were effective for only small percentages of the original roost populations in the Central Valley. This difference is likely because replacement habitat placed in the soffit of a closed box girder bridge does not retain warmth like a slab concrete bridge that is heated during the day by solar radiation. Cast-in-place panels and Oregon wedges worked well as long as the gaps were not greater than 1.5 inches. Night roosting habitat mitigation was most successful when the replacement habitat allowed bats to night roost on or near the soffit of the top deck of a bridge or in a closure pour. Small spaces (less than 3 feet by 5 feet) were not as effective as night roosting habitat that was at least 3 feet wide and over 20 feet long. Although on-site wooden bat boxes and panels initially provided good mitigation, these typically degraded and warped over time. When panels in bat boxes warp, the crevices may become too narrow or wide for bats, which makes them unattractive for roosting. For the four projects where the original habitat was lost and new off-site habitat was provided, none of the mitigation could be considered effective.

Table 8-1. Field Surveys for Bat Mitigation Transportation Projects: Summary of Results

	Site Name	Location	Original Roost Type	ANPA Detected Pre-construction/ Post-construction	EPFU Detected Pre-construction/ Post-construction	MYYU Detected Pre-construction/ Post-construction	TABR Detected Pre-construction/ Post-construction	MYCA Detected Pre-construction/ Post-construction	Other Myotis Species Detected Pre-construction/ Post-construction	Notes	Effectiveness
Original Habitat Retained											
Abutments	Auberry Bridge	District 6, Madera/Fresno County, County Bridge #42C 0003	Day/ Maternity/ Night	0	0	<5	200/200	<5	0	NA	Effective
Hinges and Expansion Joints	SR 99 Bidwell Park Viaduct	District 3, Butte County, Caltrans Bridge #12-0151	Day/ Maternity	0	0	0	2,000/600 30% Recolonized	0	0	Self-mitigating. Unintentional habitat caused by crevice in hinge	Less Effective
Hinges and Expansion Joints	Bradley Road Bridge	Monterey County Bridge Number 450	Day/ Maternity	20/0 0% Recolonized	0	220/220 100% Recolonized	3,000/3,000 100% Recolonized	0	0	ANPA had not recolonized the bridge as of 2011	Not effective for ANPA. Effective for MYYU and TABR
Hinges and Expansion Joints	I-880 Alameda Creek Bridge	District 4, Alameda County, Caltrans Bridge #33-0240	Day/ Maternity/ Night/ Overwintering	18 night roosting/ 0% Recolonized	0	100/100 100% Recolonized (Year-round)	994/1010 100% Recolonized (overwintering)	0	0	Unclear when ANPA no longer night-roosted in the bridge.	Not effective for ANPA. Effective for MYYU and TABR
Hinges and Expansion Joints	SR-101 Matadero Creek	District 4, Santa Clara County, Caltrans Bridge #37-0040	Day	0	0	40/20 50% Recolonized	0	0	0	Construction disturbed for five years.	Effective
Original Habitat Lost; New On-site Habitat Provided											
Concrete Aggregate Oregon Wedge Panels	I-215 Bi-County High Occupancy Vehicle Lane Gap Closure Project	District 8, San Bernardino County, Caltrans Bridge #54-0171R	Day/ Maternity/ Overwintering	Unknown	0	Present, estimate unknown/3,122 Percent recolonization unknown	Present, estimate unknown/3,122 Percent recolonization unknown	0	0	Number is combined for both species. Do not have breakdown by species.	Effective
Concrete Aggregate Oregon Wedge Panels	SR-128 Dry Creek Bridge Mendocino County	District 1, Mendocino County, Caltrans Bridge #10-0131	Day/ Maternity/ Night	Unknown/41	0	Unknown/20	0	0	Unknown/20	Myotis species unknown	Presumed Effective

	Site Name	Location	Original Roost Type	ANPA Detected Pre-construction/ Post-construction	EPFU Detected Pre-construction/ Post-construction	MYYU Detected Pre-construction/ Post-construction	TABR Detected Pre-construction/ Post-construction	MYCA Detected Pre-construction/ Post-construction	Other Myotis Species Detected Pre-construction/ Post-construction	Notes	Effectiveness
Concrete Aggregate Oregon Wedge Panels	SR-91 West Prado Road Overhead	District 8, Riverside County, Caltrans Bridge #56-0634	Day/ Maternity/ Night	0	Unknown/ Present, estimate unknown	2000 (Mostly TABR)/500 – 600	2000 (Mostly TABR)/500 – 600	0	0	LED lamps on overhead ramp and railroad lamps under overhead ramp are likely the main cause of inefficacy.	Not effective
Concrete Aggregate Oregon Wedge Panels	91-71 Connector	District 8, Riverside County, Caltrans Bridge #56-0635	Day	0	Unknown/1	0	0	0	Unknown/1		Not effective
Concrete Aggregate Oregon Wedge Panels	SR-91 County Line Culvert	District 8, Riverside County, Caltrans Bridge #56-0366	Day/ Maternity	0	Small maternity colony/Small maternity colony	0	Unknown/ Present, small numbers	0	0		Effective
Concrete Aggregate Oregon Wedge Panels	SR-91 Santa Ana River Bridge	District 12, Orange County, Caltrans Bridge #55-0106, EA 0C 5601	Maternity/ Day/ Night	0	0	400 (mostly MYYU, small numbers of TABR/500 MYYU in summer, >1,000 TABR in fall	400 (mostly MYYU, small numbers of TABR/500 MYYU in summer, >1,000 TABR in fall	0	0		Effective
Concrete slabs	Airport Way Bridge Over San Joaquin River	San Joaquin County, County Bridge Number Unknown	Day	0	0	1,150/10	1,150/10	1,150/10	0	Post-construction estimate is only TABR	Not Effective
Concrete panels/open sides	SR-15 Lake Hodges Bridge	District 11, San Diego County, Caltrans Bridge #57-1134L/R	Day/ Maternity	0	0	0	Estimate unknown/ present in likely many hundreds to 1,000	Estimate unknown/ present in likely many hundreds to 1,000	0	Single-chambered concrete panels mounted inside closure pour.	Effective
Plywood Oregon Wedge-style Panels	SR-36 John R. Trainor Memorial Bridge	District 1, Tehama County, Caltrans Bridge #08-0021	Day/ Maternity	Unknown	Unknown	0	Unknown/100	0	0		Not enough information to determine
Plywood Oregon Wedge-style Panels	SR-46 Culvert 3b at Dry Creek	District 5, San Luis Obispo County, Caltrans Bridge #49-0138	Unknown	Unknown/64	0		Unknown/197	0	Unknown/3		

	Site Name	Location	Original Roost Type	ANPA Detected Pre-construction/ Post-construction	EPFU Detected Pre-construction/ Post-construction	MYYU Detected Pre-construction/ Post-construction	TABR Detected Pre-construction/ Post-construction	MYCA Detected Pre-construction/ Post-construction	Other Myotis Species Detected Pre-construction/ Post-construction	Notes	Effectiveness
Plywood Oregon Wedge-style Panels	Tucker Grove Park Bridge	Santa Barbara County, County Bridge #51-C266	Unknown	0	0	0	4000/1	Unknown/3	0	Multiple slats made from plywood and installed in closure pour	Not Effective
Plywood Oregon Wedge-style Panels	SR-140 Over Bear Creek	District 10, Merced County, Caltrans Bridge #39-0095	Unknown	0	0	0	Unknown/105	Unknown/0	0		Effective
Wooden Bat Boxes	SR-202 Tehachapi Creek BOH	District 6, Kern County, Caltrans Bridge #50-0149	Unknown	0	0	Unknown	Unknown/few	Unknown/ Unknown	Unknown/ Unknown	Four pre-fabricated BCI bat boxes. No pre-construction data. Boxes are occupied with day-roosting bats (species unknown) based on presence of small amounts of guano below.	Less Effective
Wooden Bat Boxes	SR-33 Tule Creek Bridge	District 7, Ventura County, Caltrans Bridge #52-0442	Unknown	Unknown	Unknown/5	Unknown/0	Unknown/289	0	Unknown/1	Four-chambered plywood bat boxes	Effective
Wooden Bat Boxes	125 & W-54 Connector (Sweetwater)	District 11, San Diego County, Caltrans Bridge #57-1180G	Unknown	0	0	0	Unknown/<35	0	0	Six-chambered wooden bat boxes. Boxes are occupied with day-roosting bats (species unknown) based on presence of scattered guano under each box.	Presumed Effective
Wooden Bat Boxes	SR-125 Otay River Bridge	District 11, San Diego County, Caltrans Bridge #57-1186	Unknown	0	0	Unknown/<50	Unknown/ Present Estimate of 200	Unknown	Unknown	Six-chambered bat boxes. Boxes are occupied with day-roosting bats (TABR detected acoustically) based on presence of guano piles under each box.	Presumed Effective
Metal Bat Box	SR-905 Spring Canyon Bridge	District 11, San Diego County, Caltrans Bridge #57-1186L/R	Unknown	0	0	Unknown/0	Unknown/0	0	0	Metal boxes with large chamber, about 4 inches wide. Species present pre-construction unknown. No bats post-construction	Not Effective

	Site Name	Location	Original Roost Type	ANPA Detected Pre-construction/ Post-construction	EPFU Detected Pre-construction/ Post-construction	MYYU Detected Pre-construction/ Post-construction	TABR Detected Pre-construction/ Post-construction	MYCA Detected Pre-construction/ Post-construction	Other Myotis Species Detected Pre-construction/ Post-construction	Notes	Effectiveness
Recessed Cast-in-place Elongated roost boxes	Franklin Boulevard Causeway	Sacramento County, County Bridge #24C 0523	Day/ Maternity	Present, estimate unknown/0	Present, estimate unknown/ Present, percent recolonization unknown	Present, estimate unknown/ Present, recolonization ~200	40,000/82,052 (small percentage of post-construction number is MYYU)	0	0	TABR occur in double the numbers but ANPA is gone	Effective
Recessed Cast-in-place Elongated roost boxes	West El Camino Bridge	Sacramento County, County Bridge #24C-0540	Day/ Maternity/ Night	0	Present, estimate unknown/0% Recolonized	Presence unknown/50	9,000/1,000 11% recolonized	0	0		Day/Maternity Habitat: Less Effective, Night Roost Habitat: Not Effective
Recessed Cast-in-place Condominium-style Roost Boxes	Avenue 416 Kings River Bridge	Tulare County, County Bridge # Unknown	Night	NA/unknown	NA/unknown	NA/unknown	NA/unknown	Unknown	Unknown	May be too shallow and small	Not effective
Recessed Cast-in-place Condominium-style Roost Boxes	SR-145 Skaggs Bridge	District 6, Madera County, Caltrans Bridge #41-0086	Day/Night	20/0	0	100/0	2500/100 Percent recolonization unknown	0	0	Preconstruction numbers presumed until additional information can be found.	Not effective
Recessed Cast-in-place Condominium-style Roost Boxes	SR-104 Dry Creek Bridge Amador County	District 10, Amador County, Caltrans Bridge #26-0050	Day/Night	Unknown/0	Unknown/0	Unknown/0	Unknown/a few	0	0	Scattered guano was observed on the walls of the box and on the ground below, but doesn't appear to be heavily used. No day roosting documented, only night roosting. Species pre- and post-construction is not undocumented.	Not effective
Recessed Cast-in-place Condominium-style Roost Boxes	SR-46 Estrella Creek Bridge	District 5, San Luis Obispo County, Caltrans Bridge #49-0256L	Day/Night	Present, estimate unknown/0% Recolonized	Present, estimate unknown/0% Recolonized	Unknown/0	Present, estimate unknown/0% Recolonized		Present, estimate unknown/0		Not effective
Cast-in-Place Concrete Panels	SR-216 St. John's River Bridge	District 6, Tulare County, Caltrans Bridge # unknown	Day/Night	Present, estimate unknown/19	Present, estimate unknown/0% Recolonized	Presence unknown/small numbers	Present, estimate unknown/1,230		Present, estimate unknown/ Present, estimate unknown	Bats also use closure pours for night-roosting habitat.	Presumed effective

	Site Name	Location	Original Roost Type	ANPA Detected Pre-construction/ Post-construction	EPFU Detected Pre-construction/ Post-construction	MYYU Detected Pre-construction/ Post-construction	TABR Detected Pre-construction/ Post-construction	MYCA Detected Pre-construction/ Post-construction	Other Myotis Species Detected Pre-construction/ Post-construction	Notes	Effectiveness
Cast-in-Place Concrete Panels	Green River Golf Club Bridge	Riverside County, County Bridge # unknown	Day/Maternity	Unknown/0	Present, estimate unknown/0	Presence unknown/500	Presence unknown/500			Number is combined for both species. Do not have breakdown by species. Bats also use closure pours for night-roosting habitat.	Not effective for EPFU
Cast-in-Place Concrete Panels	SR-138 Cajon Creek Wash Bridge	District 8, San Bernardino County, Caltrans Bridge #54-0561	Unknown	Unknown/0	Unknown/0	Unknown/0	Unknown/0			Roost crevice may be too wide. No evidence that bats have ever used mitigation habitat.	Not effective
Cast-in-Place Diaphragms	Oakville Cross Bridge	Napa County, County Bridge #21C0137	Night	Present, estimate unknown/ Present, estimate unknown	Likely present, estimate unknown/ Present, estimate unknown	Likely present, estimate unknown/ Present, estimate unknown	Present, estimate unknown/ Present, estimate unknown		Present, estimate unknown/ Present, estimate unknown	Same species detected pre-construction were detected post-construction but no estimates are available.	Effective
Add-on Hanging Roost Boxes	SR-169 Cappell Creek Bridge	District 1, Humboldt County, Caltrans Bridge #04-0304, EA 01-364603	Day/Maternity	0	0	300/700 133% Recolonized	0	0	0		Effective
Add-on Hanging Roost Boxes	SR-128 Maacama Creek Bridge	District 4, Sonoma County, Caltrans Bridge #20-0292	Day	Present, estimate unknown/0% Recolonized	0	Present, estimate unknown/131	0	0	0		Less Effective
Add-on Hanging Roost Boxes	SR-99 Mill Creek Bridge	District 2, Tehama County, Caltrans Bridge #08-0160	Day/Night	Present, small numbers/0% Recolonized	0	Unknown	Presence unknown/5,025	0	Present, small numbers/0% Recolonized	Small numbers of TABR and Myotis night-roosting in closure pour in 2004. In 2018 evidence of bats (species unknown) using closure pours for night-roosting habitat.	Not Effective
Add-on Hanging Roost Boxes	Cathedral Oaks Road Bridge	Santa Barbara County, County Bridge #51C-0373	Day/Maternity	0	Present in small numbers/1	Unknown/0	Unknown/0	Unknown/0	Unknown/0	Texas bat abodes	Not Effective

	Site Name	Location	Original Roost Type	ANPA Detected Pre-construction/ Post-construction	EPFU Detected Pre-construction/ Post-construction	MYYU Detected Pre-construction/ Post-construction	TABR Detected Pre-construction/ Post-construction	MYCA Detected Pre-construction/ Post-construction	Other Myotis Species Detected Pre-construction/ Post-construction	Notes	Effectiveness
Add-on Hanging Roost Boxes	SR-245 Cottonwood Creek Bridge	District 6, Tulare County, Caltrans Bridge #46-0264	Day	0	0	0	Unknown/30	0	Unknown/50	One 5-chambered hanging plywood roost box	Presumed Effective
Add-on Hanging Roost Boxes	SR-18 Over Mojave River	District 8, San Bernardino County, Caltrans Bridge #54-0307	Day	0	0	Unknown/ present, estimate unknown	Unknown/ present, estimate unknown	0	0	Texas bat abodes	Presumed Effective
Add-on Hanging Roost Boxes	Avenue 416 Kings River Bridge	Tulare County, County Bridge # unknown	Day/Night	Small numbers/ Present, estimate unknown	Small numbers/ Present, estimate unknown	1,200/4,000 233% Recolonized	Small numbers/ Present, estimate unknown	0	Small numbers fringed myotis/0% Recolonized		Effective
Open-celled night roost box	SR-152 Uvas Creek Bridge	District 4, Santa Clara County, Caltrans Bridge #37-0665	Night	Unknown/0	Unknown/0	Unknown/0	Unknown/0	0	0		Not Effective
Original Habitat Lost; New Off-site Habitat Provided											
Condominiums	Franklin Causeway	Sacramento County, County Bridge #24C 0523	Day	Presence unknown/ Presence unknown	Presence unknown/ Presence unknown	Presence unknown/ Presence unknown	40,000/2,000	Presence unknown/ Presence unknown	0		Not Effective
Condominiums	US-101 Matadero Creek Bridge	District 4, Santa Clara County, Caltrans Bridge #37-0040	Day	0	0	40/0	0	0	0		Not Effective
Bat houses	I-880 Alameda Creek Bridge	District 4, Alameda County, Caltrans Bridge #33-0240	Day	18/0	0	100/0	994/0	0	0		Not Effective
Bat houses	Green River Golf Club Bridge	Riverside County, County Bridge # unknown	Day	0	Present, estimate unknown/0	Presence unknown/0	Presence unknown/0	Presence unknown/0	0		Not Effective

Notes: Abbreviations for species detected pre- and/or post-construction

ANPA = Antrozous pallidus (pallid bat), EPFU = Eptesicus fuscus (big brown bat, MYYU = Myotis yumanensis (Yuma myotis), TABRME = Tadarida brasiliensis mexicanus (Mexican free-tailed bat), MYCA = Myotis californicus (California myotis)

Section 9. Bat Mitigation Recommendations

The following recommendations 1 – 4 are based on proven best practices for successful bat mitigation planning, construction, and monitoring.

1. If potential bat habitat is present at a bridge or culvert project site, it should be evaluated at least 2 years before the construction phase begins. Caltrans biologists should initiate surveys during Phase K and complete additional surveys during Phase 0 and Phase 1. For projects with an expedited schedule, seasonal surveys can be conducted within a 1-year time frame prior to the Ready to List date.

2. Rely on qualified biologists to develop and implement bat mitigation plans. Bat biology is complex and biologists should be knowledgeable about the species and the adjacent natural communities.

3. Mitigation measures should always be tailored to the specific project. There is considerable variation among bat species with regard to life histories, as well as among members of the same species that inhabit different regions of California.

4. Ensure that appropriate pre-construction and post-construction monitoring is implemented to make certain avoidance, minimization, and mitigation measures are planned and perform appropriately.

The following recommendations 5 – 7 can greatly improve both the accuracy of the scientific data collected regarding the use of transportation structures by bats in California and help advance the development of future avoidance, minimization, and mitigation measures for bats.

5. Create standardized data sheets for the various types of bat surveys in California. These data sheets should be developed through coordination with CDFW and the California Bat Working Group because there are many variables to consider, including effects on other natural resources.

6. Provide incentives for research on off-site bat mitigation habitat. Caltrans engineers and planners have expressed interest in using off-site replacement roosting habitat; however, the bat boxes and bat condominiums that are currently used as replacement roosting habitat for bridge and culvert projects are ineffective and an inefficient use of resources.

7. Provide incentives for research on the ultrasonic noise generated by the construction equipment that is used for transportation projects. There is currently little information available regarding the attenuation of these ultrasonic noises and whether the estimated buffer zone distances are sufficient to reduce or eliminate their effects on bats.

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Appendix A. Bat Sign Photos

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Photo A-1. Urine staining between concrete girders at a night roost.

Photo A-2. Urine staining outside an expansion joint day roost primarily occupied by Mexican free-tailed bats.

Photo A-3. Scattered guano pellets underneath a day-

Photo A-4. Guano underneath a Mexican free-tailed bat day roost.

Photo A-5. Townsend's big-eared bat day roost in open abutment. Note dark area with accumulation of guano.

Photo A-6. Pallid bat night roost. Note Jerusalem cricket legs and beetle elytra

Photo A-7. Dried urine outside crevice habitat under a bridge.

Appendix B. Bat Roost Mitigation Design Plans

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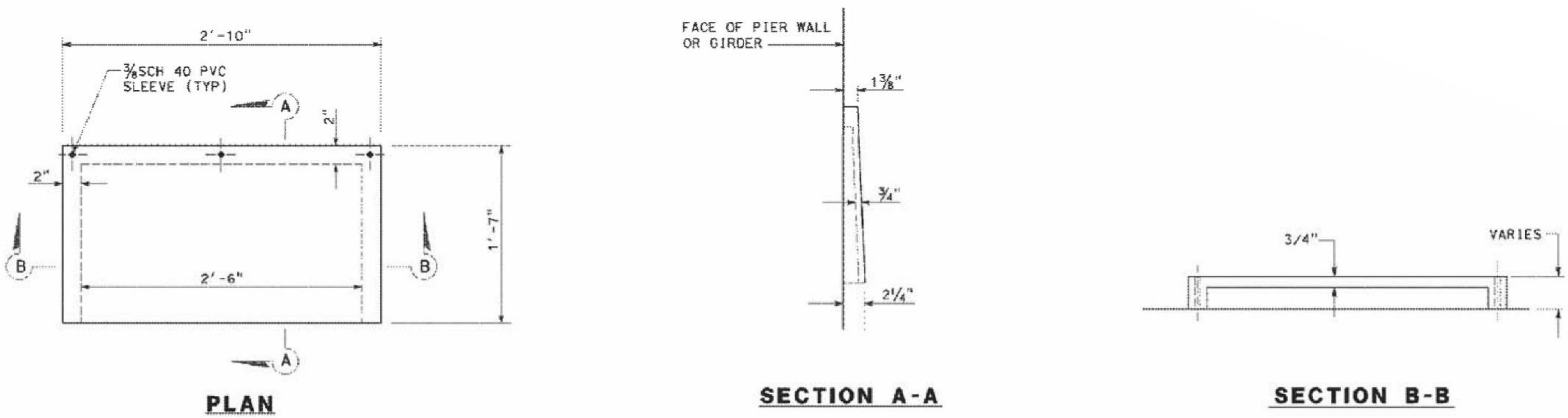
Appendix B-1. Oregon Wedge. Credit Pending



NOTES FOR BAT HOUSE:

1. USE 3⅜" SCH 40 PVC PIPES x 1¾"
   3" HILTI KWIK BOLTS
   KB 14-314 (1/4 x 3 1/4)
   f'ci = 4000 psi (LIGHT WEIGHT CONC.)

2. USE "CHICKEN WIRE" OR EQUIVALENT FOR REINFORCEMENT IN 3/4" SLAB.

LSA

FIGURE A1

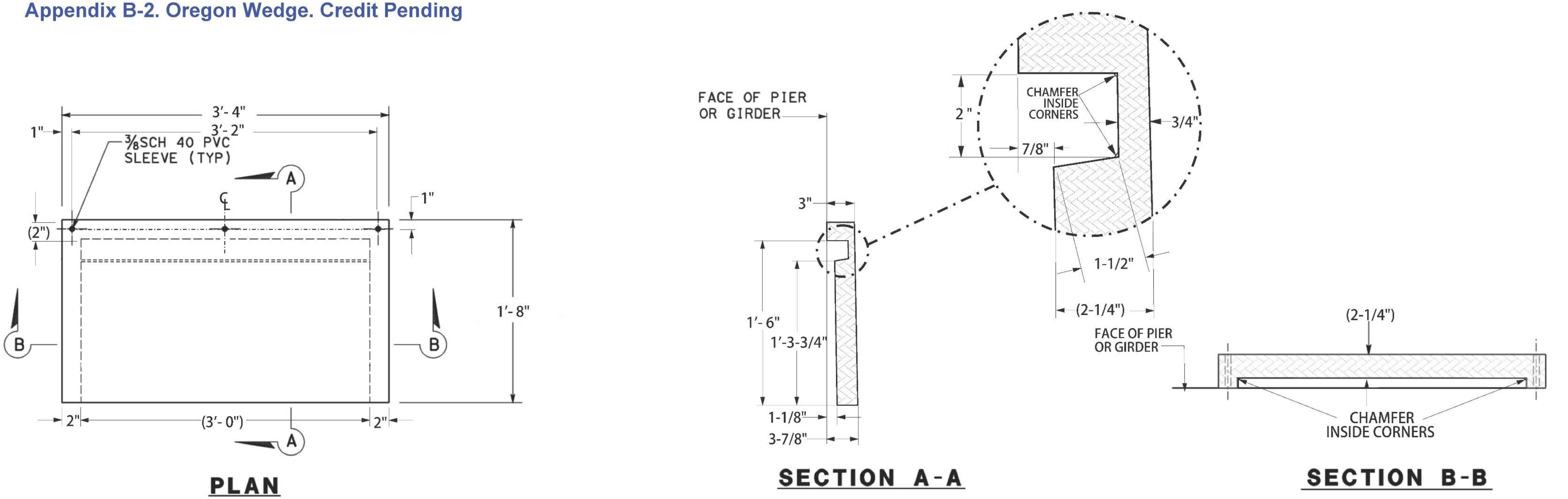
Interstate 215 (I-215) Bi-County HOV Lane Gap Closure Project
Final Report for Monitoring of Alternate Bat Roosting Habitat Panels
I-215 Bridges over the Santa Ana River

Alternate Bat Roosting Habitat Panel Specifications: Basic Oregon Wedge Design

SOURCE: SOHA ENGINEERS

I:\SBA330\G\Annual\2016-2017\Designs Alt Bat Habitat.cdr (4/3/2018)

Appendix B-2. Oregon Wedge. Credit Pending



NOTES:*

1. USE 3⅜" SCH 40 PVC PIPES x 1¾"

   3- RED HEAD WEDGE ANCHOR - 3/8" X 5"

   f'ci = 4000 psi (LIGHT WEIGHT CONC.)

2. USE "CHICKEN WIRE" OR EQUIVALENT FOR REINFORCEMENT IN 3/4" SLAB.

*These bat roosting panel designs were created and modified with input and sample designs provided by Greg Tatarian of Wildlife Research Associates, Inc. (www.wildliferesearchassoc.com)

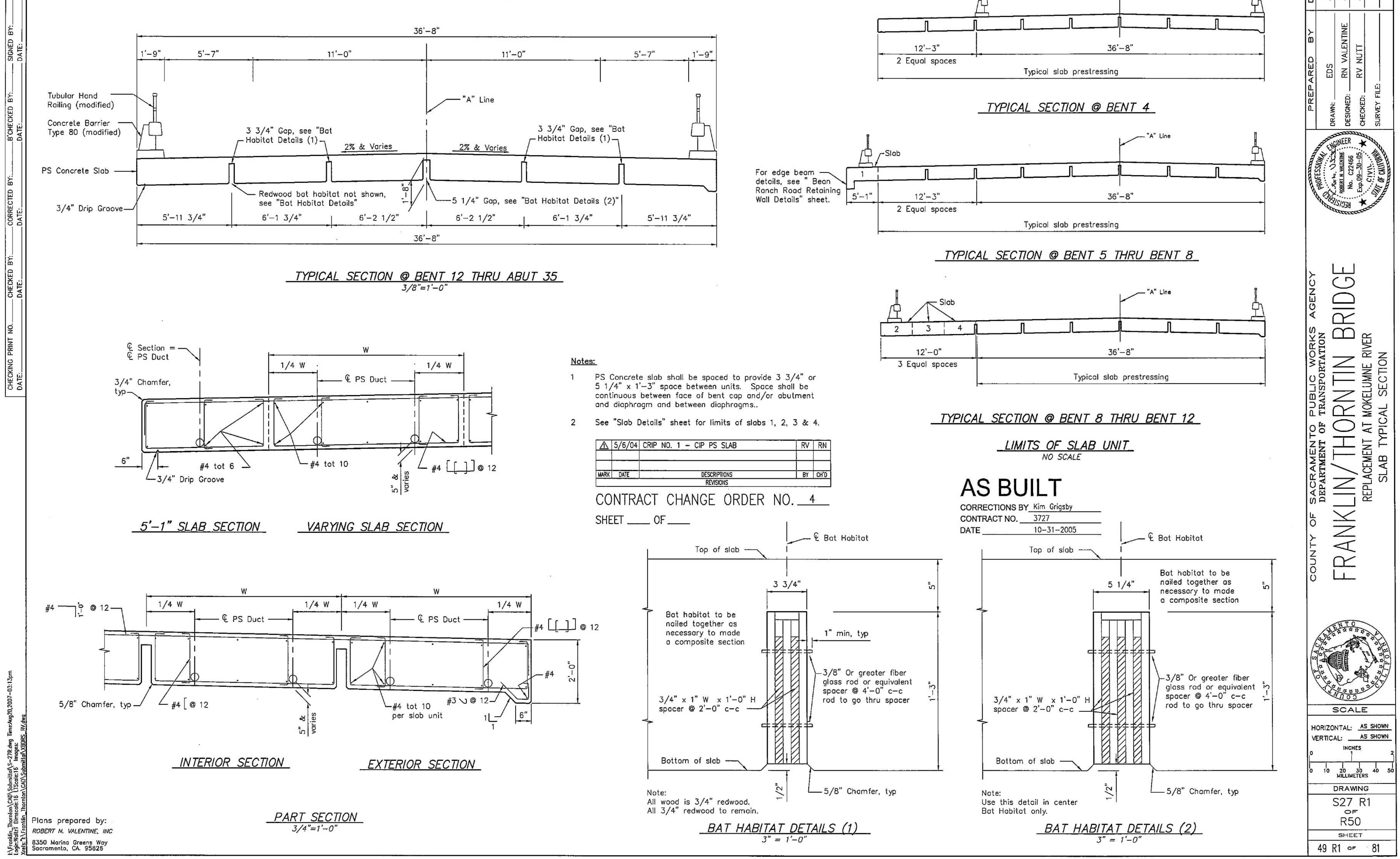
LSA

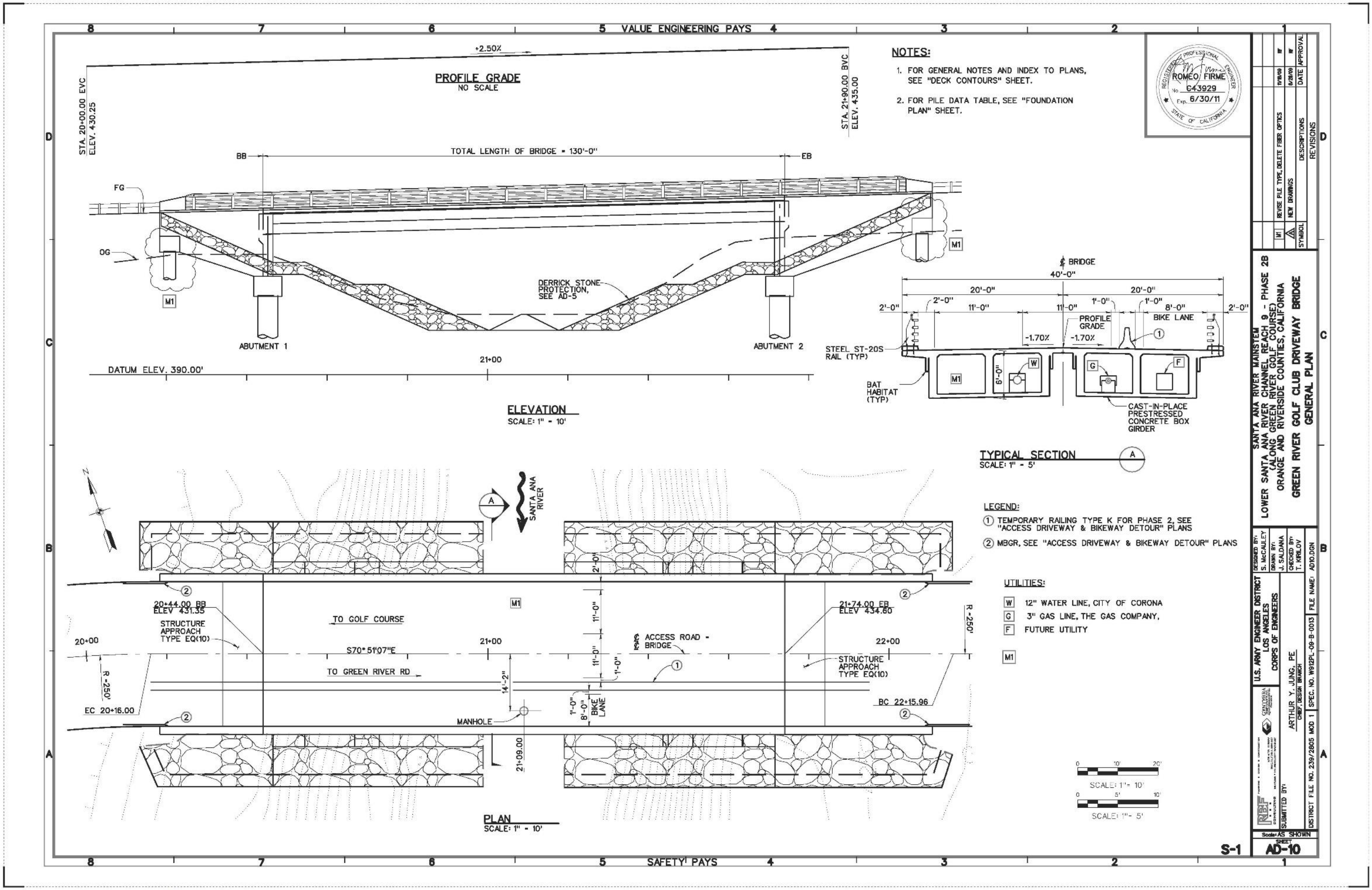
FIGURE 2

SR-91 Santa Ana River Bridge Widening Project
EA-OC5601
Bat Mitigation Plan

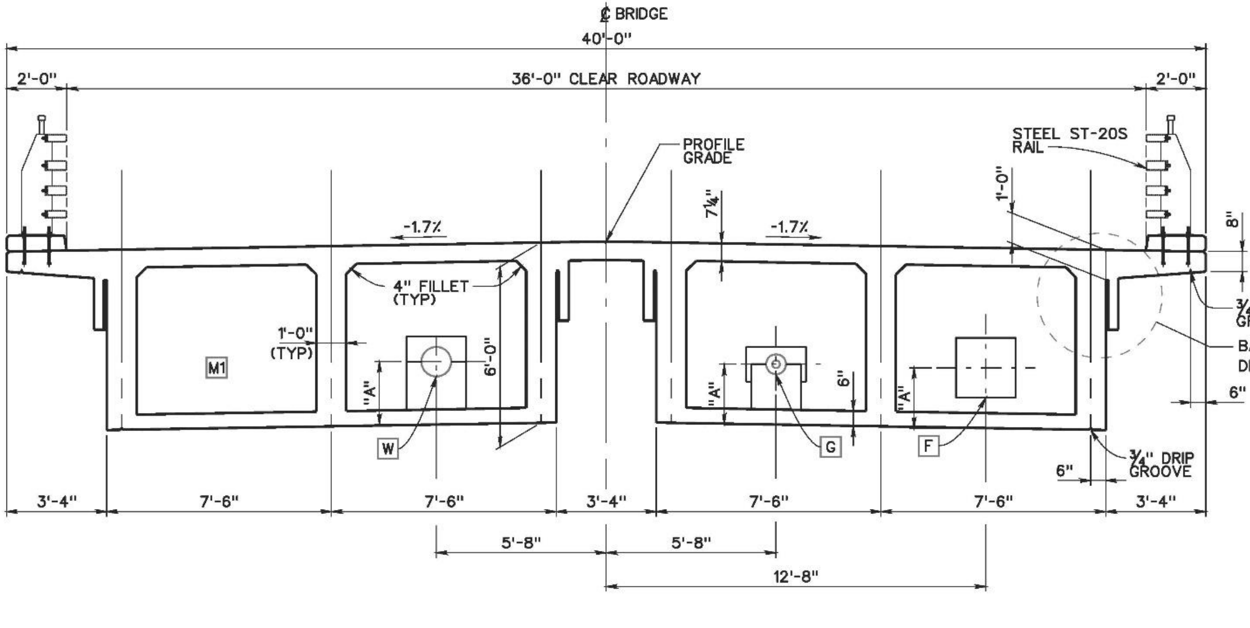
Proposed Designs for Alternative Bat Roosting Habitat Structures

Appendix B-3. Concrete Hanging Roost Box. Credit Pending





Appendix B-4 (Sheet 1) Concrete panel roost plans. Credit pending.

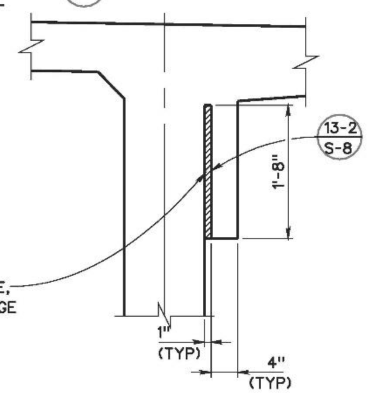


TYPICAL SECTION
SCALE ⅜" = 1'-0"

UTILITY		PIPE SIZE	CASING	
W	WATER, CITY OF CORONA	12" DIA	18" DIA STD	2
G	GAS LINE, THE GAS COMPANY	3" DIA	8" DIA STD	2
F	FUTURE UTILITY			2
M1				

NOTES:

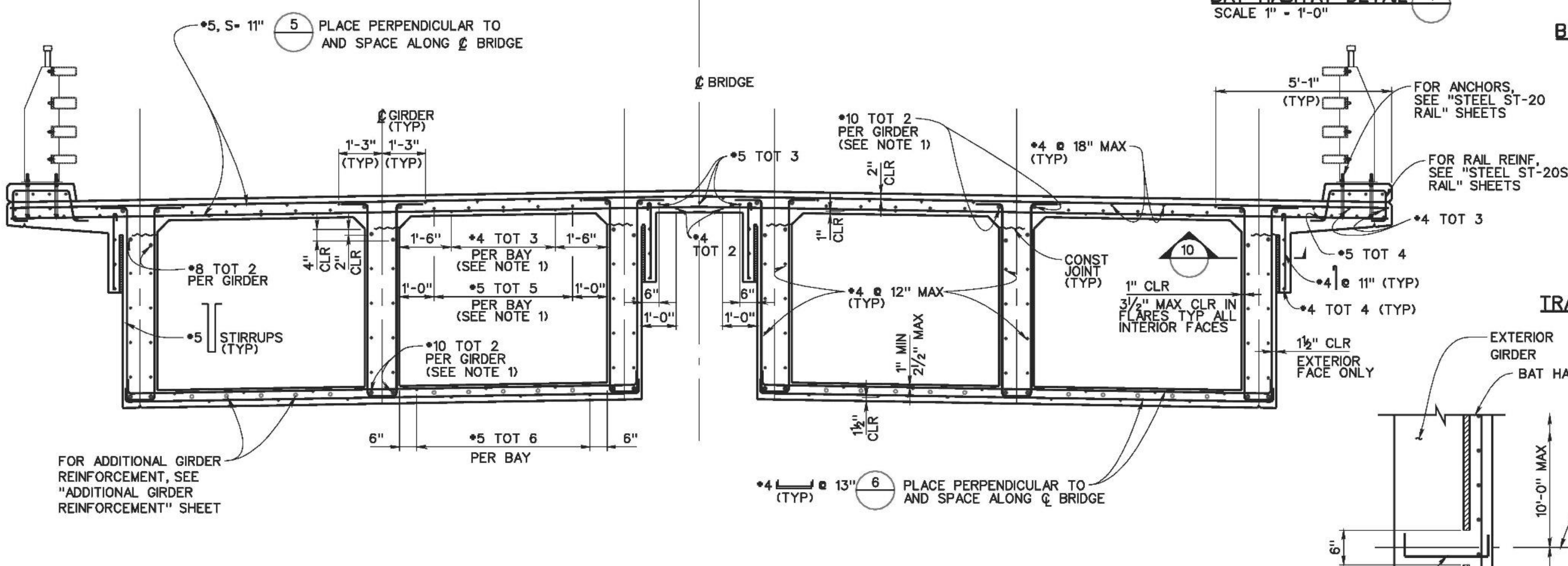
1. REINFORCING SH AND MEET "SER
2. FALSEWORK REL FALSEWORK SHA PERMITTED BY
3. THE CONTRACTO SCHEDULE FOR
4. LONGITUDINAL AI BE PERMITTED U



BAT HABITAT DETAIL 4
SCALE 1" = 1'-0"

BOTTOM SL

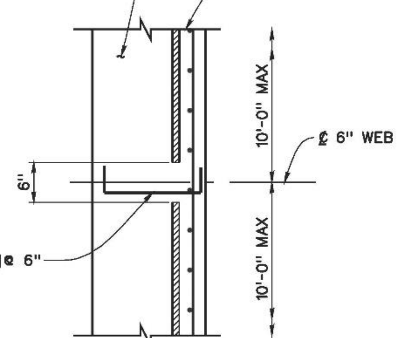
SP



TRANSVERSE

SP

FULL TYPICAL SECTION
SCALE ½" = 1'-0"

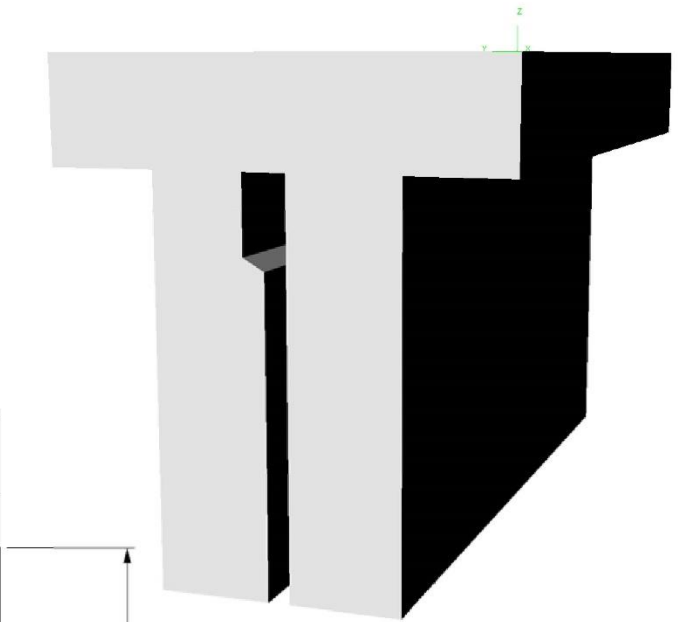


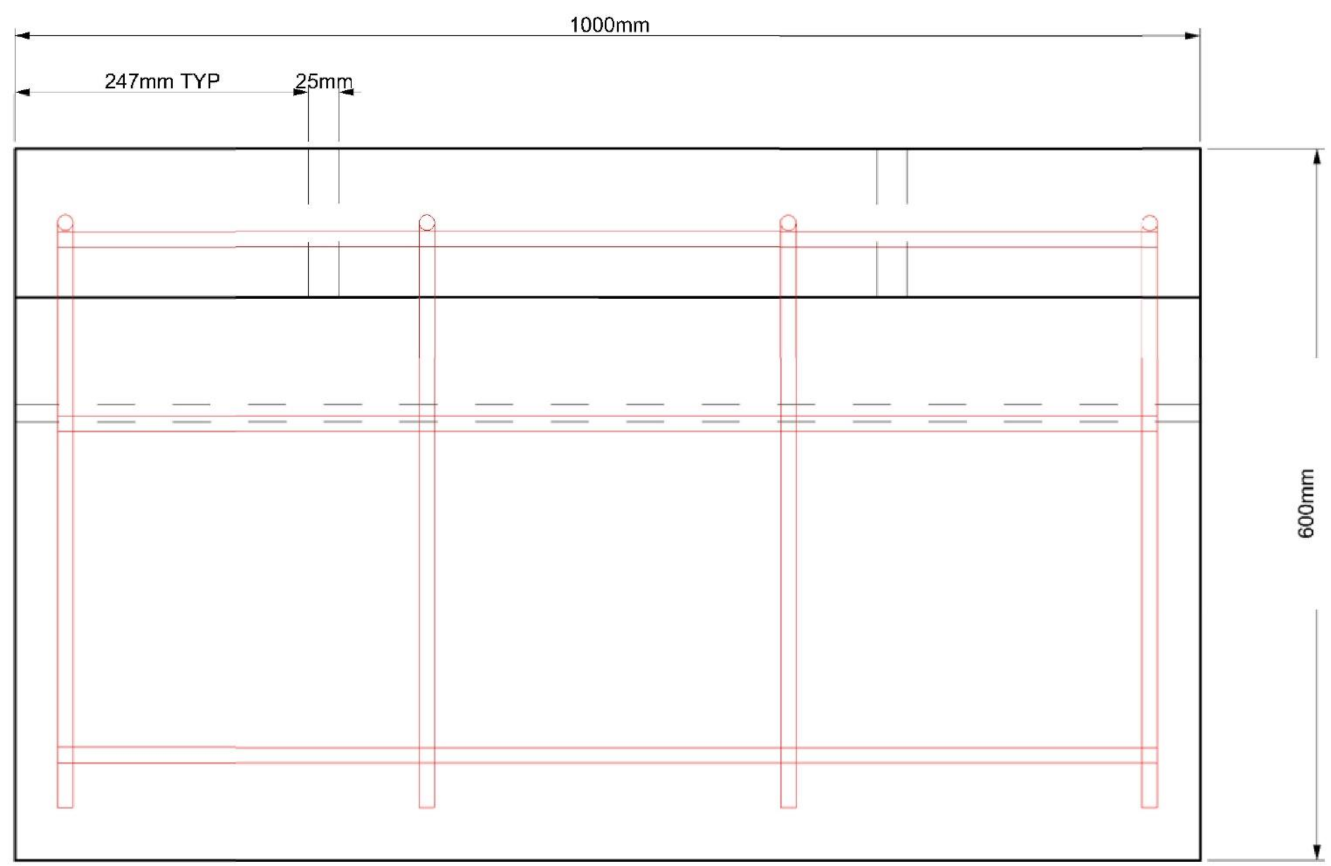
SECTION 10
SCALE 1" = 1'-0"

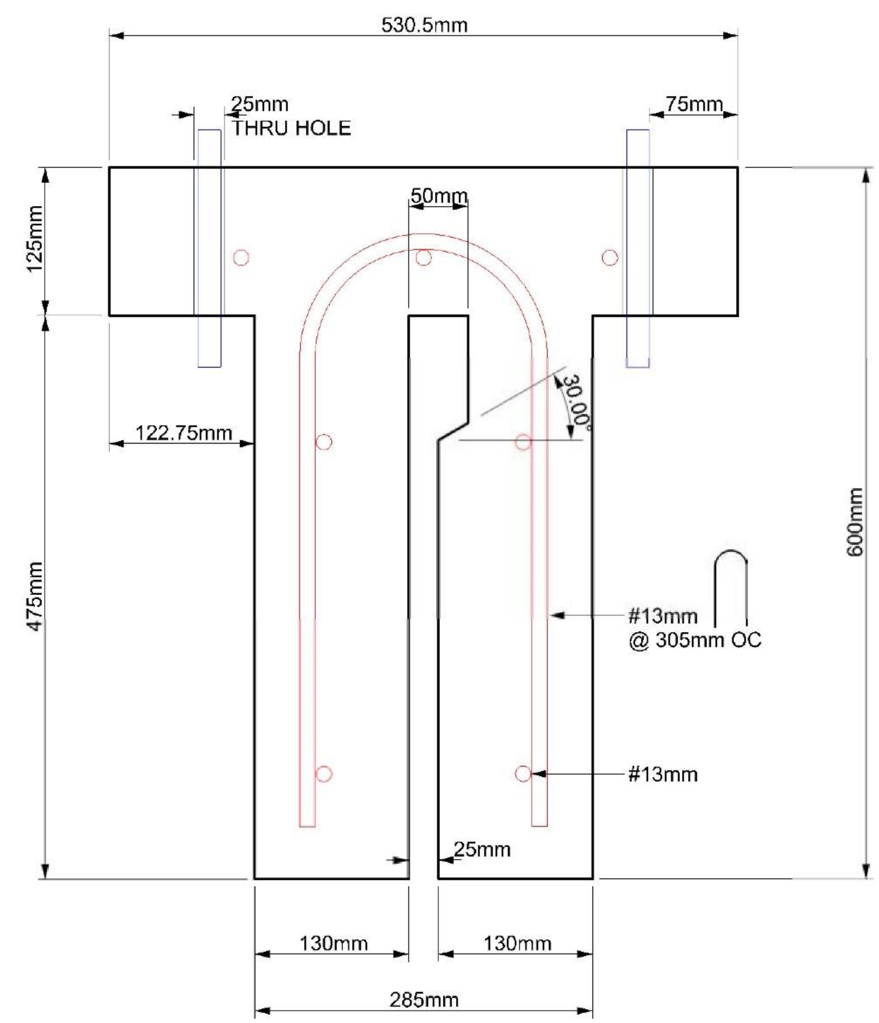
Appendix B-4 (Sheet 2) Concrete panel roost plans. Credit pending.

Appendix B-5. Concrete Hanging Roost Box. Credit Pending

General Notes:
Quantity - 4
Concrete Color - Natural Gray
Finish - Mold Smooth
Sealer - Standard







UNIVERSAL precast concrete	Client:	Mercer Fraser	Project:	Cal Trans Bat Boxes	Desc.:	Bat Boxes	Model #:	Custom	
	Contact:	Chris Hess	Phone:	530-243-6477	Fax: 530-243-6466	Email:	chrish@universalprecast.com		
	Drawing:	Chris Hess	Plant:	530-243-6477	Date: 31 Aug., 2011	Weight:	980 lbs.	Rev: 1.00	Page: 1/1

Approved By:

Name Date

Appendix C. Bat Conservation Non-Governmental Organizations in California

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Bat Conservation Non-Governmental Organizations in California[9]

Name	Contact	Website	Phone	Mission Statement
Yolo Basin Foundation		http://yolobasin.org	(530) 902-1918	To conserve the bats and surrounding habitat at the Yolo Causeway and throughout the Yolo Bypass Wildlife Area.
Bat Conservation International		http://www.batcon.org	(512) 327-9721	To conserve the world's bats and their ecosystems to ensure a healthy planet.
California Bat Working Group (CBWG)		https://www.calbatwg.org	To get on the California Bat Working Group Listserv Contact Joe Szewczak at joe @ humboldt.edu	To facilitate communication regarding bat ecology, distribution, and research techniques, and provide a forum to discuss conservation and management strategies, provide technical assistance, and encourage education.
NorCalBatsopteraoptera		http://norcalbats.org/	530-902-1918	Dedicated to the rescue, rehabilitation and release of bats throughout Northern California, and committed to public education regarding the environmental benefits of bats, and dispelling fears and myths that lead to the death of roosts and colonies.
California Bat Working Group Subgroups	Many subgroup leaders		Use regional website	Same as for CBWG

[9] This is not a comprehensive list.

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Appendix D. Training Resources

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Bat Training Opportunities in California and Beyond

Name	Organization	Website
Various Bat Ecology, Field Techniques, and Acoustics Workshops	The Western Section of the Wildlife Society	http://tws-west.org/
Ecology and Conservation of California Bats	San Francisco State University Sierra Nevada Field Campus	http://sierra.sfsu.edu/Course_BatConservation
Southwestern Desert Bat Class	Maturango Museum	https://maturango.org/southwestern-desert-bat-class/
Various Bat Ecology and Acoustic Training Workshops[1]	Bat Survey Solutions	https://batsurveysolutions.com/

[1] Training workshops are periodically held in the western United States.

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Appendix E. Bat Mitigation Plans

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BAT MITIGATION PLAN

SR-91 SANTA ANA RIVER BRIDGE WIDENING PROJECT

EA-OC5601

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
STREAMBED ALTERATION AGREEMENT NO. 1600-2012-0184-R5

LSA

July 2013

ADDED PER ADDENDUM No. 2 DATED AUGUST 2, 2013

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BAT MITIGATION PLAN

SR-91 SANTA ANA RIVER BRIDGE WIDENING PROJECT

EA-OC5601

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE STREAMBED ALTERATION AGREEMENT NO. 1600-2012-0184-R5

Prepared by:

Jill Carpenter, Senior Biologist
Bat Specialist
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(949) 553-0666
LSA Project No. CDT1127

for

Shannon Crossen
Associate Environmental Planner (Natural Sciences)/District Biologist
Caltrans, District 12
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Irvine, CA 92612

LSA

July 2013

ADDED PER ADDENDUM No. 2 DATED AUGUST 2, 2013

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TABLE OF CONTENTS

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INTRODUCTION

The purpose of this bat habitat mitigation plan is to discuss strategies to minimize impacts to bats during construction activities associated with the widening and seismic retrofit of the State Route (SR-91) bridge over the Santa Ana River for the SR-91 Santa Ana River Bridge Widening Project. These strategies will provide direction to meet the requirements described in the California Department of Fish and Wildlife (CDFW) Streambed Alteration Agreement (SAA) for the SR-91 Santa Ana River Bridge Widening Project (SAA No. 1600-2012-0184-R5) pertaining to project-related impacts to bats. This document also fulfills the requirement set forth in Compensatory Measure 3.1 of the SAA, which stipulates that if a substantial portion of the bat colony is to be excluded for a breeding season or more, a plan will be developed describing the specifics of the existing and replacement roosting habitat and will be submitted to CDFW for review and concurrence. Upon approval from CDFW, the installation of alternate bat roosting habitat, the humane eviction/exclusion of bats, and other recommended mitigation and minimization measures will proceed as described in this document. No deviation from the methodology described in this bat mitigation plan will be made without prior coordination with a qualified bat biologist as approved by CDFW and the Resident Engineer, and authorization/concurrence from CDFW.

BACKGROUND

The California Department of Transportation (Caltrans) is widening the SR-91 Santa Ana River Bridge by adding lanes on to the westbound side of the bridge structure. In addition, a seismic retrofit will be performed while a contractor is mobilized for the widening work; this activity will involve drilling directly into the two hinges and adjacent piers, installing steel cables through the hinges, and attaching the cables to the adjacent piers. The work on this bridge is anticipated to occur over a two-year period.

In February 2012, a daytime habitat assessment was performed at the SR-91 Santa Ana River bridge by LSA Associates, Inc. (LSA) Senior Biologist/bat specialist Jill Carpenter, LSA biologist Sara Louwsma, and Caltrans biologist Shannon Crossen to determine if roosting habitat for bats was present in the bridge structure. During that assessment, two hinges were observed containing crevices suitable for use by day-roosting bats. A large quantity of accumulated guano was observed beneath the southernmost hinge located between Piers 12 and 13, and bat vocalizations were heard from a large section of the hinge with fresh urine staining, indicating the presence of a large number of day-roosting bats. Although a very small quantity of scattered guano was observed beneath the northernmost hinge located between Piers 7 and 8, no fresh urine staining or bat vocalizations were observed at that location. Based upon the prevalence of staining and guano observed throughout the girders of this concrete girder bridge, bats likely utilize the entire bridge for night roosting. Night roosts are used by bats during the evening to rest during foraging bouts, thereby playing an important role in the energetics and social interaction of bats.

A nighttime emergence survey was subsequently conducted at the SR-91 Santa Ana River bridge in June 2012 by Jill Carpenter and Shannon Crossen. During this survey, at least 200 Yuma myotis (*Myotis yumanensis*) were observed emerging from within the southernmost hinge of the bridge structure, located between Piers 12 and 13. A small number of Mexican free-tailed bats (*Tadarida brasiliensis*) were also acoustically detected and observed exiting from this bridge hinge. A dead Yuma myotis juvenile was found among the accumulated guano deposits beneath the expansion joint crevice, confirming the presence of a maternity colony of this species at this location. Given the knowledge that the hinge contains a maternity colony consisting of mothers and nonvolant (flightless) young, and the fact that over 200 bats were observed exiting from the roost crevice, the biologists estimated that at the time of the survey in 2012 at least 400 bats were day-roosting within the hinge. A nighttime survey was not performed at the northernmost bridge hinge between Piers 7 and 8 because when this crevice was examined with a spotlight during the maternity season in 2012, no bats were observed roosting there. However, based upon sparse and sporadic guano deposition observed beneath the hinge, it is possible that a small number of bats was periodically roosting in this crevice. Other seasonal use of these hinge crevices outside the maternity season is not known at this time.

The substantial noise and vibration generated by cofferdam construction, pile driving, demolition of the deck overhang, and drilling into the hinges of the bridge structure for the westbound widening and seismic retrofit of the SR-91 Santa Ana River bridge will impact any bats day-roosting in areas in or adjacent to these construction activities. In addition, the seismic retrofit work, which requires drilling through the hinges and adjacent piers at regular intervals, will directly impact the roosting habitat and any bats roosting within the hinges. Maternity colonies, which often involve large numbers of individuals, are particularly vulnerable to roost disturbance. Disruption and disturbance of a maternity roost would be significant, as disturbance of these roosting areas that are crucial to reproduction in bats can lead to roost abandonment and/or mortality of the bats within that roost. Typically, noise and vibration impacts to bats are minimized by restricting this type of work to a period outside of the maternity season, which is generally considered to be April–August in southern California; however, in this case, the flood control restrictions imposed by the County of Orange limit work within the Santa Ana River drainage to the dates of May 1–October 15, which would leave only six weeks outside of the maternity season. As a result, implementing a work restriction at the bridge during the maternity season on construction activities that generate high levels of noise and vibration (e.g., cofferdam construction and pile driving) would cause excessive constraints on the contractor and substantially increase project costs.

Therefore, to minimize impacts to bats roosting within the SR-91 Santa Ana River Bridge, a humane bat eviction and exclusion should be implemented in the fall (September or October) preceding construction activity to temporarily exclude bats from directly affected work areas and thereby avoid potential direct impacts. This exclusion will be performed along the entire length of the hinge between Piers 7 and 8, and the hinge between Piers 12 and 13, which will be directly impacted by concrete drilling activities during the seismic retrofit work.

Alternative bat roosting habitat will be installed prior to the humane bat eviction/exclusion in order to provide alternative roosting sites for the bats, thereby minimizing the impacts associated with evicting a large number of bats from a roosting site. The total length of the alternative roosting structures will be at least half the total length of the crevice habitat that is utilized by bats and subject to impacts from project construction.

The details of the alternative bat roosting habitat installation and the humane eviction/exclusion are described below. Measures to further minimize impacts to bats through implementation of seasonal work restrictions and biological monitoring of the bat colony are also described.

RECOMMENDATIONS

Installation of Alternate Bat Roosting Habitat

As specified in Compensatory Measure 3.1 of the SAA, if a substantial portion of the bat colony is excluded from the bridge for a breeding season or more, alternative bat roosting habitat will be installed to replace the roosting habitat temporarily lost during the eviction/exclusion. Since the entire colony will be displaced for two maternity seasons due to the timing, length, and disruptive nature of the construction work, alternative bat roosting habitat will be created on the structure prior to excluding the bats from the hinge.

This alternative roosting habitat will replace a minimum of half of the length of the crevices known to be used by roosting bats, which was determined by measuring each section in which bats were directly observed, as well as any sections with urine staining and/or guano accumulation indicating previous use by roosting bats. The majority of bats visibly roosting in the hinge were observed in a 30-foot (ft) section of the hinge between Piers 12 and 13, and the cumulative length of the crevice sections containing roosting bats or evidence of roosting bats measured approximately 80 ft. Since sixteen panels with internal crevice spaces measuring 3.0 ft in length will be installed, a total of 48 ft of roosting habitat will be created in the two bays adjacent to the bay containing the maternity roost hinge. Therefore, this alternate bat roosting habitat will replace more than half of the total length of the crevices known to be used by roosting bats. Furthermore, if left unsealed, the section of bridge added during the widening will result in the lengthening of both hinges, further increasing the total amount of crevice habitat on the SR-91 Santa Ana River Bridge. Both the installation of bat roosting panels and the act of leaving the new hinges open for roosting meet the requirement in Compensatory Measure 3.3 of the SAA, which stipulates that similar features in the new portion of the bridge, or other form of alternative roosts, will be provided for roosting.

The general locations on the bridge structure where the panels will be installed are illustrated in Figure 1 (all figures are located in Appendix A). Eight panels will be installed on the concrete girder at the eastbound edge of the bridge between Piers 14 and 15, and eight panels will be installed on the concrete girder at the eastbound edge of the bridge between Piers 15 and 16, for a total of 16 alternative bat roosting habitat panels comprising 48 ft of crevice habitat created. The two bays between Piers 14 and 16 were selected to position the roost panels as close as possible to the bay between Piers 12 and 13 containing the maternity roost hinge crevice while also being situated away from the seismic retrofit work, which will occur in the bays between Piers 6–9 and between Piers 11–14. The roost panels will be installed along the concrete girder at the eastbound edge of the bridge in order to situate them at the farthest possible point on the bridge from the noise associated with the westbound widening activities. Half of the roost panels will be placed on the side of the girder facing the exterior of the bridge, which receives afternoon sunlight, and half of the roost panels will be placed on the side of the girder facing the interior of the bridge. These two different orientations will allow bats to choose from different temperature regimes as well as offer an option of roosting in panels facing toward and away from project-related noise. The qualified bat biologist will determine and supervise the precise placement and orientation of the bat roosting panels within the indicated areas in the field during installation.

The bat roosting habitat panels will be constructed from lightweight concrete according to the design specifications presented in Figure 2. These specifications are based upon a commonly used panel design known as the “Oregon Wedge” that has been successfully used to house maternity colonies of

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bats, including Yuma myotis, in a variety of mitigation situations. The basic Oregon Wedge design has been modified for the SR-91 Santa Ana River bridge project by adding a roosting ledge for juvenile bats, which will provide more specific and potentially desirable roosting habitat for a maternity colony. These adaptations were made using input and drawings provided by Greg Tatarian of Wildlife Research Associates, who has extensive experience throughout the State of California creating successful bat roosting habitat designs. Representative photos of Oregon Wedge-style panels installed on a bridge are presented in Figure 3. These alternative roosting habitat structures will remain in place following construction and will not be removed. The installation of the roosting habitat panels will be directly supervised and monitored by a qualified bat biologist approved by CDFW.

This work will be initiated upon approval from CDFW; if approval is granted shortly after submittal of this document, installation of the bat roosting panels may occur as soon as mid-August. The alternate bat roosting habitat panels should be installed as far in advance of the humane eviction/exclusion as possible to increase likelihood of their discovery and therefore use by the bats currently roosting in the bridge hinges. Methodology for accessing the underside of the bridge structure for the installation will be determined by the consultant biologist in coordination with the Caltrans biologist. In the event that any equipment is used in the Santa Ana River drainage, measures should be implemented per the relevant permit requirements to ensure compliance with water quality regulations.

Humane Eviction/Exclusion of Roosting Bats

Avoidance/Minimization Measure 2.3 of the SAA stipulates that bats are to be excluded selectively and only to the extent necessary to prevent direct impacts. Due to the nature of the work at the SR-91 Santa Ana River bridge, which will include operations such as cofferdam construction and pile driving that produce high levels of sound and vibration as well as drilling through the hinges for the seismic retrofit and the demolition of the westbound deck overhang, bats will be humanely evicted and excluded from the entire hinge between Piers 12 and 13 for the duration of construction work on the bridge. Although few bats are known to roost within the hinge between Piers 7 and 8, a humane eviction/exclusion will also be performed concurrently at that location to prevent the maternity colony from relocating into that crevice after the eviction. Bat roosting habitat panels will have been installed prior to the eviction/exclusion to provide the bats with an alternative roosting location on the eastbound edge of the bridge as far from the westbound widening work as possible. These locations are also situated away from the seismic retrofit work.

The humane bat eviction/exclusion will be implemented in the fall (September or October) preceding construction activity at the SR-91 Santa Ana River bridge in order to temporarily exclude bats from directly affected work areas and from areas where noise and vibration may potentially result in direct impacts. Exclusion is recommended in the fall to avoid impacts to hibernating bats during the winter months or during the maternity season (typically from April through August in Southern California), when flightless young are present.

During installation of the humane eviction/exclusion devices, each crevice will be closely inspected using flashlights and/or a fiber-optic scope for the presence of day-roosting bats. At crevices where the absence of bats can be confirmed, the crevices may be immediately sealed with material such as foam backer rod or pipe insulation secured with construction adhesive to prevent bats from entering and using these crevices. At crevices where bats are visibly roosting or where their absence cannot be confirmed, humane eviction devices will be installed that will allow the bats to exit the roosting crevice but will prevent them from returning. The qualified bat biologist performing the humane eviction will determine the exact type of humane eviction devices (i.e., one-way doors) and exclusionary material that will be used along the hinge crevice. The one-way doors will remain in place for at least 10–14 days following installation, to allow sufficient time for all bats to vacate the roosting crevice. After this exclusionary period, the one-way doors will be removed and the crevice sealed with foam backer rod and/or pipe insulation secured with construction adhesive. The exclusionary material will remain in place throughout the duration of construction activities at the bridge, and will be inspected by a qualified biologist weekly from March 1–May 31 of each year, and monthly thereafter until the conclusion of construction, as required in Avoidance/Mitigation Measure 2.3 of the SAA. A monthly report summarizing the methods and results of these inspections will be submitted to CDFW for review.

All aspects of the humane eviction/exclusion of bats from the structures will be directly supervised and monitored by a qualified bat biologist approved by CDFW. Following completion of the construction work at the SR-91 Santa Ana River bridge, the contractor (under supervision of a qualified bat biologist) shall remove the exclusionary devices from all hinge crevices where they were installed as required by Avoidance/Mitigation Measure 2.3 and Compensatory Measure 3.3 of the SAA. The action of removing all material from the crevices will allow the bats to return to the roost crevices, thereby resulting in only temporary loss of the bats' preferred roosting habitat in the hinges. If the crevices remain sealed following the end of construction, the loss of roosting habitat for these maternity colonies will be considered permanent.

Methodology for accessing the underside of the bridge structure for the humane eviction/exclusion will be determined by the consultant biologist in coordination with the Caltrans biologist, and will likely involve access from the Orange County Water District levy and associated maintenance/access roads. In the event that any equipment is used in the Santa Ana River drainage, measures should be implemented per the relevant permit requirements to ensure compliance with water quality regulations.

Seasonal Work Restrictions and Noise Minimization

Due to the noise and vibration generated during cofferdam construction and pile driving operations, these activities should not be performed at Piers 13–17 during the maternity season (April 15–August 31) to minimize impacts to maternity colonies of bats roosting in the alternative roosting habitat panels installed between Piers 14 and 15 and to avoid potential abandonment of young, which would be considered "take." The SAA does not authorize "take" of adult or juvenile bats. The contractor may install a noise shroud or sound curtain to attenuate noise from the pile driving and minimize the risk of bats abandoning the alternative roosting sites, particularly when these operations are initiated at Piers 13–17.

Since bats will be excluded from the hinge crevices during construction, and the roosting habitat panels are installed in bays outside of the areas of work for the seismic retrofit, no seasonal restriction on activities associated with the seismic retrofit is necessary.

If construction activities are performed beneath the bridge in the period between dusk and dawn, night lighting should be used only on the portion of the bridge actively being worked on, and focused on the direct area of work. This will minimize visual disturbance and allow bats to continue to utilize the remainder of the bridge for foraging and night roosting.

Biological Monitoring

As stipulated in Compensatory Measure 3.1 of the SAA, the alternative roost site will be monitored quarterly for a 5-year period until the roost is occupied, the existing roost is once again available for occupation and reoccupied as determined by monitoring, and these observations are accepted as satisfactory in writing by CDFW. As part of this monitoring effort, a census of the bat population in the bridge should be performed immediately prior to the humane eviction/exclusion by examining the hinge crevices and the sixteen roosting panels. The roost panels should be examined again at the conclusion of the eviction period to ascertain how many of the bats have moved into the alternate bat roosting habitat.

The number of bats using the alternative roosting habitat panels should be determined again immediately prior to the initiation of construction activities, and a biologist familiar with bats should be present during the start of pile driving and cofferdam installation activities to observe any potential effects on the bats residing within the panels. A biological monitor familiar with bats should also be present for the initiation of cofferdam and pile driving operations occurring at Piers 13–17. If any bats are observed exiting the roost panels when these activities are initiated at the piers near the roost panels, the biological monitor should immediately stop that construction activity for the remainder of the day. The bats will likely abandon the roost that evening, and construction may proceed again the following morning.

At the discretion of the qualified bat biologist in coordination with the Resident Engineer, if bats have completely abandoned the bridge prior to the start of the maternity season due to the high level of noise and vibration occurring from construction activities in other sections of the bridge, and are not present within the bridge during the maternity season, restrictions on work at Piers 13–17 may be lifted. However, if bats abandon the alternative roosts during the maternity season, leaving flightless young behind, this may be considered "take." The SAA does not authorize "take" of adult or juvenile bats, and consequences could include but are not limited to temporary suspension of project construction activities.

Monitoring of the exclusion devices by a qualified biologist is also required in accordance with Avoidance/Mitigation Measure 2.3 of the SAA. As stipulated in this measure, the exclusion material in the two hinge crevices will be inspected weekly from March 1–May 31 of each year, and monthly thereafter until the conclusion of construction. A monthly report summarizing the methodology and results will be submitted to CDFW for review.

Yuma myotis has been documented roosting in swallow nests, and may roost in the cliff swallow nests located along the westbound edge of the bridge. If the swallow nests are removed to prevent swallow nesting during construction activities, they should be removed in a manner that ensures they do not fall to the ground, and a biologist familiar with bats should be present to examine the swallow nests for roosting bats. This removal may be done concurrently with the humane eviction/exclusion, since equipment to access the area beneath the bridge deck will be on-site.

CONCLUSIONS

The alternative bat roosting habitat panels should be installed as far in advance of the humane eviction/exclusion as possible in order to increase likelihood of their discovery and use by the bats currently roosting in the bridge hinges; therefore, the installation of bat roosting panels will be initiated shortly after receiving approval from CDFW. If approval is granted shortly after submittal of this document, installation of the bat roosting panels is anticipated to occur in mid-August 2013. Monitoring of these roosting habitat panels will commence shortly after installation and continue for up to 5 years until released from this requirement from CDFW in writing as required in the SAA.

Implementation of the alternative roosting habitat installation, humane eviction/exclusion, seasonal work restrictions, and biological monitoring as described in this plan are expected to reduce project-related impacts to bats to the greatest extent practicable given the nature and duration of the work at the SR-91 Santa Ana River bridge. However, Caltrans does reserve the following disclaimer relating to required operations.

> Disclaimer:
>
> The structural elements and features that facilitate the life history of bat species on a bridge or other transportation facility are subject to regular inspection, repair, rehabilitation, alteration, and/or replacement as part of normal operations and maintenance, and may on occasion reduce or eliminate the habitat values provided.
>
> [Caltrans] will take reasonable measures to avoid and minimize unnecessary disruptions to the animal's normal behavior patterns, which include, but are not limited to, breeding, feeding and sheltering. However, this accommodation does not preclude [Caltrans] from future engineering actions that are found to be necessary to meet the transportation needs of California, or from measures to ensure the safety of the public or [Caltrans] personnel. Habitat values may be removed with little or no advanced notice in those situations where it is necessary to immediately prevent or inspect damage or where the stability of the structure is in question.

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APPENDIX A

FIGURE 1: PROPOSED LOCATIONS FOR ALTERNATIVE BAT ROOSTING HABITAT
FIGURE 2: PROPOSED DESIGNS FOR ALTERNATIVE BAT ROOSTING HABITAT STRUCTURES
FIGURE 3: REPRESENTATIVE PHOTOS OF ALTERNATIVE BAT ROOSTING HABITAT STRUCTURES

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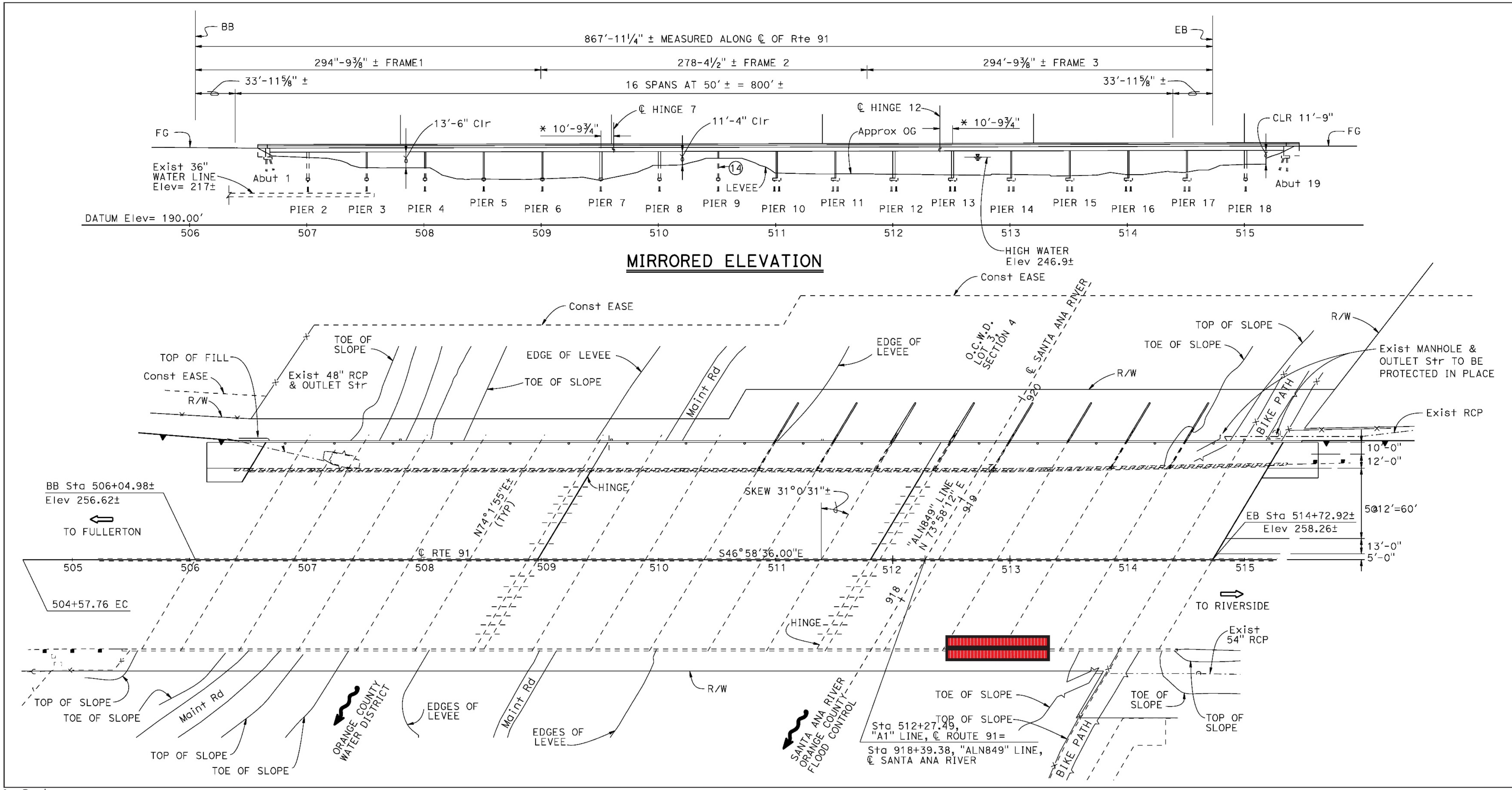

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FIGURE 1

LEGEND

- BAT ROOSTING HABITAT PANELS
- NEW STRUCTURE
- EXISTING STRUCTURE
- BRIDGE REMOVAL PORTION
- DIRECTION OF TRAFFIC FLOW
- * MEASURED PARALLEL TO ℄ Rte 91

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SR-91 Santa Ana River Bridge Widening Project
EA-OC5601
Bat Mitigation Plan

Proposed Locations for Alternative Bat Roosting Habitat Structures

SOURCE: State of California Department of Transportation 1/30/13
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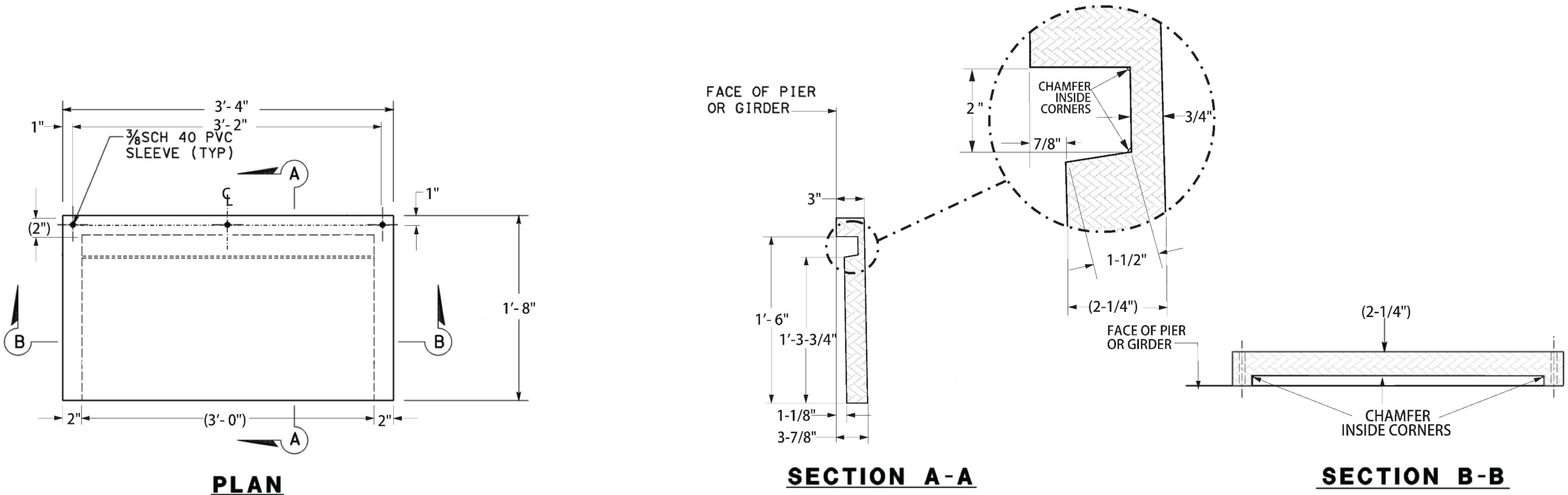

NOTES:*

1. USE 3⅜" SCH 40 PVC PIPES x 1¾"
   3- RED HEAD WEDGE ANCHOR - 3/8" X 5"
   f'ci = 4000 psi (LIGHT WEIGHT CONC.)
2. USE "CHICKEN WIRE" OR EQUIVALENT FOR REINFORCEMENT IN 3/4" SLAB.

***These bat roosting panel designs were created and modified with input and sample designs provided by Greg Tatarian of Wildlife Research Associates, Inc. (www.wildliferesearchassoc.com)**

LSA

FIGURE 2

SR-91 Santa Ana River Bridge Widening Project
EA-OC5601
Bat Mitigation Plan

Proposed Designs for Alternative Bat Roosting Habitat Structures

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Representative view of Oregon Wedge-style bat roosting panels installed on girders beneath a bridge. The panels shown here are currently occupied by a large number of day- roosting bats.

View looking straight up into the crevice spaces created by Oregon Wedge-style bat roosting panels installed on girders beneath a bridge.

LSA

FIGURE 3

SR-91 Santa Ana River Bridge Widening Project
EA-OC5601
Bat Mitigation Plan

Representative Photos of Alternative Bat Roosting Habitat Structures

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Appendix F. Climate Map

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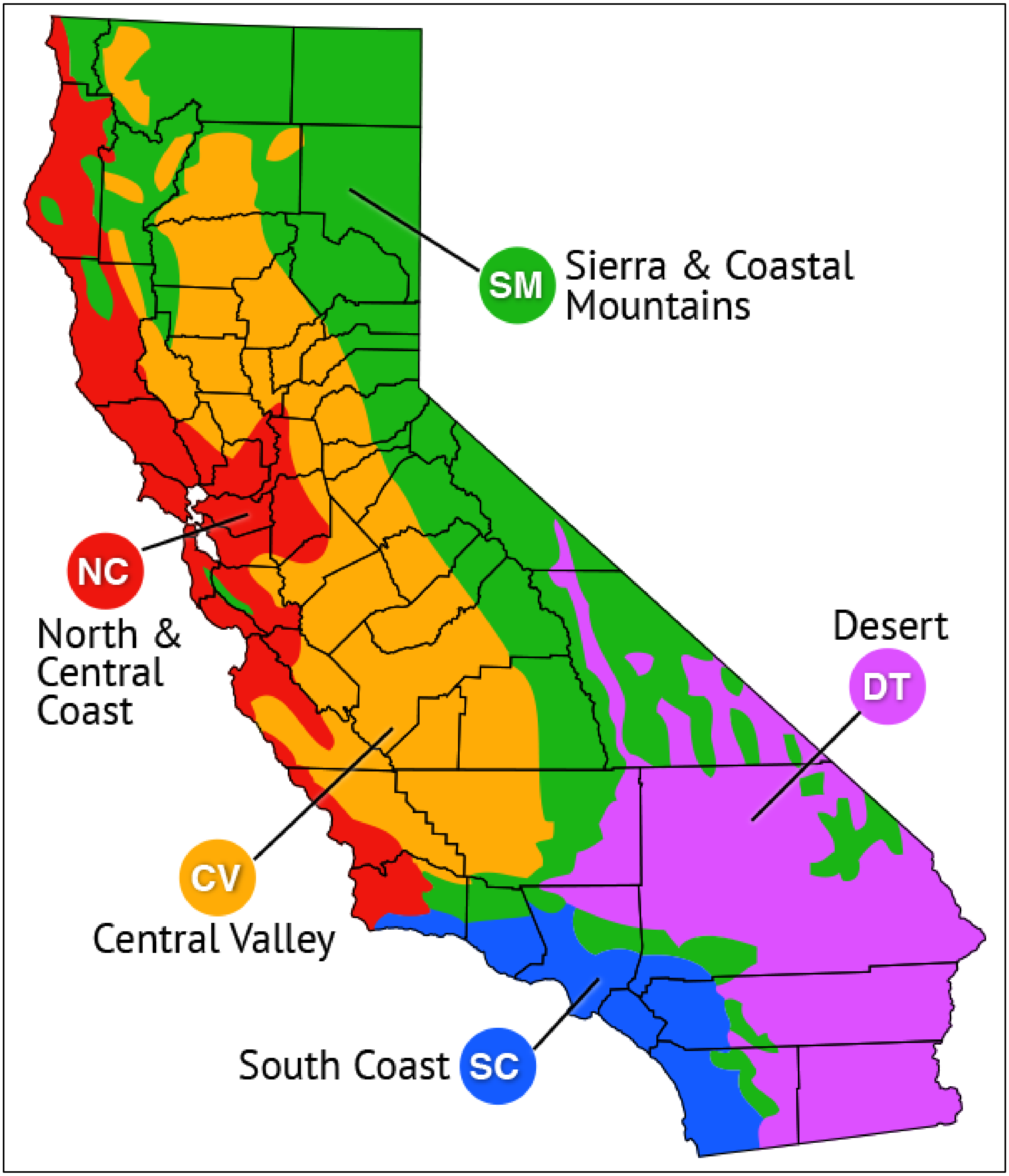

California Climate Regions. Source: plantright.org

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