Wildlife Infrastructure Plan for State Route 94, San Diego County Post Miles 15.27 to 30.00

Prepared for:

California Department of Fish and Wildlife

Natural Community Conservation Planning

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Prepared by:

Conservation Biology Institute

in collaboration with

U.S. Geological Survey

U.S. Bureau of Land Management

San Diego National Wildlife Refuge

California Department of Transportation

California Department of Fish and Wildlife

San Diego Management and Monitoring Program

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CONSERVATION BIOLOGY INSTITUTE

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List of Abbreviations

BLM	Bureau of Land Management
CalTrans	California Department of Transportation
CBI	Conservation Biology Institute
CDFW	California Department of Fish and Wildlife
CROS	California Roadkill Observation System
FHWA	Federal Highway Administration
HCWA	Hollenbeck Canyon Wildlife Area
MSCP	Multiple Species Conservation Program
MSP	Management Strategic Plan 08.27.2013
MU	Management Unit
NCCP	Natural Community Conservation Planning
RJER	Rancho Jamul Ecological Reserve
ROW	Right-of-Way
SDMMP	San Diego Management and Monitoring Program
SDNWR	San Diego National Wildlife Refuge
SDSU	San Diego State University
SR	State Route
TEE	Tribal Environmental Evaluation
TNC	The Nature Conservancy
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

Executive Summary

The California Natural Community Conservation Planning (NCCP) program is an ecosystem-based approach to conserving species and their habitats in a linked network of high quality habitat blocks, with an emphasis on maintaining landscape integrity and ecosystem functions. NCCP-conserved lands in southern San Diego County (South County) support the largest expanse of remaining coastal habitats in southern California—coastal sage scrub, maritime succulent scrub, chaparral, riparian woodlands, vernal pools, and grasslands. Intact landscapes are critical to genetic interchange within plant and animal populations and allow dispersal and recolonization of new areas. Large landscapes that span elevational gradients, such as this core area in South County, also enable populations to shift in response to environmental and land use changes.

State Route 94 (SR-94), among other roads, cuts through the heart of this core area, potentially impeding wildlife movement across otherwise intact landscapes. New residential development and a casino under construction in Jamul will increase traffic and potentially impact the wildlife value and connectivity of adjacent conserved lands. Proposed road improvements associated with these new land uses provide an opportunity to mitigate the potential barrier effects of SR-94 as well as accommodate current hydrologic flow that has increased as a result of development and additional impervious surface not anticipated in the original design of the highway. Scientific literature suggests that strategically-placed wildlife fencing along roads, combined with effective wildlife crossing areas (e.g., undercrossings, overcrossings, bridges) are the most effective means of influencing animal behavior and directing animal movement, thereby reducing roadkill, enhancing connectivity, and improving traffic safety.

The purpose of this document is to (1) identify where improvements to existing infrastructure on SR-94 could improve connectivity across the South County preserves, using Best Management Practices from the scientific literature, (2) recommend wildlife movement monitoring to identify where new crossings are needed, and (3) identify where additional conservation would enhance the integrity of South County linkages. Wildlife movement studies, camera traps, and systematic collection of roadkill data will refine the design and placement of wildlife fencing and crossing structures. Once implemented, post-construction monitoring should be conducted to ensure that the new infrastructure is functional and cost-effective.

This review prioritizes infrastructure improvements of 35 existing undercrossings inspected by wildlife experts in the field along 14.6 miles of SR-94 where the highway bisects conserved lands—particularly between the San Diego National Wildlife Refuge (SDNWR), where a box culvert has been designed specifically for this undercrossing, between Rancho Jamul Ecological Reserve (RJER) and Hollenbeck Canyon Wildlife Area (HCWA), and between Bureau of Land

Management (BLM) lands and the Lawrence and Barbara Daley Preserve (LB Daley). In total, SR-94 crosses >10 miles of conserved lands with only three bridges—at the Sweetwater River, Dulzura Creek, and Campus Grove bridge in Dulzura. Following is a summary of improvements recommended for existing undercrossings and proposed new undercrossings, by segment, presented in this document.

Seg.	Conserved lands	# linear feet (% conserved[1])	# bridges	# culvert improvements[2]	New undercrossings[3]
1	SDNWR	6,492 (91%)	Sweetwater	0	0
2	none	5,394 (0%)	0	0	0
3	SDNWR	9,127 (100%)	0	7	1
4	none	9,135 (0%)	0	0	0
5	RJER/HCWA	4,372 (100%)	0	2	1
6	RJER/HCWA	7,232 (100%)	0	3	0
7	RJER/HCWA	9,220 (100%)	Dulzura Crk	2	3
8	BLM/HCWA	6,677 (100%)	0	3	1
9	BLM/LB Daley	9,194 (100%)	0	1	0
10	BLM	10,389 (25%)	Campus Grove	7	0
TOTAL		77,232 (70%)	3		

[1] On at least one side of the highway

[2] Near-term improvements or replacements proposed for existing undercrossings

[3] Longer-term proposed new undercrossings

The majority of the recommendations for infrastructure improvement focus on increasing the diameter, and thus the openness ratio (cross-sectional area divided by length), of the undercrossing itself, removing vegetation and debris blocking the undercrossing, restoring habitat in the approach to the undercrossing, and installing fencing to both (1) keep animals off the highway and (2) funnel wildlife to the undercrossings. These improvements are intended to facilitate connectivity for the community of species, as opposed to a single target species. Monitoring wildlife movement should help inform placement of new undercrossings and evaluate their effectiveness post-construction. Increasing the diameter of existing undercrossings and restoring approaches will also facilitate the current and future volume of hydrologic flow, not anticipated in the original design of the highway.

The appendices summarize the covered species that will benefit from these improvements, along with examples of proposed infrastructure and their costs, and roadkill data over the past 5 years. The cost of not implementing these improvements will be a loss of habitat integrity and ecosystem function in the largest core area in San Diego County.

1 Introduction

The rural, mostly two-lane, portion of SR-94 through Jamul, Dulzura, and Potrero was originally a stagecoach route in the late 1800s. In 1933 the County of San Diego transferred responsibility for the highway to Caltrans. This County-designated Scenic Highway is infamous for its curves, climbs, limited sight distances, narrow shoulders, and boulders, as well as for the beauty of the conserved lands that border it. Proposed residential development, road improvements, and a casino under construction in Jamul will increase traffic on SR-94 that will impact habitat integrity and ecosystem functions of the lands conserved as part of the NCCP. Potential impacts are likely to be species-specific and include animal mortality from increased traffic and decreased survivorship (i.e., create "population sinks") for animals that do not or cannot avoid the road due to inherent spatial habitat and migratory needs. At the same time, road improvements associated with these new land uses provide an opportunity to mitigate the potential barrier effects of SR-94 to wildlife populations and conservation values, as well as accommodate existing and future hydrologic flow not anticipated in the original highway design.

Western San Diego County supports three NCCP programs that comprise a network of biological core areas and linkages aimed at maintaining and enhancing covered species and their associated vegetation communities. NCCP-conserved lands in South County alone support 22 federally and state-listed species and 53 species covered by the Multiple Species Conservation Program (Appendix A). These lands are fundamental to the integrity of the overall San Diego County NCCP preserve network (Figure 1). As population growth and development increase, management and monitoring programs are being implemented to mitigate threats to conserved lands and ecosystem functions. These programs are coordinated by the San Diego Management and Monitoring Program (SDMMP) and funded by the Environmental Mitigation Program for the regional transportation program (Transnet). The SDMMP identified eight Management Units (MU) as part of the Management Strategic Plan (MSP, SDMMP 2013). The study area for this project is within MU3 (Figure 2).

1.1 Purpose of this Plan

Many conservation actions are necessary to enhance connectivity across the South County preserves that connect the Cleveland National Forest with the Otay Mountain Wilderness Area (Figures 1 and 2). These actions include strategic land conservation, habitat restoration, land use enforcement, adaptive management, and enhanced permeability of major roads, including SR-94, Otay Lakes Road, Proctor Valley Road, and Honey Springs Road, among others.

The purpose of this review is to (1) identify where improvements to existing infrastructure along 14.6 miles of SR-94 could improve connectivity in MU3 and decrease the potential for

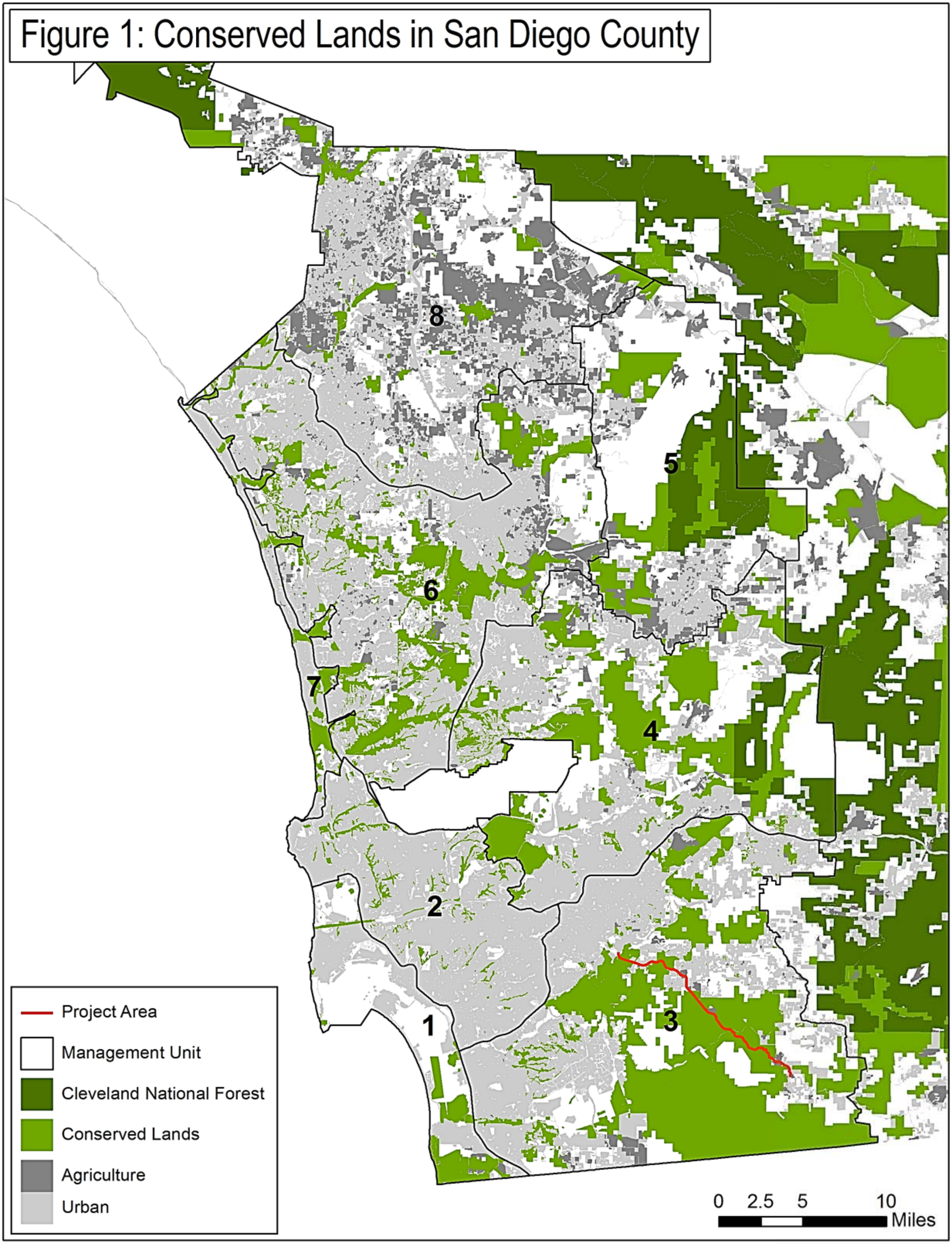
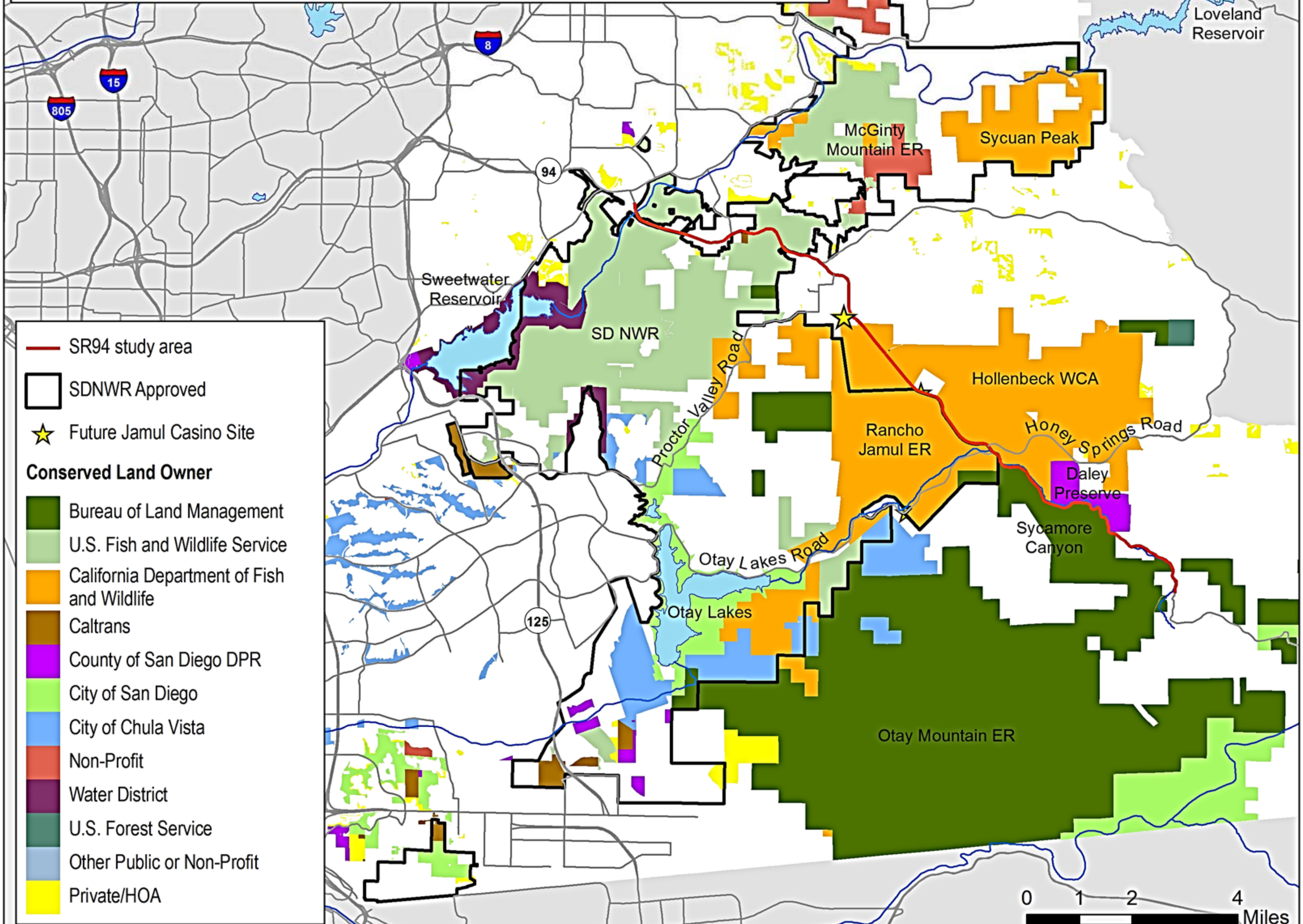


Figure 1: Conserved Lands in San Diego County
8
5
6
4
7
2
3
1
Project Area
Management Unit
Cleveland National Forest
Conserved Lands
Agriculture
Urban
0
2.5
5
10
Miles

Figure 2: SR-94 Wildlife Infrastructure Plan Study Area



wildlife-vehicle collisions, (2) recommend wildlife movement monitoring to identify where new crossings are needed on SR-94 and other roads, and (3) identify where additional conservation would enhance the integrity of South County linkages. Wildlife movement studies, camera traps, and systematic collection of roadkill data will refine the design and placement of wildlife fencing and crossing structures. Once implemented, post-construction monitoring should be conducted to ensure that the new infrastructure is functional and cost-effective. These studies should include landscape modeling, road mortality monitoring that includes daytime and night time surveys and wet-season/dry season surveys by biologists, estimates of wildlife population sizes, territory and range sizes, distance and frequency of movement within or between metapopulations, and frequency of use of various crossing areas by targeted taxa. Once road improvements are implemented, post-construction monitoring should be conducted to ensure that the new infrastructure is functional and cost-effective.

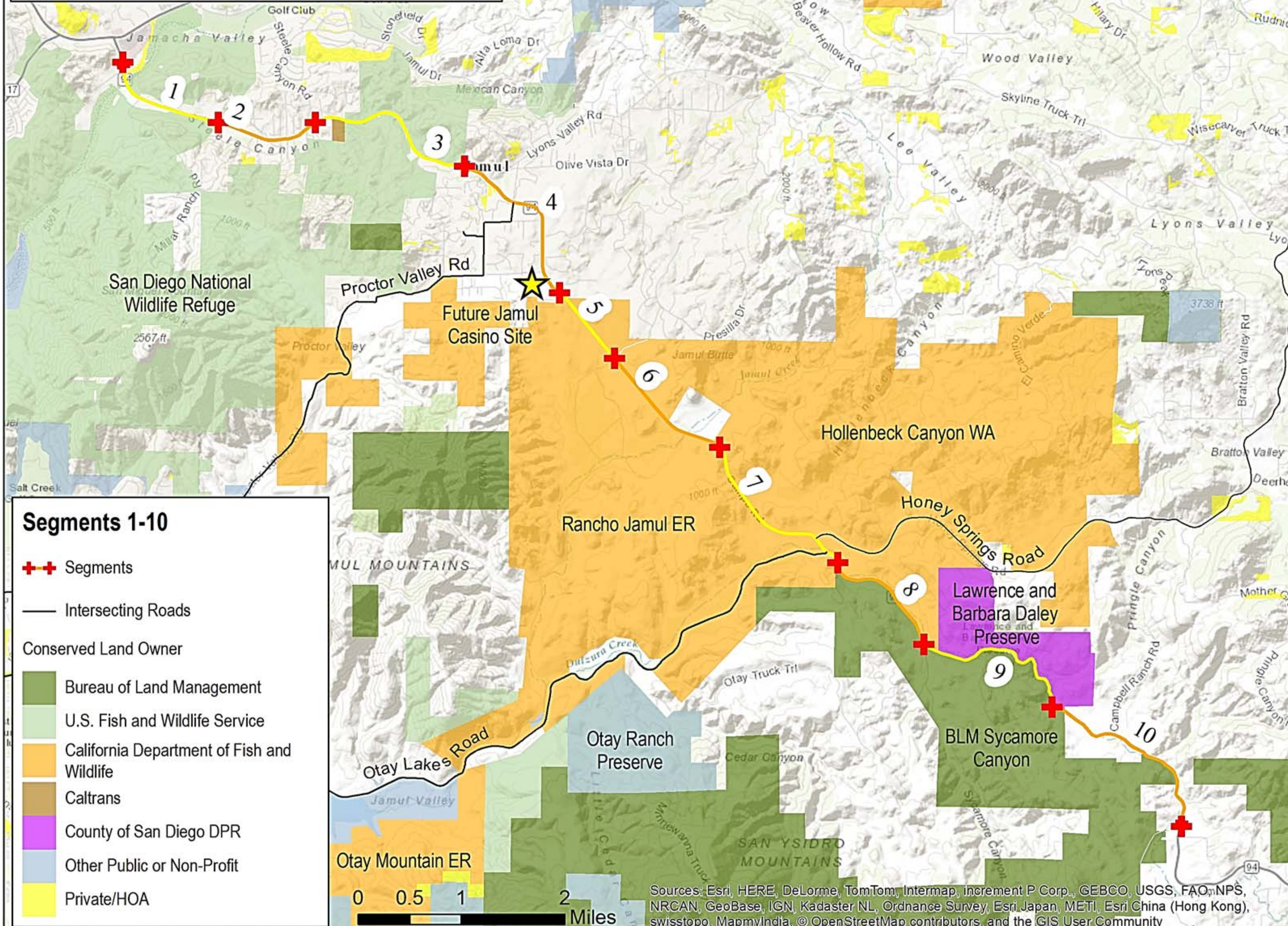
1.2 Process/Methods

This review was informed by SDMMP's Connectivity Monitoring Strategic Plan (SDMMP 2011), previous roadway and tracking studies (USGS unpublished data, W. Vickers unpublished data, Tracey et al. 2014), baseline studies and management plans for RJER and HCWA (EDAW 2008, Hathaway et al. 2002, Madden-Smith et al. 2004, TAIC 2008, 2011; USFWS SDNWR 1999, USGS et al. 2002), roadkill data (Appendix B), SDMMP species data, and on-the-ground field reconnaissance with local wildlife movement experts and land managers in the study area (Dillingham 2015)[1]. We divided SR-94 into 10 segments between the Sweetwater River and Marron Valley Road (Figure 3), based on land uses (conserved, commercial, residential, etc.), terrain, and vegetation community (flat, steep, grassland, coastal sage scrub, riparian/oaks). Under a Caltrans encroachment permit (no. 11-14-6SV-0260) authorizing fieldwork within the Caltrans Right-of-Way (ROW), we assessed the following conditions, which are summarized by segment in Section 3.4:

- Land uses, degree of human activity, and landscape condition.
- Locations and sizes of existing infrastructure (e.g., undercrossings, fences, cattle guards, gates) and presumed use, based on observed animal sign, condition, and apparent functionality of infrastructure (e.g., culvert full of sediment or water, undercrossings blocked by overgrown vegetation, broken fence, placement of undercrossings relative to landscape features, spacing of undercrossings).

[1] J. Terp, J. Martin, J. Schlachter, T. Nelson, T. Dillingham, S. Brown, R. Rempel, Y. Moore, C. Rochester, R. Fisher, B. Martin, W. Vickers, J. Vinje, J. Stallcup, SDSU engineering students, various dates 2013-2015.

Figure 3: Overview of Segments



- Potential fencing needs along the highway and access roads, considering the needs of various taxa.
- Features that influence visibility of drivers and behavior of wildlife, including topographic contours (e.g., ridgelines or ravines), vegetation communities (riparian, grassland, scrub, woodland), curvature of the highway, and width of ROW.
- Areas where potential mitigation measures can be incorporated to either keep animals off the highway (e.g., fences, cattle guards, barriers) or allow escape for wildlife on the highway (e.g., jump-outs for deer).

Monitoring of wildlife approaches to SR-94 and road-crossing behaviors of target species should inform infrastructure improvements and placement. We reviewed examples of infrastructure in the literature (Appendix C) and potential placements for an undercrossing designed by San Diego State University (SDSU) civil engineering students (Appendix D).

2 Conservation Context

While South County comprises the largest blocks of conserved land in the San Diego NCCP planning area, the MU3 preserve network is not yet completely conserved as proposed by the MSCP Plan. Many private lands needed for connectivity could be developed, and loss of these habitats will not only result in loss of significant natural resources but will fragment existing landscape-scale management initiatives on conserved lands, increase sources of fire ignition, and increase the area of habitat managed for fire (i.e., the Wildland Urban Interface). Moreover, loss of habitat could preclude linkages across elevational gradients to Forest Service lands, a factor important to accommodating adaptations in response to climate change. Continued development in South County will produce more edge effects, greater recreational pressures, and increased traffic, adding to the impacts of roads on South County preserves.

Conserving and managing connectivity between and within these conserved lands is a goal of the MSCP, a directive in the habitat management plans for the San Diego National Wildlife Refuge (SDNWR), Rancho Jamul Ecological Reserve (RJER), Hollenbeck Canyon Wildlife Area (HCWA), and Lawrence and Barbara Daley Preserve (LB Daley Preserve) along SR-94 (County of San Diego 2011, EDAW 2008, TAIC 2008, USFWS SDNWR 2014), and critical to the sustainability of the Otay Mountain Ecological Reserve (OMER), McGinty Mountain Ecological Reserve (MMER), and other lands in MU3 (Table 1).

This section identifies selected examples of important linkages that require conservation and other major roads that should be evaluated for infrastructure improvements. It also identifies the species targeted for connectivity monitoring and their habitats on either side of SR-94.

Table 1—Conservation acreages by land manager/owner in MU3.

Land manager/owner	Major preserves in study area	MU3 (acres)
US Fish and Wildlife Service	SD National Wildlife Refuge (SDNWR)	11,652
California Department of Fish & Wildlife	RJER, HCWA, OMER, MMER	18,250
Bureau of Land Management	Sycamore Canyon	27,496
County of San Diego	LB Daley Preserve	10,044
City of San Diego Public Utilities District	Otay Lakes Cornerstone Lands	8,236
City of Chula Vista	Otay Ranch Preserve	2,614
Otay Water District	San Miguel Habitat Management Area	238
Sweetwater Authority	Sweetwater Reservoir	1,777
The Nature Conservancy	McGinty Mountain	588
Endangered Habitats Conservancy	South Crest	966
TOTAL		81,861

2.1 Linkage Conservation Priorities

National Wildlife Refuge to Sycuan Peak Ecological Reserve. Functional connectivity between the SDNWR (SR-94 Segment 3) and Sycuan Peak Ecological Reserve will require strategic conservation of lands between Jamul, McGinty Mountain, and the Sycuan Peak Ecological Reserve (Figure 4).

CDFW Hollenbeck Canyon. Conservation of some or all of the Hollenbeck Canyon Conceptual Area Protection Plan (CAPP) will complete the linkage identified through SR-94 Segments 5, 6, and 7 (Figure 3) to Forest Service lands to the east (Figure 4). This linkage is a priority for large mammals, including deer and mountain lions (pers. comm. W. Vickers, R. Burg).

BLM. Strategic acquisition or conservation easements east of SR-94 Segment 10 (Figure 3) will connect BLM, City of San Diego PUD, and Forest Service lands (Figure 5). To improve connectivity in the southern portion of the SR-94 study area, we recommend evaluating lands important to complete the conservation linkage connecting BLM, City of San Diego PUD, and Forest Service lands (Figure 5). This could include acquisition (or conservation easement) of the 31.7-acre parcel to connect BLM property across SR-94 (Arbabian APN 64905009) and to other BLM lands to the east (e.g., Mottola APN 64909006).

Otay Valley Regional Park. The planning area for Otay Valley Regional Park links south San Diego Bay with Otay Mountain, San Miguel Mountain, and the Jamul Mountains. The planning area boundary encompasses 9,195 acres (Figure 6), of which 5,562 acres have been conserved, and another 1,055 acres are pending conservation as part of the Otay Ranch mitigation (County of San Diego, City of Chula Vista, and City of San Diego 2001). The area includes resources critical to the biodiversity of south San Diego County, including maritime succulent scrub, vernal pools, and endemic plant species. The Conservation Implementation Plan for the coastal cactus wren in southern San Diego County targets this area as a conservation priority for the Otay genetic subunit of the species (TNC and SDMMP 2015).

Proctor Valley—Otay Ranch. Proctor Valley lies at the center of the SDNWR planning boundary and supports Quino checkerspot butterfly, vernal pools, and foraging habitat for golden eagles, among other resources. Proctor Valley Road cuts through the middle of conserved lands managed by the SDNWR, CDFW, and City of San Diego PUD (Figure 7). Acquisition of additional lands in Proctor Valley would reduce existing edge effects from privately owned land, facilitate habitat management and restoration among the land managers, and enhance connectivity.

As Proctor Valley Road intersects with SR-94 in Segment 4, traffic associated with the Jamul Casino and Hotel will likely use Proctor Valley Road and thus further increase cumulative levels of traffic (Kimley-Horn 2012) on SR-94. Thus, closing Proctor Valley Road to through-traffic at

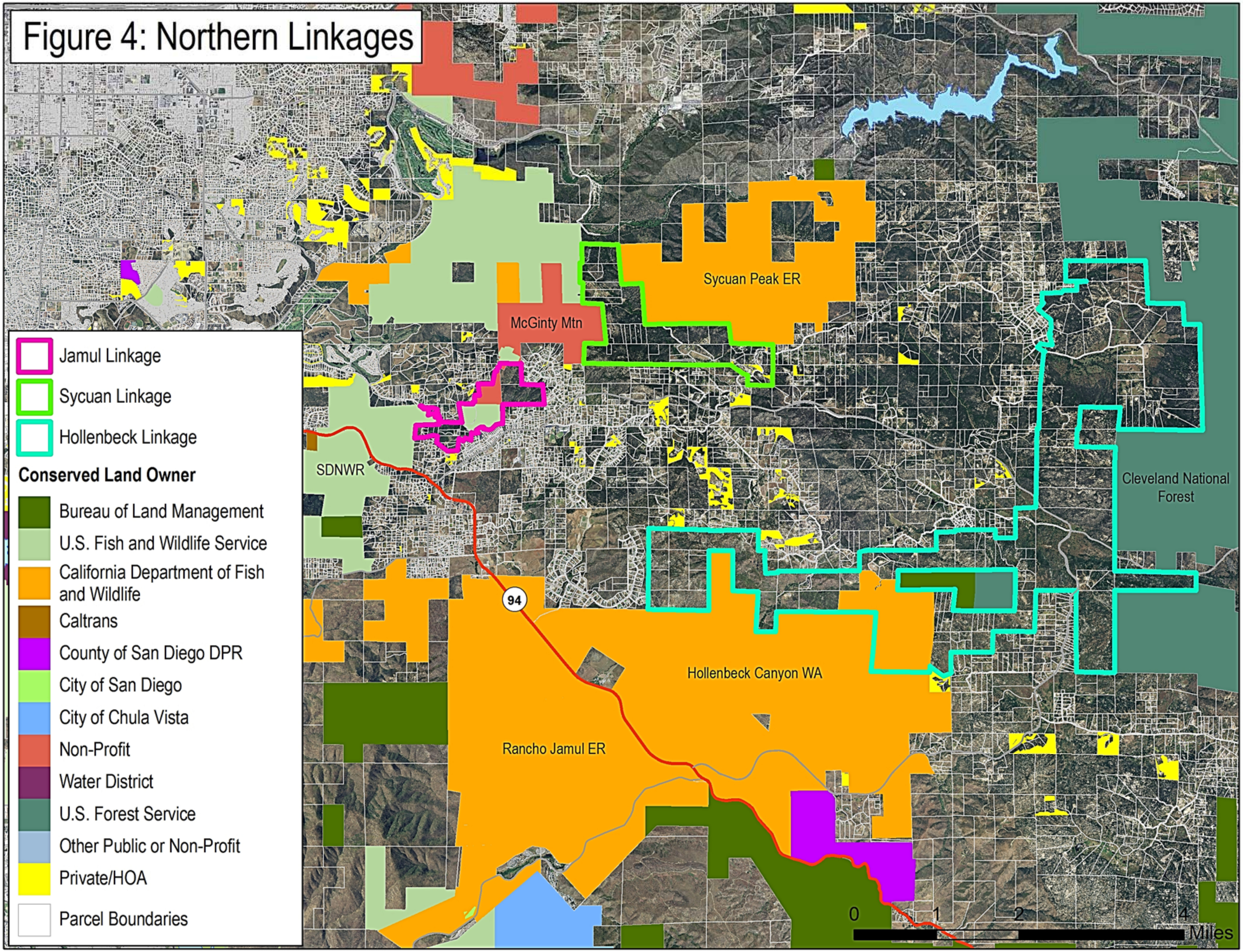


Figure 4: Northern Linkages
Jamul Linkage
Sycuan Linkage
Hollenbeck Linkage
Conserved Land Owner
Bureau of Land Management
U.S. Fish and Wildlife Service
California Department of Fish and Wildlife
Caltrans
County of San Diego DPR
City of San Diego
City of Chula Vista
Non-Profit
Water District
U.S. Forest Service
Other Public or Non-Profit
Private/HOA
Parcel Boundaries
Sycuan Peak ER
McGinty Mtn
SDNWR
Cleveland National Forest
94
Hollenbeck Canyon WA
Rancho Jamul ER
0
1
2
4
Miles

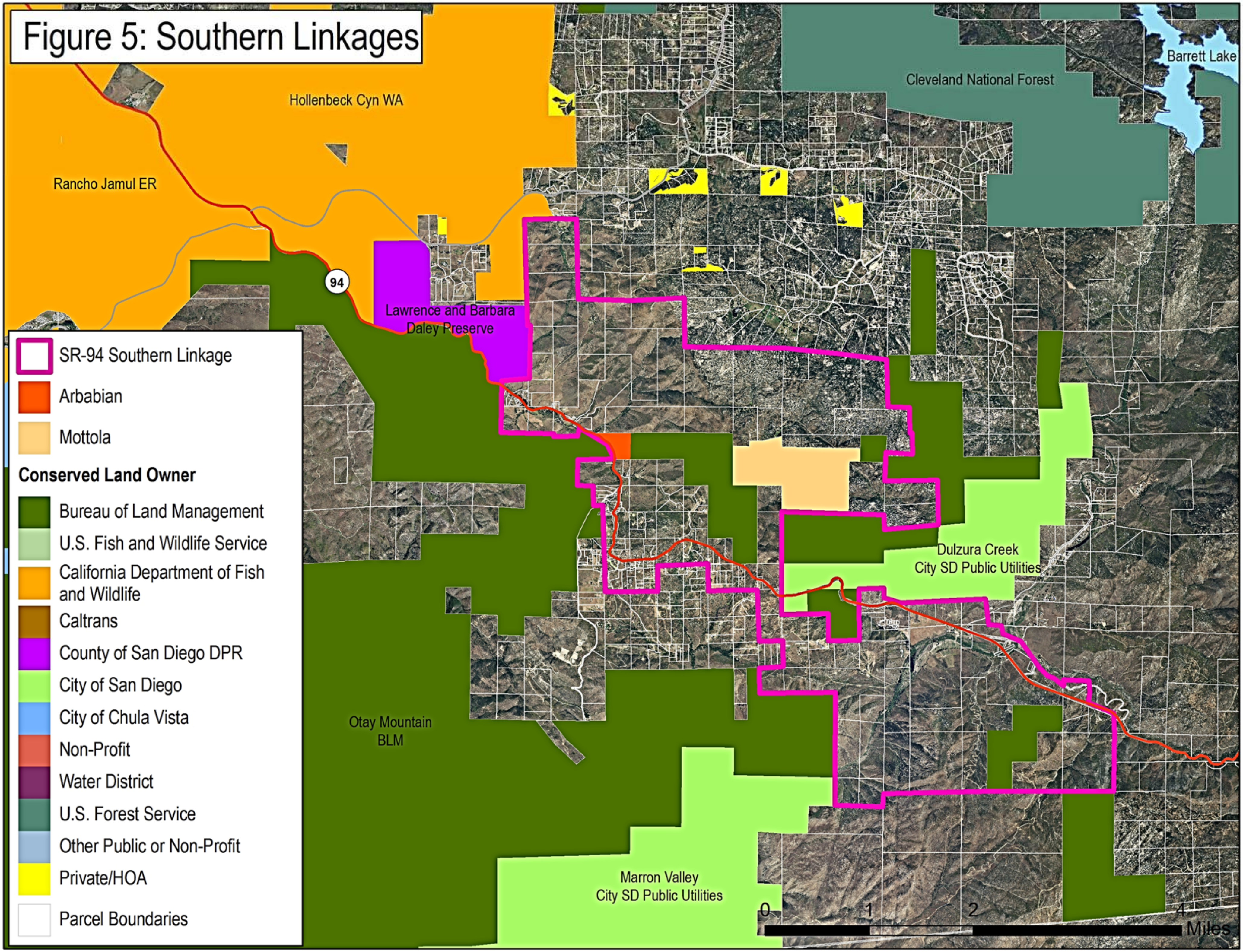


Figure 5: Southern Linkages
Hollenbeck Cyn WA
Rancho Jamul ER
Cleveland National Forest
Barrett Lake
94
Lawrence and Barbara Daley Preserve
Dulzura Creek
City SD Public Utilities
Otay Mountain
BLM
Marron Valley
City SD Public Utilities
0
1
2
4
Miles
SR-94 Southern Linkage
Arbabian
Mottola
Conserved Land Owner
Bureau of Land Management
U.S. Fish and Wildlife Service
California Department of Fish and Wildlife
Caltrans
County of San Diego DPR
City of San Diego
City of Chula Vista
Non-Profit
Water District
U.S. Forest Service
Other Public or Non-Profit
Private/HOA
Parcel Boundaries

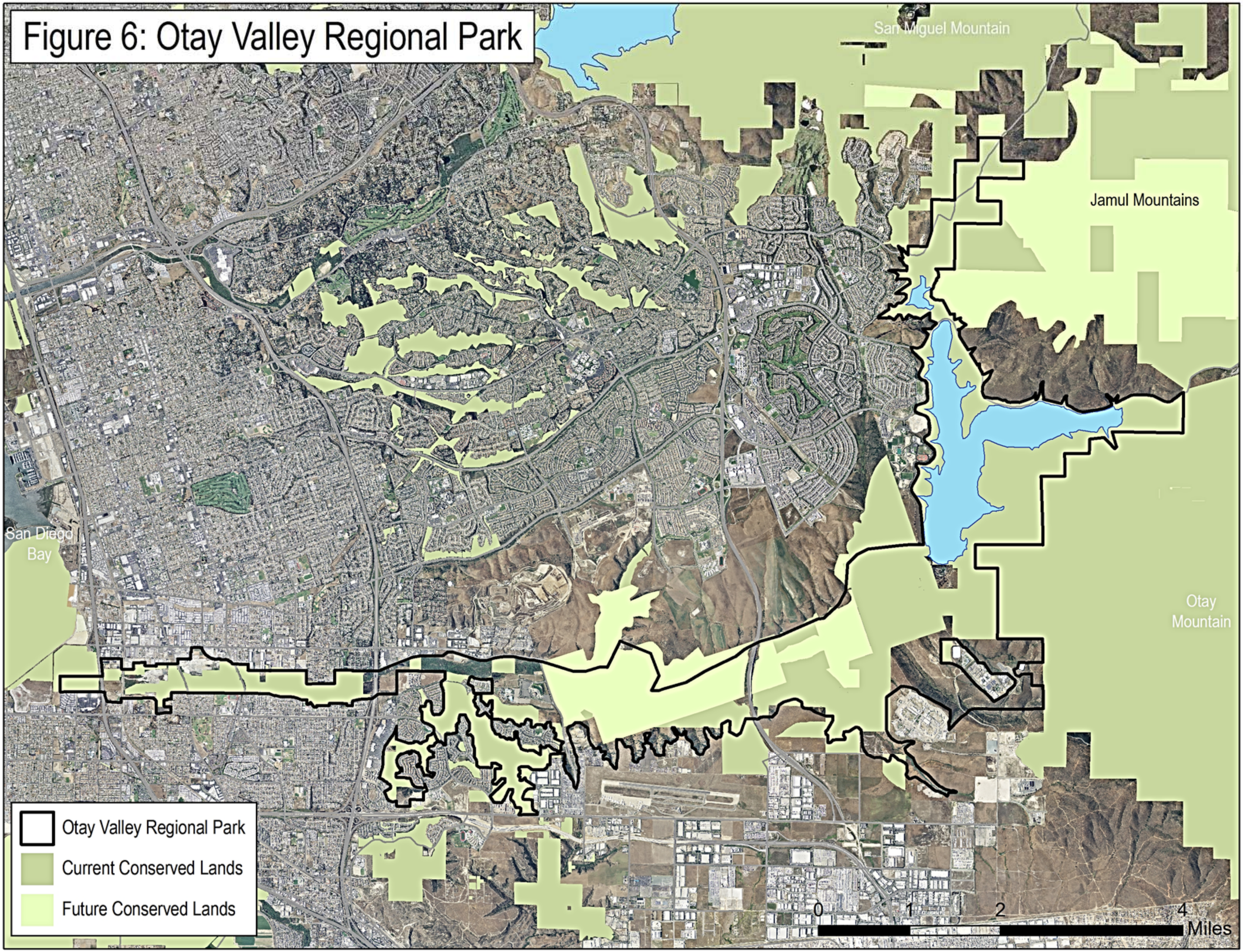


Figure 6: Otay Valley Regional Park
San Miguel Mountain
Jamul Mountains
San Diego Bay
Otay Mountain
Otay Valley Regional Park
Current Conserved Lands
Future Conserved Lands
0
1
2
4
Miles

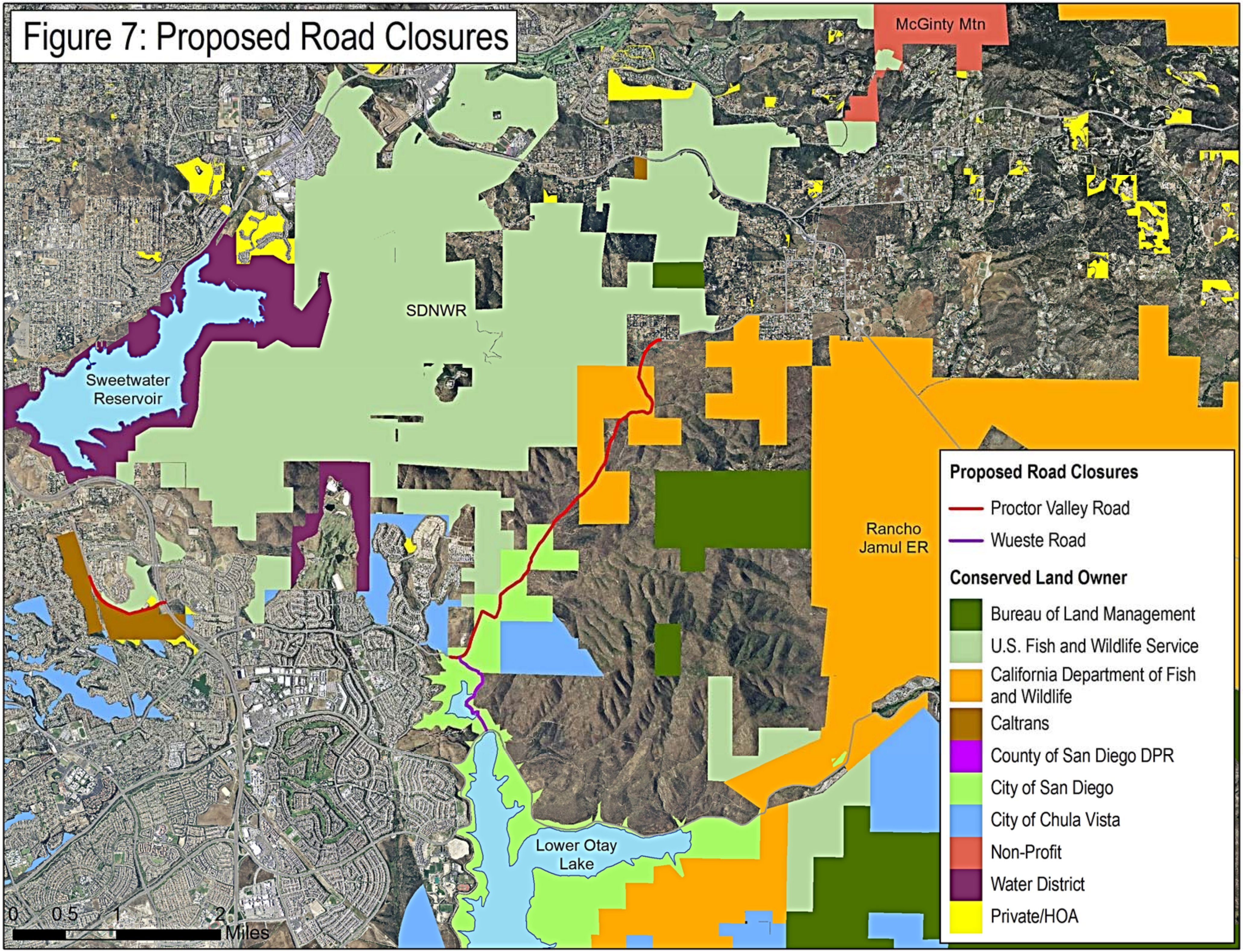


Figure 7: Proposed Road Closures
McGinty Mtn
SDNWR
Sweetwater Reservoir
Rancho Jamul ER
Lower Otay Lake
0 0.5 1 2 Miles
Proposed Road Closures
Proctor Valley Road
Wueste Road
Conserved Land Owner
Bureau of Land Management
U.S. Fish and Wildlife Service
California Department of Fish and Wildlife
Caltrans
County of San Diego DPR
City of San Diego
City of Chula Vista
Non-Profit
Water District
Private/HOA

the north and south ends (between Echo Valley Road on the north and Northwoods Drive on the south, Figure 7) will not only reduce traffic volumes on SR-94, it will also achieve another MSCP objective of improving connectivity between conserved lands in Proctor Valley. Closing the mostly dirt road to through traffic would forego the need for expensive crossing infrastructure and road improvement if it were not closed. We recommend that Proctor Valley Road be maintained as a gated, private dirt road for residents, land managers, and fire safety.

2.2 Other Road Infrastructure Priorities

Many public roads in South County cross through conserved lands and inhibit wildlife movement, including Millar Ranch Road, Jamul Drive (Rochester and Fisher 2013), Rancho Jamul Drive, Daley Ranch Truck Trail, Hollenbeck Road, Sycamore Canyon Road, Marron Valley Road, and Proctor Valley Road, among others. Otay Lakes Road and Honey Springs Road support greater levels of traffic and are priorities for wildlife movement monitoring and infrastructure improvements. As these two roads parallel creeks, they are a large source of mortality for amphibians and many other species (USGS unpublished data).

Otay Lakes Road. An infrastructure enhancement study should be conducted for Otay Lakes Road, where there are conserved lands, or lands to be conserved, on both sides of the road between SR-94 on the east and Otay Lakes on the west (Figure 2). For example, CDFW has recommended that the Dulzura Creek undercrossing by the yellow gate at the entrance to Otay Mountain Ecological Reserve should be replaced with a bridge. Wildlife movement should be monitored in this area prior to developing an infrastructure improvement plan.

Honey Springs Road. San Diego County has proposed straightening Otay Lakes Road to meet Honey Springs Road in direct alignment. This would create a new road crossing over Dulzura Creek and provide opportunities to improve wildlife movement connections across Otay Lakes Road. Wildlife movement should be monitored through the HCWA to enhance permeability across Honey Springs Road (Figure 2).

2.3 Target Species for Monitoring Connectivity

In this document we consider three functional groups of target species categorized by the Connectivity Monitoring Strategic Plan (SDMMP 2011, as amended, Y. Moore, pers. comm.):

- Large animals and bats: mountain lion, American badger, southern mule deer, bobcat, coyote, gray fox, greater roadrunner, pallid bat, Townsend's big-eared bat.
- Small animals: orange-throated whiptail, Blainville's horned lizard, Dulzura kangaroo rat, California ground squirrel, San Diego black-tailed jackrabbit, western spadefoot toad,

coastal whiptail, deer mouse, big-eared wood rat, desert woodrat, cactus mouse, San Diego pocket mouse, southwestern pond turtle, southwestern arroyo toad.

- Birds: California gnatcatcher, southwestern willow flycatcher, least Bells' vireo, northern harrier, burrowing owl, golden eagle, cactus wren.
- Invertebrates: California swollen stinger scorpion, Jerusalem cricket, Quino checkerspot butterfly, Hermes copper butterfly, and Harbison's dun skipper.
- Plants: Encinitas baccharis, Otay tarplant, salt marsh birds-beak, Orcutt's birds-beak, willow monardella.

However, the recommended improvements herein are intended to facilitate connectivity for the community of species, as opposed to a single target species or group of target species. Figure 8 shows distribution of these species and vegetation communities bordering SR-94 in MU3. The majority of the vegetation communities bordering SR-94 are coastal sage scrub and chaparral, with stringers of riparian woodland, oak woodland, and eucalyptus woodland (Table 2). Segments 2 and 4 cross commercial and residential land uses in the community of Jamul, and Segment 10 runs through the rural community of Dulzura. Segments 1, 3, 5, 6, 7, 8, and 9 bisect conserved lands. The primary drainages crossed by SR-94 are the Sweetwater River, Steele Canyon Creek, Jamul Creek, Hollenbeck Creek, Dulzura Creek, Pringle Canyon Creek, and Dutchman Canyon Creek.

Table 3 summarizes roadkill for each segment, and Figure 9 shows roadkill of target species by segment. There have been no regular roadkill observations south of Segment 6. Clearly the invertebrate species and bats have not been recorded as roadkill. The only recorded roadkill for mountain lions and bobcats is in Segment 3, where a new undercrossing is proposed (Appendix D). Coyotes, ground squirrels, desert cottontails, birds, and snakes have been killed in all segments where there has been regular roadkill reporting for the period (Sections 1-6). Section 3.4 recommends infrastructure improvements for targeted species, to be informed further by monitoring techniques using (for example) cameras, track beds, track plates, hair snags, GPS collars, roadkill observations, and fence integrity surveys.

Figure 8: Connectivity Monitoring Target Species in MU 3

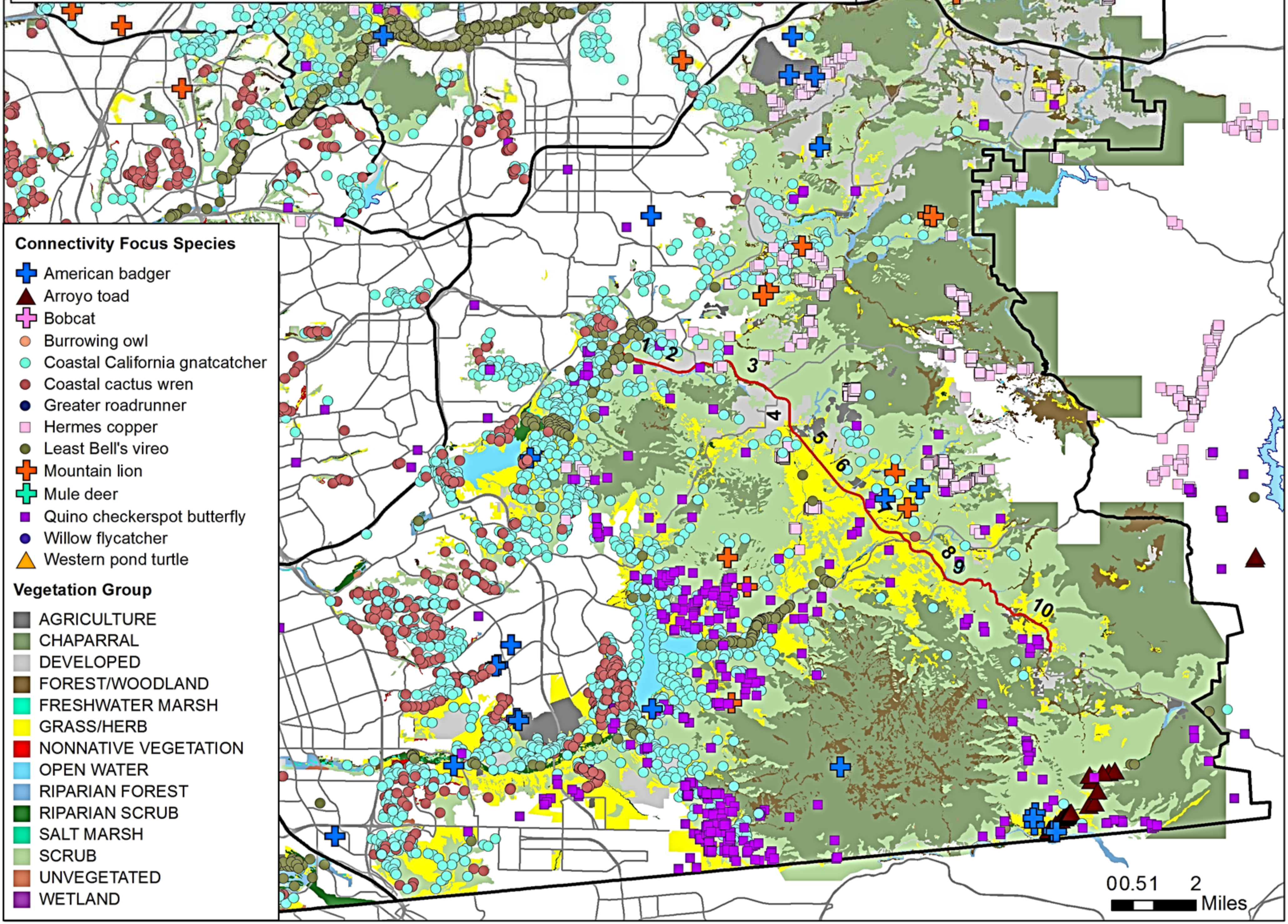


Table 2—Summary of primary land uses and vegetation communities by segment.

Seg.	Land uses	Vegetation communities[1]	Target species[2]
1	Conserved—SDNWR; private stables, playing fields	CSS, RW (Sweetwater R., Steele Canyon Crk), GL; patches of CHP, RW, DH	bobcat, coyote, mule deer, California ground squirrel, deer mouse, CAGN, LBV, spadefoot toad, Hermes copper, QCB
2	Private commercial, residential (Jamul)	DEV, CSS, CHP, RW (Steele Canyon Crk); patches of EW and OW	California ground squirrel, CAGN, QCB
3	Conserved—SDNWR	CSS, CHP, RW (Steele Canyon Crk); patches of EW and OW	mountain lion, bobcat, mule deer, California ground squirrel, deer mouse, desert woodrat, DKR, CAGN, Blainville's horned lizard, QCB, Hermes copper
4	Private commercial, residential (Jamul)	DEV, CSS, CHP, RW (Steele Canyon Crk); patches of EW and OW	California ground squirrel, black-tailed jackrabbit, deer mouse, SDPM, desert woodrat, CAGN, QCB
5	Conserved—RJER, HCWA	P, CSS, CHP; patches of EW, GL, RW	mule deer, bobcat, coyote, California ground squirrel, black-tailed jackrabbit, greater roadrunner, deer mouse, cactus mouse, DKR, desert wood rat, SDPM, CAGN, orange-throated whiptail, Blainville's horned lizard, spadefoot toad, Thorne's hair streak, QCB, Hermes copper
6	Conserved—RJER, HCWA	AG, P, CSS, GL, RW (Jamul Crk)	mule deer, bobcat, coyote, California ground squirrel, black-tailed jackrabbit, greater roadrunner, deer mouse, cactus mouse, DKR, desert wood rat, SDPM, CAGN, orange-throated whiptail, Blainville's horned lizard, spadefoot toad, QCB, Hermes copper
7	Conserved—RJER, HCWA	CHP, CSS, GL, P, RW (Hollenbeck Crk, Dulzura Crk)	mountain lion, mule deer, bobcat, coyote, California ground squirrel, black-tailed jackrabbit, greater roadrunner, deer mouse, cactus mouse, DKR, desert wood rat, SDPM, CAGN, orange-throated whiptail, Blainville's horned lizard, spadefoot toad, QCB, Hermes copper
8	Conserved—RJER, HCWA	CHP, CSS, P, CHP, RW (Dulzura Crk)	mule deer, bobcat, coyote, black-tailed jackrabbit, greater roadrunner, deer mouse, cactus mouse, DKR, desert wood rat, SDPM, CAGN, orange-throated whiptail, Blainville's horned lizard, spadefoot toad, QCB, Hermes copper
9	Conserved—BLM, LB Daley preserve	CHP, CSS, GL, RW (Dulzura Crk, Pringle Crk, Honey Springs Crk)	mule deer, bobcat, coyote, California ground squirrel, deer mouse, SDPM, DKR, cactus mouse, desert woodrat, CAGN, orange-throated whiptail, QCB, Thorne's hairstreak
10	Private residential (Dulzura); conserved BLM	AG, CSS, DEV, GL, P, RW (Dulzura Crk, Dutchman Canyon); patches of EW	mule deer, greater roadrunner, CAGN, QCB, Thorne's hairstreak

Table 2—Summary of primary land uses and vegetation communities by segment (continued).

[1] Vegetation communities (SANDAG 2012)

AG	agriculture
CHP	chaparral
CSS	coastal sage scrub
DEV	developed
DH	disturbed habitat
EW	eucalyptus woodland
GL	grassland
OW	oak woodland
P	pasture
RS	riparian scrub
RW	riparian woodland

[2] Target species (Clark 2015, County of San Diego 2011, CROS 2015 database, Famolaro 2015, Hathaway et al. 2002, ICF Jones & Stokes 2008, Madden-Smith 2004, Martin 2015, SDMMP 2015 MOM database, SDNWR 1999, TAIC 2011):

CAGN	California gnatcatcher
DKR	Dulzura kangaroo rat
LBV	Least Bell's vireo
QCB	Quino checkerspot butterfly
SDPM	San Diego pocket mouse

However, the recommended improvements are intended to facilitate connectivity for the community of species, as opposed to a single target species or group of species.

Table 3—Summary of roadkill by segment, October 2010-April 2015 (see Appendix B for full list).

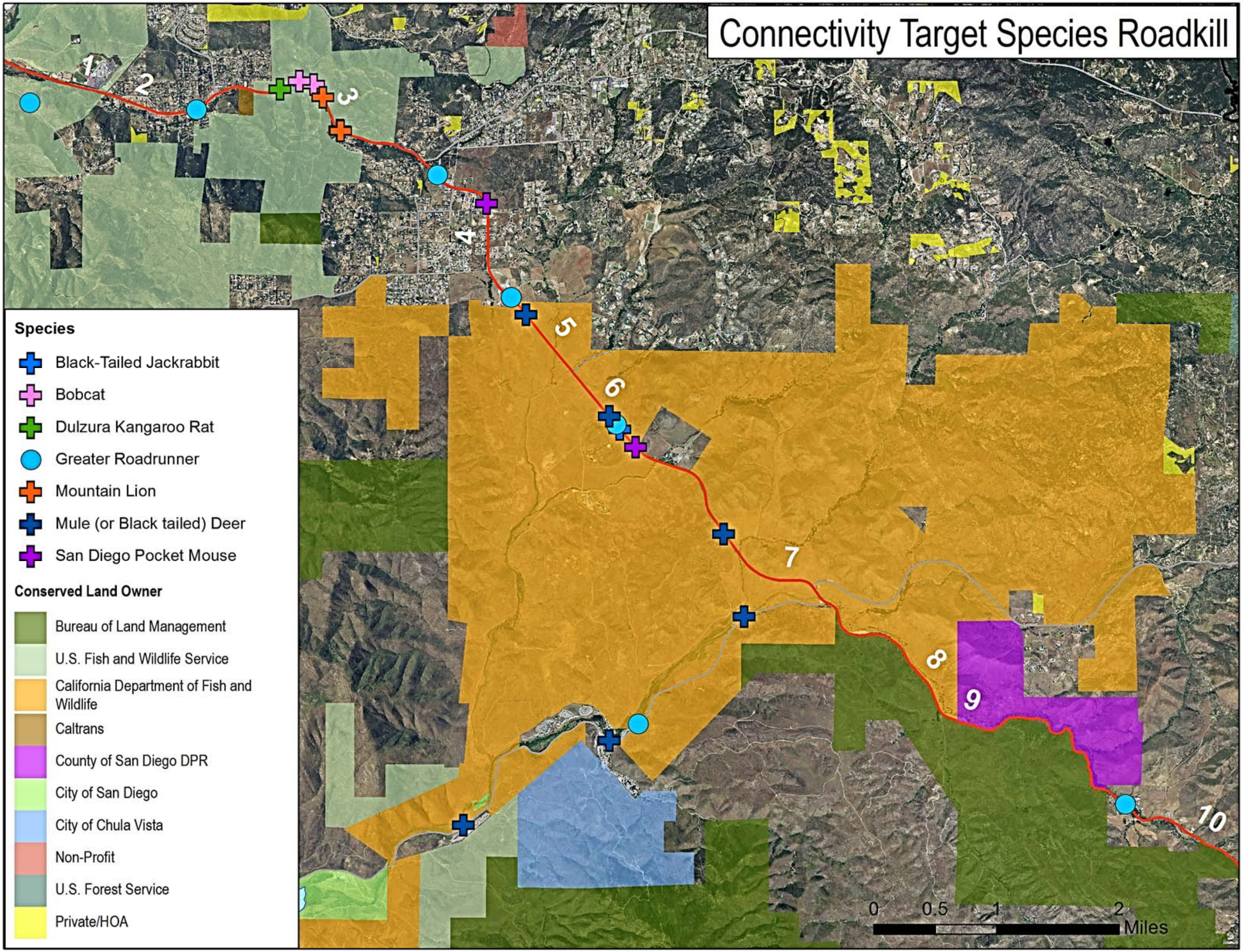
	SEGMENT OF SR-94									
TAXA/NUMBER OF INDIVIDUALS	1	2	3	4	5	6	7	8	9	10
Total number of dates recorded	105	71	125	143	74	71	11	3	1	4
Mountain lion (1994 and 2010)			2							
Mule deer					1	1	1			
Bobcat			2							
Coyote	3	1	5	4	8	21	2	1		
Greater roadrunner		1		1	1	1				1
Long-tailed weasel		1	1	7	10	10				
California ground squirrel	8	2	10	32	11	2	1			
Botta's pocket gopher		1	1		2	1				
Deer mouse	1		1	1						
San Diego pocket mouse				1		1				
Desert woodrat			3	1						
Dulzura kangaroo rat			1							
Desert cottontail	60	43	83	119	26	15	1			
Black-tailed jackrabbit						1				
Raccoon	9	1	3	2			1		1	
Striped skunk	29	15	3			1				
Western spotted skunk	1			1						
Virginia opossum	5	3	1	2						
Snakes[1]	5	1	18	9	9	8		1		1
Western fence lizard/southern alligator lizard				1		2	2			
Western toad	2				1		1			
Passerine birds (native)[2]	7	3	20	12	3	2	1			1
Anna's hummingbird			1							
Acorn woodpecker						1			1	
California quail			1							
Barn owl		1	3	3	6	8	1			
Great-horned owl		1	3							
Sharp-shinned hawk			1							
American kestrel					2					
Red-shouldered hawk										1
Water birds[3]	1	2		1	1			1		

[1] Gopher snake, western rattlesnake, red diamond rattlesnake, common kingsnake, western blind snake, rosy boa, striped racer, Baja California coachwhip

[2] Spotted towhee, California towhee, western scrub jay, northern rough-winged swallow, common yellowthroat, savannah sparrow, house wren, common raven, white-crowned sparrow, song sparrow, lark sparrow, hooded oriole, American crow, yellow-breasted chat, lesser goldfinch, California thrasher, bushtit, northern mockingbird, Cassin's kingbird, least Bell's vireo

[3] American coot, Virginia rail, mallard, western grebe

Source: J. Martin, P. Pum, J. Terp, NWR; T. Dillingham, CDFW; J. Schlachter, BLM.



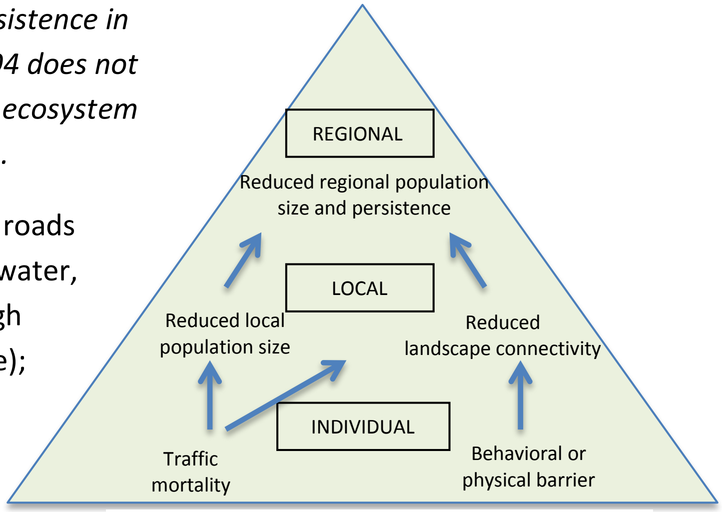
Connectivity Target Species Roadkill
Species
Black-Tailed Jackrabbit
Bobcat
Dulzura Kangaroo Rat
Greater Roadrunner
Mountain Lion
Mule (or Black tailed) Deer
San Diego Pocket Mouse
Conserved Land Owner
Bureau of Land Management
U.S. Fish and Wildlife Service
California Department of Fish and Wildlife
Caltrans
County of San Diego DPR
City of San Diego
City of Chula Vista
Non-Profit
U.S. Forest Service
Private/HOA
1
2
3
4
5
6
7
8
9
10
0
0.5
1
2
Miles

3 Wildlife Infrastructure Needs

3.1 Conservation Goal and Assumptions

Overall Goal for SR-94 Wildlife Infrastructure Plan

Enhance the integrity of and species persistence in the MU3 preserve core area so that SR-94 does not function as a barrier to connectivity and ecosystem functions at regional and preserve levels.



Source: Forman et al. 2003

The scientific literature documents how roads affect hydrological regimes; pollute air, water, and soils; degrade habitat quality through edge effects (e.g., invasive species, noise); result in wildlife mortality and indirect effects of this mortality (e.g., lower reproductive rates); change patterns of wildlife movement and communication; inhibit seasonal migration; fragment and isolate habitat patches; and reduce the persistence of populations. "Dead zones" or "virtual footprints," with reduced populations of native rodents, reptiles, amphibians, deer, birds, and other wildlife, can extend hundreds of meters on either side of even moderately traveled roads (Forman et al. 2003). Species respond differently to roads and their infrastructure, depending on traffic volumes, habitat type and patch sizes, topographic patterns, adjacent land uses and disturbance regimes, and population space needs, among others (e.g., Brehme 2003, Brehme et al. 2013, Crooks and Sanjayan 2006, Soulé and Terborgh 1999, Turner et al. 2001).

Road ecology studies in Europe and the United States (see reviews by Forman et al. 2003, Federal Highway Administration—Clevenger and Huijser 2011—and others) have informed various types of mitigation to reduce road mortality and effectively increase connectivity. Measures include wildlife fencing, overpasses and underpasses, habitat restoration or vegetation clearing, mirrors and reflectors, public relations, warning signs, warning whistles, highway lighting, visual barriers, sound barriers, and lower speed limits, among others. Strategically-placed wildlife fencing, combined with effective wildlife crossing structures, are by far the most successful means of directing animal movement, thereby reducing roadkill, enhancing connectivity, and improving traffic safety (e.g., Clevenger 2001, Forman et al. 2003).

Based on the extensive scientific literature, we can assume that SR-94 and other roads in this area fragment habitat and have negative impacts on species movement patterns and species persistence (Brehme 2003). We also assume that removing these roads, or removing or mitigating barriers to connectivity, would enhance species persistence and allow more natural ecological processes.

3.2 Before/After/Control/Impact (BACI) Studies

Baseline surveys should be conducted before construction in the portions of the SDNWR, RJER, HCWA, BLM lands, and County lands bisected by SR-94 to better understand what species are present, their population sizes, vegetation communities, and distribution in the greater project area. In addition, assess occupancy models should be conducted to assess whether they can help predict species occurrences across the greater project area, which could help inform expected use of wildlife crossings.

We recommend that, as part of making any infrastructure improvements, Caltrans conduct Before/After/Control/Impact (BACI) studies that include location and frequency of crossing use by taxon, using camera-based assessments (both at-grade and within crossing structures), tracking (track beds and track plates), radio-telemetry collars, hair snags, systematic roadkill observations, and/or genetic comparisons (e.g., using scat). These types of data can be used to develop movement models and identify barriers to dispersal for selected species. Most BACI studies have found that it takes time, often years, for regular use patterns to develop for certain species (W. Vickers, pers. comm.), including the conserved lands in the area of SR-94. We recommend that at least 3 years of pre-improvement data and 3 years of post-improvement data—followed by monitoring at longer intervals—be collected along the entire stretch of highway proposed for construction. Surveys of fence integrity (before construction) and systematic visits to jump-outs (after construction) can also contribute information on where animals are crossing at-grade. Targeted goals should be a significant reduction in mortality rates and a significant increase in use of crossing structures.

BACI studies, and continued monitoring and research, provide an excellent opportunity to understand ecosystem functions in South County, especially if monitoring is extended to include other roads, such as Otay Lakes Road, Proctor Valley Road, Honey Springs Road, and Jamul Drive. Genetic and demographic monitoring of targeted taxa within the larger reserves, such as the SDNWR, RJER, and HCWA, could identify conservation priorities in these habitats and inform long-term management and monitoring.

3.3 Best Management Practices

This section assimilates best practices from the scientific literature (see References) that apply to all portions of the study area, while Section 3.4 recommends potential infrastructure improvements by segment. Because of the significance of MU3 to the MSCP in general and to wildlife movement in particular, our potential options for mitigating the barrier effect that highways typically have on wildlife may seem more rigorous than those in areas with less conserved open space, lower traffic volumes, and less complex highway geometrics and terrain.

Theses BMPs and potential infrastructure improvements in Section 3.4 are consistent with those in the scientific literature, previous studies of other roadways (e.g., Orange County toll road SR-241, Vickers and Huber 2012), and the Caltrans (2007, 2009) and Federal Highway Administration (Clevenger and Huijser 2011) wildlife crossings manuals for maintaining, retrofitting, or supplementing existing crossing structures and fencing. As used in this document, "ROW fencing" (also called funnel fencing, exclusion fencing, or species protection fencing) is intended to keep animals off the highway, while "secondary fencing" is intended to be more of a visual barrier (and thus potentially less expensive than ROW fencing) to discourage animals from using private lands adjacent to conserved lands. Depending on the species targeted for each segment, there may be the need for extra reinforcements at the bottoms (for small animals) and tops (for mountain lions and deer) of the ROW fencing. Appendix C provides examples of infrastructure designs that have proven effective in mitigating wildlife-vehicle collisions and barrier effects.

The following BMPs should be incorporated into the specific recommendations for all segments in Section 3.4.

Fencing and Gates

1. Keep wildlife off the highway by installing impermeable Right-of-Way (ROW) fencing at or inside the Caltrans ROW boundary (depending on location and slope) along both sides of the highway where it crosses natural habitat, to reduce roadkill as informed by monitoring. Installing fencing close to the road will reduce the amount of vegetation clearing. Ensure that fence ends are directly across from each other and not offset. Use ≥10 ft fencing to prevent deer and mountain lions from crossing, and bury all ROW fencing to prevent coyotes from digging under.
2. Use ROW fencing to funnel wildlife toward culverts and bridges and to block animals attempting to cross the highway at-grade; install ROW fence at the openings of culverts and other undercrossings, on the highway side of openings, and anchor fencing securely

to culvert or bridge abutments rather than anchoring to end-posts installed next to abutments.

3. Discourage wildlife from using natural habitat that is vacant and not protected by installing secondary fencing between conserved lands and natural habitat that is not conserved, to reduce access to the highway across unprotected lands, where determined necessary by condition of habitat and potential for wildlife use. Evaluate whether this may create a trap in the case of fire.

4. Install gates that are of the same height and construction as the surrounding ROW fencing to reduce roadkill; gates must be <3 inches from the ground when closed.

5. Install fencing between drainage ditches and the highway, so that animals can access drainage ditches from the open space, and clear vegetation in the ROW to reduce animal incentives for foraging there.

6. Install one-way escape structures at ≤0.5 mi intervals along the highway (W. Vickers pers. com.), or as determined by monitoring, to allow deer and other large animals to exit the highway.

7. Install specialized fencing to exclude smaller animals (see Appendix C for examples).

Placement of Crossing Areas

8. To inform placement of new infrastructure, monitor segments seasonally for at least 3 years prior to construction to determine locations and extent of roadkill and wildlife movement through protected and unprotected lands and at the interface with the highway; monitor wildlife use of existing crossing areas.

9. Place crossings such that they provide connectivity between similar habitats in conserved areas of a size large enough to meet daily habitat requirements for the target species.

10. Take advantage of topography and natural vegetation that funnel animals to crossing points.

Structure and Function of Crossing Areas

11. Remove rip-rap on either end of the crossing area, or if rip-rap is needed for energy dissipation, cover the rip-rap with material or grouted pathways more usable by wildlife; bury rip-rap needed for scour protection below average ground level; use slopes ≤5%.

12. Use natural substrate in the undercrossing that is similar to that of the surrounding habitat.

13. Incorporate dry ledges in undercrossings and under bridges to accommodate use by small terrestrial wildlife, and incorporate natural structural features such as rocks and logs in large culverts and under bridges.

14. Make undercrossings straight (i.e., without dog-legs) and of limited length such that animals can see natural habitat through the undercrossing from one end of the crossing area to the other (see openness ratio, Caltrans 2007, 2009; Section 3.4). The undercrossing should follow the pathway of hydrologic flow; install sediment catch basins at both ends of the undercrossing.

15. Keep livestock out of crossing areas.

Monitoring and Maintenance

16. Assess effectiveness of new infrastructure by monitoring seasonally for at least 3 years duration post-construction to determine locations and extent of roadkill, wildlife movement through protected and unprotected lands, and wildlife use of new and enhanced crossing areas. Monitoring may include camera-trapping, tracking, and/or other means.

17. Clear or control vegetation and silt at entrances to and within crossing structures and approach routes, and ensure that hydrologic flow is not impeded, especially when there are changes in human development patterns, land uses, and climate.

18. Establish a maintenance budget to regularly monitor infrastructure, replace or repair damaged fencing, remove sediment build-up in the crossing areas, manage vegetation growing in approaches to crossing areas, and remove trash that builds up along the fence line and in crossing areas.

3.4 Recommendations by Segment

This section discusses near-term infrastructure priorities to improve habitat connectivity, wildlife connectivity, and therefore ecosystem function, and longer-term options that could be implemented as part of future road improvements. Targeted goals are to reduce any potential barrier effect of SR-94 as indicated by (1) a significant reduction in mortality rates, and (2) a significant increase in use of crossing structures, compared to existing conditions. These recommendations are consistent with the CDFW Wildlife Crossing and Safety Assessment (Dillingham 2015) as well as the Caltrans (2007, 2009) and Federal Highway Administration (FHWA 2011) wildlife crossings manuals for maintaining, retrofitting, or supplementing existing crossing structures and fencing. Some of the discussion of existing conditions for Segments 5, 6, and 7 is from Dillingham (2015); photos of culverts in these segments are included as part of

Appendix E. Transportation improvement measures included in the Jamul Casino Tribal Environmental Evaluation (TEE) and the SR-94 Operational Improvement Project (Caltrans 2011) described in Section 4 are included at the end of each segment's priorities as potential opportunities to implement the priority infrastructure enhancements. Section 3.5 describes public use considerations identified by the preserve land managers.

Appendix B shows roadkill data, by segment, obtained from the California Roadkill Observation System at UC Davis. Table 3 summarizes these data. There have been no regular roadkill observations south of Segment 6. Table 4 lists existing undercrossings generally >3 ft in diameter, by segment; smaller culverts are included where they may accommodate water flow. These undercrossings are shown in Maps 1-10, along with near-term priority actions, which are summarized in Table 5. Appendix C provides examples of infrastructure designs that have proven effective in mitigating wildlife-vehicle collisions and facilitating connectivity for communities of species.

Table 4—Existing infrastructure.

Post Mile	Type	Subtype	Material[1]	Diameter (ft)	Width (ft)	Height (ft)	Nearest road or feature
SEGMENT 1							
1527	Bridge	Bridge	Concrete	0	13	3	Sweetwater River
1605	Culvert	Circular	Concrete	4	0	0	HS parking lot
1630	Culvert	Circular	Concrete	4	0	0	SDG&E easement
SEGMENT 2							
1646	Culvert	Box	Concrete	0	4	2	SDG&E easement
1718	Culvert	Circular	CSP	2	0	0	riparian
1735	Culvert	Circular	Concrete	4	0	0	Steele Canyon Rd.
SEGMENT 3							
1749	Culvert	Circular	Concrete	3	0	0	edge of NWR
1755	Culvert	Box	Concrete	0	6	4	Filippi's Pizza
1790	Culvert	Circular	CSP	4	0	0	Steele Canyon Creek
1835	Culvert	Circular	CSP	4	0	0	Steele Canyon Creek
1850	Culvert	Circular	CSP	3	0	0	Steele Canyon Creek
1855	Culvert	Circular	CSP	4	0	0	Vista Sage
1885	Culvert	Circular	CSP	4	0	0	Vista Sage
1900	Culvert	Circular	CSP	3	0	0	SE end of NWR
SEGMENT 4							
1925	Culvert	Circular	CSP	2	0	0	Water tank
1948	Culvert	Box	Concrete	0	12	8	Lyons Valley Rd.
2040	Culvert	Box	Concrete	0	4	2	Maxfield Rd.

Post Mile	Type	Subtype	Material[1]	Diameter (ft)	Width (ft)	Height (ft)	Nearest road or feature
SEGMENT 5							
2151	Box	Culvert	Concrete	3	0	0	Daley Dip
2170	Culvert	Circular	Concrete	4	0	0	Rancho Jamul Drive
SEGMENT 6							
2190	Culvert	Circular	Concrete	2	0	0	riparian
2255	Culvert	Circular	CSP	4	0	0	N. end Daley property
2280	Bridge	Bridge	Concrete	0	36	12	Jamul Creek
SEGMENT 7							
2395	Culvert	Box	Concrete	0	5	4	Hollenbeck Cyn Creek
2466	Bridge	Bridge	Concrete	0	10	4	Dulzura Ck @ Otay Lakes Rd.
SEGMENT 8							
2515	Culvert	Elliptical	CSP	0	3	2	Border Patrol Station
2540	Culvert	Circular	CSP	3	0	0	Border Patrol Station
2615	Culvert	Circular	Concrete	3	0	0	Sycamore Canyon (pink gate)
SEGMENT 9							
2795	Culvert	Circular	CSP	2	0	0	BLM brown gate
SEGMENT 10							
2850	Bridge	Bridge	Concrete	0	0	0	Dulzura Creek
2870	Culvert	Circular	CSP	4	0	0	Cal Fire station Dulzura
2890	Culvert	Circular	Concrete	5	0	0	Rancho Las Nubes
2912	Bridge	Bridge	Concrete	0	0	20	Grande Ck @ Dutchman Cyn
2945	Culvert	Elliptical	CSP	0	4	3	Arbabian acquisition
2985	Culvert	Elliptical	CSP	0	3	2	Cañon de Roca
3000	Culvert	Circular	Concrete	5	0	0	Marron Valley Rd.

Note: this table includes only those culverts ≥3 ft diameter, except where there is water flow from riparian habitat.
[1]CSP = corrugated steel pipe

Table 5—Summary of recommendations for SR-94 infrastructure improvements to benefit communities of species as opposed to a single target species or groups of target species (see text for further detail and Appendix C for infrastructure examples).

RECOMMENDATIONS[1,2]	LAND OWNER
Segment 1—Funnel wildlife to Sweetwater River bridge undercrossing and reduce roadkill.	
Near-term	
1. Install ROW fencing south of SR-94 (5,200 ft).	Caltrans
2. Develop a path along the rip-rap, or cover the rip-rap, to encourage animal movement along the Sweetwater River.	
3. Determine need for replacing SDG&E gate to access utility easement.	Caltrans/SDG&E
4. Assess need for improved fencing northeast of horse facilities to funnel animals to Sweetwater River.	SDNWR
5. Install cattle guards at Singer Lane, Millar Ranch Road, dirt road to the stables, and dirt trail along river (Rochester and Fisher 2013).	Private
6. Monitor wildlife use of Sweetwater River and Steele Canyon Creek.	SDNWR
Longer-term	
Restore the Cottonwood Golf Course to enhance use as a wildlife linkage.	
Traffic signal at Cougar Canyon Road intersection (Kimley-Horn 2012).	Caltrans
Segment 2—Reduce roadkill.	
1. Assess need for secondary fencing around the knoll between NWR and private land, south side of Steele Canyon Creek.	SDNWR
2. Assess need for secondary fencing along Aurora Vista Drive and between Aurora Vista Drive and Florence Terrace along SDNWR.	SDNWR
Segment 3—Enhance integrity across the SDNWR and reduce roadkill.	
Near-term	
1. Maintain culverts at PM 1749 and PM 1855 to allow drainage.	Caltrans
2. Fence (secondary) the non-functional box culvert (PM 1755).	Caltrans
3. Install 8,400 ft ROW fencing both sides of highway, with herp guards along Steele Canyon Creek; install funnel fencing to PM 1790.	Caltrans
4. Install 1,550 ft secondary fencing between Vista Sage Lane and Steele Canyon Creek.	SDNWR
5. At bottom of the curve, install new box culvert with dry ledges for small animals; remove vegetation blocking undercrossing.	Caltrans
6. Install jump-outs on both sides of highway, before and after the curve.	Caltrans
7. Tie-in ROW fencing to new box culvert and existing culverts (PM 1835, 1850, 1855, 1885, 1900; maintain vegetation around culverts.	Caltrans
8. Install secondary fence between nursery and SDNWR and along Vista Sage Lane to Verde Lane.	SDNWR
9. Remove trash, invasive species, and dense understory within Steele Canyon Creek.	SDNWR
Longer-term	
Straighten SR-94 at the curve by re-routing SR-94 onto SDNWR lands; construct undercrossings at east and west ends.	Caltrans

RECOMMENDATIONS[1,2]	LAND OWNER
Segment 4—Reduce roadkill.	
1. Assess fencing needs by documenting wildlife movement between the SDNWR and RJER at their junction with Proctor Valley Road, to funnel wildlife to crossings in Segments 3 and 5.	Caltrans
Longer-term	
Traffic controls at intersections for the Jamul Casino (Kimley-Horn 2012).	Caltrans
Segment 5—Facilitate animal movement between RJER and HCWA.	
1. Remove vegetation, sediment, and trash at both culverts.	Caltrans
2. Install ROW fencing both sides of SR-94 and anchor at culvert abutments on both sides.	Caltrans
3. Determine need for secondary fencing perpendicular to highway along private properties.	Caltrans
4. Replace the "Daley Dip" (PM 2151) with a larger undercrossing by leveling the highway.	Caltrans
5. Replace the 2 RJER gates at the Daley Dip and anchor to fencing.	CDFW
6. Contour approaches and remove overgrown vegetation at the entrances to PM 2170.	CDFW
Longer-term	
Investigate feasibility for excavating a "basin undercrossing" north of Daley Dip.	CDFW
Install a traffic signal or stop sign at Rancho Jamul Drive to reduce roadkill through the preserves.	Caltrans
Widen the road and include a passing lane (Caltrans 2011).	Caltrans
Segment 6—Facilitate animal movement between RJER and HCWA.	
1. Install ROW fencing both sides of SR-94 and tie-into undercrossing abutments	Caltrans
2. Determine if the RJER gate and two HCWA gates should be replaced and tied into new ROW fencing.	CDFW
3. Install a stop sign or traffic signal at Rancho Jamul Drive or Daley Ranch Truck Trail so slow traffic through the preserves.	Caltrans
4. Evaluate the need for a cattle guard at Rancho Jamul Drive.	CDFW
5. Install a new undercrossing at PM 2190 and include structural features to provide cover for smaller animals.	Caltrans
6. Recontour the drainage at PM 2190 and restore riparian vegetation along the drainage on both sides SR-94.	CDFW
7. Excavate a basin undercrossing at PM 2255 and recontour the approaches.	Caltrans/CDFW
8. Install jump-outs south of Rancho Jamul Drive and on the west side of the bridge at RJER main entrance road.	Caltrans
9. Install a cattle guard at the Daley Ranch entrance road.	CDFW
10. Remove and maintain vegetation and old fence at the entrances to the PM 2280 culverts.	CDFW
Longer-term	
Widen the road and include a passing lane (Caltrans 2011).	Caltrans

RECOMMENDATIONS[1,2]	LAND OWNER
Segment 7—Facilitate animal movement between RJER and HCWA.	
1. Install ROW fencing both sides of SR-94 and tie-into undercrossing abutments.	Caltrans
2. Evaluate need to replace 2 CDFW gates at Hollenbeck Road, both sides of SR-94, and tie into ROW fencing.	CDFW
3. Replace culverts at PM 2395 with a 15-ft arch or bridge; recontour both sides with earthen benches; and remove or cover rip-rap.	Caltrans
4. Install cattle guard on Honey Springs Road and continue ROW fencing.	Caltrans
5. Conduct "hot spots analysis" along Honey Springs Road and Otay Lakes Road.	Caltrans
6. Install secondary fencing around house on HCWA to encourage wildlife movement behind house to Dulzura Creek bridge.	CDFW
7. Determine locations for at least 2 jump-outs.	Caltrans
Longer-term	
Realign curves, widen the road, and include a passing lane (Caltrans 2011).	Caltrans
Install stop controls at Honey Springs Road and Otay Lakes Road (Kimley-Horn 2012).	Caltrans
Evaluate feasibility of a land bridge for large animals.	CDFW
Evaluate feasibility of placing undercrossings both north and south of Hollenbeck Road.	CDFW
Segment 8—Facilitate animal movement between BLM Sycamore Canyon and HCWA and BLM and LB Daley Preserve.	
1. Install ROW fencing north side and secondary fencing south side of SR-94 and tie-into undercrossing abutments.	Caltrans
2. Remove and maintain sediment and vegetation at culverts PM 2515 and PM 2540.	Caltrans
3. Install at least 2 jump-outs in appropriate locations, as informed by wildlife movement monitoring.	Caltrans
4. Install a 15-ft arch at pink BLM gate (PM 2615) and contour approaches.	Caltrans
5. Install fencing to funnel animals to the new undercrossing and tie-in with abutments.	Caltrans
Longer-term	
Realign curves, widen the road, and include a passing lane (Caltrans 2011).	Caltrans
Segment 9—Facilitate animal movement between BLM Sycamore Canyon and HCWA and BLM and LB Daley Preserve.	
1. Install a 15-ft arch at the brown BLM gate (PM 2795) and tie into the fence.	Caltrans
2. Install jump-outs, as informed by wildlife movement monitoring.	Caltrans
3. Install 2 new gates and tie into fencing.	BLM/CDFW
Longer-term	
Eliminate curves by tunneling through all or a portion of this segment ("bypass alignment" alternative, Caltrans 2011).	Caltrans
Install standard 8 ft shoulders (Caltrans 2011).	Caltrans

RECOMMENDATIONS[1,2]	LAND OWNER
Segment 10—Enhance connectivity between BLM lands and Forest Service lands.	
1. Monitor seasonally to determine most likely areas for ROW fencing and jump-outs.	Caltrans
2. Install secondary fence to funnel wildlife under Camps Grove bridge (PM 2850); build dry ledges on both sides of the undercrossing.	Caltrans
3. Remove and maintain sediment load and vegetation at culvert PM 2870.	Caltrans
4. Remove invasive species and other vegetation at PM 2890; recontour the drainage, especially upstream.	Caltrans
5. Install a dry ledge under the bridge over Grande Creek (PM 2912); remove invasive species; install fencing to funnel to bridge.	Caltrans
6. Install a jump-out across from driveway southeast of Dutchman Canyon Road.	Caltrans
7. Install a larger culvert at PM 2945.	Caltrans
8. Install directional ROW fencing to PM 2945.	Caltrans
9. Install a pre-formed arch at PM 2985; fence or gate the Canon de Roca driveway; install jump-out on south side SR-94.	Caltrans
10. Remove and maintain sediment load and vegetation at PM 3000).	Caltrans
Longer-term	
Realign curves, widen the road, and include a passing lane (Caltrans 2011).	Caltrans

[1] All measurements are approximate. ROW = right-of-way (impermeable) fence along SR-94. Secondary fence separates conserved lands from private lands.

[2] Specific placement to be informed by monitoring.

Segment #1 (Map 1)

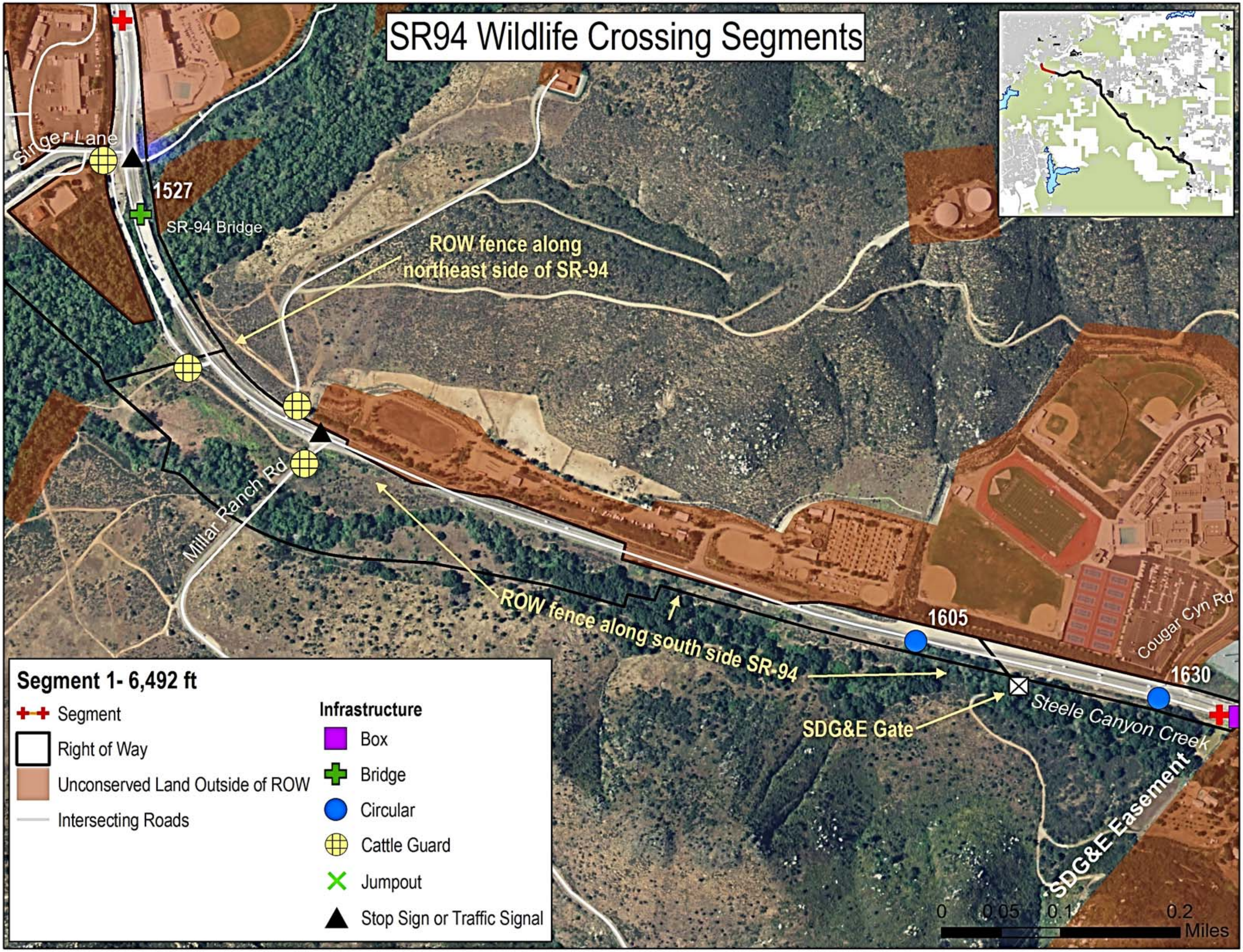
Existing conditions: The bridge over the Sweetwater River provides the best wildlife crossing opportunity through this segment where SR-94 cuts through the San Diego National Wildlife Refuge (SDNWR), which in this area supports mostly coastal sage scrub and coastal sage scrub species. There are few data on wildlife use of the riparian habitat at this location, except for some herpetofauna surveys (SDNWR 1999) and annual least Bell's vireo surveys (Martin 2015). Farther downstream, Famolaro (2015) has recorded bobcats, mule deer, coyotes, raccoons, striped skunk, opossum, red fox, cottontail, deer mice, dusky-footed woodrats, and ground squirrels on Sweetwater Authority property in the riparian habitat of the Sweetwater River. The riparian habitat along Steele Canyon Creek, which runs parallel to the south side of SR-94, likely supports wildlife that can enter the highway. Based on the SDMMP MOM database (2015), bobcats, mule deer, and other connectivity target species use the SDNWR near this segment (Table 3); Hermes copper and Quino checkerspot butterfly also occupy the SDNWR, but are not likely to successfully cross SR-94 and the other land uses in this segment. The Caltrans culvert data show 18 circular concrete pipes and slotted pipe drains in this ~1.2-mile segment; all but a couple are <3 ft in diameter. Table 4 shows the two largest of these (aside from the bridge)—both draining the Steele Canyon high school parking lot and playing fields. Based on roadkill data, coyotes are the largest animals to cross at-grade, but smaller mammals, birds, snakes, and a western toad were collected in this heavy traffic segment, including a road-killed least Bell's vireo (J. Martin, pers. comm., July 23, 2014). Caltrans is conducting a traffic study in this segment.

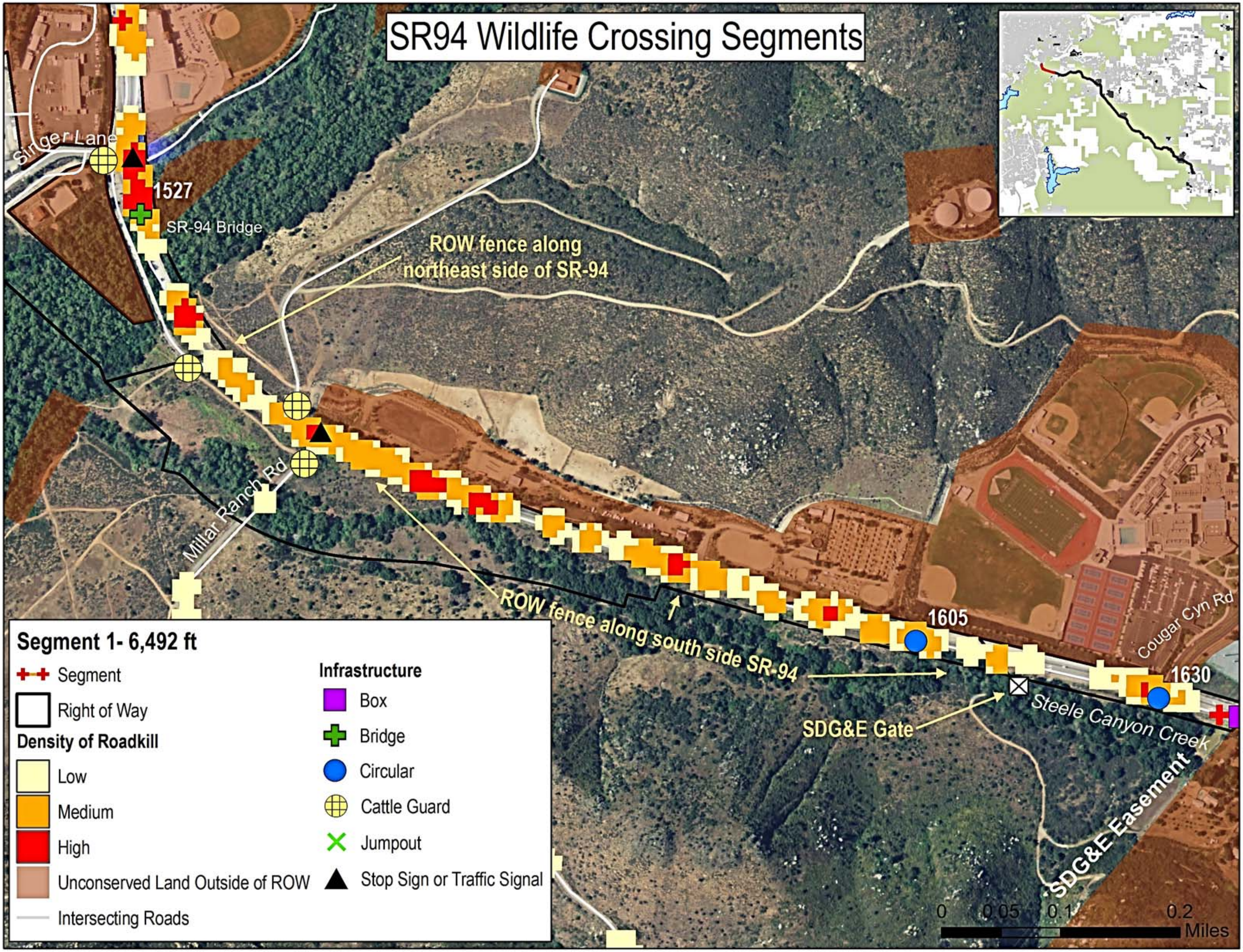
Objectives:

- *Improve habitat integrity on SDNWR land south of SR-94.*
- *Reduce roadkill by keeping the community of species off the highway and funneling them to the riparian habitat and the existing bridge at the Sweetwater River.*
- *Enhance native habitat along the Sweetwater River for wildlife movement.*
- *Protect and enhance wildlife habitat in Steele Canyon Creek.*

Near-term recommendations:

1. Install ROW fencing along the south side of the highway between the Sweetwater River bridge and the SDG&E easement, based on monitoring which species are using these areas ≥4 ft high with small mesh size (see Appendix C).


SR94 Wildlife Crossing Segments
Singer Lane
1527
SR-94 Bridge
ROW fence along northeast side of SR-94
Millar Ranch Rd
ROW fence along south side SR-94
1605
1630
Cougar Cyn Rd
SDG&E Gate
Steele Canyon Creek
SDG&E Easement
Segment 1- 6,492 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
0 0.05 0.1 0.2
Miles


SR94 Wildlife Crossing Segments
Singer Lane
1527
SR-94 Bridge
ROW fence along northeast side of SR-94
Millar Ranch Rd
ROW fence along south side SR-94
1605
1630
Cougar Cyn Rd
Steele Canyon Creek
SDG&E Gate
SDG&E Easement
0 0.05 0.1 0.2 Miles
Segment 1- 6,492 ft
Segment
Right of Way
Density of Roadkill
Low
Medium
High
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal

2. Develop a path along the rip-rap, or cover the rip-rap, to encourage animal movement along the Sweetwater River.

3. Determine the need for replacing the SDG&E gate on the south side of SR-94 to access its utility easement.

4. Check the need to improve secondary fencing along the SDNWR boundary, north of the property leased for horse facilities, to funnel animals to habitat along the Sweetwater River. There already is a secondary fence around the Steele Canyon High School property and along both sides of the SDG&E easement north and south of the highway to discourage animal movement into these areas.

5. Install cattle guards at Singer Lane, Millar Ranch Road, dirt road to the stables, and dirt trail along the river, at the intersection of SR-94 (see also Rochester and Fisher 2013).

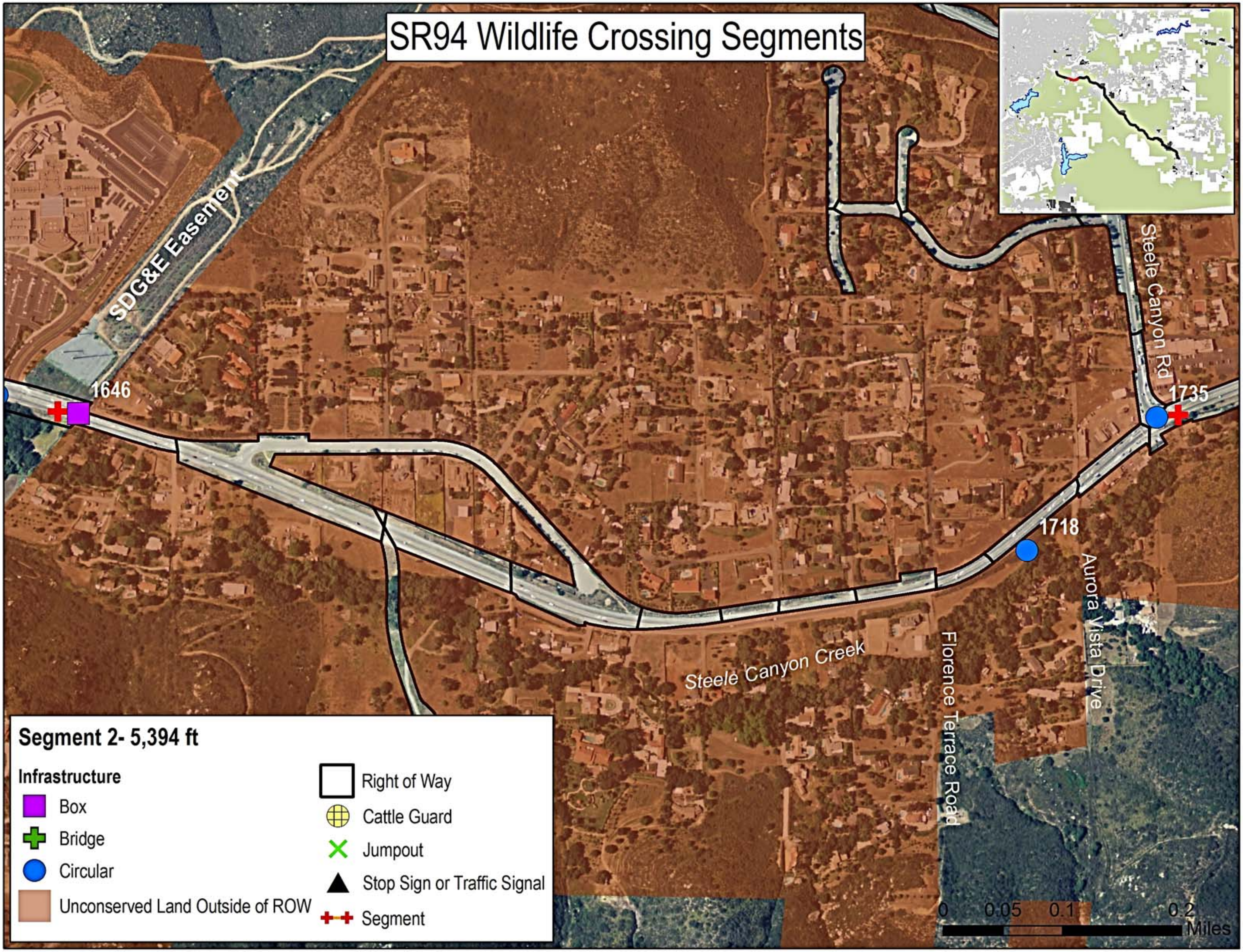
6. Document wildlife use through the riparian habitat, and animals killed crossing at-grade, by conducting a wildlife movement study for at least 1 week each season of the year for 2 years using tracking and camera traps (a) along and under the SR-94 bridge at the Sweetwater River, between Willow Glen Drive and the Otay Water District recycled water plant along El Tae Road to the west of the highway, and (b) between the edge of the riparian habitat at the river and Millar Ranch Road. This will help determine what type of fencing is needed.

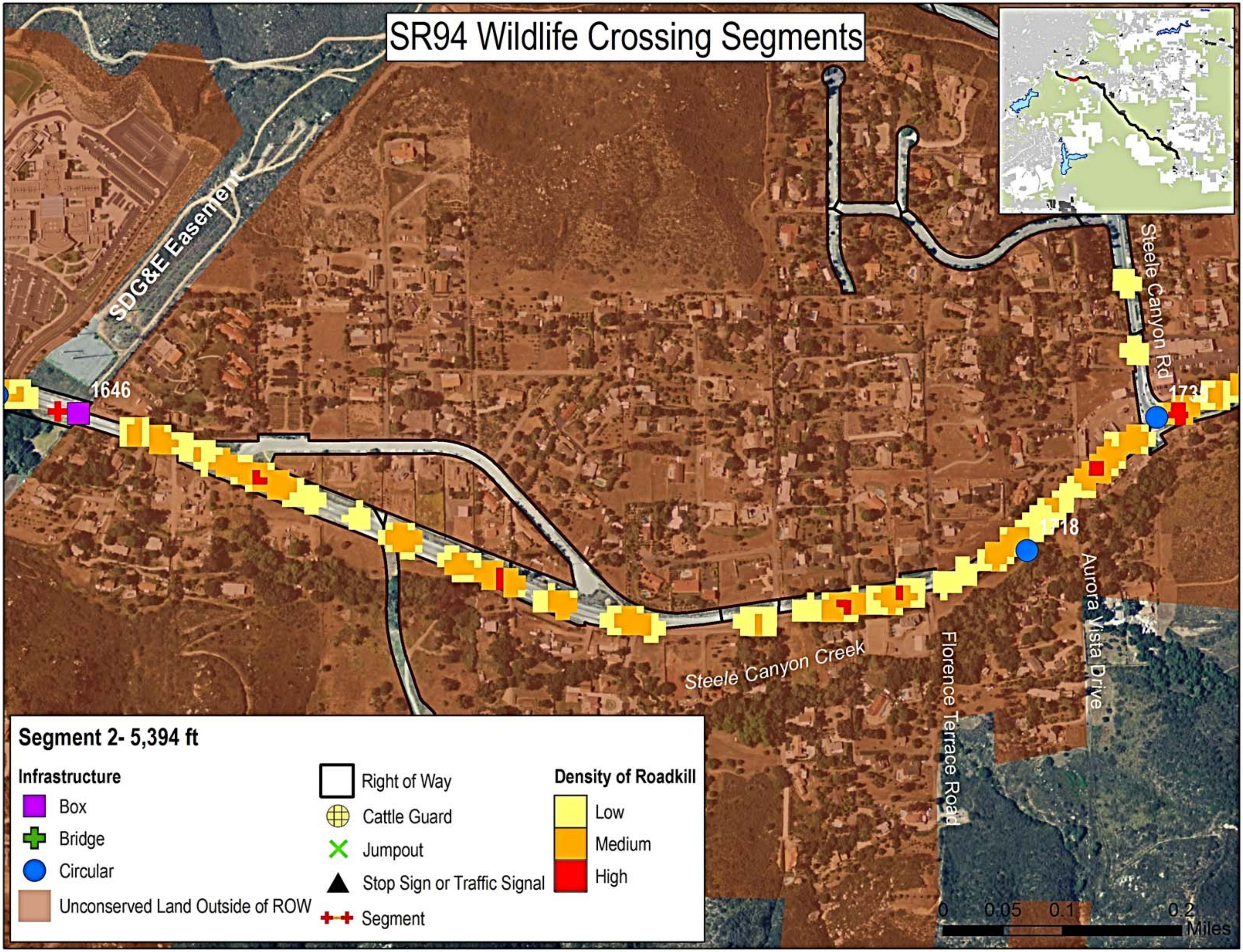
Longer-term recommendations:

- Restore the Cottonwood Golf Course to enhance use as a wildlife linkage (perhaps as a riparian mitigation project).
- The Tribal Environmental Evaluation (TEE) for the Jamul Casino includes a traffic signal at the Cougar Canyon Road intersection, which could help reduce roadkill.

Segment #2 (Map 2)

Existing conditions: Segment 2 of the highway traverses through ~1 mile of residential and commercial land uses. There is no conserved open space in this segment; although coastal sage scrub and chaparral border the developed areas, these habitats may be lost or fragmented by new development. The Caltrans culvert data show 14 circular concrete pipes and slotted pipe drains in this segment; all but the three undercrossings shown on Map 2 are <2 ft in diameter. The majority of animals killed on the road in this segment are desert cottontails and striped skunks, which are species that do well in urban areas. Monitoring could help determine the


SR94 Wildlife Crossing Segments
SDG&E Easement
1646
1735
1718
Steele Canyon Rd
Aurora Vista Drive
Florence Terrace Road
Steele Canyon Creek
Segment 2- 5,394 ft
Infrastructure
Box
Bridge
Circular
Unconserved Land Outside of ROW
Right of Way
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
Segment
0 0.05 0.1 0.2
Miles


SR94 Wildlife Crossing Segments
SDG&E Easement
1646
1735
1718
Steele Canyon Rd
Aurora Vista Drive
Florence Terrace Road
Steele Canyon Creek
Segment 2- 5,394 ft
Infrastructure
Box
Bridge
Circular
Unconserved Land Outside of ROW
Right of Way
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
Segment
Density of Roadkill
Low
Medium
High
0
0.05
0.1
0.2
Miles

need for fencing along the highway, but because of the existing and future land uses (i.e., loss of more habitat to development), highway fencing is not a priority.

Objectives:

- *Reduce roadkill by encouraging use of Segments 1 and 3 as crossing areas.*

Near-term recommendations:

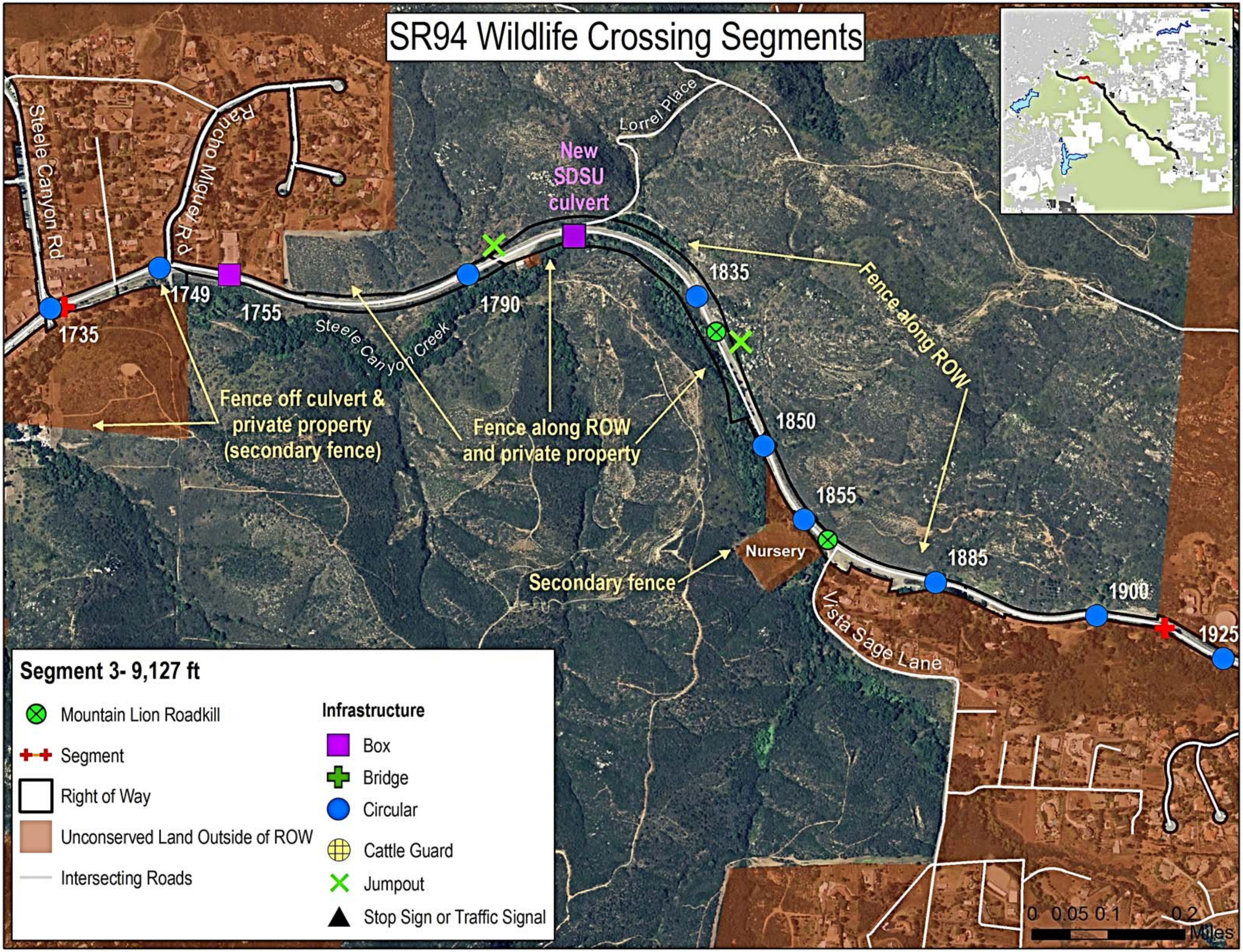
1. Assess the need for secondary fencing on the south side of the highway, around the knoll that borders the south side of Steele Canyon Creek, between SDNWR land and private land.
2. Assess the need for secondary fencing along the SDNWR boundary along Aurora Vista Drive, and between Aurora Vista Drive and Florence Terrace along the SDNWR boundary, south of SR-94.

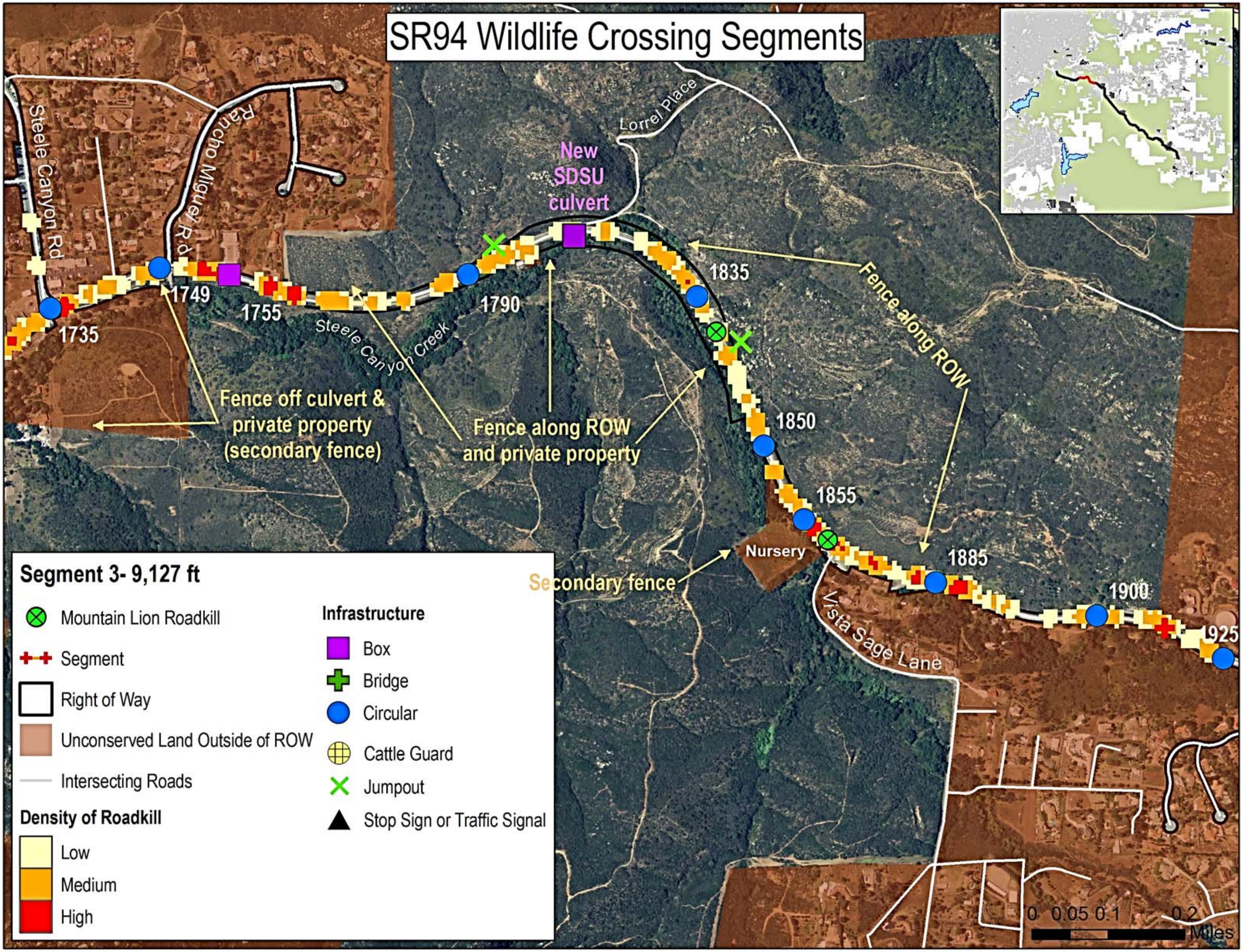
Segment #3 (Map 3)

Existing conditions: This segment of highway crosses 1.7 miles of the SDNWR, where the habitat is mostly coastal sage scrub and chaparral, and scattered oaks in the canyons. Steele Canyon Creek, lined with live oak riparian forest, parallels the south side of SR-94 but crosses under the highway at the large curve, where there is a significant dip in elevation. There are seven circular culverts ≥3 ft diameter and one box culvert through this segment. The box culvert (PM 1755) across from the parking lot for Filippi's Pizza (south of SR-94), has a dogleg in it and empties into the parking lot so probably is not functional for wildlife. The culvert at PM 1790 appears to be little used, if at all, by wildlife; it is more likely that wildlife cross at grade in this location (J. Martin, pers. comm.). The existing culvert at the bottom of the curve (not shown in Caltrans culvert data) is blocked by sediment and dense vegetation on the north side of the highway and not currently functional for wildlife movement. The culvert at PM 1835 is about half full of sediment and debris. There are no camera data for these culverts and apparently no regular maintenance by Caltrans. Two mountain lions have been killed on the southern end of this segment; other roadkill data include two bobcats, coyotes, large numbers of desert cottontails, and many birds and snakes that probably use the adjacent riparian habitat.

Objectives:

- *Reduce roadkill by keeping animals off the road and enhancing multiple crossing areas.*
- *Enhance ecological integrity across the SDNWR.*
- *Protect and enhance wildlife habitat in Steele Canyon Creek.*


SR94 Wildlife Crossing Segments
Steele Canyon Rd
Rancho Miguel Rd
Lorrel Place
New SDSU culvert
1735
1749
1755
1790
1835
1850
1855
1885
1900
1925
Steele Canyon Creek
Fence along ROW
Fence off culvert & private property (secondary fence)
Fence along ROW and private property
Nursery
Secondary fence
Vista Sage Lane
Segment 3- 9,127 ft
Mountain Lion Roadkill
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
0 0.05 0.1 0.2
Miles


SR94 Wildlife Crossing Segments
Steele Canyon Rd
Rancho Miguel Rd
Lorrel Place
New SDSU culvert
1735
1749
1755
1790
1835
1850
1855
1885
1900
1925
Steele Canyon Creek
Fence off culvert & private property (secondary fence)
Fence along ROW and private property
Fence along ROW
Nursery
Secondary fence
Vista Sage Lane
Segment 3- 9,127 ft
Mountain Lion Roadkill
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Density of Roadkill
Low
Medium
High
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
0 0.05 0.1 0.2
Miles

<u>Near-term recommendations</u>:

1. Maintain culverts at PM 1749 and PM 1855 to allow drainage.

2. Install secondary fencing to enclose the non-functional box culvert (PM 1755).

3. Install ≥10 ft ROW fencing on both sides of the highway west from this culvert to Steele Canyon Road and east across the SDNWR to Vista Diego Road (Segment 4), with small mesh size and herp guards at the bottom along Steele Canyon Creek to keep small animals from entering the highway, and funnel fencing to the culvert at PM 1790. Bury fencing to prevent coyotes from digging under.

4. Install secondary fencing between Vista Sage Lane and Steele Canyon Creek.

5. Replace the existing, nonfunctional culvert at the bottom of the curve with the new SDSU undercrossing design (box culvert) at the intersection with Lorrel Place and Steele Canyon Creek. See SDSU engineering design (Appendix D). Install the culvert at an angle following the stream course. Incorporate structural features and dry ledges to provide cover for herpetofauna and smaller wildlife (i.e., a community of wildlife species). Remove or thin existing vegetation blocking the current undercrossing, which has caused water to pool on the north side of the highway; there is now a dense thicket of willows which impedes medium-large animal movement.

6. Install jump-outs (**X**) on the north and south sides of the highway, before and after the curve where the grade drops off.

7. Tie in ROW fencing to the new SDSU undercrossing and existing culverts (PM 1835, 1850, 1855, 1885, and 1900). Remove vegetation within and around these existing culverts to allow movement for small animals, and direct ROW fencing to funnel animals to these culverts.

8. Install ROW fence along the south side of SR-94 across the private parcel (nursery), install a secondary fence between the nursery and SDNWR and along Vista Sage Lane to Verde Lane.

9. Remove trash, human encampments, invasive species, and dense understory within Steele Canyon Creek to enhance use as a wildlife movement corridor.

10. Fencing and fire breaks line the residential development along Rancho Miguel Road, and there is no vegetation cover in the adjacent habitat, so no additional secondary fencing is recommended there.

Longer-term recommendations:

- Straighten the highway at the curve in the middle of this segment, and construct wildlife crossings at both the east and west ends of this re-route. This would involve re-routing the highway onto SDNWR lands. Include infrastructure for utilities in the new highway bed, thereby reducing fire risk from overhead transmission lines.

Segment #4 (Map 4)

Existing conditions: Segment 4 of the highway traverses through ~1.7 miles of residential and commercial land uses, with some unprotected open space—mostly coastal sage scrub, north and south of Lyons Valley Road on the north side of the highway. The Caltrans culvert data show 14 small (<2 ft in diameter) circular concrete pipes and slotted pipe drains in this segment. In addition, there is one circular culvert #1925 and two box culverts that are shown on Map 4). Large numbers of road-killed desert cottontails and ground squirrels, long-tailed weasels, coyotes, and some herps and birds have been recorded through this segment. Monitoring could help determine the need for fencing along the highway, but because of the existing and future land uses, highway fencing is not a priority.

Objectives:

- *Reduce roadkill by encouraging use of Segments 3 and 5 as crossing areas.*

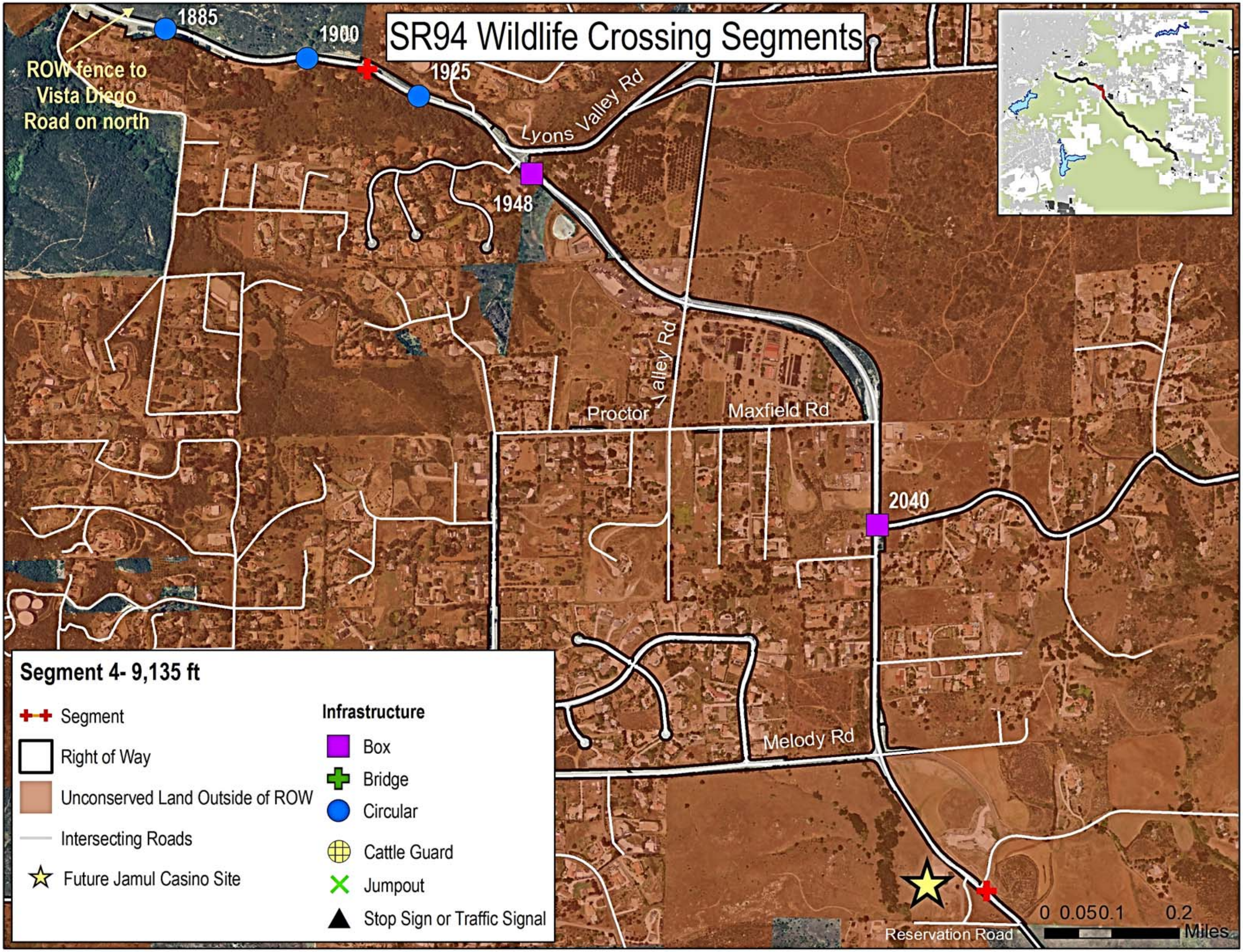
Near-term recommendations:

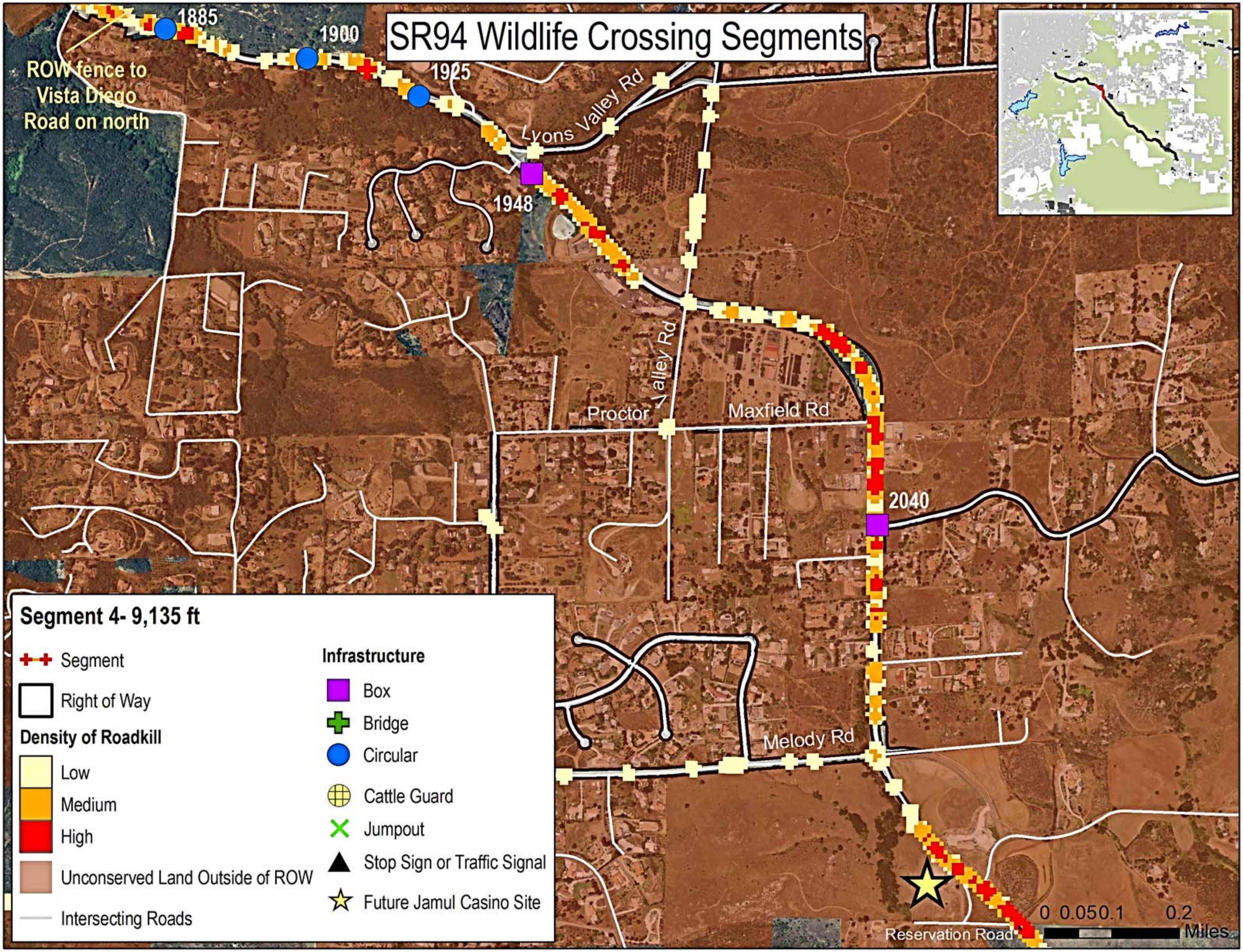
1. Assess the need for fencing at selected locations, along both sides of the highway, by documenting wildlife movement between the SDNWR and RJER at their junction with Proctor Valley Road, to funnel wildlife to crossings in Segments 3 and 5.

2. Because of the degraded nature of the habitat, and presence of residential development, there is no need for secondary fencing between undeveloped and developed land north of SR-94, between Lyons Valley Road and Melody Road (both sides of SR-94).

Longer-term recommendations:

- The TEE for the Jamul Casino includes two-way stop controls at the Lyons Valley and Melody Road/Peaceful Valley Ranch Road intersections and one-way stop controls at the Maxfield Road and Reservation Road intersections. This would have the effect of slowing eastbound traffic entering RJER.


SR94 Wildlife Crossing Segments
1885
1900
1925
1948
2040
ROW fence to Vista Diego Road on north
Lyons Valley Rd
Valley Rd
Proctor
Maxfield Rd
Melody Rd
Reservation Road
0 0.05 0.1 0.2
Miles
Segment 4- 9,135 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Future Jamul Casino Site
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal


SR94 Wildlife Crossing Segments
1885
1900
1925
1948
2040
ROW fence to Vista Diego Road on north
Lyons Valley Rd
Valley Rd
Proctor
Maxfield Rd
Melody Rd
Reservation Road
0 0.05 0.1 0.2 Miles
Segment 4- 9,135 ft
Segment
Right of Way
Density of Roadkill
Low
Medium
High
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
Future Jamul Casino Site

Segment #5 (Map 5)

Existing conditions: Segment #5 of the highway separates grassland on HCWA from the northeast part of RJER, also grassland. There are only two undercrossings in this nearly 1 mile stretch—a box culvert at the "Daley Dip," which is filled with sediment and therefore not functional for wildlife or flow, and three side-by-side circular culverts just north of Rancho Jamul Drive. The approaches to the circular culverts are partially blocked by vegetation. Coyotes are known to cross the highway at grade through this section, and previous camera traps have recorded long-tailed weasels and rabbits using the circular culverts (Dillingham 2015). Because of the lack of vegetative cover adjacent to the highway in this segment, it is unlikely to support significant use by mountain lions, but the HCWA and RJER reserves are used by bobcats, coyotes, mule deer, and many small mammals. Documented roadkill include mule deer, coyotes, ground squirrels, desert cottontails, long-tailed weasels, gopher snakes, western rattlesnakes, and birds. Fencing is three-strand barbed wire which has been damaged by storm flow.

Objectives:

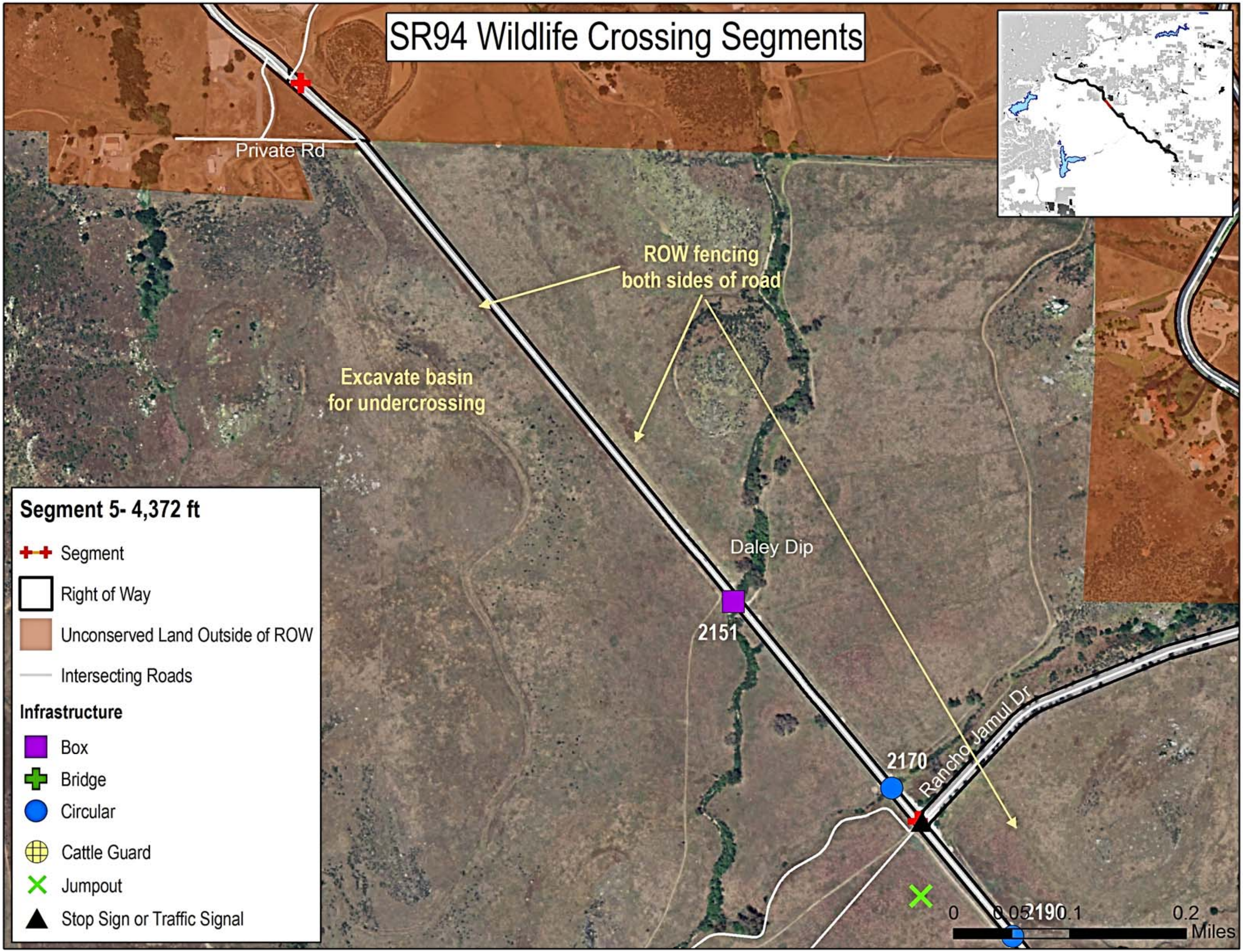
- *Provide for large animal movement between RJER and HCWA.*
- *Provide for small animal movement between CDFW lands.*
- *Reduce roadkill by enhancing two crossing areas.*

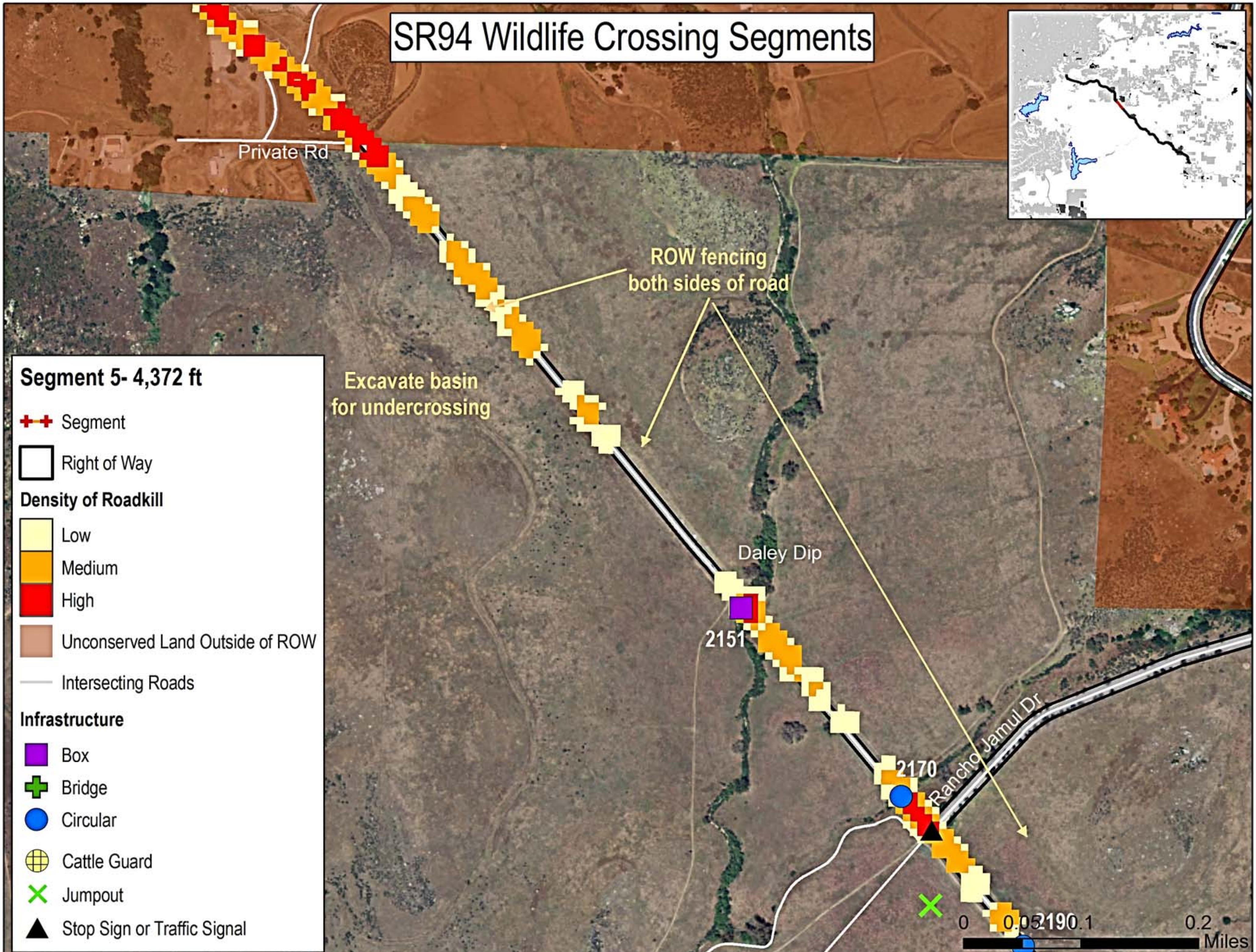
Near-term recommendations:

1. Remove vegetation and trash at entrances to existing culverts to allow movement of spadefoot toads and other herpetofauna and small animals under SR-94.

2. Install ≥4 ft ROW fencing, with small mesh size, along both sides of SR-94 through this entire segment, beginning at Melody Road in Segment 4. Install fencing between the drainage ditch and the open space on the south side of the highway, not over the drainage ditch or between the drainage ditch and the highway. Anchor fencing at the new culvert abutments on both sides. Bury fencing to prevent coyotes from digging under.

3. Based on wildlife tracking and monitoring, determine if secondary fencing should extend outward from the highway along the private properties where the habitat is degraded, with very little vegetation cover.


SR94 Wildlife Crossing Segments
Private Rd
ROW fencing
both sides of road
Excavate basin
for undercrossing
Daley Dip
2151
2170
Rancho Jamul Dr
2190
0
0.05
0.1
0.2
Miles
Segment 5- 4,372 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal


SR94 Wildlife Crossing Segments
Private Rd
ROW fencing
both sides of road
Excavate basin
for undercrossing
Daley Dip
2151
2170
Rancho Jamul Dr
2190
0 0.05 0.1 0.2
Miles
Segment 5- 4,372 ft
Segment
Right of Way
Density of Roadkill
Low
Medium
High
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal

4. Level the highway at the "Daley Dip" (PM 2151), and replace the existing Arizona-style crossing (three 3 ft diameter pipes buried by sediment) where many amphibians and small mammals have been found on the highway. This habitat does not extend very far off the current RJER boundary to the north and east. However, the buried culvert is a traffic safety issue during a large flood, which could inundate the road. Replace this non-functional undercrossing with larger culverts at a higher elevation (once the highway is leveled to eliminate the dip) to carry runoff and not fill with sediment.

5. Replace the two existing gates on RJER on both sides of SR-94 at the Daley Dip, and anchor to fencing.

6. Contour the approaches and remove overgrown vegetation and trash at the entrances to the three 4 ft culverts just north of Rancho Jamul Drive (PM 2170).

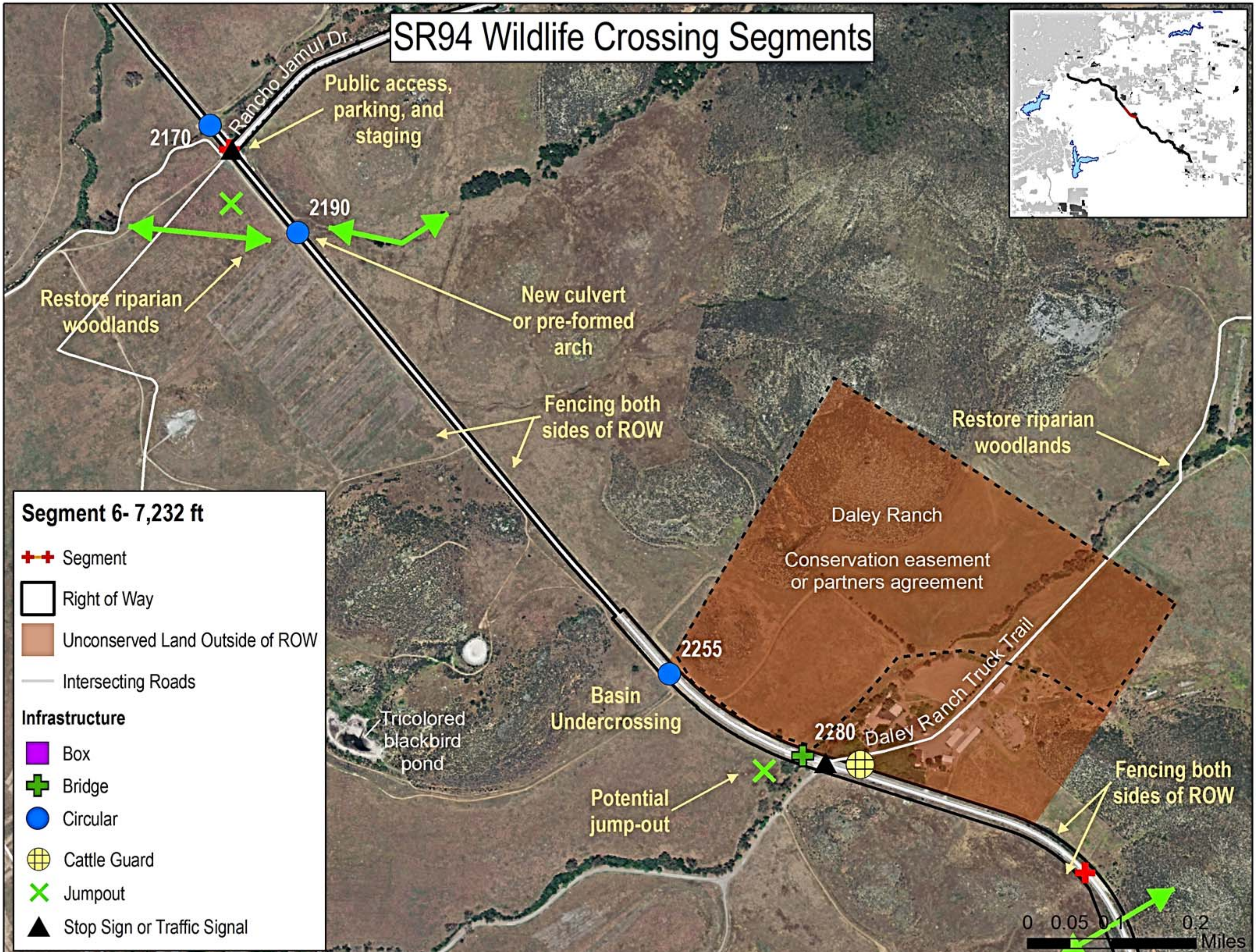
7. Because of the degraded nature of the habitat and the presence of residential development, there is no need for a secondary fence along the north side of Rancho Jamul Drive.

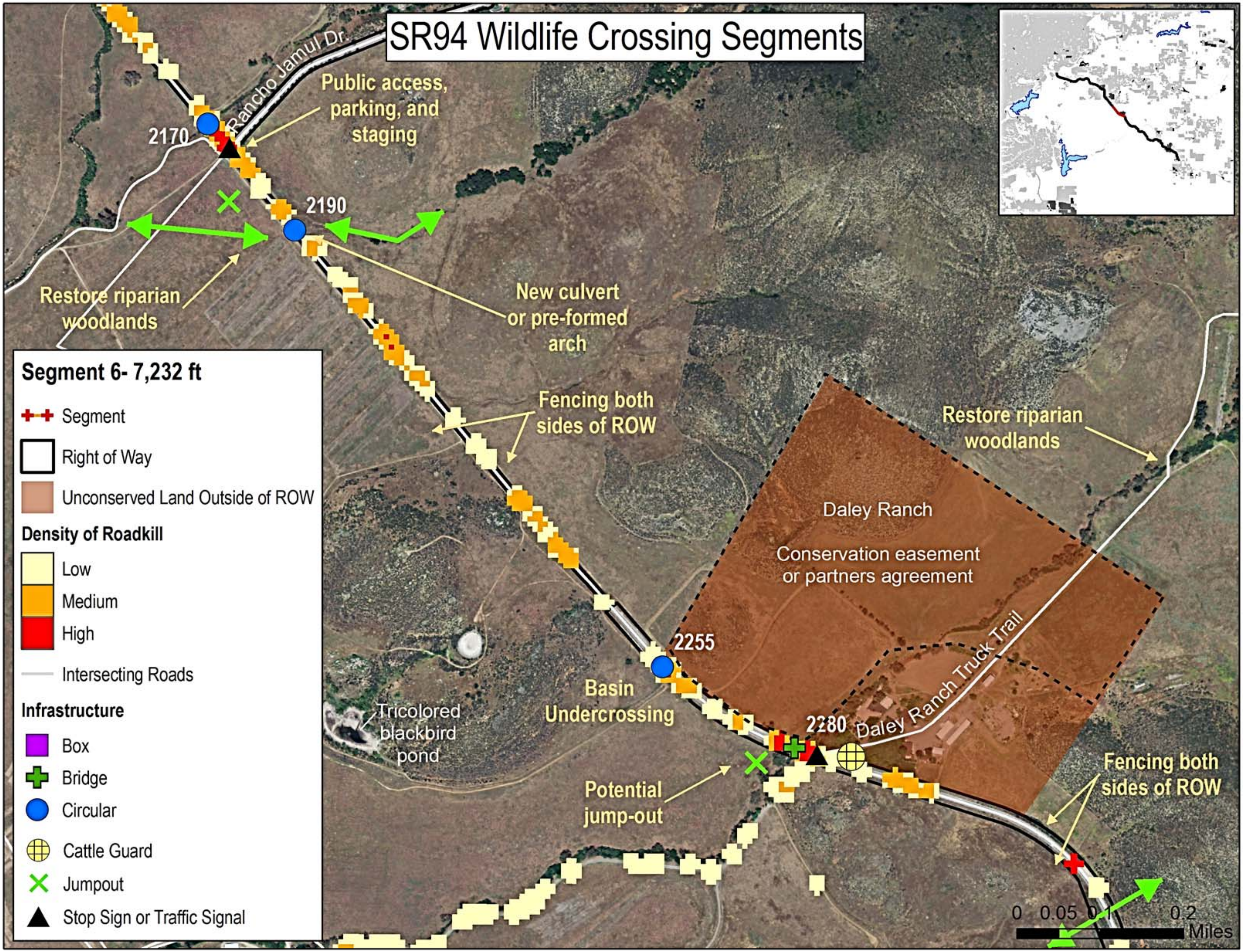
<u>Longer-term recommendations</u>:

- Caltrans (2011) includes widening and a passing lane through this segment, and thus implement the near-term priorities above.
- Consider installing a traffic signal or stop sign at Rancho Jamul Drive to reduce roadkill.
- Investigate the feasibility for an undercrossing north of the Daley Dip. It would require excavating a basin under the road (i.e., a "basin undercrossing" with location to be determined through monitoring).

Segment #6 (Map 6)

<u>Existing conditions</u>: This segment also separates grasslands on both sides of SR-94 through HCWA and RJER. There are three existing undercrossings in this 1.4 mile stretch, only one of which appears to be functional for wildlife. Just south of Rancho Jamul Drive is a very small (2 ft-diameter) culvert (PM 2190) partially blocked with sediment and brush, in a location where there is still a channel that supports riparian habitat upstream and downstream of the highway. However, a chain-link fence blocks the entrance to the culvert on the east side of the road, and the diversion box on the west side is filled with sediment and debris and obscures visibility through the culvert.


SR94 Wildlife Crossing Segments
Rancho Jamul Dr.
Public access, parking, and staging
2170
2190
Restore riparian woodlands
New culvert or pre-formed arch
Fencing both sides of ROW
Restore riparian woodlands
Daley Ranch
Conservation easement or partners agreement
Daley Ranch Truck Trail
2255
2280
Basin Undercrossing
Tricolored blackbird pond
Potential jump-out
Fencing both sides of ROW
Segment 6- 7,232 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
0 0.05 0.1 0.2
Miles


SR94 Wildlife Crossing Segments
Rancho Jamul Dr.
Public access, parking, and staging
2170
2190
Restore riparian woodlands
New culvert or pre-formed arch
Fencing both sides of ROW
Restore riparian woodlands
Daley Ranch
Conservation easement or partners agreement
Daley Ranch Truck Trail
2255
Basin Undercrossing
2280
Tricolored blackbird pond
Potential jump-out
Fencing both sides of ROW
0 0.05 0.1 0.2 Miles
Segment 6- 7,232 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Density of Roadkill
Low
Medium
High
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal

Just north of PM 2255, Dillingham (2015) describes an at-grade wildlife crossing, currently fenced with no undercrossing, where wildlife may be trying to access the pond on RJER. The 6 ft chain link fabric fence is frequently damaged by vehicle crashes in this area because of the undulating roadway, leaving openings for wildlife.

At the north end of the Daley Ranch property (PM 2255) there is a 4 ft diameter culvert with grated drains, smooth, steeply angled concrete sides, and a bend in the pipe. It is likely not functional for wildlife. The bridge over Jamul Creek at the RJER main gate is actually three side-by-side 12 ft box culverts. It is partially blocked on the east side, allowing only small and medium mammals to pass.

Although there is little vegetative cover adjacent to the highway in this segment, documented roadkill include deer, coyotes, ground squirrels, desert cottontails, long-tailed weasels, gopher snakes, western rattlesnakes, and birds. Bobcats and many other connectivity target species occupy the conserved habitats on both sides of the highway.

Objectives:

- *Provide for large animal movement, including deer and mountain lions, between RJER and HCWA.*
- *Reduce roadkill by enhancing multiple crossing areas.*

Near-term recommendations:

1. Install ≥10 ft ROW fencing along both sides of SR-94 through this segment and tie into undercrossing abutments. Include smaller mesh size at the bottom of the fencing to keep smaller animals off the road. Bury fencing to prevent coyotes from digging under.
2. Inspect the existing gate on RJER across from Rancho Jamul Drive and the two gates on both sides of the highway at the northwest end of the Daley Ranch and northwest of the RJER main entrance; determine if they need to be replaced; tie into new ROW fencing.
3. Install a stop sign or traffic signal at Rancho Jamul Drive or at the Daley Ranch Truck Trail, with right and left turn lanes both directions, to slow traffic through RJER and HCWA.
4. Determine the need for a cattle guard at Rancho Jamul Drive.
5. In place of the existing 2-ft diameter culvert (PM 2190), install a new undercrossing (box culvert, basin undercrossing, or 15 ft pre-formed arch) for large animals and to accommodate the drainage that crosses under the highway just south of Rancho Jamul Drive and continues on both sides of the highway, partially lined by oaks (this is a

tributary to Jamul Creek). Include structural features in the new undercrossing to provide cover for smaller animals.

6. Recontour the drainage at PM 2190 and plant riparian vegetation cover (e.g., sycamores, oaks, shrubs) on both sides of the highway along this drainage. The existing 2 ft culvert is partially blocked with sediment and brush and does not accommodate movement of any but potentially very small wildlife (Dillingham 2015) and is not adequate to accommodate existing hydrologic flow. Wildlands has plans for restoring the drainage that runs along Rancho Jamul Drive; their plans should be expanded to include the drainage south of Rancho Jamul Drive (green arrows, Map 6), which originally connected with the northern drainage. Restoring riparian habitat will encourage use by deer and mountain lions.

7. At PM 2255, replace the single 4 ft diameter culvert, which has a bend in the middle so that little light passes through. The culvert empties into a drainage ditch within RJER, and the two inlets on either side of SR-94 consist of grated drains with steeply angled concrete sides. Recontour the approaches to both sides of the culvert and excavate a basin undercrossing to accommodate small and large animals which may be trying to access the tricolored blackbird pond on RJER. Raising the elevation of the highway between the two rises just northwest of this location could eliminate the condition that creates vehicle crashes and connect what appears to be a major game trail from HCWA to the RJER pond.

8. Install jump-outs (**X**) south of Rancho Jamul Drive and on the west side of the bridge at the RJER main entrance road, based on wildlife movement monitoring.

9. There is already a chain link (secondary) fence along the Daley Property on the north side of SR-94, east of the main entrance to the property, which should be sufficient for discouraging animals into the Daley Ranch property. Install a cattle guard at the Daley Ranch entrance road (Daley Ranch Truck Trail).

10. Improve the entrance to the bridge over Jamul Creek (three side-by-side 12x12 ft culverts) underneath SR-94 (PM 2280) at the RJER main gate by removing plants and shrubs and by removing the Daley Ranch fence across the north side of the bridge, which restricts wildlife movement and has been used as a human hiding spot (Dillingham 2014). Maintain the vegetation on the RJER side of the bridge to allow for wildlife movement.

Longer-term recommendations:

- Caltrans (2011) includes widening and a passing lane through this segment. This could be accomplished as part of implementing the near-term priorities above.

Segment #7 (Map 7)

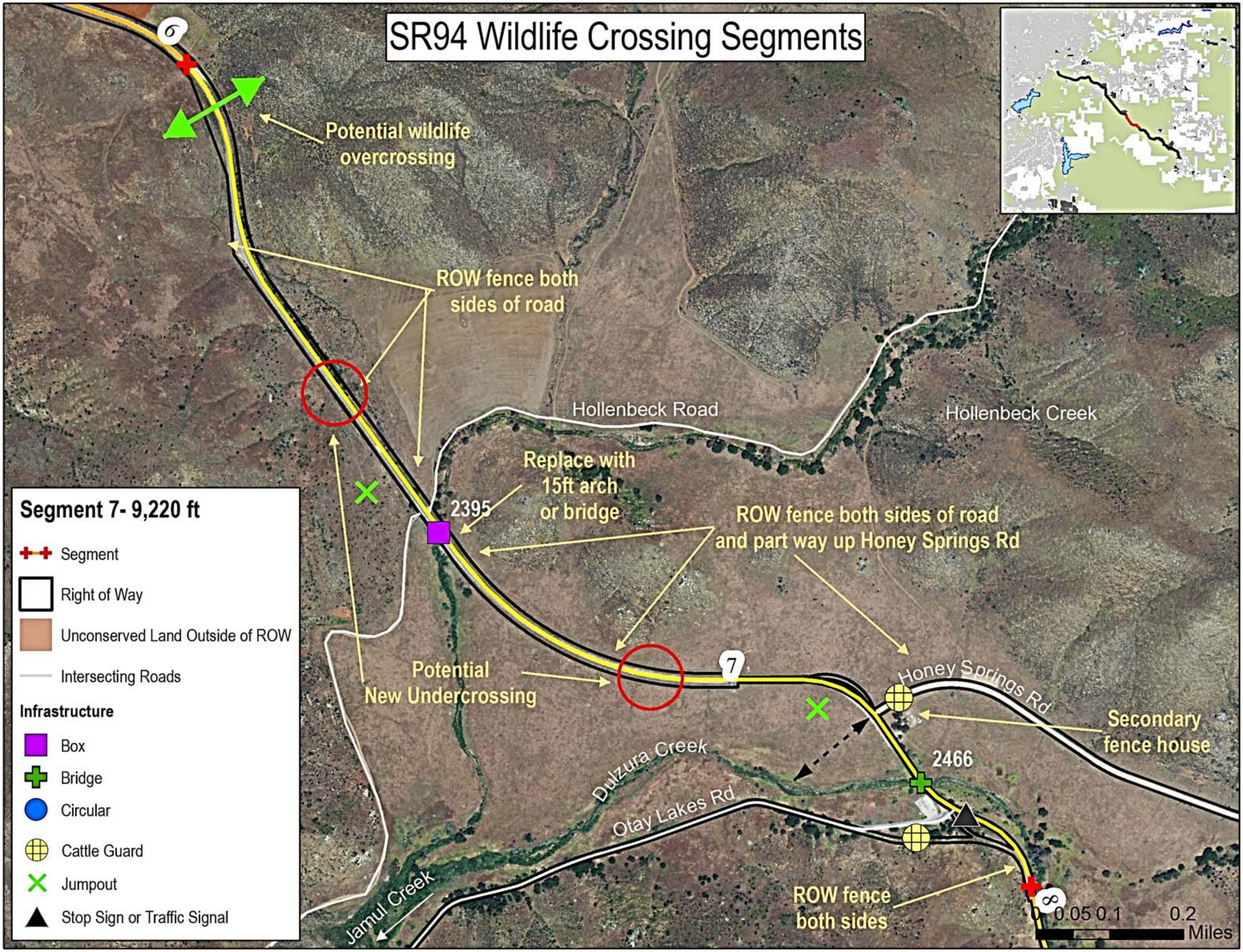
Existing conditions: This 1.7-mi segment of the highway separates mostly grassland on conserved lands at HCWA and RJER, with two riparian-lined creek crossings. Wildlife cross the highway at-grade through this segment (T. Dillingham, pers. comm.), both northwest and southeast of Hollenbeck Creek. There is a 2-ft culvert about 0.5 southeast of the RJER main gate, but is not functional and not shown on Map 7 (location of potential wildlife overcrossing). The two existing undercrossings shown on Map 7 are at Hollenbeck Creek (PM 2395) and Dulzura Creek (PM 2466). The Hollenbeck Creek undercrossing comprises two side-by-side 5x4 ft box culverts with poor access by wildlife because of a vertical drop on the west side of the highway and no directional fencing. The Otay Lakes Road bridge over Dulzura Creek is large enough to allow passage of large animals, although there is no directional fencing and no ROW fencing throughout this segment, so that wildlife can freely enter the highway. Documented roadkill include deer, coyote, ground squirrel, western toad, and barn owl. A mountain lion has been recorded at the HCWA.

Objectives:

- *Provide for large animal movement, including deer and mountain lions, between RJER and HCWA.*
- *Reduce roadkill by enhancing multiple crossing areas.*

Near-term recommendations:

1. Install ≥10 ft ROW fencing on both sides of the highway, from the RJER entrance and Daley Ranch property to Hollenbeck Road, Honey Springs Road, and Otay Lakes Road. Use smaller mesh at the bottom of the fence, and bury fencing to prevent coyotes from digging under. Funnel wildlife to the two enhanced undercrossings described below. Tie ROW fencing into the box culvert and bridge abutments.
2. Inspect and, if necessary, replace the two CDFW gates in this segment (Hollenbeck Road, both sides of highway), and tie into the ROW fencing.


SR94 Wildlife Crossing Segments
Potential wildlife overcrossing
ROW fence both sides of road
Hollenbeck Road
Hollenbeck Creek
Replace with 15ft arch or bridge
2395
ROW fence both sides of road and part way up Honey Springs Rd
Potential New Undercrossing
7
Honey Springs Rd
Secondary fence house
Dulzura Creek
2466
Otay Lakes Rd
Jamul Creek
ROW fence both sides
0 0.05 0.1 0.2 Miles
Segment 7- 9,220 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal

3. Replace the two 44-ft long, side-by-side 5x4 ft box culverts (PM 2395) in the middle of this segment with a 15-ft arch or bridge to accommodate deer and mountain lions, re-contour both sides of the bridge with earthen benches, include structural features in the new undercrossing to provide cover for smaller animals, and remove or cover rip-rap to facilitate wildlife use on the approaches to the undercrossing, especially on the downstream side where the drainage is very incised and the topography is lower than on the upstream side of the highway. Maintain trash-pickup in this area.

4. Install a cattle guard on Honey Springs Road, and continue the ROW fencing east on Honey Springs Road to the HCWA Honey Springs parking area on the north side, and past the CDFW residence on the south side. Stagger the end points of the fencing to allow a straight uphill-downhill travel path to the opposite side of the road.

5. Conduct a "Hot Spots Analysis" (Bissonette and Cramer 2008, Wilson 2012) along (a) Honey Springs Road up to Deerhorn Valley and (b) Otay Lakes Road to Otay Lakes to determine where undercrossings should be located for herpetofauna, which are victims of significant roadkill (R. Fisher pers. com.), and identify locations for special herpetofauna fencing to keep small to medium-sized animals off the roads.

6. Install secondary fencing around the house south of Honey Springs Road, beginning at the cattle guard, and tie-in fence to the Dulzura Creek bridge abutments (PM 2466) to encourage wildlife movement around the back of the house to the Dulzura Creek bridge.

7. Determine locations for at least two jump-outs through this segment, based on wildlife movement monitoring.

8. East of Otay Lakes Road, install ROW fence on both sides of SR-94 at the same location as the current barbed-wire fencing, all the way to the Border Patrol checkpoint. The fence on the south side of SR-94 is on top of the slope.

<u>Longer term recommendations</u>:

- Investigate the feasibility of a land bridge over the highway for large animals in the northwest portion of this segment, where topography allows (Map 7). Monitor to determine the most preferred crossing location here. Dodd et al. (2007a) showed that there were significantly more bird flights over vegetated overpasses compared to flights directly over the road.

- Investigate the feasibility of placing undercrossings both north of and south of Hollenbeck Road (red circles on map), as there currently are so few opportunities to cross the road except at-grade.

- The TEE includes one-way stop controls at the Honey Springs Road and Otay Lakes Road intersections.

- Caltrans (2011) includes realignment of deficient curves, highway widening, and a passing lane through this segment, so the near-term priorities listed above could be accommodated during this alignment and widening.

Segment #8 (Map 8)

Existing conditions: Segment 8 of SR-94 is mostly south of the Border Patrol Station, and Dulzura Creek borders the highway on the northeast. BLM administers the lands southwest of the highway, while CDFW (HCWA) and the County (Daley Preserve) administer lands to the north. There are only three 3-ft wide undercrossings through this 1.3-mile segment, and one of them (PM 2515) is right at the Border Patrol Station. Because of the topography through this segment—the coastal sage scrub on the southwest side is steep and higher than the more level grassland and coastal sage scrub in the valley that borders Dulzura Creek—the most likely wildlife movement corridor crosses SR-94 at Sycamore Canyon Road (BLM pink gate), through the oak riparian forest along Dulzura Creek. Although some small animals may use the five 3 ft culverts at this location (PM 2615), which are choked by vegetation, crossing by larger animals is likely at grade. There was evidence of coyote and raccoon in the approach to the culvert, but deer and bobcats are also present in the adjacent habitats, as well as roadrunners and small mammals that are connectivity targets.

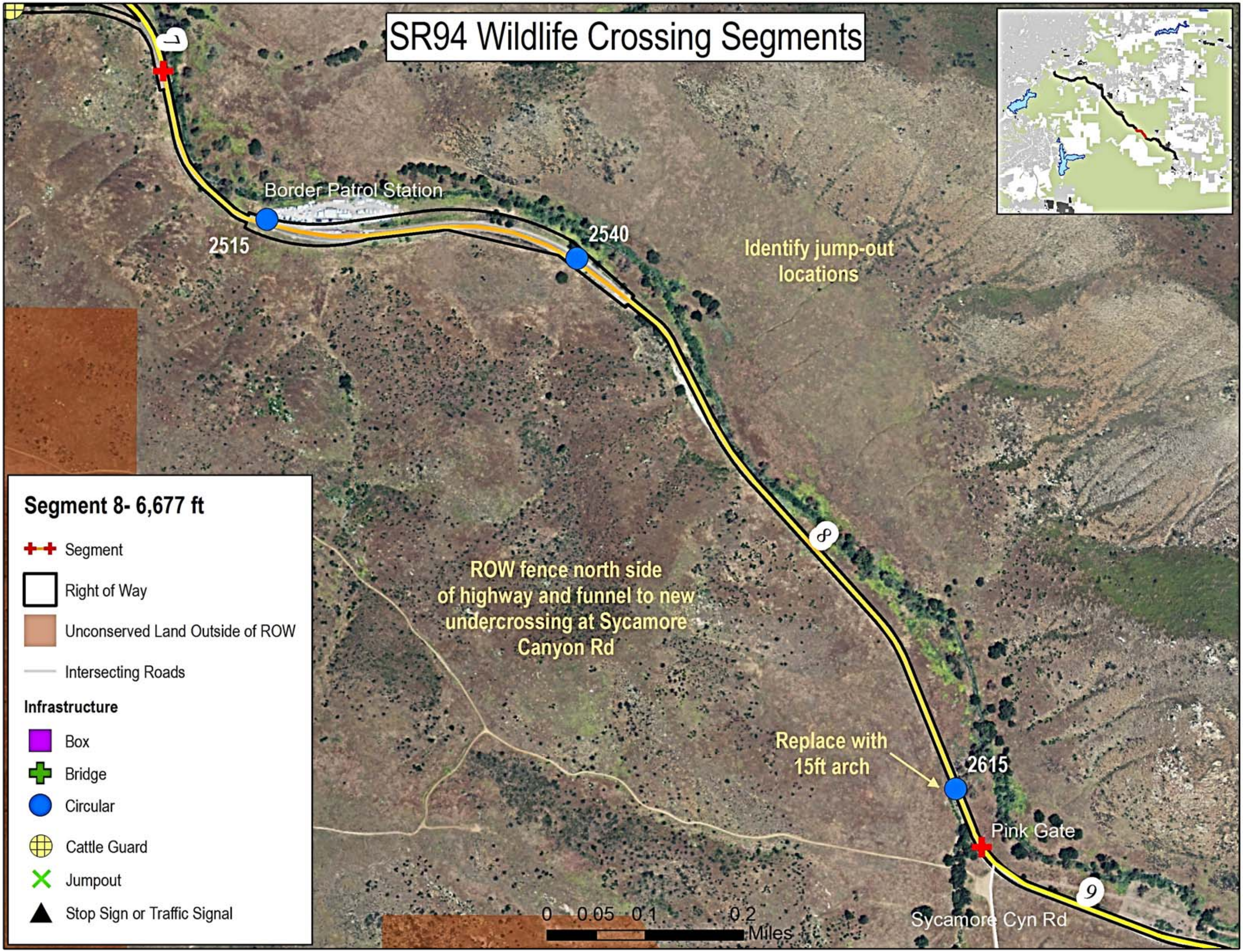
Objectives:

- *Enhance connectivity for large animals, including deer and mountain lions, between BLM Sycamore Canyon and HCWA.*

- *Reduce roadkill by enhancing crossing areas and discouraging animals from crossing the highway at-grade.*

Near-term recommendations:

1. Install ≥10 ft ROW fencing along the northeast side of the highway through this segment to discourage wildlife crossings at grade. Bury fencing to prevent coyotes from digging under. Install secondary fencing on the hill on the south side of the highway. Where the fences enter the grasslands at the south end of this segment, reinforce the bottoms


SR94 Wildlife Crossing Segments
Border Patrol Station
2515
2540
Identify jump-out locations
ROW fence north side of highway and funnel to new undercrossing at Sycamore Canyon Rd
Replace with 15ft arch
2615
Pink Gate
Sycamore Cyn Rd
8
9
0 0.05 0.1 0.2 Miles
Segment 8- 6,677 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal

of the fencing on both sides to prevent smaller animals from getting through. Determine the need for taller ROW fencing through the grassland on the southwest side.

2. Remove and maintain sediment and vegetation at culverts PM 2515 and PM 2540.

3. Install at least two jump-outs in appropriate locations, based on wildlife movement monitoring.

4. Replace the five 3 ft culverts (PM 2615) at the pink BLM gate with a 15-ft arch to accommodate large mammals. Contour the approaches as necessary, and clean out the vegetation choking entry into the undercrossing on each side). Include structural features in the new undercrossing to provide cover for smaller animals.

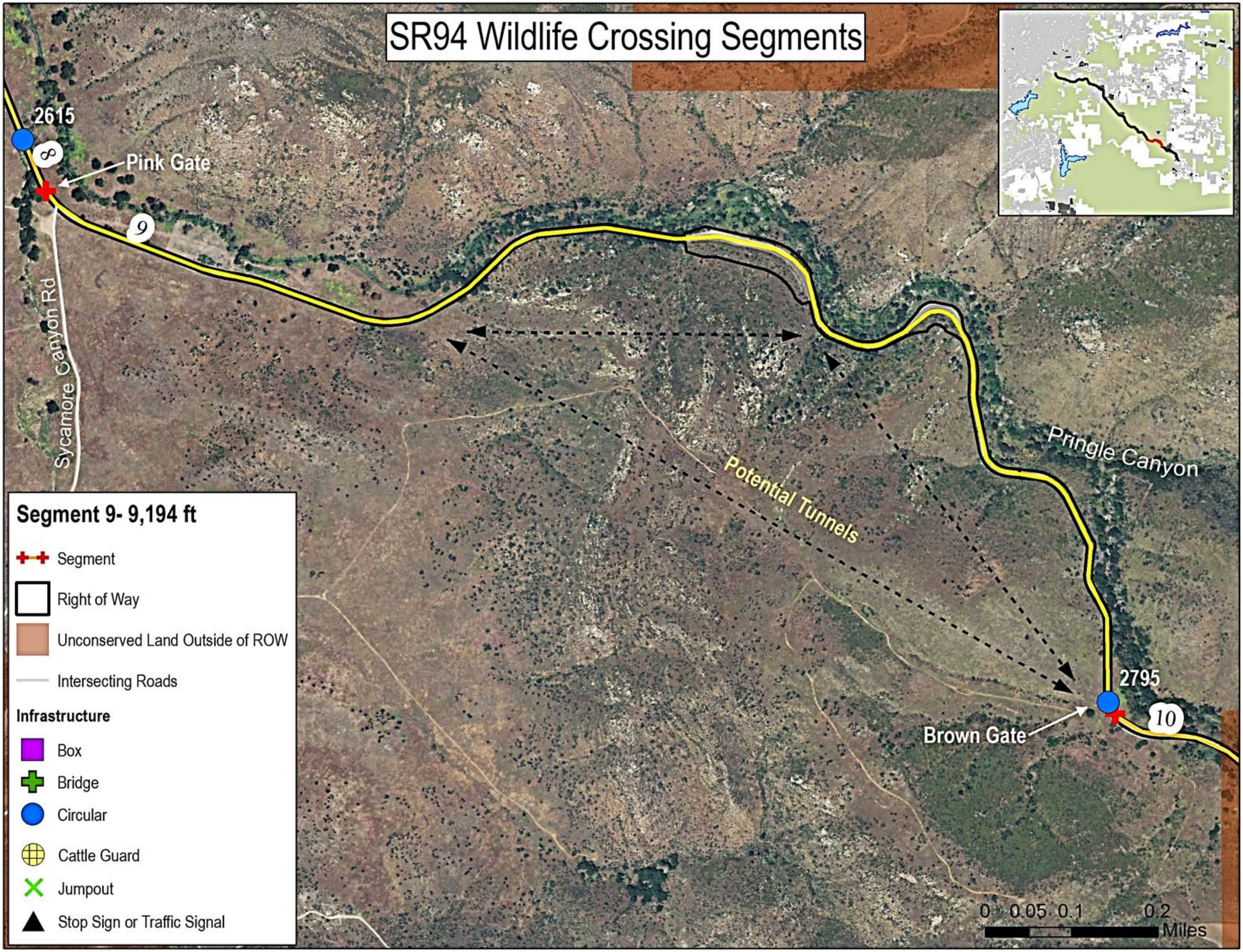
5. Install fencing to funnel animals to the new undercrossing and tie in with abutments.

Longer term recommendations:

- Caltrans (2011) includes realignment of deficient curves, road widening, and a passing lane through this segment so could install the new undercrossing concurrently with these improvements.

Segment #9 (Map 9)

Existing conditions: Segment 9 (1.7 mi) runs along the steep, north face of a mountain, with Dulzura Creek ~100 ft below the highway grade, so fencing and jump-outs through this portion are likely not needed. The highway divides BLM land on the south from the County's LB Daley Preserve on the north. Most of the vegetation is coastal sage scrub and chaparral, with oak riparian woodland lining Dulzura Creek and within Pringle Canyon. Because of the difference in elevation, and the steep rock face on the south side of the highway, there are no potential wildlife undercrossings except for the southern end of the segment at the BLM brown gate. There is a wildlife trail from Dulzura Creek to the road at the brown gate, where there is evidence of at-grade crossings by deer, bobcat, and coyote. The 2-ft diameter culvert at this location (PM 2795) is full of sediment and not functional. Coyotes and small mammals were observed in track and camera stations along an unnamed drainage in the middle of this section and in Pringle Canyon on the LB Daley Preserve (TAIC 2011); mule deer, bobcats, and smaller animals have been recorded in the area (Table 2).


SR94 Wildlife Crossing Segments
2615
8
Pink Gate
9
Sycamore Canyon Rd
Potential Tunnels
Pringle Canyon
2795
10
Brown Gate
Segment 9- 9,194 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal
0 0.05 0.1 0.2
Miles

<u>Objectives</u>:

- *Enhance connectivity for large animals between BLM lands and the County's Lawrence and Barbara Daley Preserve.*
- *Identify existing at-grade crossing points, as informed by wildlife movement monitoring.*

<u>Near-term recommendations</u>:

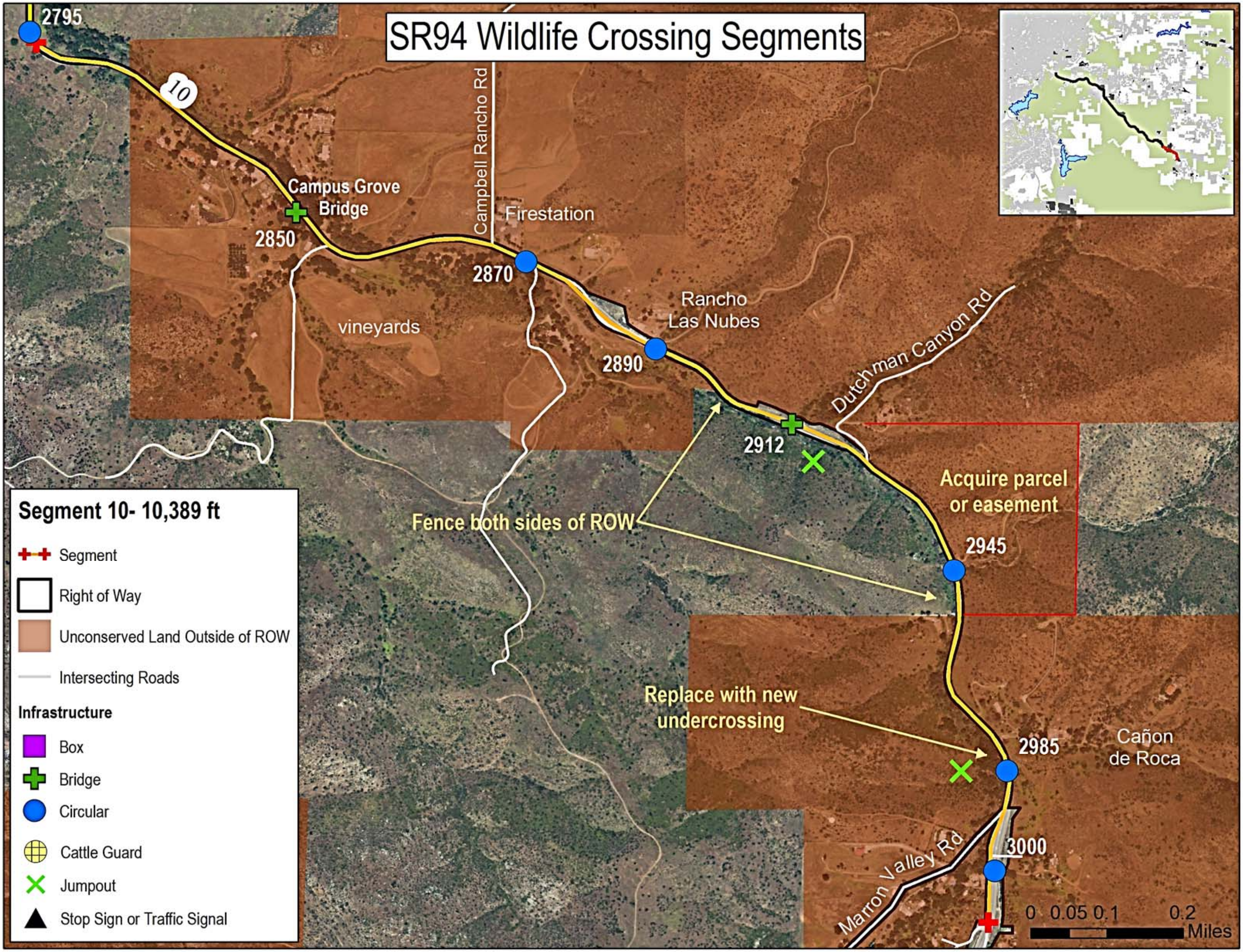
1. Replace the small 2 ft culvert at the brown BLM gate (PM 2795) with a larger undercrossing (e.g., 15 ft arch to accommodate large mammals) that is tied into the fence. Include structural features in the new undercrossing to provide cover for smaller animals.
2. Install jump-outs, as informed by wildlife movement monitoring.
3. Install new gates (replace brown gate on BLM land, south of highway, and gate to restoration area on CDFW land, north of highway); tie into fencing.

<u>Longer-term recommendations</u>:

- Eliminate the dangerous curves through this segment by tunneling through all or a portion of this segment. This would provide 1.7 miles without a highway, so that animals could move freely across conserved lands.
- Caltrans (2011) includes installation of standard 8 ft shoulders through this segment; it also identifies a "bypass alignment" alternative where there are multiple curves within a short distance, challenging traffic maneuverability.

Segment #10 (Map 10)

<u>Existing conditions</u>: Segment 10 (almost 2 miles) traverses the community of Dulzura, which is mostly private land comprising disturbed habitat, agriculture (vineyards), pasture, and houses, surrounded by coastal sage scrub. The southern end of the segment borders BLM land, with a possible connection across SR-94 to other BLM land. There is a bridge at Camps Grove, with some water flow, that is used by livestock. Oak riparian woodland lines Dulzura Creek, which borders the highway on the north, and Dutchman Canyon also supports oak riparian woodland along with some exotic species along Grande Creek, with a 20 ft high box culvert/bridge at the intersection with SR-94. Because of the narrow ROW and elevation differences between the north and south sides of the highway, there are infrequent places for crossing. In addition to one 1-ft nonfunctional culvert at Dutchman Canyon Road (not shown on Map 10 or Table 4 because of its small size), there are five partially functional culvert undercrossings in this


SR94 Wildlife Crossing Segments
2795
10
Campus Grove Bridge
2850
Campbell Rancho Rd
Firestation
2870
vineyards
Rancho Las Nubes
2890
Dutchman Canyon Rd
2912
Fence both sides of ROW
Acquire parcel or easement
2945
Replace with new undercrossing
2985
Cañon de Roca
3000
Marron Valley Rd
0 0.05 0.1 0.2 Miles
Segment 10- 10,389 ft
Segment
Right of Way
Unconserved Land Outside of ROW
Intersecting Roads
Infrastructure
Box
Bridge
Circular
Cattle Guard
Jumpout
Stop Sign or Traffic Signal

segment—at the fire station (4 ft diameter culvert) where the steep slope supports a rock wall; at Rancho Las Nubes (5 ft diameter); on the Arbabian parcel (4x3 elliptical culvert) between Dutchman Canyon Road and Canon de Roca; at Canon de Roca (3x2 ft elliptical culvert); and just south of Marron Valley Road. Fencing is not recommended through Dulzura, but the need for fencing should be assessed on BLM property. Mule deer, greater roadrunner, California gnatcatcher, Quino checkerspot butterfly, and Thorne's hairstreak have been recorded in this area, but roadkill has not been monitored regularly.

Objectives:

- *Enhance connectivity between BLM lands and Forest Service lands.*
- *Encourage wildlife movement under the bridge at Camps Grove in the western portion of the segment.*
- *Facilitate wildlife crossing at-grade in the eastern portion of the segment.*

Near-term recommendations:

1. Monitor this segment seasonally to determine most likely areas for at-grade crossings, best areas to establish jump-outs, and where ROW fencing is needed (e.g., BLM property). Assess where fencing is not needed due to topography or land use relative to the highway (e.g., through the community of Dulzura).
2. Install secondary fence to funnel wildlife under the Camps Grove bridge (PM 2850), and build dry ledges on both sides of the undercrossing. There is evidence of cows and small mammals currently using the bridge undercrossing.
3. Remove and maintain sediment load and vegetation at the culvert (PM 2870) at fire station.
4. Remove the invasive species and other vegetation at the 5 ft concrete culvert (PM 2890) at Rancho Las Nubes (17460 Campo Road). Recontour the drainage, especially upstream, where it is incised. The culvert currently is used by small mammals. Monitor this area to determine wildlife use.
5. Install a dry ledge under the 20 ft bridge over Grande Creek (PM 2912), north of Dutchman Canyon Road, which is being used by raccoons, bobcats, and foxes. Remove invasive species along the openings on each side of the bridge. Based on monitoring, evaluate where directional ROW or secondary fencing is needed to funnel animals to the bridge undercrossing.

6. Install a jump-out (**X**) for deer on the south side of the highway across from the driveway southeast of Dutchman Canyon Road (17771 Campo Road), where there is a 12" culvert that is probably not functional for wildlife movement (not shown on map because of small size). The jump-out should accommodate the 10 ft elevation drop on the south side of the highway and tie into new ROW fencing. Based on monitoring and assessment of the hydrology in this area, evaluate whether a larger culvert is needed.

7. Replace the 4x3 ft elliptical culvert (PM 2945), which does not appear functional for wildlife movement, with a larger culvert to accommodate large animals.

8. Install directional ROW fencing in the area between PM2800 and PM 2945, as informed by monitoring.

9. Elevate the highway at the dirt road intersection at Cañon de Roca (PM 2985, 17764 Campo Road) to eliminate the dip, and install a pre-formed arch or bridge to replace the three small culverts at this location, which appear to be used only by small mammals. Fence or gate the Cañon de Roca driveway. There was sign of coyote crossing at-grade in this area. Place a jump-out on the south side of the highway.

10. Remove and maintain sediment load and vegetation at the culvert (PM 3000) at Marron Valley Road.

<u>Longer term recommendations</u>:

- Caltrans (2011) includes realignment of deficient curves, road widening, and a passing lane through this segment; therefore, these priority enhancements could be accommodated in the high realignment.

3.5 Public Use Recommendations

Improving infrastructure on SR-94 presents an opportunity to also accommodate public uses on conserved lands, such as access points, parking, trails, and other facilities. Public use of wildlife crossings should be evaluated for compatibility with wildlife use as well as compatibility with the county trails master plan.

Segment #1

1. Determine the need to build an all-weather crossing to accommodate equestrians under the SR-94 bridge over the Sweetwater River by placing a hard surface material over the top of the rip-rap. This would replace the existing pedestrian/horse lane on the east side of the bridge (Map 1).

2. The SDNWR would like to build an office, parking lot, and interpretive area in the vacant lot located along the south side of SR-94 east of the Sweetwater River. A trail for pedestrians and horses could be routed from the SDNWR parking lot to the old SR-94 bridge that crosses the Sweetwater River and tie into the existing trail along the south side of the river.

3. Discuss the need for gates with SDG&E; there are no gates now for accessing the easement from SR-94; the dirt road that accesses the easement is across the highway from the baseball fields (Map 1).

4. Improve traffic safety and facilitate traffic entering and exiting at the Millar Ranch Road intersection.

5. Install a traffic signal or stop sign and horse-crossing over SR-94 at Singer Lane. This would allow westward continuation of the trail on the north side of the river.

6. Install a left turn lane to Millar Ranch Road on SR-94 westbound. There already is a left turn lane on SR-94 eastbound.

Segment #2

1. Maintain traffic safety for residential access.

Segment #3

1. Add a parking lot at the pump station for hikers.

Segment #4

1. Maintain traffic safety for residential access.

2. Reduce traffic from Proctor Valley Road.

3. The TEE includes a traffic signal at the Jefferson Road/Proctor Valley Road intersection.

4. The TEE includes two-way stop controls at the Lyons Valley and Melody Road/Peaceful Valley Ranch Road intersections and one-way stop controls at the Maxfield Road and Reservation Road intersections. This would have the effect of slowing east-bound traffic entering RJER.

5. The TEE includes improvements to culverts and the Melody Road bridge to address hydrologic impacts.

Segment #5

1. Consider installing a traffic signal or stop sign at Rancho Jamul Drive. There is already a left-turn lane onto Rancho Jamul Drive eastbound on SR-94 (Map 5).

2. Caltrans (2011) includes widening and a passing lane through this segment. This could be accomplished as part of the near-term priorities above. However, crossings should be improved or created as soon as possible to reduce roadkill regardless of the implementation of a road improvement project.

Segment #6

1. Install a stop sign or traffic signal at Rancho Jamul Drive or at the Daley Ranch Truck Trail, with right and left turn lanes both directions, to slow traffic through RJER and HCWA (Map 6).

2. Investigate the feasibility for having a public entry point, parking, and staging area for RJER across from Rancho Jamul Drive (south side of SR-94).

3. Caltrans (2011) includes widening and a passing lane through this segment.

4. Level the section of highway immediately north of the RJER main gate, where many car accidents occur (T. Dillingham, pers. comm.).

Segment #7

1. Conduct a "Hot Spots Analysis" along (a) Honey Springs Road up to Deerhorn Valley and (b) Otay Lakes Road to Otay Lakes to determine where undercrossings should be located for herpetofauna; identify locations for special herpetofauna fencing to keep small to medium-sized animals off the roads.

2. Re-route Otay Lakes Road to intersect SR-94 at the Honey Springs Road intersection. While this may not improve connectivity, it should improve traffic safety (Map 7). Maintain the left-turn lane from SR-94 westbound to Otay Lakes Road. Install a cattle guard at Otay Lakes Road and a traffic sign or signal at the intersection.

3. The TEE includes one-way stop controls at the Honey Springs Road and Otay Lakes Road intersections.

4. Caltrans (2011) includes realignment of deficient curves through this segment.

5. Caltrans (2011) includes widening and a passing lane through this segment. This could be accomplished as part of implementing the near-term priorities in this segment.

Segment #8

1. Caltrans (2011) includes realignment of deficient curves, road widening, and a passing lane through this segment; a new undercrossing could be accommodated with these improvements.

Segment #9

1. Eliminate the dangerous curves through this segment by tunneling through all or a portion of this segment (Map 9).

2. Caltrans (2011) includes installation of standard 8 ft shoulders through this segment; it also identifies a "bypass alignment" alternative where there are multiple curves within a short distance, challenging traffic maneuverability. These improvements could be accomplished as part of implementing the near-term priorities above and tunneling through all or a portion of this segment.

Segment #10

1. Enhance traffic safety through the community of Dulzura.

2. Caltrans (2011) includes realignment of deficient curves, road widening, and a passing lane through this segment.

4 Opportunities for Infrastructure Improvements

This section summarizes (1) the results of the Jamul Casino environmental evaluation and (2) the improvements that Caltrans has proposed to improve traffic safety and level of service in light of the casino and other development projects. These developments will increase traffic levels on SR-94, Otay Lakes Road, Proctor Valley Road, and other roads in south San Diego County. Proposed improvements to SR-94 provide the opportunity to enhance highway permeability while helping to mitigate regional impacts on wildlife movement and preserve integrity.

4.1 Jamul Indian Village Gaming Development Project

The Tribal Environmental Evaluation (TEE) for the Jamul Casino and Hotel lists the most prominent issues yet to be resolved and areas of controversy as:

- Traffic—potential impacts to level of service for SR-94 and neighboring county roadways
- Community character/visual effects—change in the rural character of the community, impacts to dark skies, and visual effects on the County-designated Scenic Highway
- Fire/emergency service and police service—impacts to the Fire District's ability to respond to calls in a timely fashion
- Biological resources—operational impacts on the SDNWR and MSCP.

A traffic analysis was conducted that assumes additional traffic controls such as signal lights and one-way and two-way stop signs at various intersections (Kimley-Horn 2012). The County of San Diego has significance criteria that would require additional controls. Kimley-Horn (2012) estimates that almost 80% of the traffic would travel from the direction of Jamacha Road to the casino project site, i.e., through Segments 1-4, regardless of the casino entrance alternative.

The direct and cumulative traffic analyses for the proposed developments do not consider potential impacts of increased traffic to wildlife (i.e., wildlife-vehicle collisions, barrier effects) as part of the significance criteria, but rather evaluate the capacity of the road networks to accommodate projected traffic increases compared to existing traffic. The TEE for the Jamul Casino concludes that, with the recommended intersection improvements, all project-related impacts would be mitigated. The TEE identifies the Willow Creek channel that drains north to south on the reservation property as the only "wildlife corridor" in the project area. The TEE does not consider potential indirect and cumulative impacts of traffic increases to various wildlife species and landscape connectivity and integrity.

Based on the casino traffic analyses and anticipated traffic increases generated by other new developments proposed for Segment 4, Segments 1-4 will receive considerably more daily trips. As traffic volume is a factor in wildlife mortalities and wildlife avoidance, we can infer that these predictions for increased traffic reinforce the need for improvements to address wildlife crossing issues, especially for affected roads (e.g., SR-94, Otay Lakes Road, Proctor Valley Road).

4.2 Caltrans Transportation Concept Summary

Caltrans (2011) developed a Transportation Concept Summary as an analysis tool and conceptual long-range guide to inform future roadway investment decisions. This summary documents existing (2009) and future (2030) Levels of Service (LOS) and Annual Average Daily Traffic (AADT) for different portions of the highway (Table 6). Major development projects proposed for the study area will increase average daily traffic (ADT) levels (Table 7).

Table 6—Levels of service, by segment (Figure 3).

Location	Segments & preserves	2009 AADT	LOS 2009	2030 AADT	LOS 2030
Jamacha Rd to Steele Canyon Rd	1-2, SDNWR	17,700	D	39,700	F
Steele Canyon Rd to Lyons Valley Rd	3-4, SDNWR	18,400	D	35,700	F
Lyons Valley Rd to Honey Springs Rd	4-7, RJER, HCWA	11,400	C	19,800	F
Honey Springs Rd to Otay Lakes Rd	7, RJER, HCWA	6,800	B	12,300	D
Otay Lakes Rd to Dulzura	7-10, RJER, HCWA, BLM, Daley Preserve	7,100	B	15,800	D

Source: Caltrans 2011; only relevant segments included.

Table 7—Major development projects, by segment.

Segment	Project	Description	ADT
4	Jamul Highlands	23 large acre homes	2,400
4	Simpson Farm	97 residential units	7,690
4	Jamul Casino and Hotel	Casino and hotel	9,442
4	Peaceful Valley	Residential units	750
5	Rancho Jamul Estates	120 residential units	1,440

Source: Caltrans 2011; only relevant segments included.

Based on these estimates, District 11 has recommended the following improvements which provide opportunities to address wildlife crossing issues.

- Realignment of deficient curves (Segments 7-10);
- Installation of passing lanes (Segments 5-8, Segment 10);

- Widening of the traveled way (Segments 5-8, Segment 10);
- Installation of standard 8 ft shoulders (Segment 9);
- Adding/improving turn pockets (selected intersections);
- Bridge rails (Segments 6-10); and
- Centerline rumble strip (all segments).

4.3 SR-94 Infrastructure Priorities, Costs, and Schedule

There are immediate actions that could be taken to improve existing undercrossings at minimal cost, as detailed in Section 3.4, for example:

- Remove sediment blocking undercrossings.
- Remove or thin vegetation at the entrances to culverts, remove trash, and install catch basements.
- Improve approaches to undercrossings, such as contouring approaches to decrease elevation differences between sides of the highway.
- Cover rip-rap along Sweetwater River and within undercrossings.
- Install structural cover for small animals under bridges, and create dry ledges for movement.
- Repair or remove existing fencing as described in Section 3.4, and add directional fencing where needed.
- Install cattle guards.

Decisions on priorities and schedule by segment will obviously depending on funding and funding sources. However, prioritization should consider these factors:

1. The presence of conserved lands on both sides of the highway, where the highway is assumed to be a barrier to movement and ecosystem function (i.e., all but segments 2, 4, and 10).

2. Existing and proposed land uses, and thus level of traffic and loss of habitat near the highway. Based on the Jamul Casino traffic analyses and proposed new developments, there will be greater habitat loss to development and increased traffic in Segments 1-4. Sections 3 and 5 bisect conserved lands within and adjacent to these segments. Based on this analysis, the highest priorities for infrastructure improvements to SR-94 are Segments 3 and 5 (Table 5). However, not included in the TEE analysis was the potential traffic from Tecate, by Mexican workers supporting the casino and hotel. There will also

be traffic increases on Otay Lakes Road and Proctor Valley Road, where infrastructure improvements should be addressed (see Section 1.3).

3. Segments 6, 7, 8, and 9 cross the areas most likely to support large animals, i.e., deer and mountain lions, especially where riparian areas cross the highway and there are conserved lands on both sides of the highway. Tunneling through Segment 9 would remove 1.7 miles of highway where large animals could cross freely.

See Appendix C for costs and schedule examples.

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Appendices

Appendix A
MSCP Covered Species in MU-3

Common Name	Scientific Name	Status	Conservation Significance
PLANTS			
San Diego thorn-mint	*Acanthomintha ilicifolia*	FT, CE, MSCP	Narrow endemic to San Diego County and northern Baja California
San Diego ambrosia	*Ambrosia pumila*	FE, MSCP	Narrow endemic to Riverside and San Diego counties and northern Baja California–major populations in Otay-Sweetwater area
Otay manzanita	*Arctostaphylos otayensis*	MSCP	Narrow endemic–majority of distribution in Otay-Sweetwater area, including San Miguel and McGinty Mtns
Orcutt's brodiaea	*Brodiaea orcuttii*	MSCP	Regional endemic to Ventura, Riverside, and San Diego counties and northern Baja California
Dense reed grass	*Calamagrostis densa*	MSCP	Major population on Otay Mountain
Dunn's mariposa lily	*Calochortus dunnii*	CR, MSCP	Regional endemic to southern San Diego County and northern Baja California; occurs on San Miguel Mtn
Orcutt's bird's beak	*Cordylanthus orcuttianus*	MSCP	Regional endemic–northern limit of range in Otay-Sweetwater area
Tecate cypress	*Cupressus forbesii*	MSCP	Narrow endemic–isolated populations on gabbroic and metavolcanic peaks in Southern California and northern Baja CA
Snake cholla	*Cylindropuntia californica* var. *californica*	MSCP	Narrow endemic–majority of distribution in Otay-Sweetwater area (Sweetwater River, Otay Ranch), northern Baja CA
Otay tarplant	*Deinandra conjugans*	FT, CE, MSCP	Narrow endemic–restricted to Otay-Sweetwater area; only 1 known occurrence in Baja; largest known population occurs on NWR
Variegated dudleya	*Dudleya variegata*	MSCP	Narrow endemic to San Diego County and northern Baja California; occurs on San Miguel Ranch
Palmer's ericameria	*Ericameria palmeri* ssp. *palmeri*	MSCP	Regional endemic; major populations in Otay-Sweetwater area
San Diego button-celery	*Eryngium aristulatum* ssp. *parishii*	FE, CE, MSCP	Narrow endemic restricted to vernal pools in San Diego County and northern Baja California except for a disjunct population at Santa Rosa Plateau

Common Name	Scientific Name	Status	Conservation Significance
Coast barrel cactus	*Ferocactus viridescens* var. *viridescens*	MSCP	Regional endemic to South Coast Ecoregion; major populations in Otay-Sweetwater area
Mexican flannelbush	*Fremontodendron mexicanum*	FE, CR, MSCP	Narrow endemic–currently known only in Otay-Sweetwater area
Gander's pitcher sage	*Lepechinia ganderi*	MSCP	Narrow endemic on gabbroic or metavolcanic soils; major populations in Otay-Sweetwater area; San Miguel Mtn
Felt-leaved monardella	*Monardella hypoleuca* ssp. *lanata*	MSCP	Narrow endemic; major population on Otay Mountain; suitable habitat on San Miguel and McGinty Mtns
Willowy monardella	*Monardella linoides viminea*	FE, CE, MSCP	Narrow endemic to San Diego County and limited in northern Baja; geographically disjunct population in Cedar Canyon
San Diego goldenstar	*Muilla clevelandii*	MSCP	Narrow endemic; major populations in Proctor Valley/Jamul Mtns, Otay Ranch, Otay Mesa, and south of Sweetwater Reservoir
Spreading navarretia	*Navarretia fossalis*	FT, MSCP	Regional endemic to vernal pools in S. CA and northern Baja CA; nearly 60% concentrated in 3 locations, 1 of which is on Otay Mesa
Dehesa beargrass	*Nolina interrata*	CE, MSCP	Regional endemic on gabbroic or metavolcanic soils; major pop'ns in Otay-Sweetwater area (S. Crest, McGinty Mtn, Sycuan Pk)
California Orcutt grass	*Orcuttia californica*	FE, CE, MSCP	Regional endemic from Los Angeles to San Quintín; 4 pool complexes on Otay Mesa
Otay mesa mint	*Pogogyne nudiuscula*	FE, CE, MSCP	Narrow endemic; only in 7 vernal pool complexes on Otay Mesa
Small-leaved rose	*Rosa minutifolia*	CE, MSCP	Only known U.S. occurrence is on Otay Mesa
San Miguel savory	*Satureja chandleri*	MSCP	Regional endemic to Orange/Riverside counties south to northern Baja CA; major populations on San Miguel Mtn, McGinty Mtn, Otay Mtn, Jamul Mtns
Gander's butterweed	*Senecio ganderi*	CR, MSCP	Narrow endemic to Riverside/San Diego counties on metavolcanic soils; major populations on McGinty Mtn and Sycuan Peak
Narrow-leaved nightshade	*Solanum xanti*	MSCP	Regional endemic to southern San Diego Co. and Baja California; major populations in Jamul Mtns, Otay Mtn, San Miguel Mtn
Parry's tetracoccus	*Tetracoccus dioicus*	MSCP	Regional endemic to Riverside and San Diego counties and Baja CA; major populations on San Miguel Mtn, McGinty Mtn, Sycuan Peak

Common Name	Scientific Name	Status	Conservation Significance
ANIMALS			
Quino checkerspot butterfly	*Euphydryas editha quino*	FE	Regional endemic– Otay-Sweetwater area supports habitat complexes important to the recovery of this species
Thorne's hairstreak	*Mitoura thornei*	MSCP	Regional endemic–larvae obligate to Tecate cypress
Riverside fairy shrimp	*Streptocephalus woottoni*	FE, MSCP	Regional endemic–occurs in vernal pools on Otay Mesa
San Diego fairy shrimp	*Branchinecta sandiegonensis*	FE, MSCP	Regional endemic– vernal pools on Otay Mesa and Proctor Valley
Arroyo toad	*Bufo californicus*	FE, CSC, MSCP	Occurs along Sweetwater River
California red-legged frog	*Rana aurora draytoni*	FT, MSCP	Historically occupied core area #34 along the Sweetwater River; potential for re-establishment
San Diego horned lizard	*Phrynosoma coronatum blainvillei*	CSC, MSCP	South Coast Ecoregion; sensitive to habitat fragmentation and edge effects
Orange-throated whiptail	*Cnemidophorus aspidosceles beldingi*	CSC, MSCP	Orange, Riverside, and San Diego counties to Baja California
Southwestern pond turtle	*Clemmys marmorata pallida*	CSC, MSCP	Petitioned for listing
Bald eagle	*Haliaeetus leucocephalus*	FT, CE, MSCP	Uses Sweetwater Reservoir for foraging
Golden eagle	*Aquila chrysaetos*	CSC, CFP, MSCP	Historically nested on San Diego NWR
Cooper's hawk	*Accipiter cooperii*	CSC, MSCP	Major population in Otay-Sweetwater area
Northern harrier	*Circus cyaneus*	CSC, MSCP	Breeds in Otay-Sweetwater area (1 pair at San Miguel)
Ferruginous hawk	*Buteo regalis*	CSC, MSCP	Winter visitor, Rancho Jamul
Swainson's hawk	*Buteo swainsoni*	CSC, MSCP	Migrant

Common Name	Scientific Name	Status	Conservation Significance
American peregrine falcon	*Falco peregrinus anatum*	CE, CFP, MSCP	Uses Sweetwater Reservoir for foraging
Burrowing owl	*Athene cunicularia*	CSC, MSCP	One of the few remaining nesting locations in San Diego County is on Otay Mesa; recent recolonization at Sweetwater Reservoir
Southwestern willow flycatcher	*Empidonax traillii extimus*	FE, MSCP	Sweetwater River, Jamul Creek, Dulzura Creek
Least Bell's vireo	*Vireo bellii pusillus*	FE, CE, MSCP	Major populations along Sweetwater River; also nests on Dulzura Ck
Coastal cactus wren	*Campylorhynchus brunneicapillus couesi*	CSC, MSCP	Small population in Otay area; may soon be extirpated by lack of connectivity with Sweetwater population
Coastal California gnatcatcher	*Polioptila californica californica*	FT, CSC, MSCP	Major population in Otay-Sweetwater area
Rufous-crowned sparrow	*Aimophila ruficeps lambi (=canescens)*	CSC, MSCP	Santa Barbara to San Quintín; suffered habitat loss along coast and foothills; major research subject in Otay Sweetwater area
Western bluebird	*Sialia mexicana*	MSCP	Breeds in the Otay-Sweetwater area
Tricolored blackbird	*Agelaius tricolor*	CSC, MSCP	Only colony in MSCP known from Rancho Jamul
Southern mule deer	*Odocoileus hemionus*	MSCP	Wide-ranging; MSCP preserve design species
Mountain lion	*Felix concolor*	MSCP	Wide-ranging; MSCP preserve design species

FE = federally listed as Endangered
FT = federally listed as Threatened
CE = California listed as Endangered
CT = California listed as Threatened
CR = California listed as Rare
CFP = California Fully Protected Species
CSC = California Species of Concern
MSCP = species covered by Multiple Species Conservation Program

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
SEGMENT 1		
Coyote	*Canis latrans*	6/20/2007
Coyote	*Canis latrans*	5/29/2012
Coyote	*Canis latrans*	1/30/2014
Coyote	*Canis latrans*	3/17/2014
Black Rat	*Rattus rattus*	7/12/2012
California Ground Squirrel	*Spermophilus beecheyi*	11/16/2010
California Ground Squirrel	*Spermophilus beecheyi*	1/10/2011
California Ground Squirrel	*Spermophilus beecheyi*	3/14/2011
California Ground Squirrel	*Spermophilus beecheyi*	4/22/2012
California Ground Squirrel	*Spermophilus beecheyi*	6/19/2012
California Ground Squirrel	*Spermophilus beecheyi*	4/20/2013
California Ground Squirrel	*Spermophilus beecheyi*	4/27/2013
California Ground Squirrel	*Spermophilus beecheyi*	6/30/2013
California Vole	*Microtus californicus*	12/3/2012
Deer Mouse	*Peromyscus maniculatus*	9/20/2011
Desert Cottontail	*Sylvilagus audubonii*	11/16/2010
Desert Cottontail	*Sylvilagus audubonii*	1/19/2011
Desert Cottontail	*Sylvilagus audubonii*	1/31/2011
Desert Cottontail	*Sylvilagus audubonii*	2/16/2011
Desert Cottontail	*Sylvilagus audubonii*	2/16/2011
Desert Cottontail	*Sylvilagus audubonii*	4/27/2011
Desert Cottontail	*Sylvilagus audubonii*	5/16/2011
Desert Cottontail	*Sylvilagus audubonii*	5/16/2011
Desert Cottontail	*Sylvilagus audubonii*	5/16/2011
Desert Cottontail	*Sylvilagus audubonii*	5/19/2011
Desert Cottontail	*Sylvilagus audubonii*	5/19/2011
Desert Cottontail	*Sylvilagus audubonii*	5/20/2011
Desert Cottontail	*Sylvilagus audubonii*	5/20/2011
Desert Cottontail	*Sylvilagus audubonii*	5/20/2011
Desert Cottontail	*Sylvilagus audubonii*	6/13/2011
Desert Cottontail	*Sylvilagus audubonii*	6/28/2011
Desert Cottontail	*Sylvilagus audubonii*	6/30/2011
Desert Cottontail	*Sylvilagus audubonii*	7/20/2011
Desert Cottontail	*Sylvilagus audubonii*	7/20/2011
Desert Cottontail	*Sylvilagus audubonii*	8/1/2011
Desert Cottontail	*Sylvilagus audubonii*	8/2/2011
Desert Cottontail	*Sylvilagus audubonii*	11/7/2011
Desert Cottontail	*Sylvilagus audubonii*	11/14/2011
Desert Cottontail	*Sylvilagus audubonii*	11/14/2011
Desert Cottontail	*Sylvilagus audubonii*	1/17/2012

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	1/19/2012
Desert Cottontail	*Sylvilagus audubonii*	2/2/2012
Desert Cottontail	*Sylvilagus audubonii*	3/13/2012
Desert Cottontail	*Sylvilagus audubonii*	3/24/2012
Desert Cottontail	*Sylvilagus audubonii*	4/19/2012
Desert Cottontail	*Sylvilagus audubonii*	4/30/2012
Desert Cottontail	*Sylvilagus audubonii*	5/20/2012
Desert Cottontail	*Sylvilagus audubonii*	5/20/2012
Desert Cottontail	*Sylvilagus audubonii*	5/20/2012
Desert Cottontail	*Sylvilagus audubonii*	5/29/2012
Desert Cottontail	*Sylvilagus audubonii*	6/4/2012
Desert Cottontail	*Sylvilagus audubonii*	6/4/2012
Desert Cottontail	*Sylvilagus audubonii*	6/6/2012
Desert Cottontail	*Sylvilagus audubonii*	6/18/2012
Desert Cottontail	*Sylvilagus audubonii*	7/5/2012
Desert Cottontail	*Sylvilagus audubonii*	7/5/2012
Desert Cottontail	*Sylvilagus audubonii*	7/10/2012
Desert Cottontail	*Sylvilagus audubonii*	7/30/2012
Desert Cottontail	*Sylvilagus audubonii*	7/30/2012
Desert Cottontail	*Sylvilagus audubonii*	8/2/2012
Desert Cottontail	*Sylvilagus audubonii*	9/10/2012
Desert Cottontail	*Sylvilagus audubonii*	11/19/2012
Desert Cottontail	*Sylvilagus audubonii*	12/3/2012
Desert Cottontail	*Sylvilagus audubonii*	1/15/2013
Desert Cottontail	*Sylvilagus audubonii*	1/29/2013
Desert Cottontail	*Sylvilagus audubonii*	3/28/2013
Desert Cottontail	*Sylvilagus audubonii*	3/27/2013
Desert Cottontail	*Sylvilagus audubonii*	4/2/2013
Desert Cottontail	*Sylvilagus audubonii*	5/8/2013
Desert Cottontail	*Sylvilagus audubonii*	4/4/2014
Desert Cottontail	*Sylvilagus audubonii*	5/18/2014
Desert Cottontail	*Sylvilagus audubonii*	7/8/2014
Desert Cottontail	*Sylvilagus audubonii*	1/26/2015
Desert Cottontail	*Sylvilagus audubonii*	2/24/2015
Desert Cottontail	*Sylvilagus audubonii*	3/12/2015
Raccoon	*Procyon lotor*	11/16/2010
Raccoon	*Procyon lotor*	6/21/2011
Raccoon	*Procyon lotor*	5/20/2013
Raccoon	*Procyon lotor*	8/2/2013
Raccoon	*Procyon lotor*	9/10/2013
Raccoon	*Procyon lotor*	9/12/2013

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Raccoon	*Procyon lotor*	10/7/2013
Raccoon	*Procyon lotor*	10/7/2013
Raccoon	*Procyon lotor*	11/20/2013
Striped Skunk	*Mephitis mephitis*	5/2/2011
Striped Skunk	*Mephitis mephitis*	5/5/2011
Striped Skunk	*Mephitis mephitis*	5/10/2011
Striped Skunk	*Mephitis mephitis*	5/17/2011
Striped Skunk	*Mephitis mephitis*	5/17/2011
Striped Skunk	*Mephitis mephitis*	5/17/2011
Striped Skunk	*Mephitis mephitis*	5/23/2011
Striped Skunk	*Mephitis mephitis*	5/26/2011
Striped Skunk	*Mephitis mephitis*	6/7/2011
Striped Skunk	*Mephitis mephitis*	6/13/2011
Striped Skunk	*Mephitis mephitis*	6/17/2011
Striped Skunk	*Mephitis mephitis*	6/21/2011
Striped Skunk	*Mephitis mephitis*	8/2/2011
Striped Skunk	*Mephitis mephitis*	4/25/2012
Striped Skunk	*Mephitis mephitis*	6/14/2012
Striped Skunk	*Mephitis mephitis*	7/3/2012
Striped Skunk	*Mephitis mephitis*	7/11/2012
Striped Skunk	*Mephitis mephitis*	8/2/2012
Striped Skunk	*Mephitis mephitis*	5/12/2013
Striped Skunk	*Mephitis mephitis*	6/16/2013
Striped Skunk	*Mephitis mephitis*	7/13/2013
Striped Skunk	*Mephitis mephitis*	8/5/2013
Striped Skunk	*Mephitis mephitis*	8/5/2013
Striped Skunk	*Mephitis mephitis*	8/5/2013
Striped Skunk	*Mephitis mephitis*	3/25/2014
Striped Skunk	*Mephitis mephitis*	5/6/2014
Striped Skunk	*Mephitis mephitis*	6/26/2014
Striped Skunk	*Mephitis mephitis*	8/5/2014
Striped Skunk	*Mephitis mephitis*	11/8/2014
Western Spotted Skunk	*Spilogale gracilis*	10/17/2012
Virginia Opossum	*Didelphis virginiana*	2/8/2011
Virginia Opossum	*Didelphis virginiana*	4/21/2011
Virginia Opossum	*Didelphis virginiana*	3/26/2012
Virginia Opossum	*Didelphis virginiana*	9/5/2012
Virginia Opossum	*Didelphis virginiana*	3/24/2015
Gopher Snake	*Pituophis catenifer*	5/8/2012
Gopher Snake	*Pituophis catenifer*	3/12/2013
Gopher Snake	*Pituophis catenifer*	4/7/2013

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Gopher Snake	*Pituophis catenifer*	3/30/2015
Gopher Snake	*Pituophis catenifer*	4/7/2015
Western Toad	*Bufo boreas*	7/26/2012
Western Toad	*Bufo boreas*	2/4/2015
American Crow	*Corvus brachyrhynchos*	6/19/2012
American Crow	*Corvus brachyrhynchos*	7/2/2012
Bell's Vireo	*Vireo bellii*	7/23/2014
California Thrasher	*Toxostoma redivivum*	7/11/2012
California Thrasher	*Toxostoma redivivum*	7/22/2013
California Towhee	*Pipilo crissalis*	3/8/2012
Common Yellowthroat	*Geothlypis trichas*	1/20/2012
Western Grebe	*Aechmophorus occidentalis*	10/21/2011
SEGMENT 2		
Coyote	*Canis latrans*	11/17/2014
Greater Roadrunner	*Geococcyx californianus*	8/19/2013
Black Rat	*Rattus rattus*	2/9/2015
Botta's Pocket Gopher	*Thomomys bottae*	2/9/2015
California Ground Squirrel	*Spermophilus beecheyi*	5/20/2012
California Ground Squirrel	*Spermophilus beecheyi*	2/12/2014
Desert Cottontail	*Sylvilagus audubonii*	12/7/2010
Desert Cottontail	*Sylvilagus audubonii*	12/27/2010
Desert Cottontail	*Sylvilagus audubonii*	2/9/2011
Desert Cottontail	*Sylvilagus audubonii*	2/17/2011
Desert Cottontail	*Sylvilagus audubonii*	3/14/2011
Desert Cottontail	*Sylvilagus audubonii*	3/14/2011
Desert Cottontail	*Sylvilagus audubonii*	3/24/2011
Desert Cottontail	*Sylvilagus audubonii*	4/13/2011
Desert Cottontail	*Sylvilagus audubonii*	4/13/2011
Desert Cottontail	*Sylvilagus audubonii*	4/20/2011
Desert Cottontail	*Sylvilagus audubonii*	4/21/2011
Desert Cottontail	*Sylvilagus audubonii*	5/16/2011
Desert Cottontail	*Sylvilagus audubonii*	5/17/2011
Desert Cottontail	*Sylvilagus audubonii*	5/20/2011
Desert Cottontail	*Sylvilagus audubonii*	6/9/2011
Desert Cottontail	*Sylvilagus audubonii*	6/9/2011
Desert Cottontail	*Sylvilagus audubonii*	6/14/2011
Desert Cottontail	*Sylvilagus audubonii*	8/1/2011
Desert Cottontail	*Sylvilagus audubonii*	8/1/2011
Desert Cottontail	*Sylvilagus audubonii*	9/6/2011
Desert Cottontail	*Sylvilagus audubonii*	9/15/2011

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	3/4/2015
Desert Cottontail	*Sylvilagus audubonii*	1/9/2012
Desert Cottontail	*Sylvilagus audubonii*	3/24/2012
Desert Cottontail	*Sylvilagus audubonii*	4/10/2012
Desert Cottontail	*Sylvilagus audubonii*	5/24/2012
Desert Cottontail	*Sylvilagus audubonii*	6/28/2012
Desert Cottontail	*Sylvilagus audubonii*	7/5/2012
Desert Cottontail	*Sylvilagus audubonii*	8/2/2012
Desert Cottontail	*Sylvilagus audubonii*	8/21/2012
Desert Cottontail	*Sylvilagus audubonii*	12/4/2012
Desert Cottontail	*Sylvilagus audubonii*	12/5/2012
Desert Cottontail	*Sylvilagus audubonii*	12/26/2012
Desert Cottontail	*Sylvilagus audubonii*	1/29/2013
Desert Cottontail	*Sylvilagus audubonii*	3/20/2013
Desert Cottontail	*Sylvilagus audubonii*	4/1/2013
Desert Cottontail	*Sylvilagus audubonii*	6/13/2013
Desert Cottontail	*Sylvilagus audubonii*	6/17/2013
Desert Cottontail	*Sylvilagus audubonii*	8/5/2013
Desert Cottontail	*Sylvilagus audubonii*	2/8/2014
Desert Cottontail	*Sylvilagus audubonii*	2/26/2014
Desert Cottontail	*Sylvilagus audubonii*	3/15/2014
Desert Cottontail	*Sylvilagus audubonii*	5/24/2014
Long-Tailed Weasel	*Mustela frenata*	7/19/2013
Raccoon	*Procyon lotor*	11/15/2012
Striped Skunk	*Mephitis mephitis*	12/29/2010
Striped Skunk	*Mephitis mephitis*	1/5/2011
Striped Skunk	*Mephitis mephitis*	8/4/2011
Striped Skunk	*Mephitis mephitis*	8/9/2011
Striped Skunk	*Mephitis mephitis*	9/6/2011
Striped Skunk	*Mephitis mephitis*	11/16/2011
Striped Skunk	*Mephitis mephitis*	1/17/2012
Striped Skunk	*Mephitis mephitis*	7/27/2012
Striped Skunk	*Mephitis mephitis*	8/14/2012
Striped Skunk	*Mephitis mephitis*	12/24/2012
Striped Skunk	*Mephitis mephitis*	1/7/2013
Striped Skunk	*Mephitis mephitis*	4/13/2013
Striped Skunk	*Mephitis mephitis*	5/5/2013
Striped Skunk	*Mephitis mephitis*	2/1/2015
Striped Skunk	*Mephitis mephitis*	2/3/2015
Virginia Opossum	*Didelphis virginiana*	1/10/2011
Virginia Opossum	*Didelphis virginiana*	3/19/2012

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Virginia Opossum	*Didelphis virginiana*	5/29/2012
Gopher Snake	*Pituophis catenifer*	8/4/2014
American Crow	*Corvus brachyrhynchos*	5/24/2012
Barn Owl	*Tyto alba*	6/14/2011
Cassin's Kingbird	*Tyrannus vociferans*	2/27/2012
European Starling	*Sturnus vulgaris*	2/14/2012
Great Horned Owl	*Bubo virginianus*	7/7/2013
Mallard	*Anas platyrhynchos*	6/11/2012
Mallard	*Anas platyrhynchos*	6/11/2012
Northern Mockingbird	*Mimus polyglottos*	2/9/2015
Rock Pigeon	*Columba livia*	2/6/2012
Rock Pigeon	*Columba livia*	5/8/2012
Rock Pigeon	*Columba livia*	1/12/2011
SEGMENT 3		
Bobcat	*Lynx rufus*	12/13/2013
Bobcat	*Lynx rufus*	6/24/2014
Coyote	*Canis latrans*	8/3/2011
Coyote	*Canis latrans*	11/9/2011
Coyote	*Canis latrans*	1/26/2012
Coyote	*Canis latrans*	4/25/2012
Coyote	*Canis latrans*	9/11/2014
Mountain Lion	*Puma concolor*	4/15/2010
Botta's Pocket Gopher	*Thomomys bottae*	4/9/2013
California Ground Squirrel	*Spermophilus beecheyi*	3/14/2011
California Ground Squirrel	*Spermophilus beecheyi*	6/14/2011
California Ground Squirrel	*Spermophilus beecheyi*	6/21/2011
California Ground Squirrel	*Spermophilus beecheyi*	3/21/2012
California Ground Squirrel	*Spermophilus beecheyi*	3/27/2012
California Ground Squirrel	*Spermophilus beecheyi*	5/7/2012
California Ground Squirrel	*Spermophilus beecheyi*	5/10/2012
California Ground Squirrel	*Spermophilus beecheyi*	6/11/2012
California Ground Squirrel	*Spermophilus beecheyi*	7/9/2012
California Ground Squirrel	*Spermophilus beecheyi*	3/28/2014
California Vole	*Microtus californicus*	8/2/2011
Deer Mouse	*Peromyscus maniculatus*	7/21/2011
Desert Cottontail	*Sylvilagus audubonii*	10/13/2010
Desert Cottontail	*Sylvilagus audubonii*	10/23/2010
Desert Cottontail	*Sylvilagus audubonii*	11/2/2010
Desert Cottontail	*Sylvilagus audubonii*	11/2/2010
Desert Cottontail	*Sylvilagus audubonii*	11/15/2010

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	12/27/2010
Desert Cottontail	*Sylvilagus audubonii*	12/28/2010
Desert Cottontail	*Sylvilagus audubonii*	1/11/2011
Desert Cottontail	*Sylvilagus audubonii*	1/13/2011
Desert Cottontail	*Sylvilagus audubonii*	1/27/2011
Desert Cottontail	*Sylvilagus audubonii*	2/7/2011
Desert Cottontail	*Sylvilagus audubonii*	2/7/2011
Desert Cottontail	*Sylvilagus audubonii*	2/17/2011
Desert Cottontail	*Sylvilagus audubonii*	2/25/2011
Desert Cottontail	*Sylvilagus audubonii*	4/14/2011
Desert Cottontail	*Sylvilagus audubonii*	5/10/2011
Desert Cottontail	*Sylvilagus audubonii*	5/16/2011
Desert Cottontail	*Sylvilagus audubonii*	5/20/2011
Desert Cottontail	*Sylvilagus audubonii*	5/20/2011
Desert Cottontail	*Sylvilagus audubonii*	6/17/2011
Desert Cottontail	*Sylvilagus audubonii*	6/28/2011
Desert Cottontail	*Sylvilagus audubonii*	7/12/2011
Desert Cottontail	*Sylvilagus audubonii*	7/21/2011
Desert Cottontail	*Sylvilagus audubonii*	7/21/2011
Desert Cottontail	*Sylvilagus audubonii*	7/21/2011
Desert Cottontail	*Sylvilagus audubonii*	7/28/2011
Desert Cottontail	*Sylvilagus audubonii*	8/3/2011
Desert Cottontail	*Sylvilagus audubonii*	9/13/2011
Desert Cottontail	*Sylvilagus audubonii*	9/13/2011
Desert Cottontail	*Sylvilagus audubonii*	9/19/2011
Desert Cottontail	*Sylvilagus audubonii*	11/1/2011
Desert Cottontail	*Sylvilagus audubonii*	11/3/2011
Desert Cottontail	*Sylvilagus audubonii*	12/5/2011
Desert Cottontail	*Sylvilagus audubonii*	12/5/2011
Desert Cottontail	*Sylvilagus audubonii*	1/9/2012
Desert Cottontail	*Sylvilagus audubonii*	1/9/2012
Desert Cottontail	*Sylvilagus audubonii*	2/6/2012
Desert Cottontail	*Sylvilagus audubonii*	2/15/2012
Desert Cottontail	*Sylvilagus audubonii*	2/23/2012
Desert Cottontail	*Sylvilagus audubonii*	3/12/2012
Desert Cottontail	*Sylvilagus audubonii*	3/12/2012
Desert Cottontail	*Sylvilagus audubonii*	3/15/2012
Desert Cottontail	*Sylvilagus audubonii*	4/4/2012
Desert Cottontail	*Sylvilagus audubonii*	4/5/2012
Desert Cottontail	*Sylvilagus audubonii*	4/9/2012
Desert Cottontail	*Sylvilagus audubonii*	4/10/2012

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	4/22/2012
Desert Cottontail	*Sylvilagus audubonii*	4/25/2012
Desert Cottontail	*Sylvilagus audubonii*	5/4/2012
Desert Cottontail	*Sylvilagus audubonii*	5/24/2012
Desert Cottontail	*Sylvilagus audubonii*	5/29/2012
Desert Cottontail	*Sylvilagus audubonii*	6/6/2012
Desert Cottontail	*Sylvilagus audubonii*	6/7/2012
Desert Cottontail	*Sylvilagus audubonii*	7/3/2012
Desert Cottontail	*Sylvilagus audubonii*	7/10/2012
Desert Cottontail	*Sylvilagus audubonii*	7/12/2012
Desert Cottontail	*Sylvilagus audubonii*	7/31/2012
Desert Cottontail	*Sylvilagus audubonii*	7/30/2012
Desert Cottontail	*Sylvilagus audubonii*	8/6/2012
Desert Cottontail	*Sylvilagus audubonii*	8/27/2012
Desert Cottontail	*Sylvilagus audubonii*	9/5/2012
Desert Cottontail	*Sylvilagus audubonii*	9/17/2012
Desert Cottontail	*Sylvilagus audubonii*	10/31/2012
Desert Cottontail	*Sylvilagus audubonii*	10/31/2012
Desert Cottontail	*Sylvilagus audubonii*	11/6/2012
Desert Cottontail	*Sylvilagus audubonii*	11/13/2012
Desert Cottontail	*Sylvilagus audubonii*	11/15/2012
Desert Cottontail	*Sylvilagus audubonii*	1/31/2013
Desert Cottontail	*Sylvilagus audubonii*	2/13/2013
Desert Cottontail	*Sylvilagus audubonii*	2/13/2013
Desert Cottontail	*Sylvilagus audubonii*	2/23/2013
Desert Cottontail	*Sylvilagus audubonii*	3/11/2013
Desert Cottontail	*Sylvilagus audubonii*	4/1/2013
Desert Cottontail	*Sylvilagus audubonii*	4/1/2013
Desert Cottontail	*Sylvilagus audubonii*	4/1/2013
Desert Cottontail	*Sylvilagus audubonii*	4/27/2013
Desert Cottontail	*Sylvilagus audubonii*	6/20/2013
Desert Cottontail	*Sylvilagus audubonii*	7/7/2013
Desert Cottontail	*Sylvilagus audubonii*	6/1/2014
Desert Cottontail	*Sylvilagus audubonii*	2/27/2015
Desert Cottontail	*Sylvilagus audubonii*	3/18/2015
Desert Cottontail	*Sylvilagus audubonii*	3/21/2015
Desert Cottontail	*Sylvilagus audubonii*	4/7/2015
Desert Woodrat	*Neotoma lepida*	5/4/2011
Desert Woodrat	*Neotoma lepida*	5/10/2011
Desert Woodrat	*Neotoma lepida*	3/20/2014
Dulzura Kangaroo Rat	*Dipodomys simulans*	8/27/2012

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Long-Tailed Weasel	*Mustela frenata*	7/30/2012
Norway Rat	*Rattus norvegicus*	4/27/2011
Raccoon	*Procyon lotor*	11/16/2010
Raccoon	*Procyon lotor*	7/11/2011
Raccoon	*Procyon lotor*	1/10/2013
Striped Skunk	*Mephitis mephitis*	5/20/2011
Striped Skunk	*Mephitis mephitis*	5/23/2011
Striped Skunk	*Mephitis mephitis*	5/12/2013
Virginia Opossum	*Didelphis virginiana*	2/4/2013
Common Kingsnake	*Lampropeltis getula*	5/9/2011
Common Kingsnake	*Lampropeltis getula*	5/13/2014
Gopher Snake	*Pituophis catenifer*	4/20/2011
Gopher Snake	*Pituophis catenifer*	4/20/2011
Gopher Snake	*Pituophis catenifer*	4/26/2011
Gopher Snake	*Pituophis catenifer*	5/5/2011
Gopher Snake	*Pituophis catenifer*	4/25/2012
Gopher Snake	*Pituophis catenifer*	6/4/2012
Red Diamond Rattlesnake	*Crotalus ruber*	9/19/2013
Rosy Boa	*Charina trivirgata*	6/30/2011
Rosy Boa	*Charina trivirgata*	5/17/2013
Striped Racer	*Masticophis lateralis*	4/27/2011
Striped Racer	*Masticophis lateralis*	6/1/2012
Striped Racer	*Masticophis lateralis*	3/31/2015
Striped Racer	*Masticophis lateralis*	4/2/2015
Western Blind Snake	*Leptotyphlops humilis*	6/28/2011
Western Rattlesnake	*Crotalus viridis*	8/2/2011
Western Rattlesnake	*Crotalus viridis*	9/15/2014
Anna's Hummingbird	*Calypte anna*	3/31/2015
Barn Owl	*Tyto alba*	3/14/2011
Barn Owl	*Tyto alba*	4/5/2012
Barn Owl	*Tyto alba*	1/30/2013
Bushtit	*Psaltriparus minimus*	11/1/2011
Bushtit	*Psaltriparus minimus*	11/15/2012
California Thrasher	*Toxostoma redivivum*	1/27/2011
California Thrasher	*Toxostoma redivivum*	9/19/2011
California Towhee	*Pipilo crissalis*	10/26/2010
California Towhee	*Pipilo crissalis*	3/12/2012
California Towhee	*Pipilo crissalis*	4/4/2012
California Towhee	*Pipilo crissalis*	6/30/2013
California Towhee	*Pipilo crissalis*	11/5/2013
California Towhee	*Pipilo crissalis*	7/26/2014

Common Name	Scientific Name	Date
California Towhee	*Pipilo crissalis*	1/26/2015
California Quail	*Callipepla californica*	11/1/2011
Common Raven	*Corvus corax*	7/10/2012
Great Horned Owl	*Bubo virginianus*	7/20/2011
Great Horned Owl	*Bubo virginianus*	9/14/2011
Great Horned Owl	*Bubo virginianus*	9/24/2012
House Wren	*Troglodytes aedon*	3/13/2012
Lesser Goldfinch	*Carduelis psaltria*	4/30/2012
Lesser Goldfinch	*Carduelis psaltria*	7/12/2013
Sharp-Shinned Hawk	*Accipiter striatus*	1/17/2012
Song Sparrow	*Melospiza melodia*	7/12/2013
Spotted Towhee	*Pipilo maculatus*	1/13/2011
Spotted Towhee	*Pipilo maculatus*	5/20/2011
White-Crowned Sparrow	*Zonotrichia leucophrys*	1/20/2012
Yellow-Breasted Chat	*Icteria virens*	6/30/2011
SEGMENT 4		
Coyote	*Canis latrans*	4/13/2011
Coyote	*Canis latrans*	7/24/2013
Coyote	*Canis latrans*	4/8/2014
Coyote	*Canis latrans*	4/28/2014
Greater Roadrunner	*Geococcyx californianus*	9/19/2011
California Ground Squirrel	*Spermophilus beecheyi*	2/15/2011
California Ground Squirrel	*Spermophilus beecheyi*	3/24/2011
California Ground Squirrel	*Spermophilus beecheyi*	4/27/2011
California Ground Squirrel	*Spermophilus beecheyi*	5/5/2011
California Ground Squirrel	*Spermophilus beecheyi*	5/20/2011
California Ground Squirrel	*Spermophilus beecheyi*	6/14/2011
California Ground Squirrel	*Spermophilus beecheyi*	7/28/2011
California Ground Squirrel	*Spermophilus beecheyi*	9/20/2011
California Ground Squirrel	*Spermophilus beecheyi*	1/26/2012
California Ground Squirrel	*Spermophilus beecheyi*	2/13/2012
California Ground Squirrel	*Spermophilus beecheyi*	2/14/2012
California Ground Squirrel	*Spermophilus beecheyi*	4/4/2012
California Ground Squirrel	*Spermophilus beecheyi*	5/29/2012
California Ground Squirrel	*Spermophilus beecheyi*	6/19/2012
California Ground Squirrel	*Spermophilus beecheyi*	6/25/2012
California Ground Squirrel	*Spermophilus beecheyi*	7/3/2012
California Ground Squirrel	*Spermophilus beecheyi*	8/14/2012
California Ground Squirrel	*Spermophilus beecheyi*	1/15/2013
California Ground Squirrel	*Spermophilus beecheyi*	2/4/2013

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
California Ground Squirrel	*Spermophilus beecheyi*	2/13/2013
California Ground Squirrel	*Spermophilus beecheyi*	3/27/2013
California Ground Squirrel	*Spermophilus beecheyi*	5/29/2013
California Ground Squirrel	*Spermophilus beecheyi*	8/5/2013
California Ground Squirrel	*Spermophilus beecheyi*	8/29/2013
California Ground Squirrel	*Spermophilus beecheyi*	9/27/2013
California Ground Squirrel	*Spermophilus beecheyi*	3/28/2014
California Ground Squirrel	*Spermophilus beecheyi*	5/18/2014
California Ground Squirrel	*Spermophilus beecheyi*	1/21/2015
California Ground Squirrel	*Spermophilus beecheyi*	1/22/2015
California Ground Squirrel	*Spermophilus beecheyi*	1/22/2015
California Ground Squirrel	*Spermophilus beecheyi*	1/27/2015
California Ground Squirrel	*Spermophilus beecheyi*	2/9/2015
Deer Mouse	*Peromyscus maniculatus*	5/22/2012
Desert Cottontail	*Sylvilagus audubonii*	1/18/2011
Desert Cottontail	*Sylvilagus audubonii*	2/24/2011
Desert Cottontail	*Sylvilagus audubonii*	3/14/2011
Desert Cottontail	*Sylvilagus audubonii*	3/15/2011
Desert Cottontail	*Sylvilagus audubonii*	3/16/2011
Desert Cottontail	*Sylvilagus audubonii*	4/11/2011
Desert Cottontail	*Sylvilagus audubonii*	4/11/2011
Desert Cottontail	*Sylvilagus audubonii*	4/14/2011
Desert Cottontail	*Sylvilagus audubonii*	5/5/2011
Desert Cottontail	*Sylvilagus audubonii*	5/9/2011
Desert Cottontail	*Sylvilagus audubonii*	5/10/2011
Desert Cottontail	*Sylvilagus audubonii*	5/16/2011
Desert Cottontail	*Sylvilagus audubonii*	5/16/2011
Desert Cottontail	*Sylvilagus audubonii*	5/17/2011
Desert Cottontail	*Sylvilagus audubonii*	5/19/2011
Desert Cottontail	*Sylvilagus audubonii*	6/14/2011
Desert Cottontail	*Sylvilagus audubonii*	6/13/2011
Desert Cottontail	*Sylvilagus audubonii*	6/13/2011
Desert Cottontail	*Sylvilagus audubonii*	6/13/2011
Desert Cottontail	*Sylvilagus audubonii*	6/27/2011
Desert Cottontail	*Sylvilagus audubonii*	6/27/2011
Desert Cottontail	*Sylvilagus audubonii*	6/27/2011
Desert Cottontail	*Sylvilagus audubonii*	6/28/2011
Desert Cottontail	*Sylvilagus audubonii*	6/30/2011
Desert Cottontail	*Sylvilagus audubonii*	7/14/2011
Desert Cottontail	*Sylvilagus audubonii*	7/14/2011
Desert Cottontail	*Sylvilagus audubonii*	7/14/2011

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	7/20/2011
Desert Cottontail	*Sylvilagus audubonii*	7/20/2011
Desert Cottontail	*Sylvilagus audubonii*	7/21/2011
Desert Cottontail	*Sylvilagus audubonii*	7/21/2011
Desert Cottontail	*Sylvilagus audubonii*	7/28/2011
Desert Cottontail	*Sylvilagus audubonii*	7/28/2011
Desert Cottontail	*Sylvilagus audubonii*	8/4/2011
Desert Cottontail	*Sylvilagus audubonii*	8/15/2011
Desert Cottontail	*Sylvilagus audubonii*	8/15/2011
Desert Cottontail	*Sylvilagus audubonii*	8/15/2011
Desert Cottontail	*Sylvilagus audubonii*	9/1/2011
Desert Cottontail	*Sylvilagus audubonii*	9/6/2011
Desert Cottontail	*Sylvilagus audubonii*	9/13/2011
Desert Cottontail	*Sylvilagus audubonii*	9/13/2011
Desert Cottontail	*Sylvilagus audubonii*	9/13/2011
Desert Cottontail	*Sylvilagus audubonii*	11/3/2011
Desert Cottontail	*Sylvilagus audubonii*	11/3/2011
Desert Cottontail	*Sylvilagus audubonii*	11/9/2011
Desert Cottontail	*Sylvilagus audubonii*	12/8/2011
Desert Cottontail	*Sylvilagus audubonii*	12/22/2011
Desert Cottontail	*Sylvilagus audubonii*	1/19/2012
Desert Cottontail	*Sylvilagus audubonii*	1/25/2012
Desert Cottontail	*Sylvilagus audubonii*	1/26/2012
Desert Cottontail	*Sylvilagus audubonii*	2/1/2012
Desert Cottontail	*Sylvilagus audubonii*	2/16/2012
Desert Cottontail	*Sylvilagus audubonii*	2/23/2012
Desert Cottontail	*Sylvilagus audubonii*	3/6/2012
Desert Cottontail	*Sylvilagus audubonii*	3/6/2012
Desert Cottontail	*Sylvilagus audubonii*	3/12/2012
Desert Cottontail	*Sylvilagus audubonii*	3/27/2012
Desert Cottontail	*Sylvilagus audubonii*	4/9/2012
Desert Cottontail	*Sylvilagus audubonii*	4/16/2012
Desert Cottontail	*Sylvilagus audubonii*	4/22/2012
Desert Cottontail	*Sylvilagus audubonii*	4/30/2012
Desert Cottontail	*Sylvilagus audubonii*	5/7/2012
Desert Cottontail	*Sylvilagus audubonii*	5/30/2012
Desert Cottontail	*Sylvilagus audubonii*	6/6/2012
Desert Cottontail	*Sylvilagus audubonii*	6/6/2012
Desert Cottontail	*Sylvilagus audubonii*	6/11/2012
Desert Cottontail	*Sylvilagus audubonii*	6/11/2012
Desert Cottontail	*Sylvilagus audubonii*	6/18/2012

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	6/18/2012
Desert Cottontail	*Sylvilagus audubonii*	6/19/2012
Desert Cottontail	*Sylvilagus audubonii*	6/20/2012
Desert Cottontail	*Sylvilagus audubonii*	6/25/2012
Desert Cottontail	*Sylvilagus audubonii*	6/25/2012
Desert Cottontail	*Sylvilagus audubonii*	6/25/2012
Desert Cottontail	*Sylvilagus audubonii*	6/28/2012
Desert Cottontail	*Sylvilagus audubonii*	6/28/2012
Desert Cottontail	*Sylvilagus audubonii*	7/2/2012
Desert Cottontail	*Sylvilagus audubonii*	7/11/2012
Desert Cottontail	*Sylvilagus audubonii*	7/11/2012
Desert Cottontail	*Sylvilagus audubonii*	7/26/2012
Desert Cottontail	*Sylvilagus audubonii*	8/6/2012
Desert Cottontail	*Sylvilagus audubonii*	8/6/2012
Desert Cottontail	*Sylvilagus audubonii*	8/8/2012
Desert Cottontail	*Sylvilagus audubonii*	8/21/2012
Desert Cottontail	*Sylvilagus audubonii*	9/17/2012
Desert Cottontail	*Sylvilagus audubonii*	9/18/2012
Desert Cottontail	*Sylvilagus audubonii*	10/25/2012
Desert Cottontail	*Sylvilagus audubonii*	10/31/2012
Desert Cottontail	*Sylvilagus audubonii*	10/31/2012
Desert Cottontail	*Sylvilagus audubonii*	1/14/2013
Desert Cottontail	*Sylvilagus audubonii*	3/4/2013
Desert Cottontail	*Sylvilagus audubonii*	3/4/2013
Desert Cottontail	*Sylvilagus audubonii*	3/12/2013
Desert Cottontail	*Sylvilagus audubonii*	3/27/2013
Desert Cottontail	*Sylvilagus audubonii*	5/16/2013
Desert Cottontail	*Sylvilagus audubonii*	5/20/2013
Desert Cottontail	*Sylvilagus audubonii*	6/17/2013
Desert Cottontail	*Sylvilagus audubonii*	6/18/2013
Desert Cottontail	*Sylvilagus audubonii*	6/18/2013
Desert Cottontail	*Sylvilagus audubonii*	6/19/2013
Desert Cottontail	*Sylvilagus audubonii*	7/1/2013
Desert Cottontail	*Sylvilagus audubonii*	7/3/2013
Desert Cottontail	*Sylvilagus audubonii*	7/15/2013
Desert Cottontail	*Sylvilagus audubonii*	7/25/2013
Desert Cottontail	*Sylvilagus audubonii*	8/7/2013
Desert Cottontail	*Sylvilagus audubonii*	9/19/2013
Desert Cottontail	*Sylvilagus audubonii*	11/19/2013
Desert Cottontail	*Sylvilagus audubonii*	12/14/2013
Desert Cottontail	*Sylvilagus audubonii*	2/3/2014

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	2/12/2014
Desert Cottontail	*Sylvilagus audubonii*	7/25/2014
Desert Cottontail	*Sylvilagus audubonii*	7/30/2014
Desert Cottontail	*Sylvilagus audubonii*	8/5/2014
Desert Cottontail	*Sylvilagus audubonii*	12/8/2014
Desert Cottontail	*Sylvilagus audubonii*	2/9/2015
Desert Cottontail	*Sylvilagus audubonii*	2/18/2015
Desert Cottontail	*Sylvilagus audubonii*	3/5/2015
Desert Cottontail	*Sylvilagus audubonii*	3/12/2015
Desert Cottontail	*Sylvilagus audubonii*	3/12/2015
Desert Woodrat	*Neotoma lepida*	12/8/2011
Long-Tailed Weasel	*Mustela frenata*	4/11/2011
Long-Tailed Weasel	*Mustela frenata*	3/20/2012
Long-Tailed Weasel	*Mustela frenata*	6/11/2012
Long-Tailed Weasel	*Mustela frenata*	6/11/2012
Long-Tailed Weasel	*Mustela frenata*	7/2/2012
Long-Tailed Weasel	*Mustela frenata*	5/21/2013
Long-Tailed Weasel	*Mustela frenata*	5/28/2013
Raccoon	*Procyon lotor*	9/18/2012
Raccoon	*Procyon lotor*	8/8/2013
San Diego Pocket Mouse	*Chaetodipus fallax*	5/5/2011
Virginia Opossum	*Didelphis virginiana*	9/8/2011
Virginia Opossum	*Didelphis virginiana*	6/28/2012
Western Spotted Skunk	*Spilogale gracilis*	1/19/2012
Baja California Coachwhip	*Masticophis fuliginosis*	5/14/2013
Common Kingsnake	*Lampropeltis getula*	5/31/2012
Common Kingsnake	*Lampropeltis getula*	6/26/2014
Gopher Snake	*Pituophis catenifer*	5/31/2012
Gopher Snake	*Pituophis catenifer*	9/7/2012
Gopher Snake	*Pituophis catenifer*	8/13/2014
Striped Racer	*Masticophis lateralis*	3/15/2012
Striped Racer	*Masticophis lateralis*	5/31/2012
Western Fence Lizard	*Sceloporus occidentalis*	5/5/2011
Western Rattlesnake	*Crotalus viridis*	4/10/2012
American Coot	*Fulica americana*	11/3/2011
American Crow	*Corvus brachyrhynchos*	3/24/2011
American Crow	*Corvus brachyrhynchos*	7/2/2012
Barn Owl	*Tyto alba*	8/9/2011
Barn Owl	*Tyto alba*	2/2/2012
Barn Owl	*Tyto alba*	10/1/2012
California Towhee	*Pipilo crissalis*	4/10/2011

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
California Towhee	*Pipilo crissalis*	5/9/2013
Common Raven	*Corvus corax*	6/27/2011
European Starling	*Sturnus vulgaris*	3/20/2012
Hooded Oriole	*Icterus cucullatus*	7/2/2012
House Sparrow	*Passer domesticus*	4/1/2013
Lark Sparrow	*Chondestes grammacus*	4/9/2012
Rock Pigeon	*Columba livia*	6/10/2013
Song Sparrow	*Melospiza melodia*	5/22/2012
Western Scrub-Jay	*Aphelocoma californica*	4/6/2015
White-Crowned Sparrow	*Zonotrichia leucophrys*	12/21/2011
White-Crowned Sparrow	*Zonotrichia leucophrys*	1/17/2012
White-Crowned Sparrow	*Zonotrichia leucophrys*	4/19/2013
SEGMENT 5		
Coyote	*Canis latrans*	6/27/2011
Coyote	*Canis latrans*	2/6/2012
Coyote	*Canis latrans*	2/27/2012
Coyote	*Canis latrans*	4/2/2012
Coyote	*Canis latrans*	9/12/2012
Coyote	*Canis latrans*	9/15/2014
Coyote	*Canis latrans*	10/9/2014
Coyote	*Canis latrans*	3/10/2015
Mule (or Black tailed) Deer	*Odocoileus hemionus*	6/16/2011
Greater Roadrunner	*Geococcyx californianus*	5/22/2012
Botta's Pocket Gopher	*Thomomys bottae*	3/15/2012
Botta's Pocket Gopher	*Thomomys bottae*	6/28/2012
California Ground Squirrel	*Spermophilus beecheyi*	6/27/2011
California Ground Squirrel	*Spermophilus beecheyi*	7/20/2011
California Ground Squirrel	*Spermophilus beecheyi*	1/17/2012
California Ground Squirrel	*Spermophilus beecheyi*	3/6/2012
California Ground Squirrel	*Spermophilus beecheyi*	3/13/2012
California Ground Squirrel	*Spermophilus beecheyi*	5/14/2012
California Ground Squirrel	*Spermophilus beecheyi*	5/20/2012
California Ground Squirrel	*Spermophilus beecheyi*	1/30/2013
California Ground Squirrel	*Spermophilus beecheyi*	2/25/2013
California Ground Squirrel	*Spermophilus beecheyi*	5/1/2013
California Ground Squirrel	*Spermophilus beecheyi*	12/10/2014
Desert Cottontail	*Sylvilagus audubonii*	6/27/2011
Desert Cottontail	*Sylvilagus audubonii*	6/30/2011
Desert Cottontail	*Sylvilagus audubonii*	7/21/2011
Desert Cottontail	*Sylvilagus audubonii*	8/15/2011

Common Name	Scientific Name	Date
Desert Cottontail	*Sylvilagus audubonii*	9/1/2011
Desert Cottontail	*Sylvilagus audubonii*	1/25/2012
Desert Cottontail	*Sylvilagus audubonii*	2/23/2012
Desert Cottontail	*Sylvilagus audubonii*	2/23/2012
Desert Cottontail	*Sylvilagus audubonii*	4/9/2012
Desert Cottontail	*Sylvilagus audubonii*	4/16/2012
Desert Cottontail	*Sylvilagus audubonii*	6/6/2012
Desert Cottontail	*Sylvilagus audubonii*	6/7/2012
Desert Cottontail	*Sylvilagus audubonii*	6/20/2012
Desert Cottontail	*Sylvilagus audubonii*	7/2/2012
Desert Cottontail	*Sylvilagus audubonii*	7/9/2012
Desert Cottontail	*Sylvilagus audubonii*	9/6/2012
Desert Cottontail	*Sylvilagus audubonii*	10/22/2012
Desert Cottontail	*Sylvilagus audubonii*	10/22/2012
Desert Cottontail	*Sylvilagus audubonii*	10/23/2012
Desert Cottontail	*Sylvilagus audubonii*	12/3/2012
Desert Cottontail	*Sylvilagus audubonii*	3/5/2013
Desert Cottontail	*Sylvilagus audubonii*	3/20/2013
Desert Cottontail	*Sylvilagus audubonii*	7/8/2013
Desert Cottontail	*Sylvilagus audubonii*	9/9/2013
Desert Cottontail	*Sylvilagus audubonii*	9/27/2013
Desert Cottontail	*Sylvilagus audubonii*	12/9/2014
Long-Tailed Weasel	*Mustela frenata*	3/10/2011
Long-Tailed Weasel	*Mustela frenata*	5/3/2011
Long-Tailed Weasel	*Mustela frenata*	6/17/2011
Long-Tailed Weasel	*Mustela frenata*	10/22/2011
Long-Tailed Weasel	*Mustela frenata*	4/30/2012
Long-Tailed Weasel	*Mustela frenata*	5/3/2012
Long-Tailed Weasel	*Mustela frenata*	8/30/2012
Long-Tailed Weasel	*Mustela frenata*	4/1/2013
Long-Tailed Weasel	*Mustela frenata*	4/22/2013
Long-Tailed Weasel	*Mustela frenata*	4/29/2013
Gopher Snake	*Pituophis catenifer*	3/14/2011
Gopher Snake	*Pituophis catenifer*	6/17/2011
Gopher Snake	*Pituophis catenifer*	6/30/2011
Gopher Snake	*Pituophis catenifer*	9/19/2011
Gopher Snake	*Pituophis catenifer*	6/11/2012
Western Rattlesnake	*Crotalus viridis*	5/6/2010
Western Rattlesnake	*Crotalus viridis*	6/17/2011
Western Rattlesnake	*Crotalus viridis*	9/8/2011

Common Name	Scientific Name	Date
Western Rattlesnake	*Crotalus viridis*	2/23/2015
Western Toad	*Bufo boreas*	12/13/2011
American Coot	*Fulica americana*	11/22/2011
American Kestrel	*Falco sparverius*	6/20/2011
American Kestrel	*Falco sparverius*	6/12/2013
Barn Owl	*Tyto alba*	1/19/2011
Barn Owl	*Tyto alba*	9/1/2011
Barn Owl	*Tyto alba*	11/3/2011
Barn Owl	*Tyto alba*	4/3/2012
Barn Owl	*Tyto alba*	6/28/2012
Barn Owl	*Tyto alba*	3/16/2015
Common Raven	*Corvus corax*	7/5/2011
House Wren	*Troglodytes aedon*	1/20/2011
Ring-Necked Pheasant	*Phasianus colchicus*	11/9/2010
Ring-Necked Pheasant	*Phasianus colchicus*	3/14/2011
Ring-Necked Pheasant	*Phasianus colchicus*	1/21/2014
Savannah Sparrow	*Passerculus sandwichensis*	12/16/2011
SEGMENT 6		
Coyote	*Canis latrans*	9/29/2009
Coyote	*Canis latrans*	10/26/2010
Coyote	*Canis latrans*	1/24/2011
Coyote	*Canis latrans*	6/8/2011
Coyote	*Canis latrans*	12/22/2011
Coyote	*Canis latrans*	2/13/2012
Coyote	*Canis latrans*	2/13/2012
Coyote	*Canis latrans*	4/21/2012
Coyote	*Canis latrans*	6/16/2012
Coyote	*Canis latrans*	7/12/2012
Coyote	*Canis latrans*	9/4/2012
Coyote	*Canis latrans*	10/3/2012
Coyote	*Canis latrans*	10/23/2012
Coyote	*Canis latrans*	4/1/2013
Coyote	*Canis latrans*	6/24/2013
Coyote	*Canis latrans*	6/25/2013
Coyote	*Canis latrans*	6/25/2013
Coyote	*Canis latrans*	6/27/2013
Coyote	*Canis latrans*	8/14/2013
Coyote	*Canis latrans*	1/10/2014
Coyote	*Canis latrans*	4/9/2014

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Mule (or Black tailed) Deer	*Odocoileus hemionus*	4/22/2013
Greater Roadrunner	*Geococcyx californianus*	8/15/2011
Black-Tailed Jackrabbit	*Lepus californicus*	7/26/2011
Botta's Pocket Gopher	*Thomomys bottae*	3/26/2014
California Ground Squirrel	*Spermophilus beecheyi*	2/24/2012
California Ground Squirrel	*Spermophilus beecheyi*	6/11/2012
Desert Cottontail	*Sylvilagus audubonii*	6/21/2011
Desert Cottontail	*Sylvilagus audubonii*	10/25/2011
Desert Cottontail	*Sylvilagus audubonii*	2/27/2012
Desert Cottontail	*Sylvilagus audubonii*	3/14/2012
Desert Cottontail	*Sylvilagus audubonii*	3/29/2012
Desert Cottontail	*Sylvilagus audubonii*	4/24/2012
Desert Cottontail	*Sylvilagus audubonii*	5/4/2012
Desert Cottontail	*Sylvilagus audubonii*	6/6/2012
Desert Cottontail	*Sylvilagus audubonii*	6/28/2012
Desert Cottontail	*Sylvilagus audubonii*	7/10/2012
Desert Cottontail	*Sylvilagus audubonii*	8/2/2012
Desert Cottontail	*Sylvilagus audubonii*	8/14/2012
Desert Cottontail	*Sylvilagus audubonii*	11/20/2012
Desert Cottontail	*Sylvilagus audubonii*	7/12/2013
Desert Cottontail	*Sylvilagus audubonii*	9/9/2013
Long-Tailed Weasel	*Mustela frenata*	5/3/2012
Long-Tailed Weasel	*Mustela frenata*	5/4/2012
Long-Tailed Weasel	*Mustela frenata*	5/4/2012
Long-Tailed Weasel	*Mustela frenata*	5/7/2012
Long-Tailed Weasel	*Mustela frenata*	5/8/2012
Long-Tailed Weasel	*Mustela frenata*	5/31/2012
Long-Tailed Weasel	*Mustela frenata*	6/20/2012
Long-Tailed Weasel	*Mustela frenata*	10/17/2012
Long-Tailed Weasel	*Mustela frenata*	4/29/2013
Long-Tailed Weasel	*Mustela frenata*	5/29/2013
San Diego Pocket Mouse	*Chaetodipus fallax*	3/19/2015
Striped Skunk	*Mephitis mephitis*	6/3/2013
Gopher Snake	*Pituophis catenifer*	6/9/2011
Gopher Snake	*Pituophis catenifer*	4/22/2012
Gopher Snake	*Pituophis catenifer*	4/25/2012
Gopher Snake	*Pituophis catenifer*	5/4/2012
Southern Alligator Lizard	*Elgaria multicarinata*	4/25/2012

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
Southern Alligator Lizard	*Elgaria multicarinata*	3/26/2014
Western Rattlesnake	*Crotalus viridis*	4/25/2012
Western Rattlesnake	*Crotalus viridis*	9/13/2012
Western Rattlesnake	*Crotalus viridis*	5/1/2013
Western Rattlesnake	*Crotalus viridis*	9/10/2014
Acorn Woodpecker	*Melanerpes formicivorus*	6/4/2012
Barn Owl	*Tyto alba*	11/4/2010
Barn Owl	*Tyto alba*	7/20/2011
Barn Owl	*Tyto alba*	10/25/2011
Barn Owl	*Tyto alba*	12/16/2011
Barn Owl	*Tyto alba*	2/23/2012
Barn Owl	*Tyto alba*	6/7/2012
Barn Owl	*Tyto alba*	8/13/2012
Barn Owl	*Tyto alba*	3/27/2013
Common Yellowthroat	*Geothlypis trichas*	4/8/2013
European Starling	*Sturnus vulgaris*	4/25/2011
European Starling	*Sturnus vulgaris*	3/20/2014
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*	5/1/2013
Ring-Necked Pheasant	*Phasianus colchicus*	12/13/2010
Ring-Necked Pheasant	*Phasianus colchicus*	5/21/2012
Ring-Necked Pheasant	*Phasianus colchicus*	1/7/2013
Rock Pigeon	*Columba livia*	1/15/2013
SEGMENT 7		
Coyote	*Canis latrans*	2/24/2012
Coyote	*Canis latrans*	10/11/2014
Mule (or Black tailed) Deer	*Odocoileus hemionus*	2/24/2014
California Ground Squirrel	*Spermophilus beecheyi*	2/23/2013
Desert Cottontail	*Sylvilagus audubonii*	12/4/2014
Raccoon	*Procyon lotor*	3/19/2015
Western toad	*Bufo boreas*	12/10/2011
Gopher Snake	*Pituophis catenifer*	5/8/2014
Gopher Snake	*Pituophis catenifer*	7/8/2014
Barn Owl	*Tyto alba*	9/16/2013
California Towhee	*Pipilo crissalis*	4/26/2014
SEGMENT 8		
Coyote	*Canis latrans*	6/28/2012
Baja California Coachwhip	*Masticophis fuliginosis*	3/29/2012
Virginia Rail	*Rallus limicola*	6/27/2012

Appendix B--Roadkill by Segment
(sorted by large animals, small animals, and birds)

Common Name	Scientific Name	Date
SEGMENT 9		
Raccoon	*Procyon lotor*	7/25/2013
Acorn Woodpecker	*Melanerpes formicivorus*	7/25/2013
SEGMENT 10		
Greater Roadrunner	*Geococcyx californianus*	4/18/2014
Common Kingsnake	*Lampropeltis getula*	9/19/2014
Red-Shouldered Hawk	*Buteo lineatus*	7/3/2013
Western Scrub-Jay	*Aphelocoma californica*	6/23/2013

Source: UC Davis California Roadkill Observation System database
(F.M. Shilling and D.P. Waetjen, pers. comm., http://wildlifecrossing.net

Data from J. Martin, J. Terp, Pek-Pum NWR; T. Dillingham, CDFW; J. Schlachter, BLM; Oct. 2010-July 2015.

Appendix C—Example Infrastructure Designs, Costs, and Schedules

There is extensive scientific literature on the effectiveness and economic benefits of various infrastructure designs as mitigation for wildlife vehicle collisions, including signs, lighting, visibility, animal detection systems, traffic controls, crossing guards, escape structures, undercrossings, overpasses, and fencing (e.g., Arizona Department of Transportation, Dodd et al. 2012, Forman et al. 2003, Gagnon et al. 2009, Huijser et al. 2008, 2009, Kintsch and Cramer 2011). Fencing combined with crossing structures are by far the most effective, reducing collisions of deer and carnivores by 80% or more in many cases. Funnel fencing, modifications to undercrossing approaches, and vegetation management and restoration can improve use of undercrossings that previously were used only marginally. Wildlife warning signs and reduced speed limits have not proven very effective in preventing wildlife vehicle collisions but could improve traffic safety.

Phased reconstruction along the highway will allow before-and-after comparisons of animal use and roadkill and adaptive management of the infrastructure plan; it will also allow animals to change their routes during construction. Moreover, long-term maintenance funding must be budgeted to ensure that the initial construction funding is cost-effective and that the function for wildlife linkage across the highway is not diminished with time.

Fencing

Caltrans, in coordination with CDFW and FWS, will determine type and location of fencing. In this document, we specify two types of fencing, both of which should be used to direct animals to crossing structures, and should consider landscape condition and topography as well as the home range size of the target species:

1. ROW fencing (funnel fencing, exclusion fencing, or "species protection fences," Caltrans 2013b) should be impermeable to keep wildlife off the highway; fence height and design are specific to the target species (Table C-1, Figures C-1a,b). For example, there may be the need for extra reinforcements at the bottom (for small animals) and top (for mountain lions and deer) of the ROW fencing.

2. Secondary fencing between public and private land is a less costly alternative to discourage animals from entering private lands, and may be sufficient along some stretches of the highway.

While chain link fencing is often used for access control in developed areas, it is very expensive for use in large projects. In rural areas such as Jamul and Dulzura, fences can be metal, galvanized wire mesh on posts of either wood (more esthetically pleasing) or metal (more durable, probably 20-30 year life span). Wire mesh fencing should be placed on the side of the poles facing away from the road so that animals inside the fence are less likely to loosen the fence from the poles. Fencing should tie directly into crossing structures.

In specific areas where the topography is not suitable for culverts or undercrossings and where wildlife are likely to cross the road at-grade, wildlife escape structures should be built into the fence to allow animals that penetrate the fence to get off the road (Figures C-2a,b). These structures should be sited in the field, approximately 0.5 mi apart, depending on number and spacing of undercrossings, at locations to be determined by landscape features and additional wildlife movement monitoring.

1. For ROW fencing, use impermeable 8 ft high (height dependent on location, slope, and target species) mesh fence, with smaller mesh sizes or hardware cloth along the bottom where needed to prevent small mammals and herpetofauna from entering the highway and to block vehicle-generated sparks from entering habitat areas. Where deer and lions are not target species, fence heights can be lower (e.g., 6 ft).

2. In areas where mountain lions are a focal species (based on pre-construction monitoring), use a 3-5-strand barbed wire overhang to deter them from climbing the fence.

3. At the bottom of the ROW fence, secure a skirt of 18-24 inches of fence buried in a trench underground or extending from the base of the fence 20-36 inches and anchored to prevent wildlife digging.

4. A coyote roller is a free-rolling tube on bearings, attached to the top of a fence, so that the coyote can't get traction to climb over.

Table C-1—ROW fence design by target species (also see Figure C-1 and Attachment 1).

Structure	Lions	Deer	Medium	Small	Herps
Fence height[1]	10-12 ft	8-9 ft	3-4 ft	±1.3 ft	±1.3 ft
Mesh size	6x6 in.	6x6 in.	6x4 in.	0.5x0.5 in.	0.25x0.25 in.
Dig barrier[2]	2-3 ft	-	2 ft	2 ft	4-6 in.
Overhang	2-strand barbed wire	-	-	-	-
Short concrete wall	-	-	-	-	18-48 in.

[1] Height depends on slope; higher fences are required for places where animals approach the fence from above.

[2] Rolled hardware cloth

Source: compiled from Huijser et al. 2008

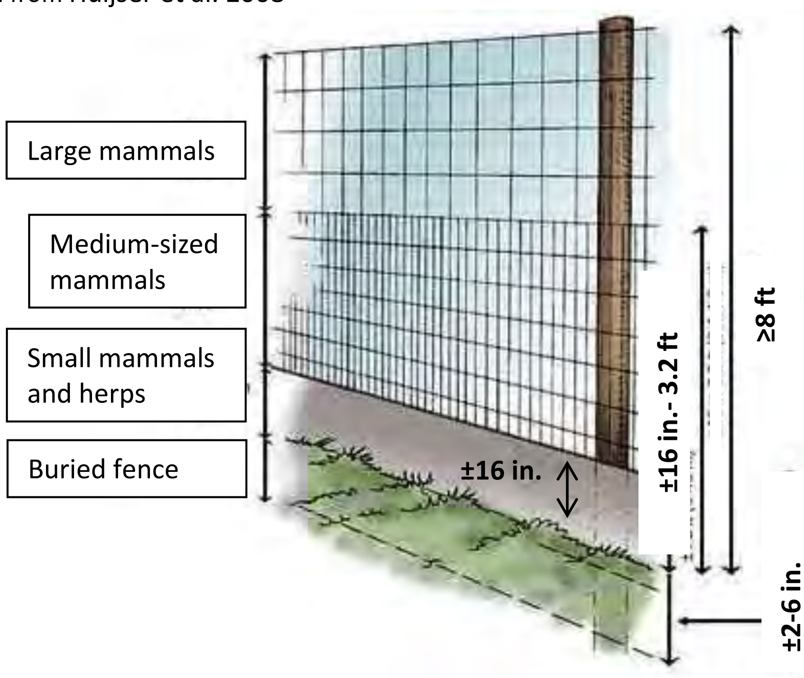


Figure C-1a—Schematic drawing of a large-mammal ROW fence in combination with smaller mesh and/or barriers at the bottom for smaller species (Source: Huijser et al. 2008, from Kruidering et al. 2005).

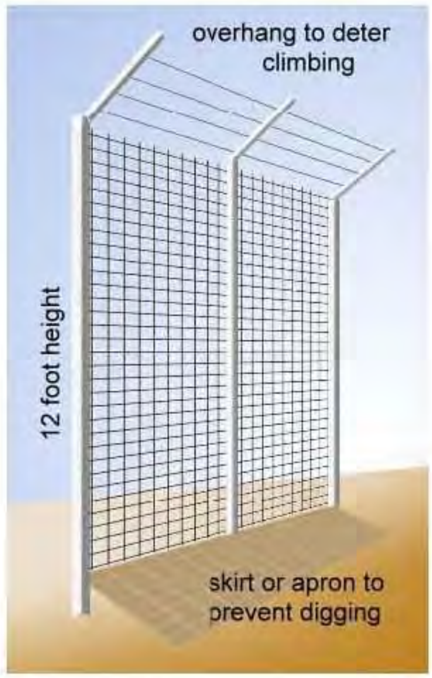


Figure C-1b—Example fence design to deter climbing (e.g., for mountain lions).
Source: Vickers and Huber 2012.

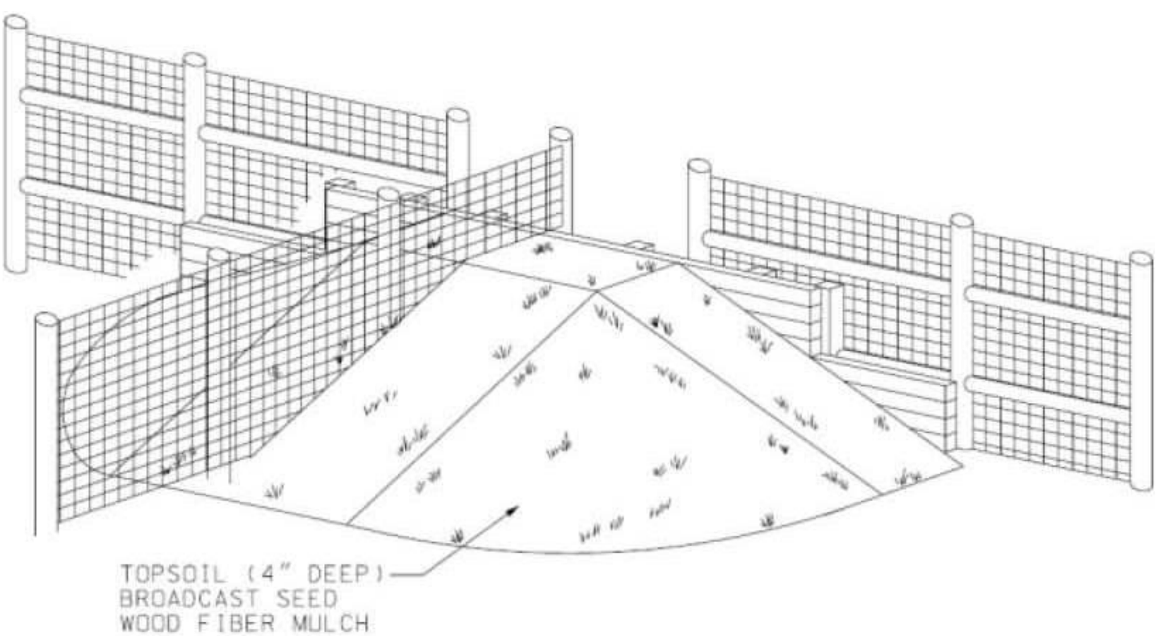


Figure C-2a—Example jump-out design for deer and other wildlife; consists of an earthen berm or ramp that slopes up from the highway, with a drop on the other side of the ROW fence.
Source: Caltrans 2007.

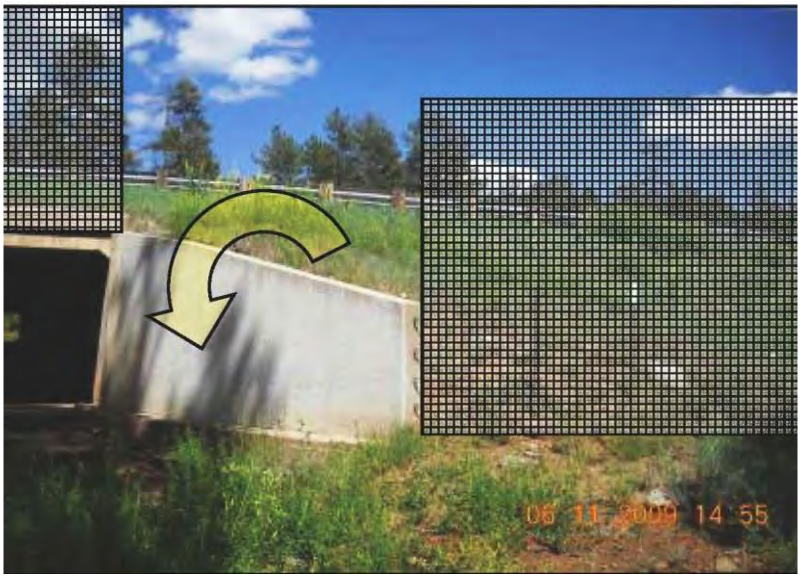


Figure C-2b—Lower cost escape structure. Source: AZDOT wildlife escape measures.

Undercrossings

Openness is important to achieving a high probability of successful crossings. The length of the crossings along SR-94 currently do not exceed 30 ft, thus minimizing the distance an animal has to travel and maximizing the visibility through the underpass; this increases the likelihood that animals can see the other side of the highway through the underpass. However, as Caltrans has plans to widen the highway in areas, the openness ratio of each undercrossing must be considered, as the length of the crossing corresponds to the width of the roadway (Caltrans 2007, 2009). Table C-2 provides examples of recommended dimensions for undercrossings designed for different species.

The openness ratio of an undercrossing is defined as a structure's (height x width)/length (the distance of an underpass perpendicular to the road). A large openness ratio (i.e., >0.75) provides more natural lighting and is recommended to allow an animal to see all the way through a crossing structure to the other side (e.g., Cain et al. 2003, Clevenger and Waltho 2005). In addition to the openness ratio, however, one must consider brightness, distance to safety from predators, traffic volume and noise, vegetation cover, and similarity to natural environmental conditions. Where undercrossings also support water flow, it is important to have a ledge or shelf that animals can use to stay above the water level (Figures C-3a—C-3d).

Dodd et al. (2007a) suggest that all bridges include natural 2:1 slopes approaching the undercrossing, to enhance openness, rather than rip-rap or other concrete material. If rip-rap is used, it should be covered with a material that animals can more easily traverse. Mitigate the vehicle noise impact on bridges or large box culverts by using rubberized asphalt or installing “Rhino Liner” type material on the underside of the bridge.

In drainages subject to high flows, a piece of woven wire can be placed across the channel, upstream from the culvert, to collect debris during floods so that the debris does not clog the culvert and impede movement.

Construction is typically a concrete bridge span, steel beam span, box culvert, or arch made of prefabricated concrete or corrugated steel, without a bottom or with a bottom covered by natural substrate >6 in. deep.

Table C-2—Types of undercrossings for target species (source: Huijser et al. 2008, AZDOT 2008).

Type	Example Dimensions	Walkway w/i Underpass[4]
Open-span vehicle bridge	40-45 ft wide X 12-17 ft high	7-10 ft wide
Large-mammal undercrossing (arched culvert)[1]	26 ft wide X 17 ft high	7-10 ft wide
Medium mammal undercrossing (box culvert)[2]	3-10 ft wide X 2-8 ft high	2-3 ft wide
Small animal pipe[3]	1-3 ft diameter	1-2 ft wide

[1] Large mammals = deer, lions; underpass is an arched culvert or box culverts; deer prefer overpasses but will use undercrossings with large cross-sectional areas and an openness ratio of ≥0.75 (height x width/length).

[2] Medium mammals = weasels, skunks, bobcats, fox, coyote, badger, jackrabbits.

[3] Small animals = cottontail rabbits, rodents, herpetofauna.

[4] Underpasses that also accommodate waterflow should include walkways for terrestrial species (see Figure D-3).

Figure C-3a—Bridge with channel that allows water to flow seasonally.
Source: M.Huijser et al. 2008.

Figure C-3b—Arched culvert with a ditch on left that allows water to flow seasonally.
Source: M.Huijser et al. 2008.

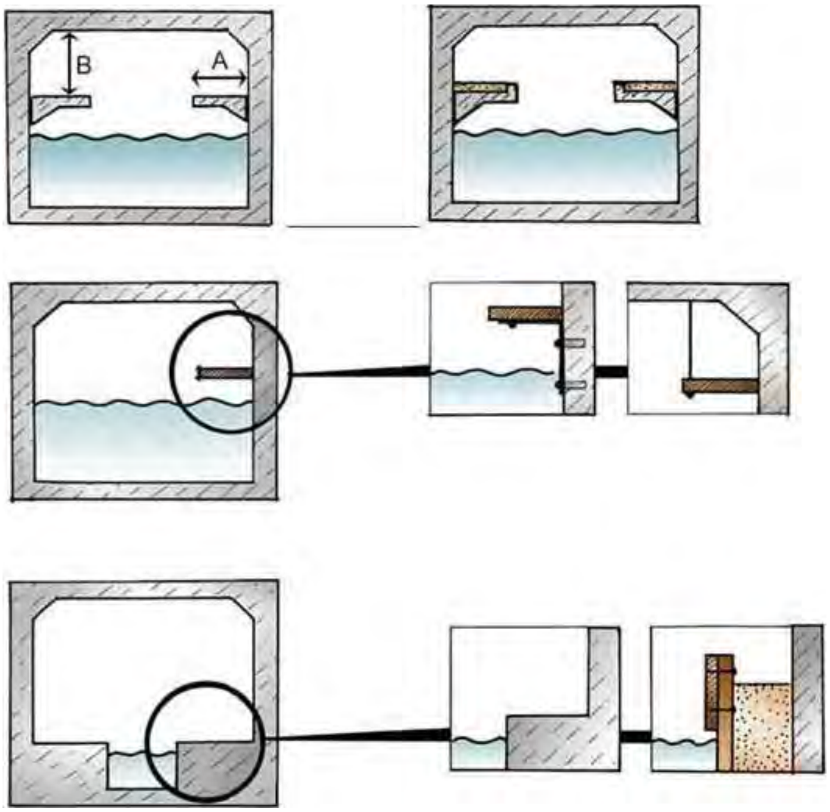


Figure C-3c—Walkway or "shelf" designs for small-and medium-sized mammals in box culverts.
Source: M.Huijser et al. 2008, from Kruidering et al. 2005.

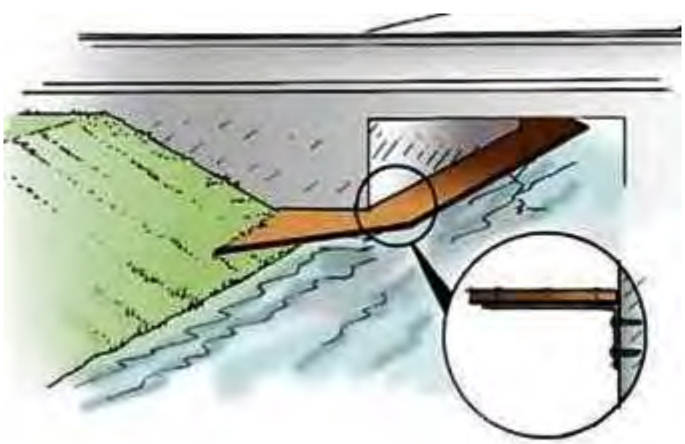


Figure C-3d—Connection of walkway to adjacent bank.
Source: M.Huijser et al. 2008, from Kruidering et al. 2005.

Pre-cast concrete or pre-formed metal structures are effective and typically less expensive (e.g., $110,000 in 1997) than bridges (Lotz et al. 1997). These modular structures can consist of a combination of cast in-place concrete footings, precast arch elements, headwalls, and/or wingwalls. They are designed for a specific site and can be used to span from 12-102 ft (BEBO Arch Systems), with minimal long-term maintenance. Corrugated pipes also are relatively inexpensive and easy to install. See examples Figure C-4 and http://www.conteches.com/products/bridges-and-structures/precast/bebo-bridge.aspx.

Figure C-4—Examples of pre-cast concrete and pre-formed metal structures.

Special Considerations for Amphibians and Reptiles

Like other species, amphibians and reptiles need light to see and pass through tunnels. But in addition, amphibians especially need moisture in their passages, so the tunnel should be open at top and fitted with an iron grate, to allow light, rain, and air to equilibrate ambient temperatures and moisture conditions. The tunnel should have a detritus and leafy substrate which is not prone to flooding (e.g., a wildlife "shelf") and situated at the base of the slope coming off the road grade (Tracey et al. 2014, http://www.aco-wildlife.com/home/).

Where larger culverts are also used as undercrossings for small mammals and herps, place rocks, log, natural debris, or pipes inside the culverts to provide cover (Figure C-7) (Tracey et al. 2014).

Drift fencing, or exclusion fencing, sunk into the ground 3-4 in. is needed to direct small animals toward the tunnels, and wing walls should angle out from each end of the tunnel at ~45° for 100-300 ft, more for larger animals (Figure C-8).

Figure C-7—Structural elements inside culverts
to provide cover for small animals.
Source: Clevenger and Huijser 2011.

Figure C-8—Examples of small animal exclusion fencing (frogs, lizards, salamanders, toads, snakes, small mammals). Source: http://animexfencing.com/; Clevenger and Huijser 2011.

Overcrossing or Wildlife Overpass

Sight lines and widths are the most important considerations for effective overcrossing designs, with the ends of the structure being wider than the middle portion (Kintsch and Cramer 2011). Clevenger et al. (2002) recommend that the narrowest portion of the parabolic-shaped structure be 230 ft wide for a multiple-species overpass; however, existing overcrossings of some two-lane roads are <200 ft wide (Huijser et al. 2008). Some literature refers to landscape bridges that are wider (>330 ft) than wildlife overpasses, with a soil depth of 5-8 ft that is taken from adjacent habitat (Clevenger and Huijser 2011). Construction is typically a steel truss or concrete bridge span or pre-fabricated cast-in-place concrete arches or corrugated steel). The overpass should be exclusively for wildlife, with human use prohibited (see example Figure C-9).

Figure C-9—Example of overcrossing.
Source: www.bluevalleyranch.com

Example Infrastructure Costs and Schedule

Costs for wildlife infrastructure are site-specific and species-specific, depending on terrain, mobilization, size of the project (economies of scale), and types of equipment used (e.g., jack and bore vs cut and cover). Another cost consideration is maintaining traffic flow on an existing roadway during construction. Moreover, costs in the scientific literature are not comparable because of differences in target species, construction dates, and whether costs include labor for installation. Attachment 1 provides 3 years of costs for Caltrans projects statewide.

Fencing and Jumpouts

Costs for fencing depend on material and mesh size (for specific target species), terrain, height and depth below ground, as well as requirements to withstand high winds (Table C-3; see

Attachment 1). Costs for jump-outs vary widely, depending on structure. Jump-outs can be as simple as lowering the height of one section of fence.

Table C-3—Example costs for fencing and jump-outs.

Type	Material	Cost	Source
UNIT COSTS[1]			
Fence	8'Wire mesh (4")	$100/LF[3]	Siepel 2015
Fence	"Ungulate-proof"	$30/LF[3]	Nordhaugen 2009
Fence	Wire mesh	$33/LF[3]	Caltrans 2013 District 11
Fence	Barbed wire	$12/LF[3]	Caltrans 2013 District 11
Fence	Chain link	$20-$22/LF[3]	Caltrans 2012 District 11
Fence with posts	Wire mesh, metal post	$45/LF[3]	Caltrans 2013 District 11
Gate (pedestrian)		$3,000	Siepel 2015
Gate	4 ft chain link	$756-$1,238	Caltrans 2012, 2013 District 11
Gate	4 ft chain link, vinyl clad	$2,000	Caltrans 2013 District 11
Gate	8 ft chain link	$1,000-$1,380	Caltrans 2012, 2013 District 11
Gate	10 ft chain link	$850-$880	Caltrans 2012, 2013 District 11
Jump-outs	Wildlife escape ramp	$8,000	Siepel 2015
Wildlife guard	Electric mat	$8,000	Siepel 2015
Wildlife guard	Metal guard	$60,000-$80,000	Siepel 2015
TOTAL COSTS[2]			
Fence, mountain lions	Hwy 241, Orange County	$1 million/mile	W. Vickers, pers. comm.
Jump-outs	various	$7,207-$15,267[4]	Huijser et al. 2008
Jump-outs, ungulates and mountain lions	SR-77, Arizona Hwy 241, Orange County	$40,000-$50,000 each	Nordhaugen 2009, W. Vickers, pers. comm.

[1] Unit Costs for materials may vary based on quantity ordered, contractor, location, terrain, and type of equipment used for installation; does not include installation.
[2] Total Costs include installation.
[3] LF = linear foot
[4] Corrected by 15.3% inflation rate between 2008-2015 in San Diego County

Wildlife Crossings

Table C-4 provides some examples from the literature, wildlife crossing handbooks, Caltrans contracts across the state, and personal communication from scientists and engineers. Also see Attachment 1 for unit costs.

Table C-4—Example costs for undercrossings and overpasses. Add 15.3% due to inflation in San Diego County over the period 2007-2015.

Type	Material	Size	Cost[1]	Source
UNIT COSTS[1]				
Vehicle bridge, open span		40' x 16'	$10-12,000/ft	Caltrans 2007
Box culvert		12' x 16'	$36,632/linrst gy	Siepel 2015
Box culvert	Concrete	10' x 8'	$575/ft	Caltrans 2007
Box culvert	Class 1 concrete		$565-$1,380/cu m	Caltrans 2009
Box culvert	Class 2 concrete		$620-$3,630/cu m	Caltrans 2009
Concrete pipe	Reinforced concrete	7'	$650/linear ft	Caltrans 2013
Steel pipe	Corrugated steel	4'	$150/linear ft	Caltrans 2013
Elliptical culvert	Corrugated metal	23' x 13'	$1,100/ft	Caltrans 2007
Overpass		170' wide	$6,890/ft	Caltrans 2007
TOTAL COSTS[2]				
Arch culvert SR-91, Orange County			$8 million	Pers. comm. W. Vickers
Overpass, 101, Orange County			$25-50 million	Pers. comm. W. Vickers
Box culvert 13x13			$10-12 million	Pers. comm. W. Vickers
Undercrossing	Prefabricated concrete with head and wing walls	32' wide x 12' high x 190' long	$615,790	Nordhaugen 2009
Undercrossing	Prefabricated concrete	50' wide x 12' high x 190' long	$729,680	Nordhaugen 2009
Overpass	Prefabricated concrete	72' span x 26' rise	$2,622,500	Nordhaugen 2009
Tunnel, SR-91 Riverside County	Prefabricated concrete	12' x 37' arch	$4.9 million	L. Correa, WRCRCA pers. comm.
Bridge, SR-91, Riverside County	SR-91, Riverside County		$20 million	L. Correa, WRCRCA pers. comm.

[1] Unit Costs may vary based on quantity ordered, contractor, location, terrain, and type of equipment used for installation.

[2] Total Costs include labor for installation, but do not include design, engineering, mobilization, traffic control, erosion control, surveying and layout

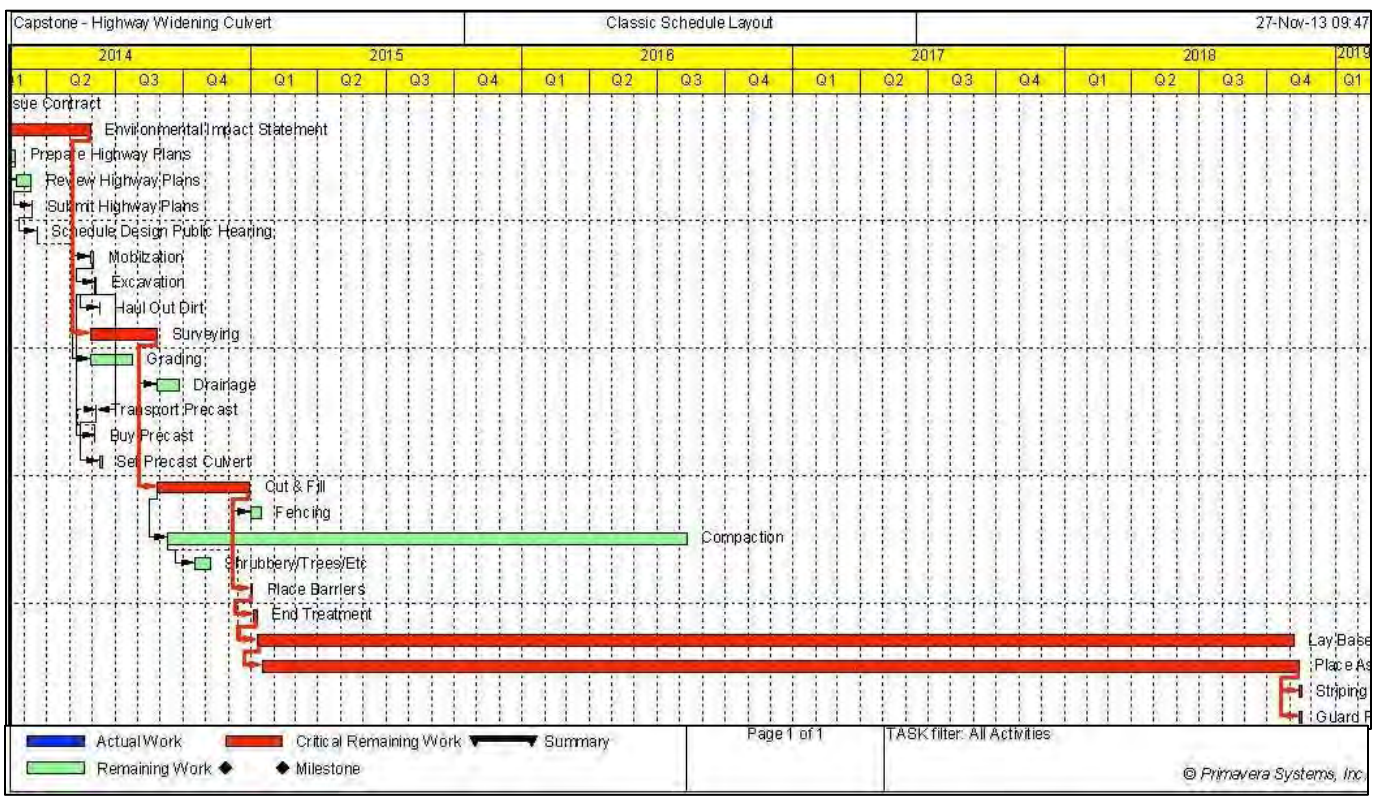
Box Culvert for Segment 3

San Diego State University engineering students designed a precast concrete box culvert with wing walls specifically for the location in Segment 3 (Map 3) at the bottom of the hill on the SR-94 curve that bisects the San Diego National Wildlife Refuge (see Appendix D). The 15x20 ft box culvert is intended to support large and small mammals, birds, and herpetofauna. The culvert has an openness ration of 1.20. The bottom of the culvert will be covered with soil from the area, and is designed to accommodate flow from a 100-year storm. The culvert is designed to extend underneath 4 lanes of highway (64 ft).

Table C-5—Approximate costs of Segment 3 box culvert (SIMBA Engineering 2013).

Item	Cost
Transportation: Traffic management, construction signs, excavation, aggregate base, asphalt	$2,370,330
Structural: Precast concrete box culvert	$100,000
Environmental: Fencing, planting erosion control	$1,181,968
Total Project	$3,752,298

Table C-6—Approximate construction schedule (SIMBA 2013).



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Attachment 1—Unit Cost Examples

http://www.dot.ca.gov/hq/esc/oe/awards/

Appendix D—SR-94 wildlife crossing and highway expansion (SIMBA 2013)

SR-94 WILDLIFE CROSSING AND HIGHWAY EXPANSION

12/6/2013

100% Design Submittal

Project Manager-Brian Tran [Environmental]

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Jecelyn Carranza [Construction]

Frank Shamas [Hydraulics]

Matthew Balan [Transportation]

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SR-94 Wildlife Crossing and Highway Expansion

Introduction:

Recent dramatic increases in urban, highway, and road development have increased interactions with wildlife and led to fragmented habitat. Inadequate size, poor design, poor placement, and insufficient availability result in limited use or avoidance of culverts by wildlife and fish. Since hydrological structures may not be adequate, crossing structures developed specifically for wildlife passage are now being incorporated into roadway designs. Projects currently in the planning stages are now being developed to provide for drainage as well as fish passage and wildlife movement. Employing multiple-use designs allows planners proactively employ comprehensive strategies that incorporate watershed integrity, habitat connectivity, and provide cost savings by decreasing collisions, injuries to humans, and damage to vehicles. [1]

Executive Summary:

The purpose of this project is to address the issue of habitat connectivity and wildlife crossing State Route 94 safely in an area north of the city of Jamul. It is little to no surprise that road and highway developments have a large impact on natural habitats and wildlife. State Route 94 is no exception, dividing the north side from the south side of the San Diego National Wildlife Refuge. Too often, animals attempt to cross the highway and end up endangering not only themselves but human motorist as well. The fundamental basis of this project includes designing a culvert that will ideally serve all different species in the area, effectively decreasing the mortality rate of wildlife and increasing safety for motorist. This project will also include widening of SR-94 to have a LOS A by determining how many more lanes will be needed to service traffic flow in future years. Additional considerations are the local watershed welfare and major pipelines from the Otay Water District pump station that will need to be avoided or redirected at the discretion of the water consultant. While all this is underway, construction management will address construction access, budgeting, and phasing of the project as to not congest traffic during working hours. The wildlife-crossing project must also keep in mind to minimize environmental impact, especially due to the nature of the wildlife refuge.

Assumptions/Constraints

Certain assumptions and constraints must be made.

Assumptions	Constraints
Wildlife movement corridor – Access to wildlife movement cameras were limited.	Monitoring equipment and data – Monitoring Equipment too expensive to buy and use.
Width of highway after expansion – Used typical widths of highway roads	Lack of soil information – USGS does not have soil data for particular region
Depth of Creek – Unable to properly measure depth of creek.	Watershed data – Unable to find various watershed data
Peak hour direction slip traffic data – Data unavailable from traffic count	Highway Cross-section data – Cross-sectional area data cost money to view
Relative cost – Impossible to find accurate prices of items	Unable to acquire data until design phase – Time constraint

Management Scope:

Figure 1.1 shown below describes the management scope and steps to take in planning, implementation, and adaptive management when designing a wildlife culvert.

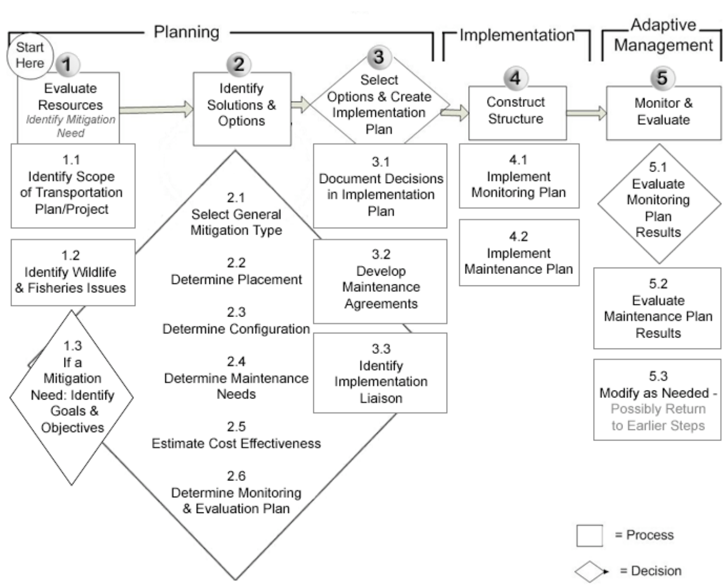


FIGURE 1. 1

Environmental

Background:

To help better understand the interactions between roads and environment the discipline of road ecology has emerged in the last 10 years. Road ecology strives to understand surface transportation infrastructure and its impacts on wildlife and motorist safety, aquatic resources, habitat connectivity, and many other environmental values. Roads affect populations in numerous ways, from habitat loss and fragmentation, to barriers to animal movement, and wildlife mortality. The impact of roads on wildlife populations is a significant and growing problem worldwide.[2]

Figure 2.1 shown below represents the inversely proportional relationship between road density and wildlife density. As road density increases, wildlife populations diminish.

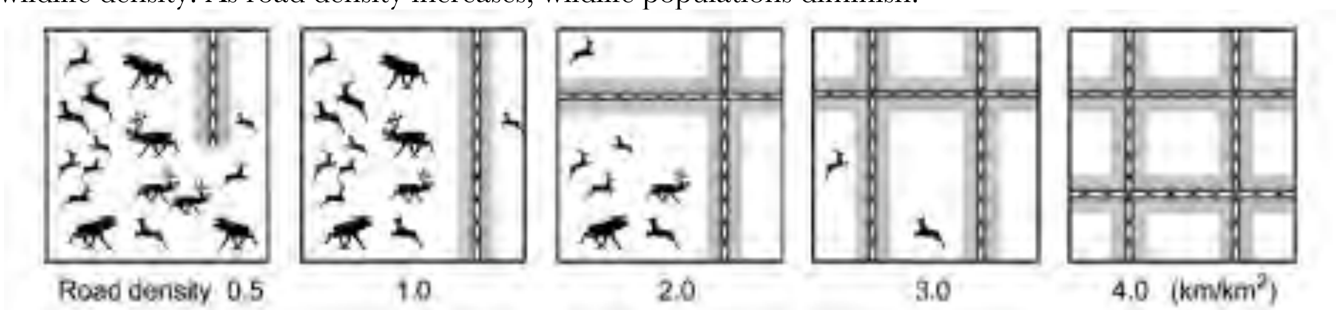


FIGURE 2. 1

Figure 2.2 shown below represents the barrier effect on wildlife populations. (A) Shows a healthy unaltered diverse population with subpopulations linked together through dispersal. (B) Shows the barrier effect of placing a road in a habitat thereby isolating populations.

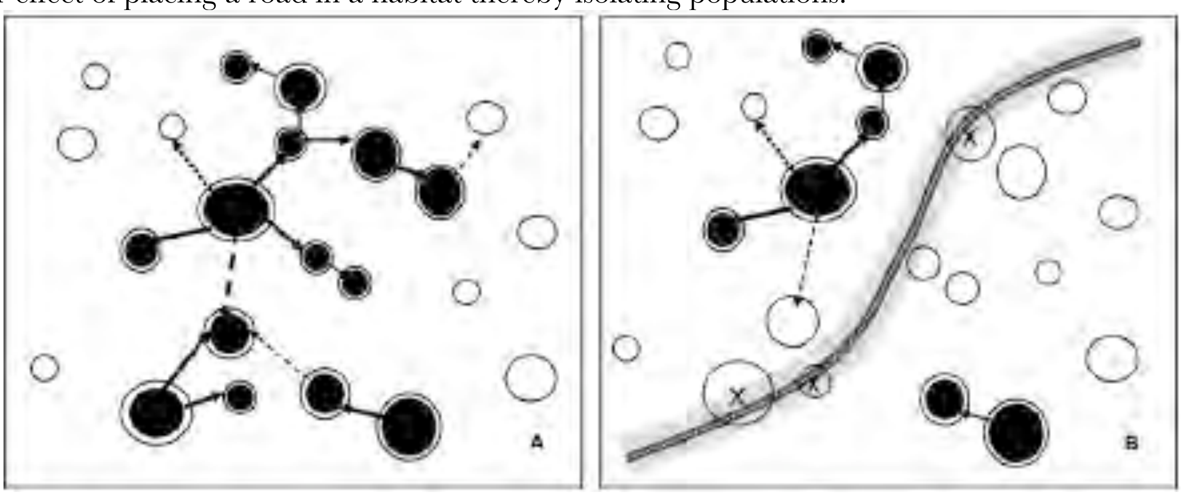


FIGURE 2. 2

Figure 2.3 shown below describes the effect traffic volume has on (1) animal avoidance of roads, (2) the likelihood of them getting killed while trying to cross, and (3) successful crossing attempts.

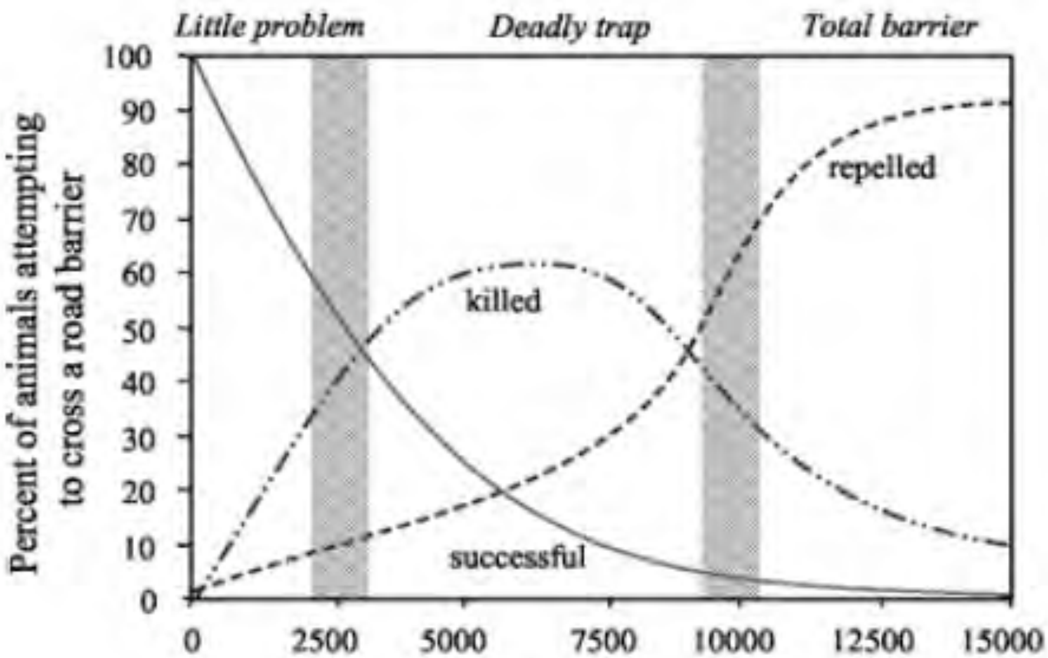


FIGURE 2. 3

Culvert Environmental Considerations:

When implementing a culvert, it is imperative to consider designs that offer the lowest impact to the surrounding environment. Along with federal and local regulations, certain environmental criteria must be met to ensure proper use of the culvert.

1. Identify species of concern species in the area such as threatened or endangered or any Species of Concern as defined by state or federal agencies, paying attention to those with special culvert needs.
    a. This can be done by monitoring fish and wildlife movements in the area to determine natural wildlife movement corridors, crossing areas, behaviors, and crossing frequency.
    b. This was also provided from client – mainly large animals
2. Determine number of culverts necessary to facilitate both water drainage and wildlife crossing.
3. Identify culvert shape and size requirements for the species in the area with special consideration to:
    a. Noise/sound
    b. Temperature
    c. Light/Viewable openings
    d. Moisture
    e. Entrance cover
    f. Nature/Artificial footings

4. Consider designs that enhance the overall appeal and attraction of culvert to accommodate various types of species.
5. Culverts should be durable and able to withstand high flow rates during peak rainfall seasons as well as buildup from dirt and debris.
6. Fencing designed to accommodate multiple species should be installed to prevent wildlife from reaching the road
7. Proper maintenance of culverts to ensure proper functionality including cleaning debris, repairing fencing issues, planting vegetation, and ensuring structural integrity.

Shown above is a picture of a bobcat using a medium-sized box culvert from the Florida Department of Transportation.

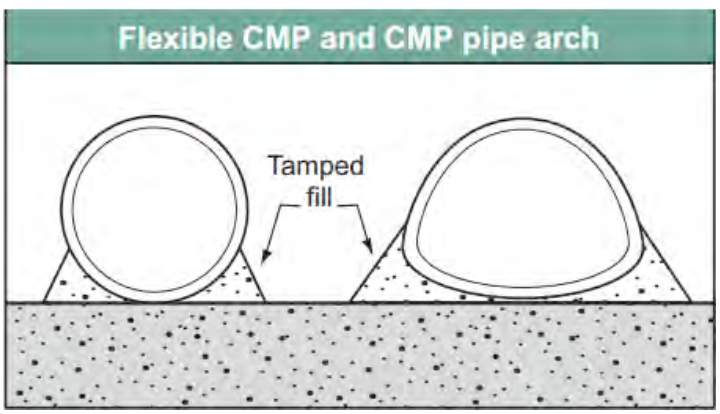
1. Species of concern typically range from large mammals such as mountain lions to small reptiles and rodents.
2. In this case, only one culvert will be implemented to ideally serve all animals in the region
3. As discussed in the next section, an openness ratio of 1.20 will be used for the culvert. An openness ratio value of 0.75 is the minimum require for large mammals, so the culvert is more than adequately sized for its purpose.
4. When placed, the bottom of the culvert will be covered with natural soil from the local area, this ensures animals are comfortable to utilize the culvert.
5. Discussed in the hydrology sections of this report, the culvert will be able to withstand high flow rates during peak rainfall seasons using a 100-year storm report.
6. Often times, fences are utilized to help promote and encourage wildlife to use underground culverts. Appropriate fencing is crucial to the success of a culvert because it funnels wildlife into the culvert and away from roads. Fences are embedded to a certain depth to restrict animals from digging underneath fences and crossing roads. When placing fencing, trees and large bushes should be taken into consideration because some animals tend to climb trees and can jump over the fence, rendering it useless.
7. With proper care and maintenance, the use of a culvert will last much longer.

Structural

Introduction
The design of a wildlife culvert requires the consideration of a number of factors. These factors include the type of culvert, the likeliness that animals will use it, the stability of the soil, bearing capacity and foundation requirements, cast in place or precast structures, total loading, and concrete reinforcement.

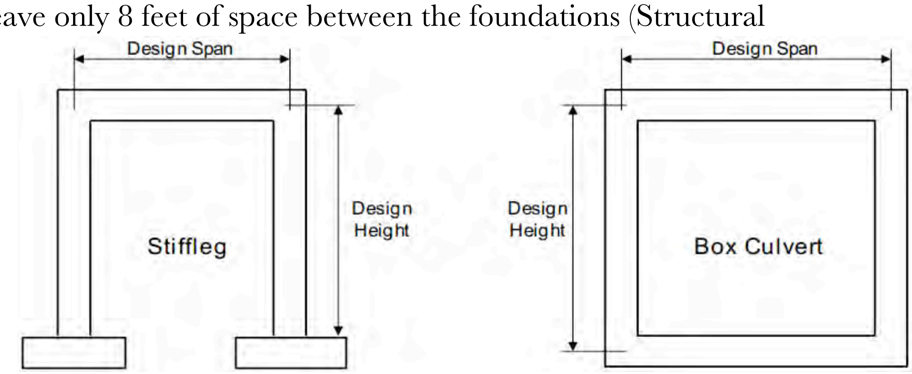
Type of Culvert
During the design process a number of culvert designs were considered. These included a corrugated metal pipe arch (CMP Arch), a 3-sided stiffleg culvert, and finally a precast concrete box culvert.

The idea to use a corrugated metal pipe arch was discarded because, while such a structure would have a relatively low materials and installation cost, it would not be suitable for the heavy soil and highway loading the culvert would be subjected to. The structure would easily flex under the heavy load, which would create significant problems for the highway above. It would also be impractical to create a natural channel bottom in such a structure. As a result, the bumpy metal pipe would offer inadequate footing for animals and the round shape would not seem spacious enough to encourage animal use.



The next design choice was a 3-sided stiffleg culvert. This option would eliminate the issues of the corrugated metal pipe. The design would be strong enough to support the soil and highway loads while allowing for a natural channel bottom. The square design would also allow for a greater span width and would be much more inviting to passing wildlife. While the initial material and installation costs would be greater than those of the CMP Arch, the lifetime of the concrete culvert would be significantly longer.

This design was to be supported by strip footings, which would run the length of the culvert. When calculating bearing capacity of the soil and the associated width of the strip footings it became apparent that the width of the footing would leave only 8 feet of space between the foundations (Structural Appendix). As a result it was decided that a concrete box culvert would be more practical. By extending the base 3 feet deeper into the ground and filling the culvert until 12 feet of clearance is available all of the requirements for the culvert would be satisfied.



Ease of maintenance is another

benefit of this design. By creating a wide open and easily accessible pathway maintenance workers can easily traverse the length of the passage and remove any debris that might accumulate.

Openness Ratio

The determination of a wildlife culvert's size is based on the size of animals that will utilize the structure as well as the width of the road under which the culvert will pass. The width of the road corresponds to the length of the culvert. To encourage animals to use the structure, they must be able to have a clear field of view from the entrance to the exit, therefore, as the culvert length increases so must the cross sectional area. The 'openness ratio' is a relationship which factors in the dimensions of the culvert and provides a ratio that determines suitability for animals of a certain size whereby [1]:

Openness Ratio = (Culvert Height x Culvert Width)/ Culvert Length

Large mammals require a height of at least 6 feet and an openness ratio of at least 0.75, although 0.90 is prefered. In order to encourage the use of the culvert by large mammalian fauna an openness ratio of no less than 1.20 will be used for this project. Visible in Structural Appendix are calculations regarding the openness ratio for a CMP and for a box culvert. Based on client needs, a three sided stiffleg culvert was designed with 80 feet length, 12 feet height, and 22 feet span width which provides an openness ratio of 3.3. The 80 foot width is based on the lane width for the highway expansion. Supplemental calculations in Structural Appendix provide openness ratio calculations and basic assumptions used during the design process.

Foundation Requirements

Soil data for the project site was not readily available and as such it was necessary to make assumptions regarding the soil type based on site visit observations and available data for sites with similar soil characteristics.

By using San Diego County Recon Survey data for the Jamul Mountains it was a safe assumption to make that the soil type is a San Miguel-Exchequer rocky silt loam. When the 3-sided stiffleg structure was being considered it was necessary to calculate the bearing capacity of the strip footings that were to run along the length of the culvert. Terzaghi's Bearing Capacity Theory was used to find the ultimate bearing capacity and the width of the footing. These calculations are available in the Structural Appendix a graph of the footing width compared to the total bearing capacity. Once these calculations were complete the decision was made to change the design to a box culvert.

Cast in Place or Precast Design

Cast in place and precast culvert designs offer unique characteristics and are chosen based on the needs of the project. Based on AASHTO LRFD Bridge Design Specifications Class 40A concrete and Grade 60 reinforcement are required for this design.

A cast in place design would require adequate time to place the reinforcement, prepare the molds, pour the concrete, and allow the concrete to cure. This would be difficult due to the need for a staging area to store extra materials and concrete trucks. On site concrete testing would also increase costs and time. Weather would also have to be optimal for pouring the concrete.

A precast design would allow for completion of the culvert on the same day that the trench is excavated. A precast design would still require a staging area for the precast segments to be stored. Various trenchless technologies for culvert installation are available and would allow for cheaper and significantly faster culvert installation while minimizing the need for closures of the road above.

This method would be advantageous when compared to a cast in place design due to the elimination of a number of factors, which include errors in pouring, on site sample testing, and concrete curing in the truck. It would also decrease construction time by eliminating the need to place molds and reinforcement prior to pouring.

For the reasons listed above it was decided that a precast design would be the most practical and economically feasible choice.

Total Loading

The various loads on the culvert were determined by following design standards in the Federal Highway Administration IP-83-6 design manual. The loads calculated in this section include culvert weight, fluid loads, live loads, unexpected loads, and earth loads which are verified by determining distribution of earth pressures.

<u>Culvert Weight</u>

Approximate culvert weight can be calculated using an equation in the Structural Appendix. This formula is provided by the FHWA; however, it is more appropriate to use culvert weight tables provided by the American Concrete Association Pipe Design Handbook. These resources estimate the weight of the culvert to be approximately 100 kips per square foot, which is approximately equal to 700 pounds per square foot.

Earth Loads & Distribution of Earth Pressures

Earth loads were calculated in kips per square foot using an equation from the Structural Appendix. This formula, which was provided by the FHWA yielded results of approximately 36 kips per square foot (250 pounds per square foot) from soil pressure on the top of the culvert. This value was verified by checking the distribution of earth pressures using FHWA supplied equations.

Fluid Loads

Due to the natural channel bottom and the minimal flow that will be present in the culvert it is not necessary to consider fluid loads.

Live Loads

Due to the depth of the culvert transient loads will not have any significant impact. Instead loads will be added to simulate loading from stopped traffic on the highway above.

Unexpected Loads

To account for unanticipated loading on the culvert a surcharge of 2 feet of 120 pound per cubic foot soil is added to the load. This summation equals approximately 250 pounds per square inch and simulates stopped vehicles on the highway above the culvert.

Total Loading

The total loading summed up to approximately 1200 psi. During design, all calculations were rounded up in order to add a factor of safety. It is unlikely that there will be loads exceeding what have been calculated.

Concrete Reinforcement

By using design guidelines provided by the American Concrete Institute Committee 314 it was possible to calculate the required reinforcement in the concrete culvert. By calculating self weight, ultimate and nominal moments, and the reinforcement ratio it was determined that 2 rows of 4 #7 steel bars spaced approximately 3.8 inches apart with two #5 stirrup bars would be sufficient to support the load on the culvert. These calculations and a representative cross section are available in Structural Appendix.

Additional Considerations

As visible on the Structural Appendix it will be important to add flared wingwalls to the opening of the culvert. These wingwalls will hold up the earth surrounding the culvert in the event of a flood or storm and will prevent soil failures that would result in landslides. The wingwalls will need to extend almost perpendicular to the opening for 6-10 feet with a gradual slope. The pressures on these wingwalls will not be significant enough to cause failure. They are simply in place to prevent erosion that could result in soil failure.

Hydrology

This design approach provides for the development of a natural streambed within the crossing structure, which is continuous with the upstream and downstream channel. The approach also provides a corresponding width and height of opening to ensure the long-term viability of the culvert. The SR-94 culvert is to have the following characteristics:

1. The culvert will allow proper flow through it as to not constrict or stop flow from the drainage basin.
2. Although the culvert will have a concrete floor, the bed material will be the same as the creek bed.
3. It provides for terrestrial passage of wildlife during “normal” flow conditions

Runoff

Runoff currently flows into nearby creeks that run adjacent to the highway. Since the majority of the creeks will be undisturbed runoff will continue to flow into these natural channels. There is one 10-yard stretch in which the highway widening intrudes on a creek. This can be remediated by excavating a new segment for the creek into the nearby hill. The runoff on the North side of the SR-94 will be diverted underneath the freeway through the culvert to the creek. The runoff that flows through the culvert, either from the highway or from the adjacent hills, will contain silt that can build up in the culvert. This buildup will only occur when the velocity of the flow is slow enough to deposit silt without eroding the soil that is present. Due to the cross sectional area of the culvert it is unlikely that enough buildup will occur to prevent the flow of water or use of the culvert by wildlife. Regardless of congestion by silt, the removal of plant detritus and other materials, such as litter, will require regular maintenance. During this maintenance, workers will be able to note the amount of congestion and level the soil if necessary.

Depending on the duration and velocity of flow that might occur, erosion of the natural bed in the culvert must be considered. Since flow will be diverted to the culvert it is likely that new creeks will form leading water through the new passage. This could create issues for the usability of the culvert for wildlife. This problem can be resolved through regular maintenance and inspections to insure the condition of the culvert lining.

Drainage Basin

The drainage Basin for the culvert was taken from USGS topography maps. The basin is only North of the SR-94. Any drainage south of the SR-94 collects in the stream running parallel to the road. The drainage basin for the culvert that collects North of the road is approximately 40 acres. With this area the flow is determined Q=CIA (.3)(3)(40)=36cfs

Culvert Flow

Many different flow conditions exist over time, but at a given time the flow is either governed by the inlet geometry or by a combination of the culvert inlet configuration, the characteristics of the barrel, and the tail water. Control may oscillate from inlet to outlet. While the culvert may operate more efficiently at times, it will never operate at a lower level of performance than calculated. The culvert design method used on this culvert is based on the use of design charts. These charts based on data from numerous hydraulic tests and on theoretical calculations.

Type of Control

The culvert in the design has a width of 22 feet and height of 12 feet. For this vast size the culvert will never be full when compared to the runoff of the drainage basin. In this condition neither the inlet nor the outlet end of the culvert are submerged. The flow passes through critical depth just downstream of the culvert entrance and the flow in the culvert is supercritical. The culvert flows partly full over its length, and the flow approaches normal depth at the outlet end. Since the control is at the upstream end in inlet control, only the headwater and the inlet configuration affect the culvert performance.

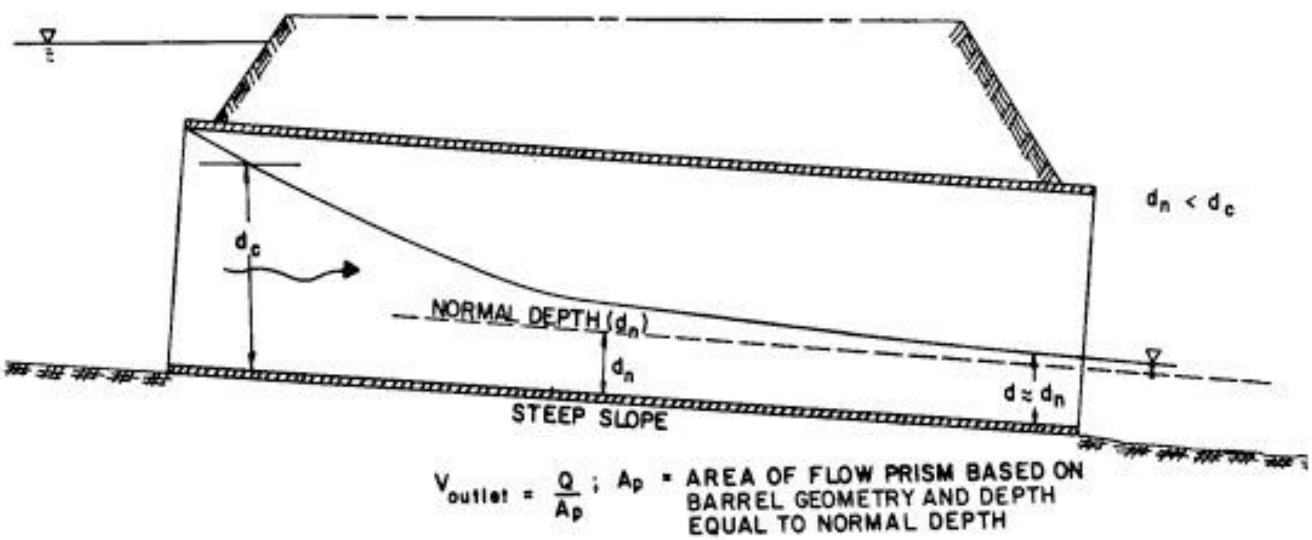
Roadway Overtopping

The results from the HY-8 concluded that in a 100-year event that there will be no roadway overtopping. Therefore the will be no design needed to satisfy an overtopping situation.

Outlet Velocity

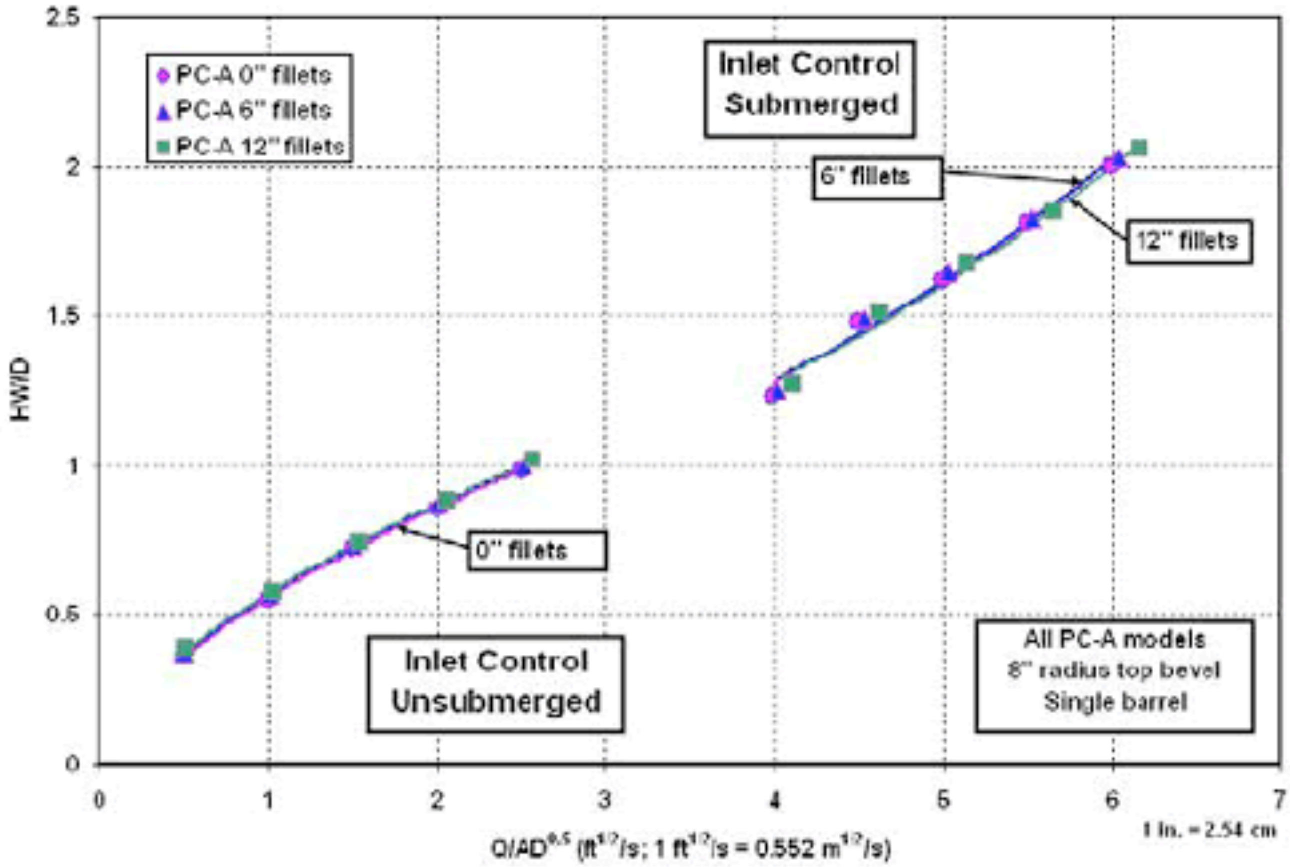
The outlet velocity of the culvert was determined by using the max volume of water for a 100 year event in HY-8 that equaled **27cfs/22ft=1.22ms**

The inlet control, backwater calculations are not needed to determine the outlet velocity because they are not critical as shown in the hydrology report. The critical depth of the culvert is .96ft



Performance Curve

The performance curve is represented by the flow rate versus headwater depth or elevation for the culvert. The performance curve was acquired from the use of HY-8. The performance curve for the culvert is shown below.



Erosion, Sedimentation, and Debris Control

Natural streams and manmade channels are subject to the forces of moving water. Sedimentation, erosion and debris flow happen naturally in flowing bodies of water. This process is accelerated during storm events when stream depths and velocities are high. Inserting a culvert into this natural flowing body will cause anyone of these problems.

Scouring

A culvert normally constricts the natural channel, thereby forcing the flow through a reduced opening. As the flow contracts, the velocity of the flow increases causing scouring at the embankments. To battle this, 10-foot winged walls will be use on both sides of the culvert. The winged walls inhibit scouring of the embankment.

Sedimentation

The companion problem to erosion is sedimentation. Most streams carry a sediment load and tend to deposit this load when their velocities decrease. Therefore, barrel slope and roughness are key indicators of potential problems at culvert sites. The SR-94 culvert will have a 22 foot by 6 inch sedimentation trap to eliminate sedimentation from filling the culvert. In high flows this trap will empty from the flowing water.

Debris Control

Debris along with sediment will be controlled with a sediment trap. The trap is to be the span of the culvert and have a 6" depth. For larger debris, the large width of the culvert will eliminate them from settling in the culvert

Site Pump

A pump is needed for the construction to divert water from the culvert location during seasonal precipitation. The pump must adequately divert all incoming flow around the new construction. The pump should be sufficient enough to handle a 20-year event during the construction phase.

Type of Pump

During a 20 year event the pump required must be capable of draining at least 4000gpm from the site an adequate pump must be comparable to the one below.

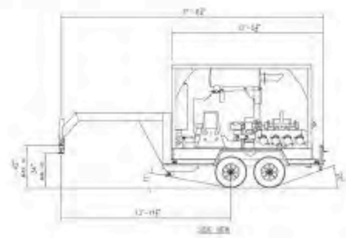
Dependapower DPPAT 4025 CAT-R
Patterson/Caterpillar 4,000 GPM

Description:

The Dependapower DPPAT 4025 CAT-R is a trailer mounted, diesel driven horizontal split case centrifugal fire water pumping system. Nominal performance rating is 4,000 gpm @ 150 psi (10' lift). The pump and driver come mounted on a skid containing an integral 325 gallon fuel cell with level indicator. The easily detachable skid is transported on a dual-axle trailer. The 12" suction and 10" discharge headers provide minimal pressure loss for maximum efficiency. The 24VDC electrical system comes standard with two group-D batteries. Paint is basic red polyurethane finish on pump, skid and trailer. (*Not on Driver) Total Package Weight with Fuel = 15,000 lbs.

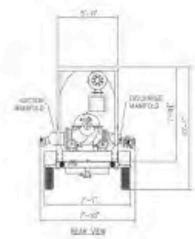
Trailer:

Gooseneck style dual axle 14,000 lb. GAWR trailer, complete with: electric brakes & coupler; DOT lighting package; 235/85 R16 LRF tires/wheels. Deck areas covered with safety "Grip" surface.



Pump Detail:

Manufacturer	Patterson
Series	MAA
Model	12 x 8 x 20.3
Fittings	Cast iron casting, Bronze trim, SS packing sleeve
Performance @	Shutoff 200 psi 4,000 gpm - 150 psi / 2,500 gpm - 175 psi
Priming	One 24 VDC Electric vane primer & reservoir



Driver Detail:

Manufacturer	Caterpillar
Model	3406-DITA
Power	500 BHP @ 2100 rpm
Electrical System	24 VDC
Cooling System	Radiator with pusher fan
*Paint	Standard base unit Caterpillar yellow

Suction Manifold:

12" diameter flange-fitted header furnished with: four (4) 6" (M) NH inlet connections, capped & one (1) 2.5" valved (F) NST swivel w/plug.

Discharge Manifold:

10" diameter flange-fitted header, furnished with: four (4) 5" storz discharge connections, capped, with gated discharge valves: (1) 2.5" (M) valved discharge connections.

Control Panel:

Includes: start/stop switch, tachometer, oil pressure gauge, coolant temperature gauge, amp meter, vernier throttle, compound suction gauge, discharge pressure gauge, fuel pressure gauge, primer valves & switches, hour meter.

Options:

Manual clutch between pump & driver
Four suction hose racks (passenger side only)
for use with 10' hoses only
SS Suction/Discharge Manifolds
Jet pump back-up primer
Automatic battery charger
Retractable awning over pump operator
6" NH hard suction hoses
(20' each - 4 req'd) or (10' each - 8 req'd)
6" NH "Light Weight" hard suction hoses
(20' each - 4 req'd) or
(10' each - 8 req'd)
6" Non-floating basket strainers (4 req'd)
6" Floating basket strainers (4 req'd)
Full skid cover
Add, 2.5" Discharge/Suction
4 Work Lights

Hydrology Report

This report is intended for the runoff and drainage study for the SR-94 culvert location and widening. The site is to be widened and have a new wildlife culvert added. The scope of this report is to show the current and proposed drainage system.

Brief Explanation of Site

The site is an un-urbanized wildlife area. There are many types of animals that need to cross the freeway both large and small. There is an existing culvert that is buried under sediment. The existing culvert is also much too small to adequately handle all the runoff to it.

Description Location

The site is located on the SR-94 approximately 3.2 miles east on SR-94 from the junction of campo road in Rancho San Diego. The site is a 2-lane freeway that travels in both directions. It is located in an un-urbanized area. The watershed comes from the North from primarily 2 hills that approximate to 30 acres.

Description existing structures

Currently there is a circular corrugated culvert hat is 3 feet in diameter at the location. Although this size would be sufficient for runoff, a sediment trap was not used therefore burying the culvert. The freeway has two lanes with no drainage. The runoff for the road goes into the nearby creeks. The road has a few utilities under it for water and sewage.

Description proposed structures

A new culvert will be put in place to replace the outdated corrugated culvert. The new culvert will also be a wildlife crossing for all animals in the area. The culvert is to be made of concrete and be a box shape. The size must be large enough to handle any large animals in the area. It must also be capable of handling the watershed and runoff. The freeway will be widened to 4 lanes after the culvert is put into place

Existing drainage

Currently there is no drainage collection system put in place for the road. The runoff currently distributes to the surrounding creeks.

Hydrology and Precipitation Analysis

The precipitation is shown for the area determined by the San Diego Hydrology manual. This is included in Appendix B

Computed project drainage basin

The rain intensity from the Hydrology manual in a 100-year event is 3in/hr shown in appendix B. The soil in the area is type C that has a c runoff coefficient equal to .3. The drainage basin area determined by USGS topography map is 40 acres. With that the max flow is Q=CIA

$$Q=(.3)(.3in/s)(40acres)=36cfs$$

Determine minimum culvert size for drainage

The minimum culvert size that can sustain a 100 year event will need to require 36cfs shown by Hy-8 in appendix C. The size for this would have to be approximately 9sqft determined by calculations and HY-8 shown in appendix. Since this culvert is also a wildlife crossing it is larger to handle the animals. The size determined for the crossing is 22’ by 12’, therefore the drainage is more than adequate for the culvert.

Computed maximum drainage available for future projects

With the data from the Hy-8 computation, a max flow for the culvert is determined. The max flow the culvert can handle is 1985cfs before overtopping. This allows for 90% expansion of the drainage basin for future projects that can handle more drainage.

Transportation

The highway expansion will occur along the State Route-94, between Steele Canyon Road and Honey Springs Road. Approximately 7.1 miles of roadway will be expanded. The entire length of the expansion will be increased from 2 lanes to 4.

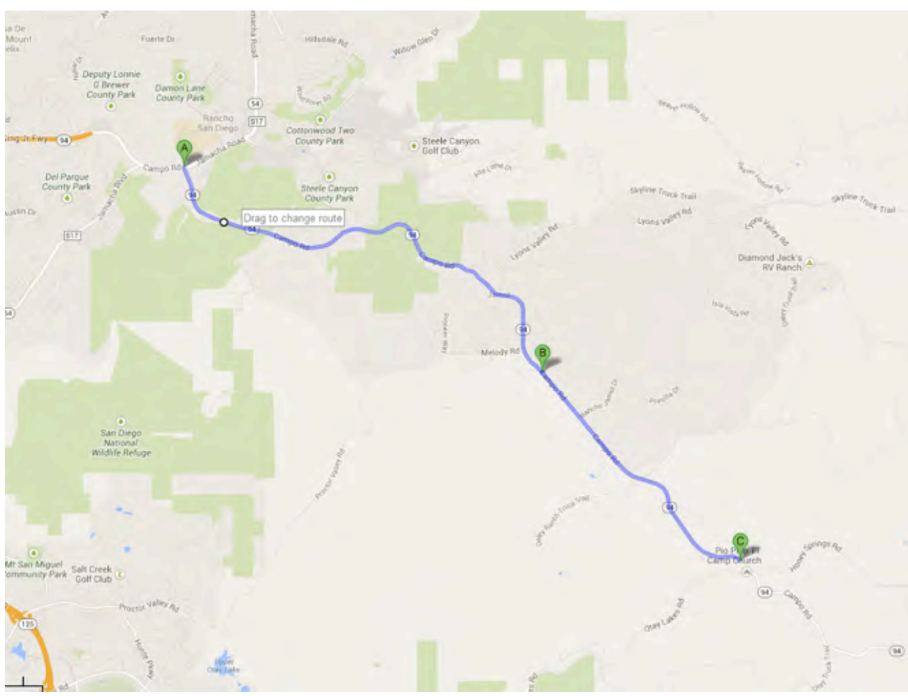
A Right of Way must be granted, since the high way expansion occurs on public land. Since the application process takes 60 or more days, it is assumed that all Right of Way is obtained, including tribal land.

Since no alterations were made to grading and additional lanes do not affect vertical curve calculations, it is safe to assume that the vertical curves for the existing road will remain the same for the highway expansion.

With an assumed design speed of 60 mph, the minimum radius of each curve is 1150 ft, designated by Table 203.2 in the HDM 200. The actual posted speed of SR-94 is 55 mph, 60 mph is assumed because 55 mph is not on Table 203.2 and can be considered a factor of safety. Based on this assumption, the super elevation for the highway expansion is the same as the 2 lane highway, 0.09.

Due to problems obtaining proper elevations, earthwork will be assumed and explained, in detail, in the Construction section of the project.

During excavation, lane sizes will be reduced to 10 feet each way. In order to accommodate for machinery that will be used during construction. As instructed by the HCM Table 5, the speed will be reduced by 6.4 mph for 10 feet lanes with 0-2 feet shoulders, resulting in an approximately 48 mph zone. This will be reduced to 45 mph. During the highway expansion, one-lane two-way traffic would be necessary to accommodate for lack of roadway available. Due to the length of the expansion, it may be necessary to stagger flaggers along highway in increments of less than 1 mile, as described in MUTCD Section 6C.



Construction

The SR-94 Wildlife Project entails adding box culverts to connect the San Diego Wildlife Refuge from the north side of the highway to the south side in order to reduce road kill. For the purpose of this project, only one large box culvert is being taken into account. Also, this project includes highway widening because plans show a casino being built in the Jamul area, which will eventually increase the traffic flow on the SR-94. Expansion will be for 10 miles, a change from the previously estimated 2 miles, and nearly all expenses are covered in the following page estimate.

Unit prices are found from the Caltrans site and quantity for the activity/item is an estimate (assumption) and pricing for the box culvert is from Jensen.

		Estimated Cost
I. Transportation Items	$	2470330
II. Structural Items	$	100000
III. Environmental Items	$	1181968
Total Project Cost	**$**	3752298

	month	year
Date (Month/Year) of Estimate	10/	2013

Section 1 Transportation

	item code	Description	unit	quantity		unit price	Cost
1	860090	Maintain Existing Traffic Management	LS	6	x	$ 865	$ 5190
2	120090	Construction Area Signs	LS	5	x	$ 5800	$ 29000
3	190101	Roadway Excavation	CY	1000	x	$ 225	$ 225000
4	194001	Structure Excavation	CY	670	x	$ 650	$ 435500

5	390129	Hot Mix Asphalt	TON	100	x	$ 146	$ 14600
6	260201	Class 2 Aggregate Base	CY	50	x	$ 40	$ 2000
7	374492	Asphaltic Emulsion (Polymer Modified)	TON	100	x	$ 1200	$ 120000
8	394090	Place Hot Mix Asphalt	SQYD	65	x	$ 200	$ 13000
9	066062A	COZEEP Expenses	LS	5	x	$ 160	$ 800
10	840656	Paint Traffic Strip	LF	25000	x	$ 1	$ 25000
11	128650	Portable Changeable Message Signs	EA	2	x	$ 3300	$ 6600
12	832001	Metal Beam Guard Railing	M	6420	x	$ 242	$ 1553640
13	39588	Guard Railing End Treatment	EA	16	x	$ 2500	$ 40000

Total Transportation Items	**$** 2470330

Definitions:

Maintain existing traffic is so that traffic flow will be sustained during construction hours.

Construction signs are to inform drivers of the ongoing construction.

Roadway excavation is to cut into the mountains in order to widen highway to desired width of 2 lanes for a total of 4 lanes. Pricing is based on how much cut.

Structure excavation is the cut needed to insert pre-engineered box culvert. Pricing based on how many cubic yards required to cut.

Hot mix asphalt is for the construction road. Pricing is based on how much needed in tons to expand the highway for 10 miles

Class 2 aggregate bases are needed to place the asphalt upon. Pricing based upon how much needed for 10 miles in cubic yards

Asphaltic emulsion is for surface treatment and is also based on tons for pricing.

Place hot mix asphalt is based on area in square yards for pricing.

COZEEP Expenses is so that police protects the workers.

Paint traffic strip is the alternating traffic strip and is based on linear feet for pricing.

Portable changeable message signs is so that it can inform drivers of any new information when construction changes in terms of phases and pricing is based on how many.

Metal beams guardrails is to protect the drivers from going off course or crashing into fixed objects. Pricing based on how many meters needed.

Section 2 Structural

Date of Estimate	11/30/13
Structure Type	Box Culvert
Width (FT)	20
Total Length	15
Total Area	19200
Structure Depth	64
Cost	100000

Total Structural Items	**$**	100000

Definition

Pricing of box culvert is from Jensen Precast, based upon its dimensions.

Section 3 Environmental

	item code	Description	unit	quantity		unit price($)	cost
	71325	Temporary Fence	LF	27900	x	26	$ 725400
1	20001	Highway Planting	LS	1	x	117690	$ 117690

2	201700	Exported Topsoil	CY	53	x	26	$	1378
3	203000	Erosion Control	SQYD	10	x	200	$	2000
4	21823	CHAIN LINK FENCE	M	6100	x	55	$	335500

Definition:

Temporary fence is to prohibit unauthorized workers from entering the site.

Highway planting is for aesthetics and for the animals.

Exported topsoil is to remove any excess soil from cutting into the mountains.

Erosion control is for if it rains sediment doesn't runoff into the creek because the excess soil will drain into the ocean.

Chain link fence is a permanent fixture to discourage animals from crossing the highway and funnel them into the culvert.

Based on the assumptions made, this project will cost nearly 4 million dollars. However, this does not cover a variety of things, such as contractors, legal fees, etc, so actual cost is much greater.

A Gant chart, was also created that shows the project duration of the culvert and highway widening. Because the expansion was increased to 10 miles, the project duration is nearly 4 years. This assumption is based on the 805 freeway widening and examples from the construction and scheduling class. The activities do not need to wait for the predecessor to finish and so duration is cut in half. There is about a 2-station lag between laying base and placing asphalt.

The project is broken down into 4 parts; the design, site work, structural, and transportation. Details of each activity, such as duration, predecessor, and successors can be seen in the construction appendix.

Definitions:

Issue contract is when the firm legally has the project and can begin planning and design

Environmental impact statement is a document required by the National Environment Policy Act to describe the positive and negative impacts on the site.

Prepare highway plans are the design of the widening and the culvert.

Reviewing the plans is for another engineer with a fresh eye to see if any mistakes or flaws are made and fixed.

Submitting the plans is sending the plans to the client.

The firm needs to schedule a design public hearing to see what the community has to say of the new additions.

Once all that is complete mobilization of the project can begin. Mobilization is the moving of the equipment needed to start the project.

Then afterwards is excavation, which is the removing of dirt in order to place the culvert.

After excavating, the dirt will be hauled to wherever fill is needed and then hauled out of the site.

Surveying is how elevations, curves and such for the highway will be determined.

Grading is to have the roads at a slope of 2% for runoff is order to keep water of the asphalt.

Drainage is a system for the water to go into pipes that drain to the ocean or to a station.

Buying the precast with enough time to get the structure to the site.

Transport precast is moving the pre-engineered culvert to the site.

Once it is transported, the precast structure is set into its ditch.

Cut and fill can begin once surveying is done, which will cut into the parts of the mountain that are obstructing the way for the widened road and filling in parts that need more land to widen the road.

There is temporary fencing to deter trespassers from entering and then fencing in order to funnel the animals towards the culvert and prevent them from crossing the highway.

Compaction is compacting the dirt for foundation reasons as a base for the highway.

Shrubbery is for aesthetics because all the previous greens will have been uprooted when cutting and filling.

Placing barriers is for the safety of the workers to protect them from oncoming traffic.

End treatment is the barriers for the guardrails themselves, also for safety.

Laying base is for the base of the highway, which is below the asphalt.

Placing asphalt is the body of the road, and will be expanded one lane at a time for traffic flow reasons.

Afterwards, striping is done and finally, guardrails can be placed for safety, so that cars do not go off the road or crash into trees.

Concluding Remarks

Sustainability and Life Cycle Costs

Wildlife Culvert

The overall design of the culvert and highway expansion is highly sustainable. The design and material of the culvert has a long lifespan and only requires occasional maintenance to remove any debris and observe any erosion of the natural channel bottom. Due to the width of the culvert and the minimal amount of water expected to flow through the culvert erosion is not expected to occur.

Unfortunately, life cycle costs are difficult to estimate for culverts. The only data available consist of qualitative statements regarding a range of widely varying types of culverts. A large scale study by the State Department of Transportation would be required to create procedures for describing all costs which include design and maintenance. Additionally, there is no guidance at the national level that can offer comparisons between various culvert designs as far as life cycle costs.

Highway Expansion

Since the expansion is based on an already existing roadway the expansion is also highly sustainable and does not make any major intrusions on the surrounding area. As with any road, the asphalt is likely to wear down and while typical asphalt roads last at least 35 years, rain damage, frost, and excessive braking can cause potholes and other damages. Considering the currently low traffic volume, the highway is expected to last for it's lifetime without the need for any major repairs, barring any unforeseen natural disasters.

Social, Environmental, and Cultural Objections

Social

Social objections to this project are likely to be limited. Complaints could include traffic jams and noise pollution during the construction of the highway expansion. Fortunately, there are means to remediate these problems and once construction is complete the expansion will benefit those of the nearby communities by alleviating traffic.

Others in the community might also complain about the expenditure of tax dollars on a project that they might see no merit in completing. Community meetings will be a crucial part of the project and will be required in order to address the various concerns that the community is likely to have.

It is highly unlikely that there will be any objections to the highway culvert. Since the staging area for construction is away from the highway and the culvert will be installed using trenchless technology, the community will not be affected by the construction of the culvert.

Environmental

This project will ultimately have a positive environmental effect. Since the culvert will guide wildlife underneath the highway instead of across it there will be a significant reduction in the number of animal fatalities and the associated number vehicular damages. The highway expansion was designed with environmental concerns in mind and while it may make crossing for animals more difficult in areas, the fencing that will guide local fauna to the culvert should remediate this problem and eliminate any concern.

Cultural

The area which the highway expansion will cross through is on Native American land owned by the Kumeyaay Tribe. This could cause concerns should the highway expansion cross through any sacred sites. This is a concern that will need to be addressed long before construction begins and at the beginning of the design process. Ultimately, the expansion will benefit the Kumeyaay by allowing more traffic to travel to the proposed Kumeyaay Casino. For this reason it is likely that the Kumeyaay will be highly cooperative with construction and planning efforts.

Final Remarks

This project will ultimately be beneficial to the community and to the environment. The highway expansion, although inconvenienceing during construction, will ultimately alleviate heavy traffic by doubling the number of lanes. The addition of the wildlife culvert will also have a significant and positive environmental impact by giving animals an opportunity to cross to the other side of the highway without the concern of becoming roadkill. The community will also benefit from safer driving conditions and reduced traffic accidents resulting from animals on the road.

The lifetime and maintenance costs of this project are also expected to be very manageable. Since asphalt highways in low traffic conditions often exceed their expected 35 year lifespan minimal maintenance will be required and major repairs are only likely should a natural disaster, such as an earthquake, occur.

Maintenance and construction of the culvert is also expected to be within a fairly reasonable range. Since the final design will be precast construction will be swift and maintenance will be minimal, consisting of debris removal and soil leveling in the event of a large flood.

Implementation of the designs for this project will result in significant positive impacts on the community and the environment and should be given serious consideration in order to create a more sustainable future for people and wildlife.

From everyone at team SIMBA, we would like to thank our instructors and advisors:
Ron Rempel – San Diego Management and Monitoring Program, SR-94 Connectivity Coordinator
Kris Preston – San Diego Management and Monitoring Program, Biologist
Carlton Rochester – US Geological Survey, Connectivity Evaluations
John Martin – US Fish and Wildlife Service, San Diego
Zaid Bayasi – San Diego State University, Structural Professor
Sam Amen – San Diego State University, Highway Transportation Professor

Without your help and guidance, this project would not be where is it. At this point in the project, team SIMBA is finalizing minor details in the planning phase. When further information can be obtained, missing areas can be filled in. In the remaining weeks of this project, we will be working on the design phase, using computer aided design programs to achieve a detailed visual representation of the wildlife culvert and highway expansion. Although this is a school-based project, we hope our project can inspire capable others to actually implement a wildlife culvert along SR-94 to save wildlife and increase habitat connectivity.

Best regards,

Brian Tran
Project Manager
San Diego State University

Appendix A – References

http://www.azgfd.gov/hgis/pdfs/CulvertGuidelinesforWildlifeCrossings.pdf

http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/03_Chapter_1_Introduction.pdf

Figure 1.1 http://www.wildlifeandroads.org/decisionguide/2_1_6.cfm

Figure 2.1 http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

Figure 2.2 http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

Figure 2.3 http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

Figure 3.1 http://www.azgfd.gov/hgis/pdfs/CulvertGuidelinesforWildlifeCrossings.pdf

Figure 3.2 http://www.azgfd.gov/hgis/pdfs/CulvertGuidelinesforWildlifeCrossings.pdf

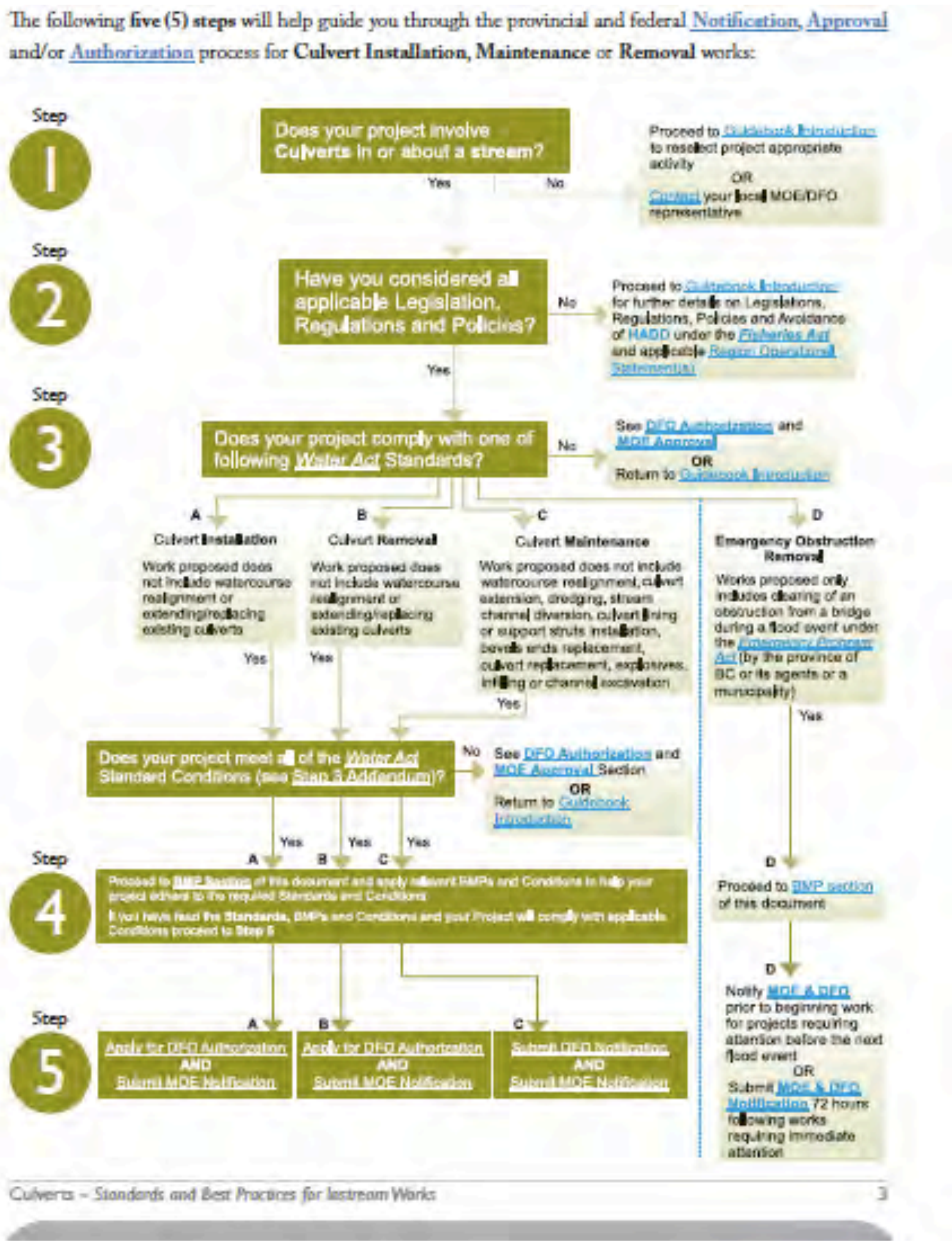
http://www.usgs.gov/pubprod/

http://www.sandag.org/index.asp?classid=26&fuseaction=home.classhome

http://pereview.net/wp-content/uploads/pdf/hcm-extracts.pdf

http://sv08data.dot.ca.gov/contractcost/index.php

Appendix B – Environmental



Appendix C – Structural

See Attached papers

Appendix D – Hydrology

Calculations

INLET CONTROL:

$AD^{0.5} = (40)(1.3)^{0.5} = 14.28$

$Q/AD^{0.5} = 36 / 14.28 = 2.52$

HW/D = 0.90, therefore:

$HW = HW_t (0.90)(20) = 18$ ft

EL_{hi} 620+18= 638.0 ft

For the check flow:

$Q/AD^{0.5} = 3.44$

HW/D = 1.13, therefore:

$HW = HW_t (1.13)(20)$ 22.6 ft

$EL_{hi} =$620+ 22.6= 642.6 ft

OUTLET CONTROL:

Backwater calculations will be necessary to check Outlet Control.

Backwater Calculations

From hydraulic tables for concrete box:

for Q = 30 ft^3/s, dc = 12.4 ft

for Q = 36ft^3/s, dc = 14.6 ft

Since TW > dc, start backwater calculations at TW depth.

Determine normal depths (dn) using hydraulic tables.

for Q = 30 ft^3/s, n = 0.034 ;

dn = 13.1 ft

for Q = 36 ft^3/s, n = 0.034 ;

dn = 16.7 ft

since dn > dc, flow is subcritical

since TW > dn, water surface has an M-1 profile

Plot Area and Hydraulic Radius vs. depth from data obtained from tables.

d/D	d	A/BD	A	R/D	R
0.65	13.0	0.5537	332.2	0.3642	7.28
0.70	14.0	0.6013	360.8	0.3781	7.56
0.75	15.0	0.6472	388.3	0.3886	7.77
0.80	16.0	0.6908	414.5	0.3950	7.90
0.85	17.0	0.7313	438.8	0.3959	7.92
0.90	18.0	0.7671	460.3	0.3870	7.74
0.95	19.0	0.7953	477.2	0.3649	7.30
1.00	20.0	0.8108	486.5	0.3060	6.12

Complete Water Surface Computations

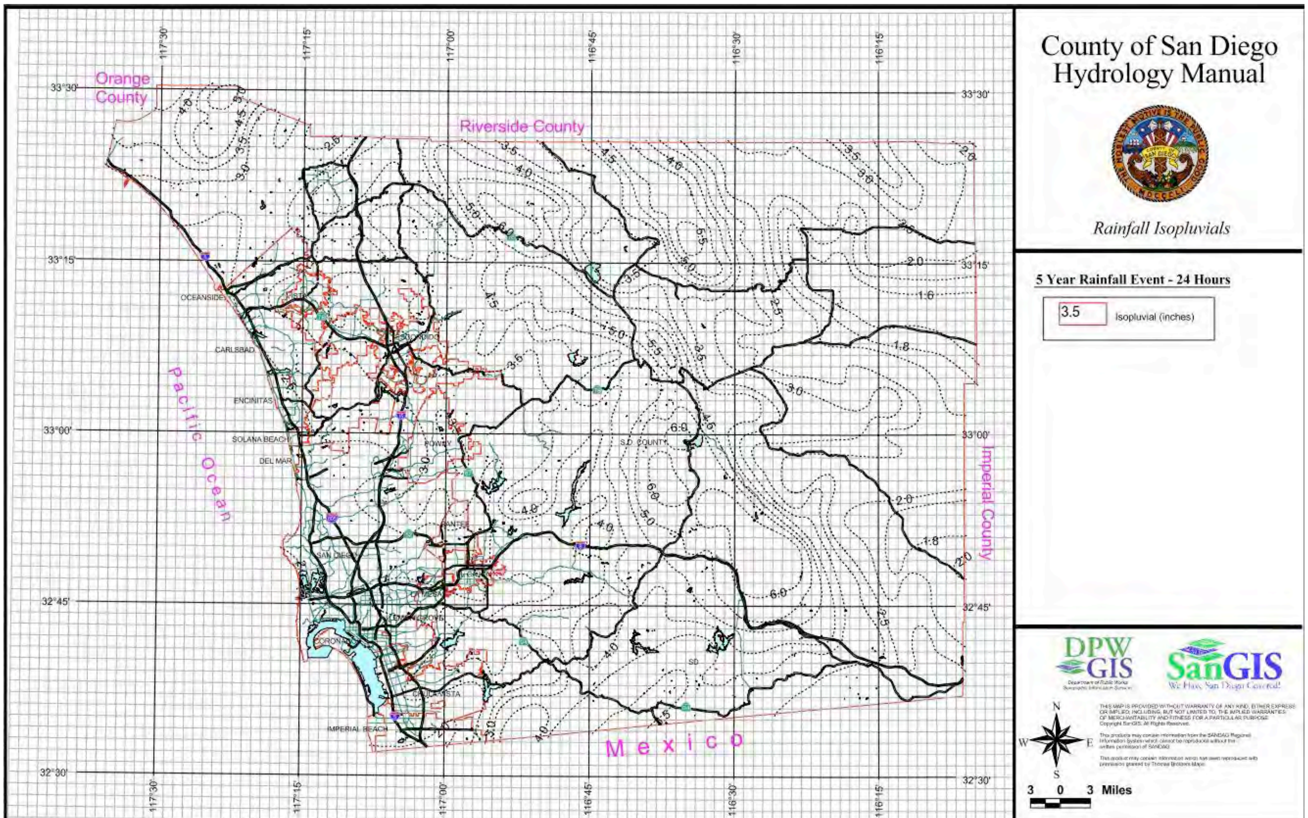
HW = specific head (H) + $k_e (V^2/2g)$

Neglecting approach velocity head :

for Q = 30 ft³/s:
HW = 18.004 + (0.5)(3.208) = 19.6 ft
EL_{ho} = 620 + 19.6 = 639.6 ft

for Q = 36 ft³/s:
HW_f = 22.627 + (0.5)(3.89) = 24.6 ft
EL_{ho} = 620 + 24.6 = 644.6 ft
SUMMARY:
DESIGN Q:

EL_{hd}	EL_{hi}	EL_{ho}
640.0	638.0	639.6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Rainfall Isopluvials
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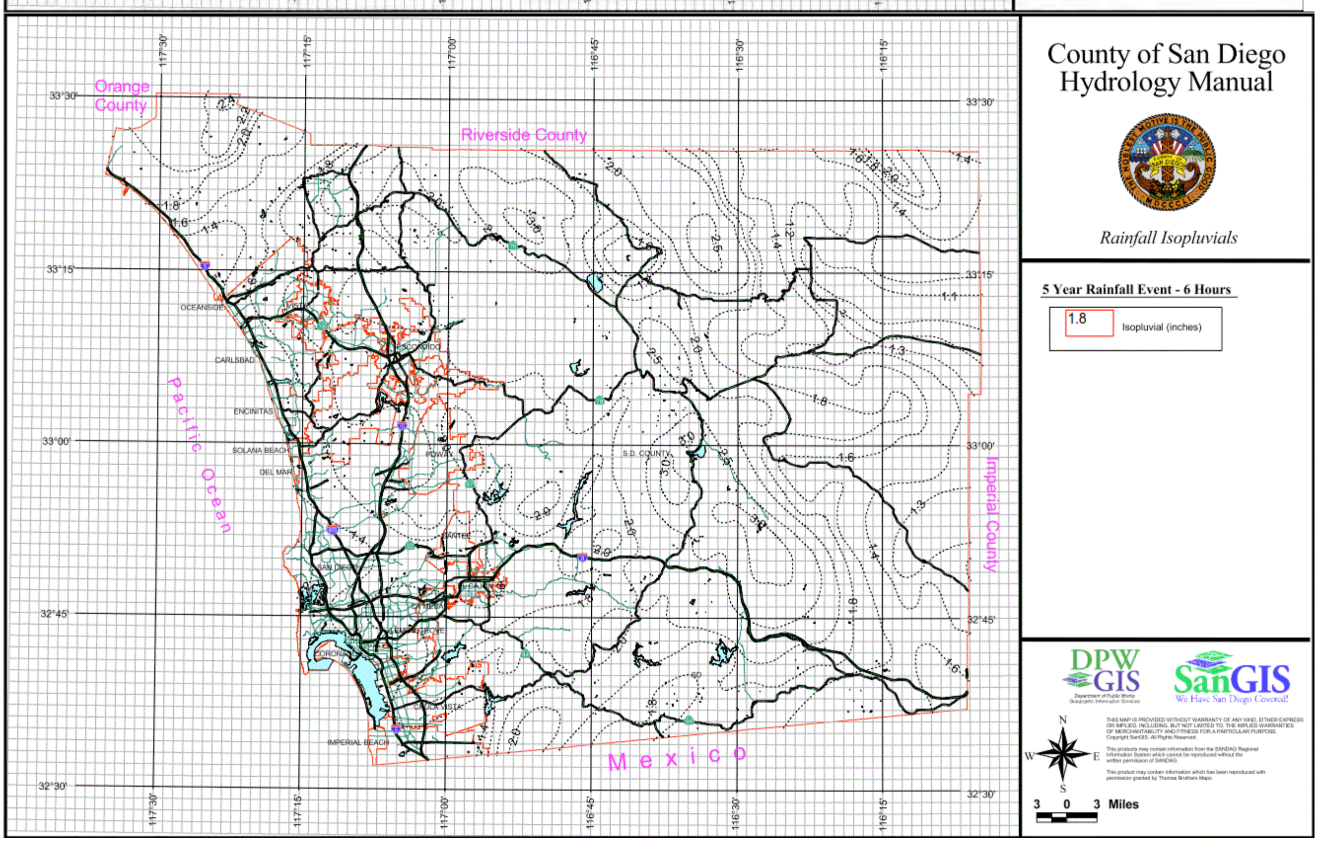
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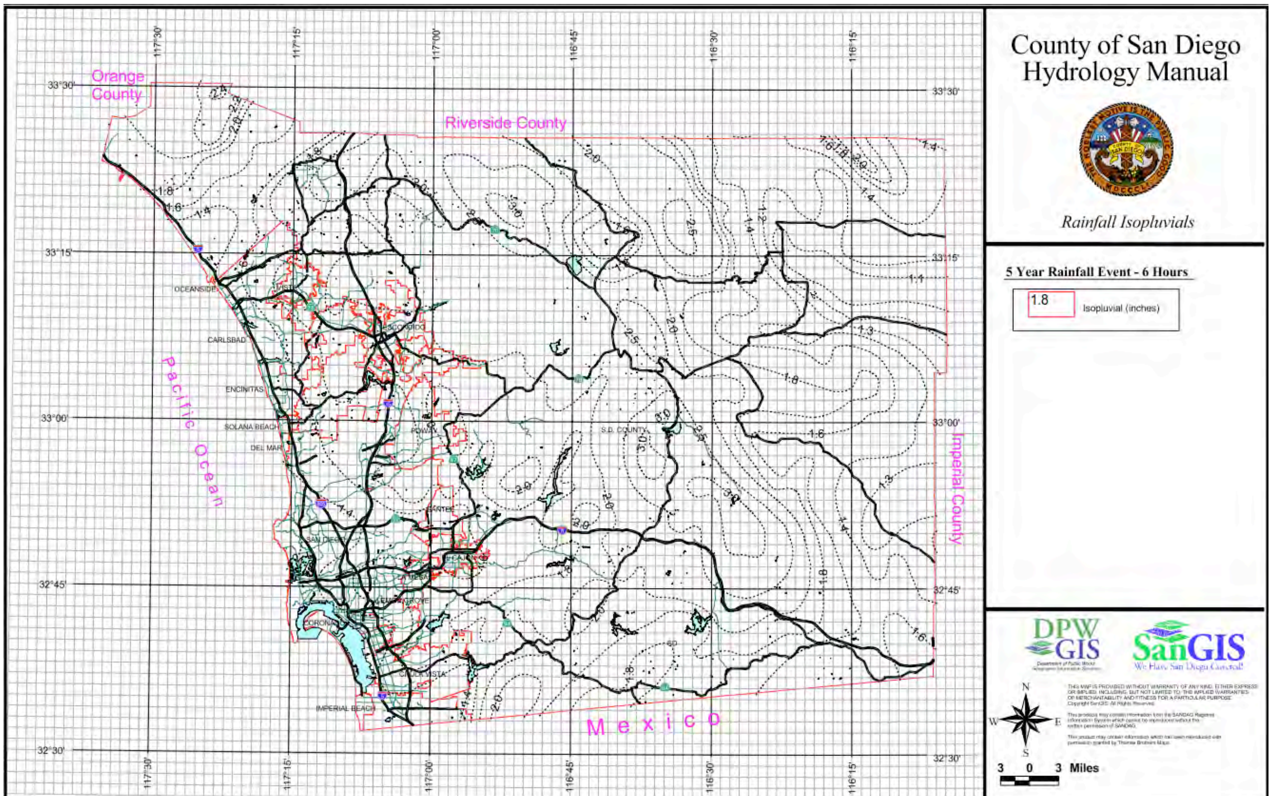
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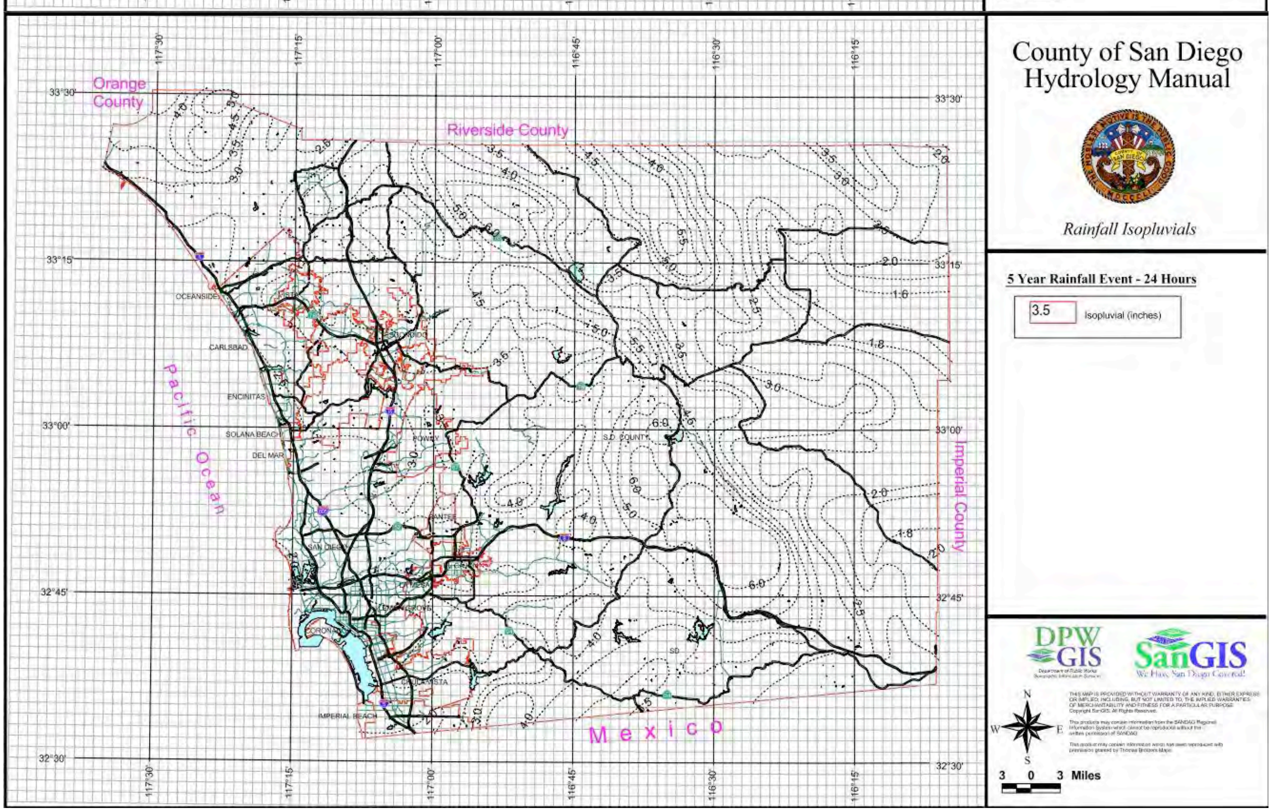
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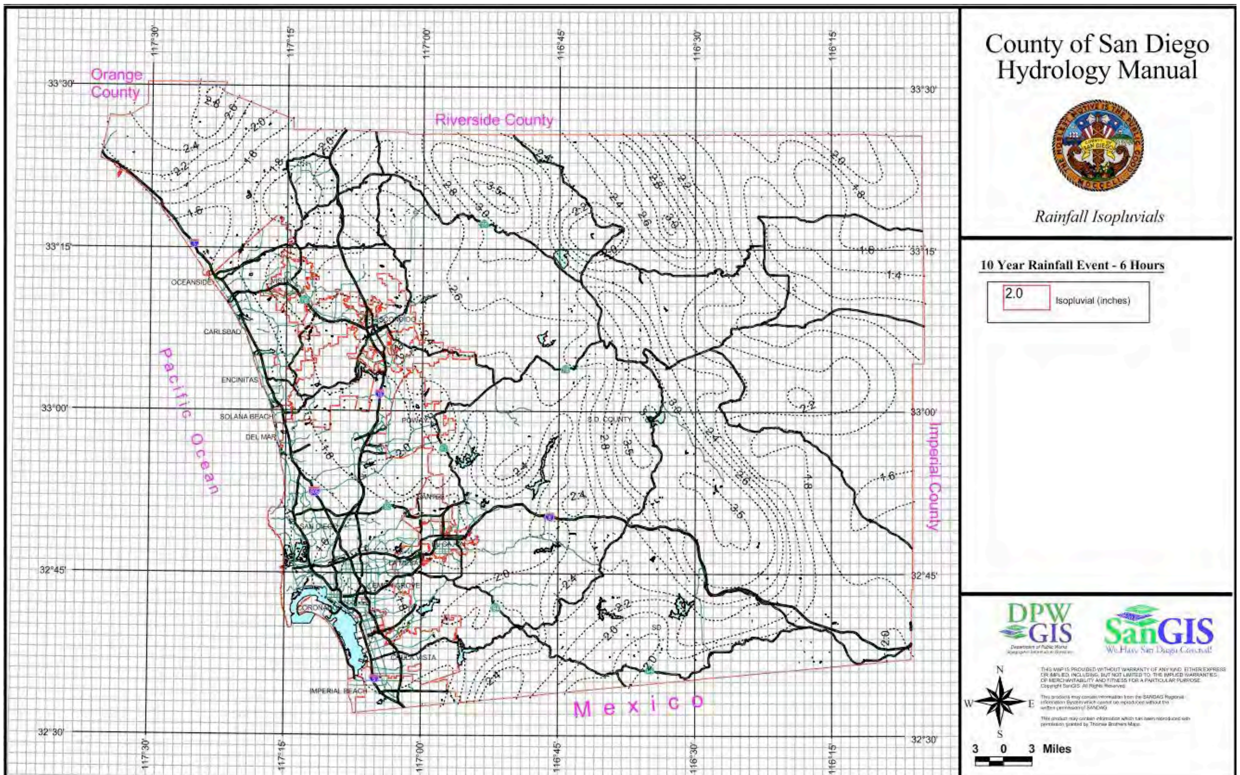
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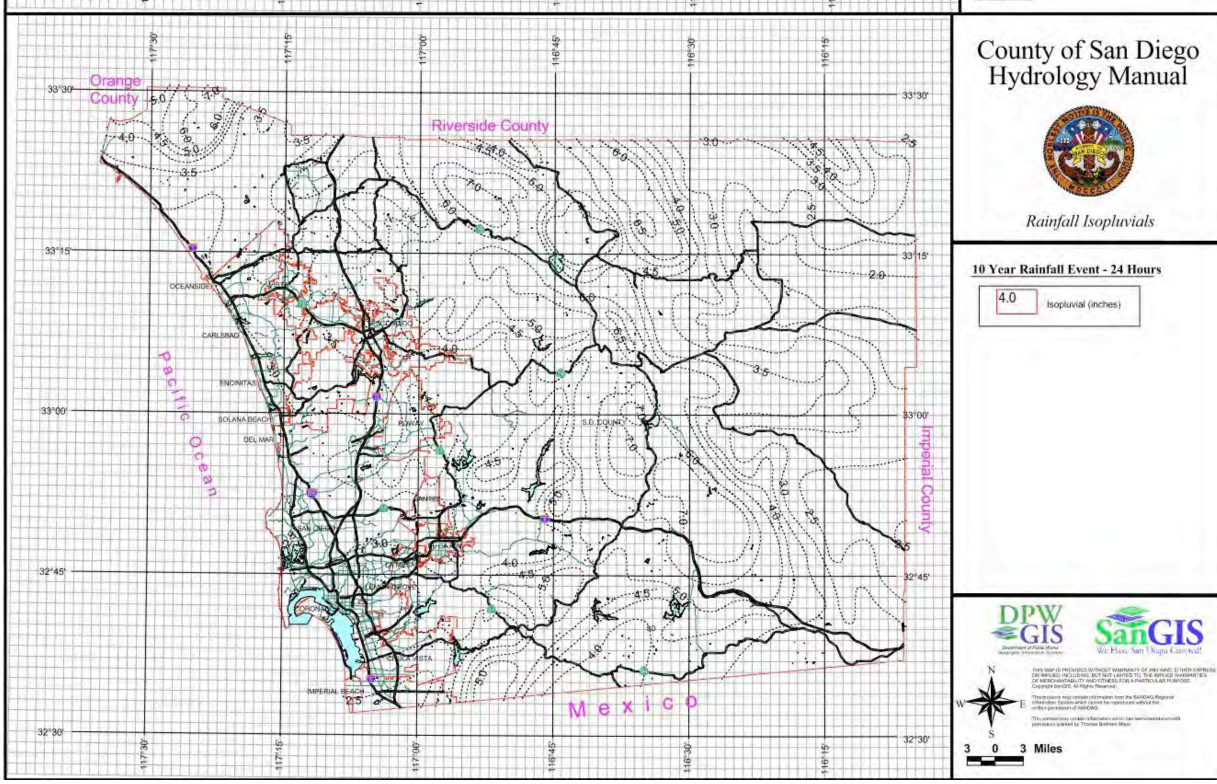
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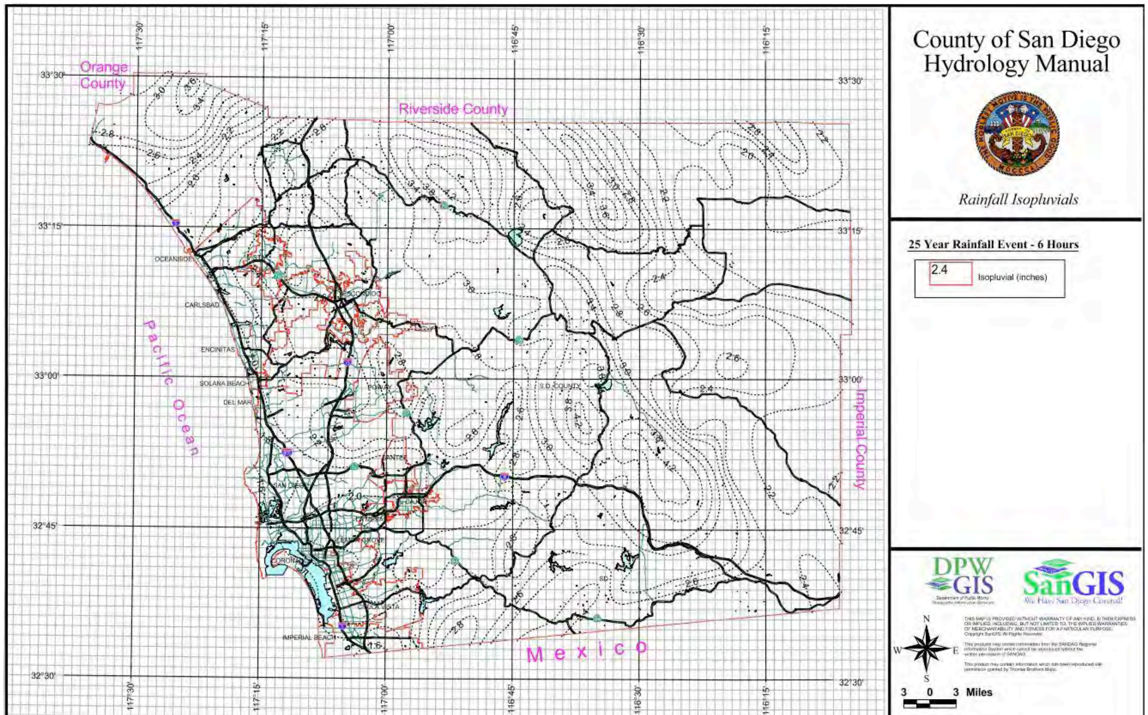
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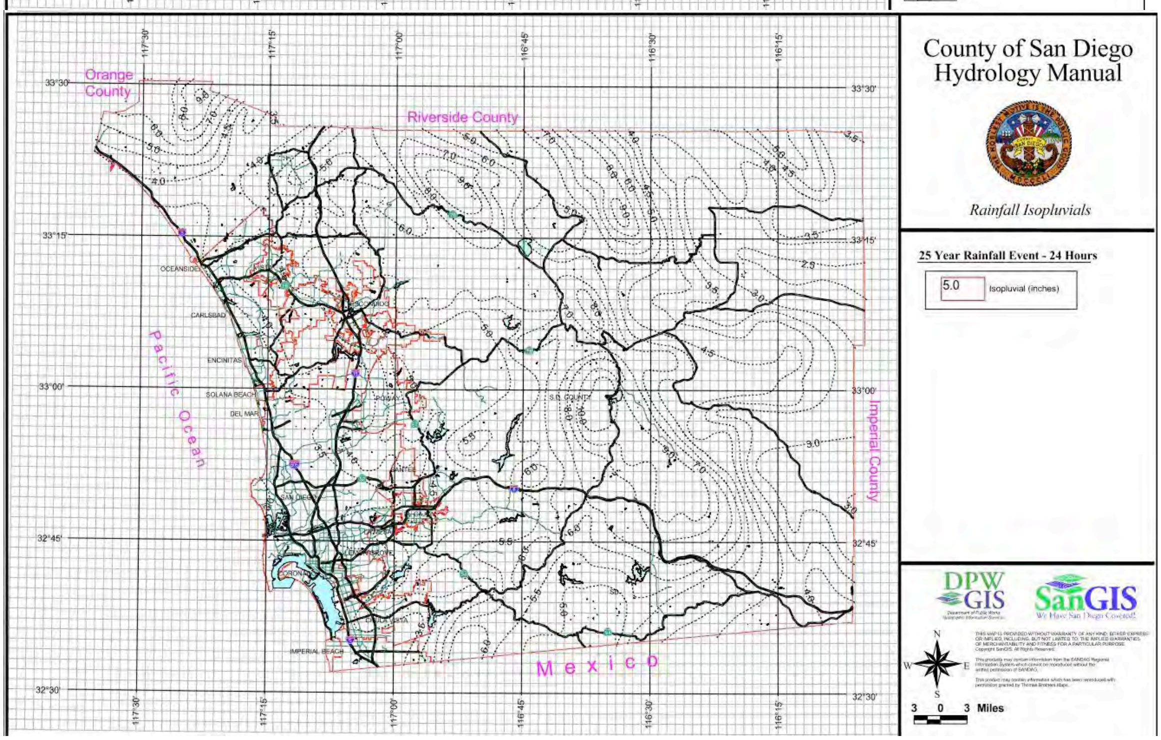
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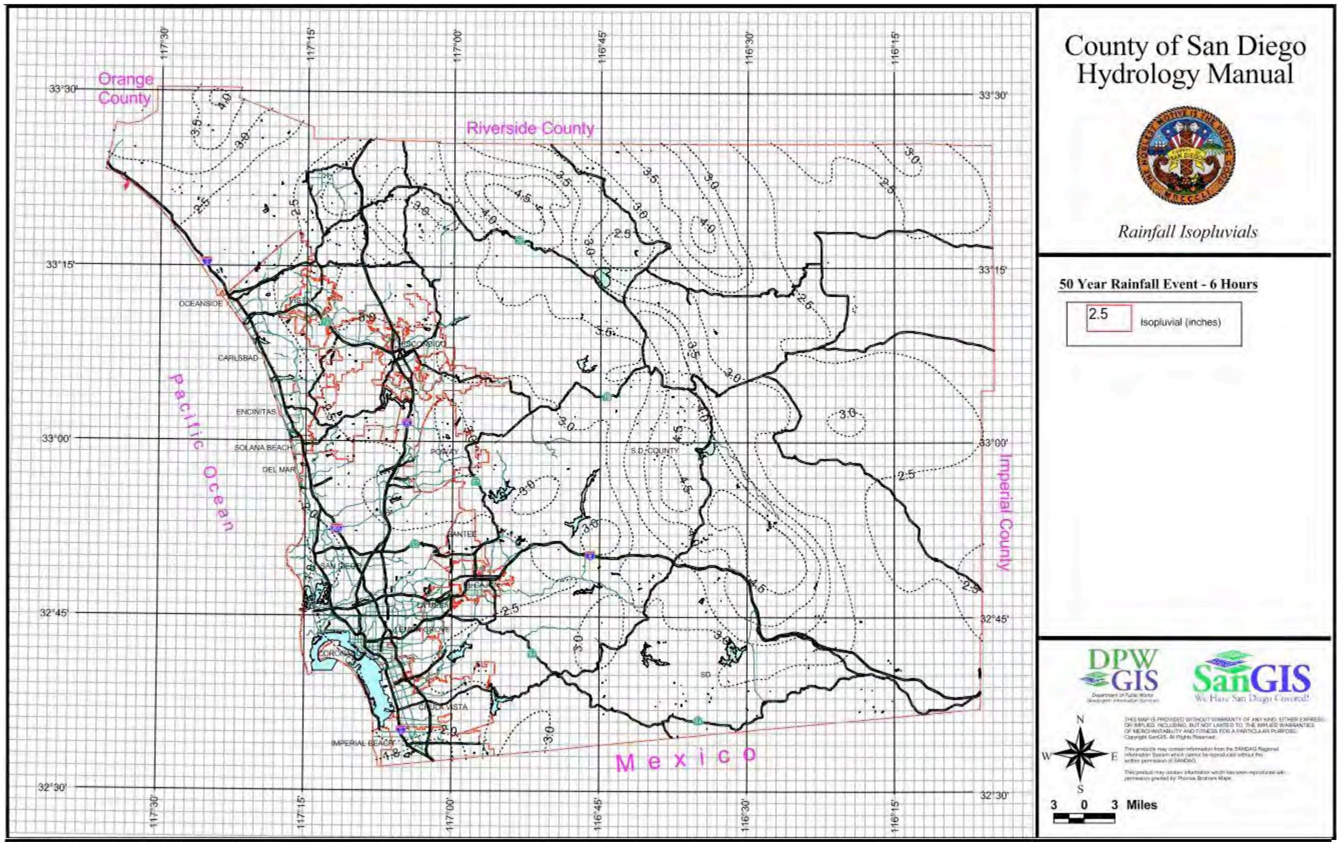

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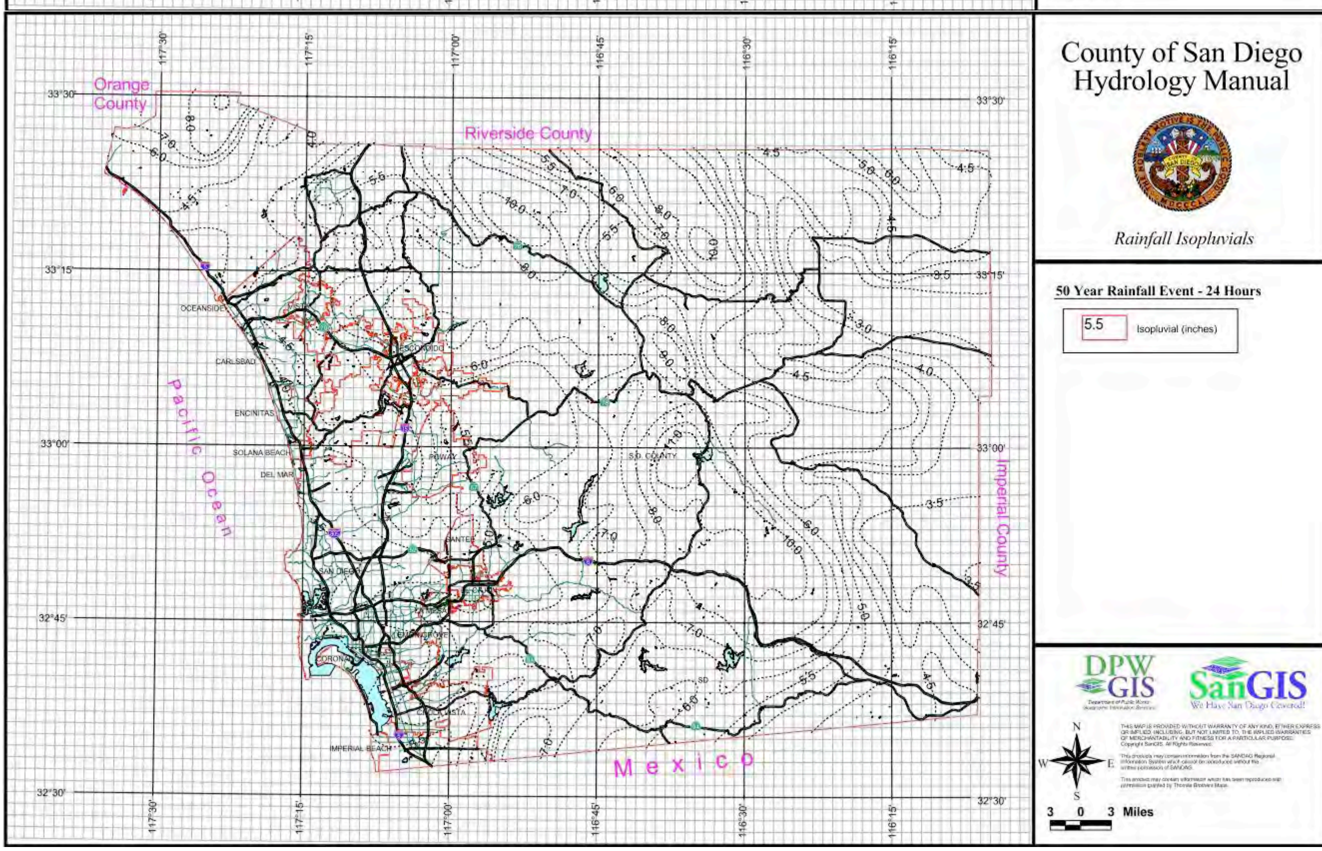

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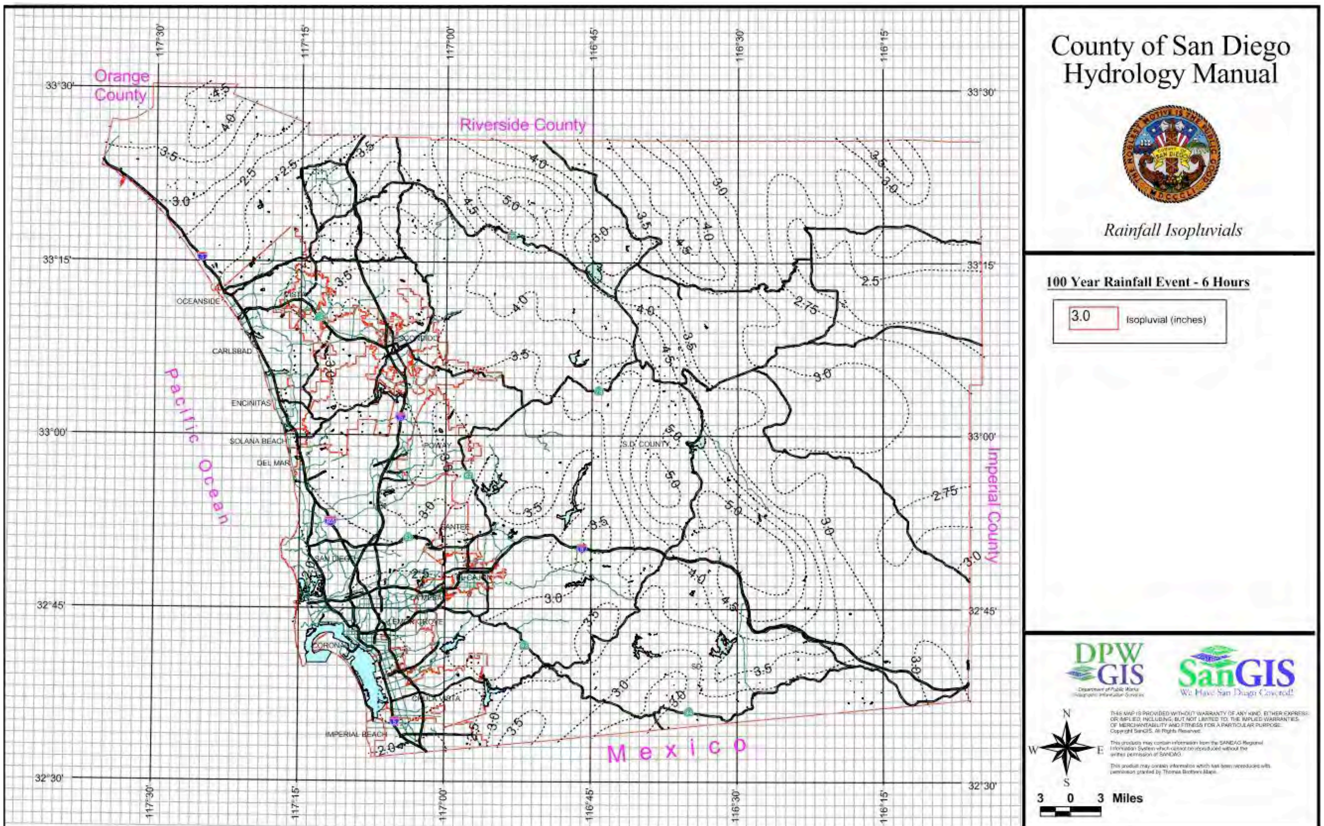
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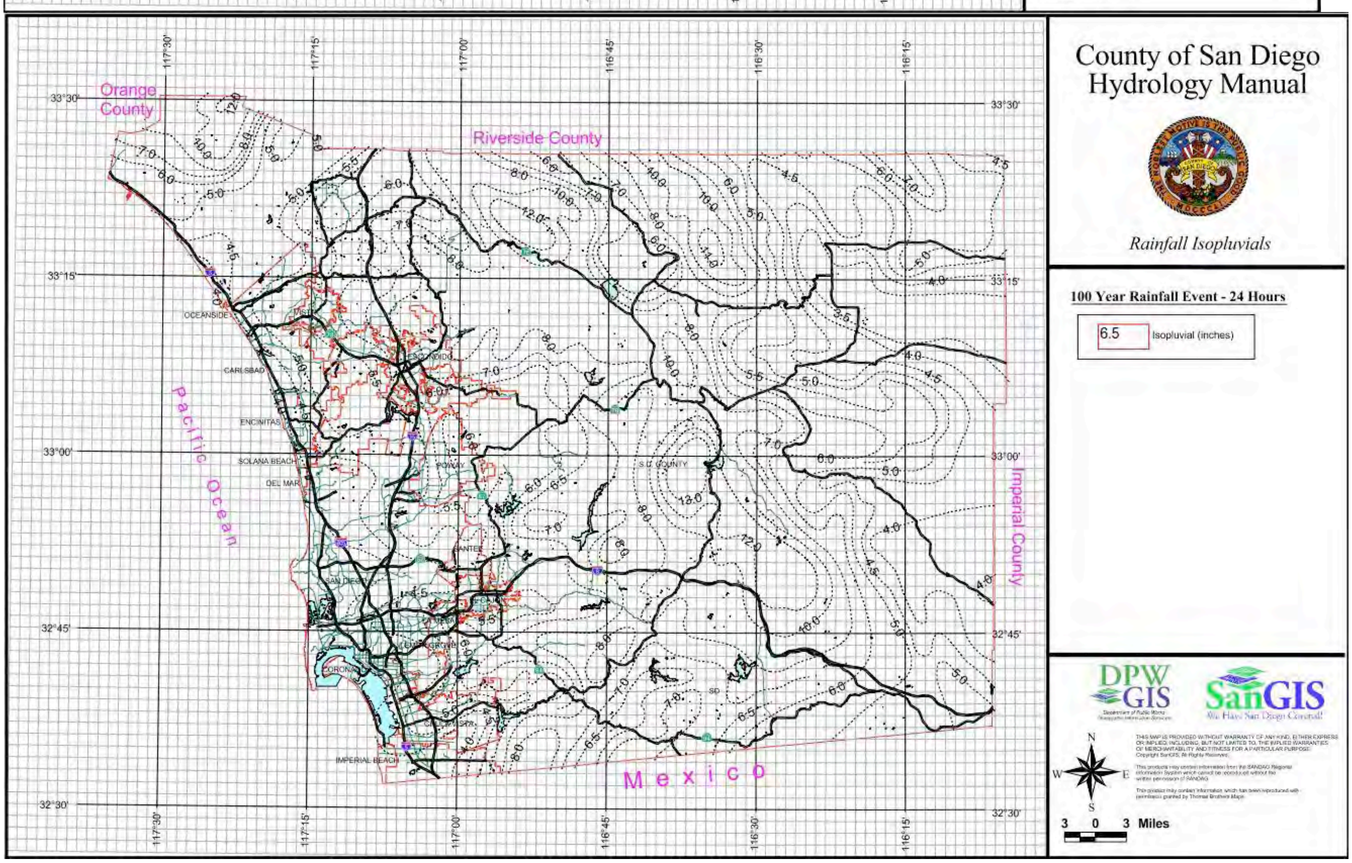
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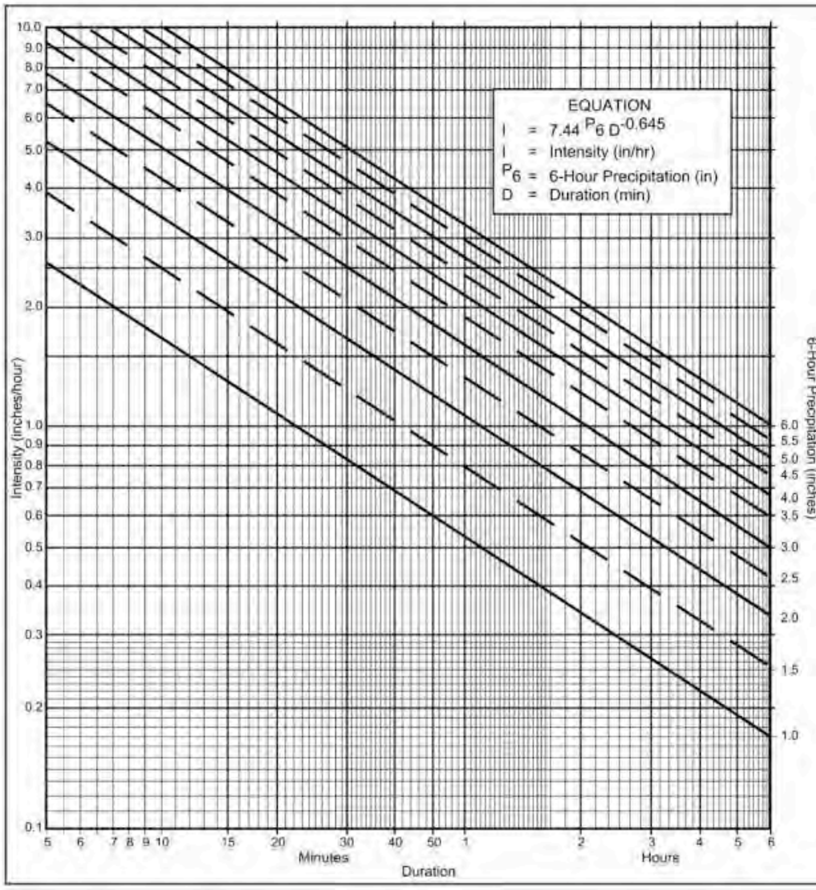


Directions for Application:

(1) From precipitation maps determine 6 hr and 24 hr amounts for the selected frequency. These maps are included in the County Hydrology Manual (10, 50, and 100 yr maps included in the Design and Procedure Manual).

(2) Adjust 6 hr precipitation (if necessary) so that it is within the range of 45% to 65% of the 24 hr precipitation (not applicaple to Desert).

(3) Plot 6 hr precipitation on the right side of the chart.

(4) Draw a line through the point parallel to the plotted lines.

(5) This line is the intensity-duration curve for the location being analyzed.

Application Form:

(a) Selected frequency 100 year

(b) P_6 = 3.0 in., P_{24} = 6.5, $\frac{P_6}{P_{24}}$ = 46 %[(2)]

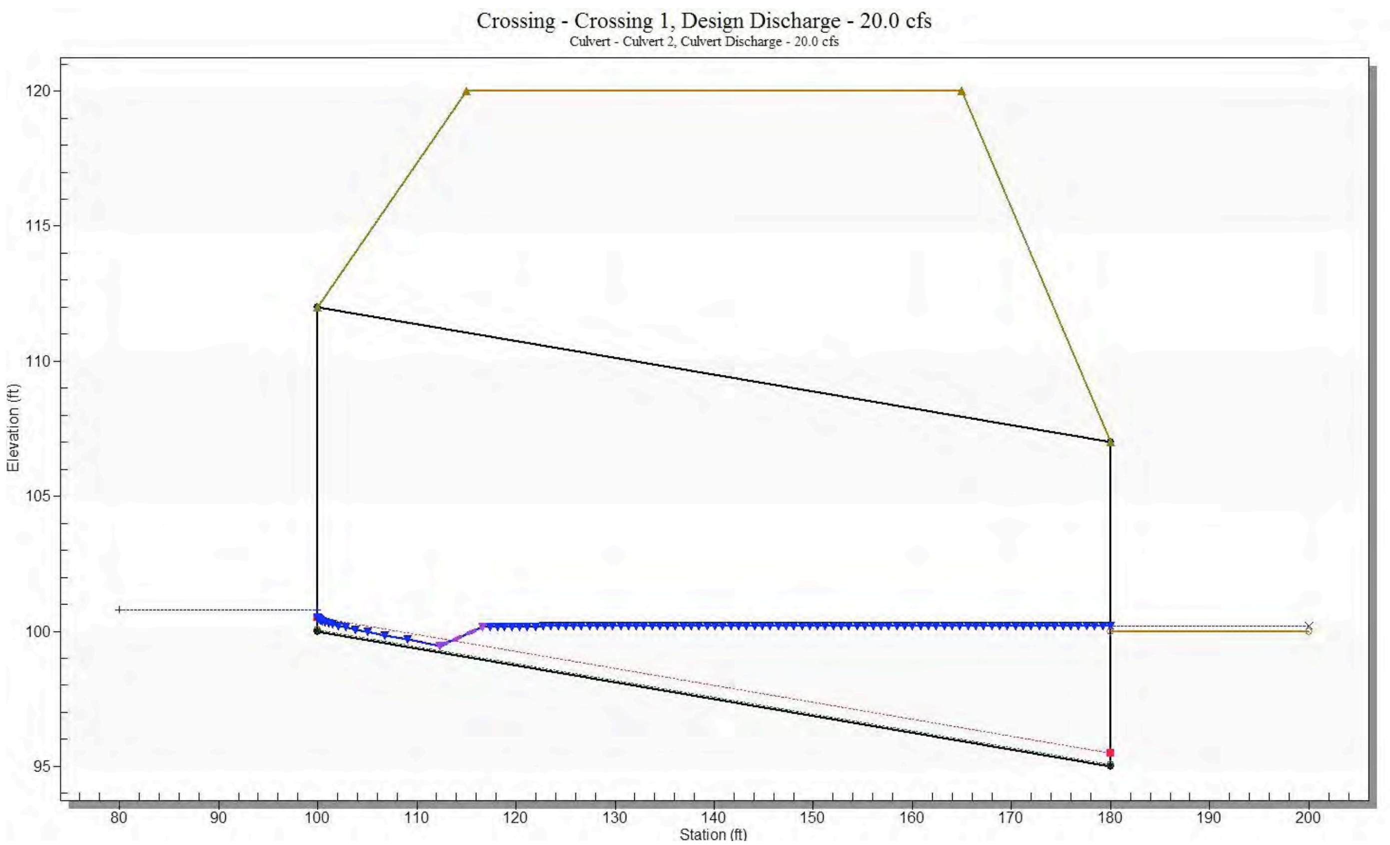
(c) Adjusted P_6[(2)] = 3.5 in.

(d) t_x = 30 min.

(e) I = 3.0 in./hr.

Note: This chart replaces the Intensity-Duration-Frequency curves used since 1965.

P6	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
Duration	I	I	I	I	I	I	I	I	I	I	I
5	2.63	3.95	5.27	6.59	7.90	9.22	10.54	11.86	13.17	14.49	15.81
7	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54	10.60	11.66	12.72
10	1.68	2.53	3.37	4.21	5.05	5.90	6.74	7.58	8.42	9.27	10.11
15	1.30	1.95	2.59	3.24	3.89	4.54	5.19	5.84	6.49	7.13	7.78
20	1.08	1.62	2.15	2.69	3.23	3.77	4.31	4.85	5.39	5.93	6.46
25	0.93	1.40	1.87	2.33	2.80	3.27	3.73	4.20	4.67	5.13	5.60
30	0.83	1.24	1.66	2.07	2.49	2.90	3.32	3.73	4.15	4.56	4.98
40	0.69	1.03	1.38	1.72	2.07	2.41	2.76	3.10	3.45	3.79	4.13
50	0.60	0.90	1.19	1.49	1.79	2.09	2.39	2.69	2.98	3.28	3.58
60	0.53	0.80	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	3.18
90	0.41	0.61	0.82	1.02	1.22	1.43	1.63	1.84	2.04	2.25	2.45
120	0.34	0.51	0.68	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04
150	0.29	0.44	0.59	0.73	0.88	1.03	1.18	1.32	1.47	1.62	1.76
180	0.26	0.39	0.52	0.65	0.78	0.91	1.04	1.18	1.31	1.44	1.57
240	0.22	0.33	0.43	0.54	0.65	0.76	0.87	0.98	1.08	1.19	1.30
300	0.19	0.28	0.38	0.47	0.56	0.66	0.75	0.85	0.94	1.03	1.13
360	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.84	0.92	1.00



HY-8 Analysis Results

Culvert Summary Table - Culvert 2

Culvert Crossing: Crossing 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	100.00	0.00	0.0	0-NF	0.00	0.00	5.00	0.00	0.00	0.00
2.70	2.68	100.21	0.21	0.06	1-JS1t	0.01	0.13	5.06	0.06	0.05	1.13
5.40	5.38	100.34	0.34	0.09	1-JS1t	0.02	0.21	5.09	0.09	0.11	1.49
8.10	8.07	100.44	0.44	0.12	1-JS1t	0.03	0.27	5.12	0.12	0.16	1.75
10.80	10.78	100.53	0.53	0.14	1-JS1t	0.04	0.33	5.14	0.14	0.21	1.97
13.50	13.49	100.62	0.62	0.16	1-JS1t	0.05	0.38	5.16	0.16	0.26	2.15
16.20	16.16	100.70	0.70	0.18	1-JS1t	0.06	0.43	5.18	0.18	0.31	2.31
18.90	18.87	100.77	0.77	0.19	1-JS1t	0.07	0.48	5.19	0.19	0.36	2.46
20.00	19.99	100.80	0.80	0.20	1-JS1t	0.07	0.50	5.20	0.20	0.38	2.52
24.30	24.27	100.92	0.92	0.22	1-JS1t	0.08	0.57	5.22	0.22	0.46	2.72
27.00	26.98	100.98	0.98	0.24	1-JS1t	0.09	0.61	5.24	0.24	0.52	2.83

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	Crossing 1	
Culvert	Culvert 2	
Flow	27.00	cfs
Culvert Data		
Culvert Width (including multiple barrels)	10.0	ft
Culvert Height	12.0	ft
Outlet Depth	5.24	ft
Outlet Velocity	0.52	ft/s
Froude Number	0.04	
Tailwater Depth	0.24	ft
Tailwater Velocity	2.83	ft/s
Tailwater Slope (SO)	0.0625	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 3 min	
Time to Peak	30.00	min
Cohesion	Noncohesive	
D16 Value	0.00	mm
D84 Value	0.00	mm
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Enter all required input before computation will occur		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ROAD CLASSIFICATION
JAMUL MOUNTAINS, CA

Appendix E – Transportation

Current Traffic Data:

Description	Back Peak hour	Back Peak Month	Back AADT	Ahead Peak Hour	Ahead Peak AADT	Ahead AADT
JCT. RTE. 54 NORTH	5300	63000	61000	1450	17000	16700
STEEL CANYON ROAD	1300	15500	15700	1350	16600	16100
LYONS VALLEY ROAD	1350	16600	16100	920	10900	10800
HONEY SPRINGS ROAD	690	7700	7500	570	6400	6300

ADT - Average Daily Traffic

DHV - Design Hour Volume, percentage of traffic that flows during peak hour volume

-(Assumed)

$$DHV = ADT * \%DHV * D$$

D - Peak hour Direction Split (Assumed)

V - Speed (mph)

Lane Capacity - Vehicles per lane (vpl)

N - Number of lanes

Current Lane Size:

Steele Canyon Road - Lyons Valley Road:

$$ADT(2012) = 16600$$
$$DHV = 11\%*ADT$$
$$D = 60\%$$
$$V = 55 \ mph$$
$$Lane \ Capacity = 2200 \ vpl$$

$$DHV = 16600*0.11*0.6 = 1095.6$$
$$LOS(C) = 0.64$$
$$Capacity = 0.64*2200 = 1408$$

LOS (C) obtained from HCM Exhibit 23-2

$$N = \frac{1095.6}{1408} = 0.78$$

N = 1 lane in each direction , or 2 lanes total.

Lyons Valley Road - Honey Springs Road:

$$ADT(2012) = 10900$$
$$DHV = 11\%*ADT$$
$$D = 60\%$$
$$V = 55 \ mph$$
$$Lane \ Capacity = 2200 \ vpl$$

$$DHV = 10900*0.11*0.6 = 719.4$$
$$LOS(C) = 0.64$$
$$Capacity = 0.64*2200 = 1408$$
$$N = \frac{719.4}{1408} = 0.51$$

N = 1 lane in each direction, or 2 lanes total.

References.

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Table 203.2
Standards for Curve Radius

Design Speed mph	Minimum Radius of Curve (ft)
20	130
30	300
40	550
50	850
60	1,150
70	2,100
80	3,900

Table 202.2

Standard Superelevation Rates
(Superelevation in Feet per Foot for Curve Radius in Feet)

Ramps, 2-Lane Conventional Highways, Frontage Roads[1]		Freeways, Expressways, Multilane Conventional Highways		When Snow & Ice Conditions Prevail (Usually over 3,000 ft elevation)		Urban Roads (35 – 45 mph)		Urban Roads (less than 35 mph)	
For $e_{max} = 0.12$		For $e_{max} = 0.10$		For $e_{max} = 0.08$		For $e_{max} = 0.06$		For $e_{max} = 0.04$	
Range of Curve Radii	e Rate	Range of Curve Radii	e Rate	Range of Curve Radii	e Rate	Range of Curve Radii	e Rate	Range of Curve Radii	e Rate
Under 625	0.12								
625 – 849	0.11								
850 – 1,099	0.10	Under 1,100	0.10						
1,100 – 1,349	0.09	1,100 – 1,349	0.09						
1,350 – 1,599	0.08	1,350 – 1,599	0.08	Under 1,600	0.08				
1,600 – 1,899	0.07	1,600 – 1,899	0.07	1,600 – 1,899	0.07				
1,900 – 2,199	0.06	1,900 – 2,199	0.06	1,900 – 2,199	0.06	Under 600	0.06		
2,200 – 2,699	0.05	2,200 – 2,699	0.05	2,200 – 2,699	0.05	600 – 999	0.05		
2,700 – 3,499	0.04	2,700 – 3,499	0.04	2,700 – 3,499	0.04	1,000 – 1,499	0.04	Under 500	0.04
3,500 – 4,499	0.03	3,500 – 4,499	0.03	3,500 – 4,499	0.03	1,500 – 1,999	0.03	500 – 999	0.03
4,500 – 19,999	0.02	4,500 – 19,999	0.02	4,500 – 19,999	0.02	2,000 – 6,999	0.02	1,000 – 4,999	0.02
20,000 & over	(2)	20,000 & over	(2)	20,000 & over	(2)	7,000 & over	(2)	5,000 & over	(2)

NOTES:

(1) For frontage roads under other jurisdictions see Index 202.7.

(2) Use standard crown section.

TABLE 5

Operational Effects of Lane and Shoulder Width on Two-Lane Highways

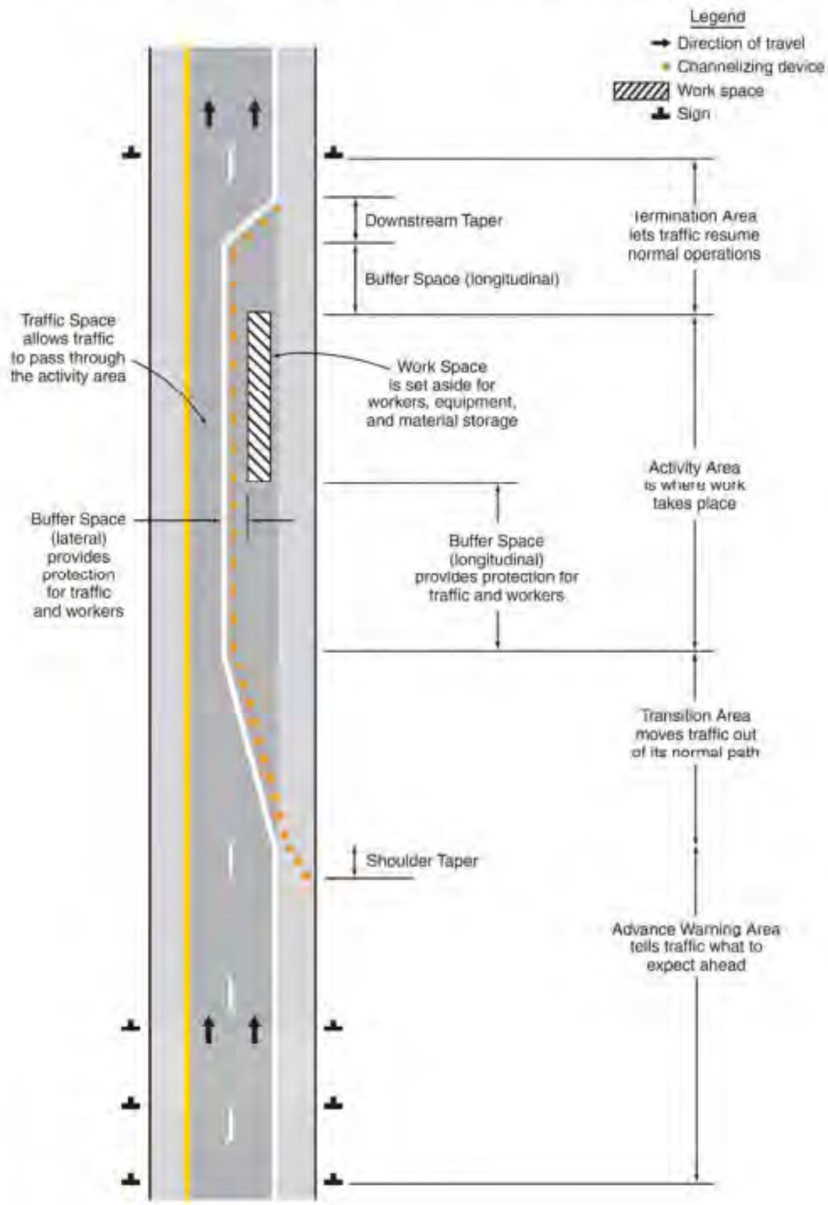
Lane width (ft)	**Reduction in Free-Flow Speed (mi/h)**			
	Shoulder Width (ft)			
	≥0<2	≥2<4	≥4<6	≥6
9<10	6.4	4.8	3.5	2.2
≥10<11	5.3	3.7	2.4	1.1
≥11<12	4.7	3.0	1.7	0.4
≥3.6	4.2	2.6	1.3	0.0

EXHIBIT 23-2. LOS CRITERIA FOR BASIC FREEWAY SEGMENTS

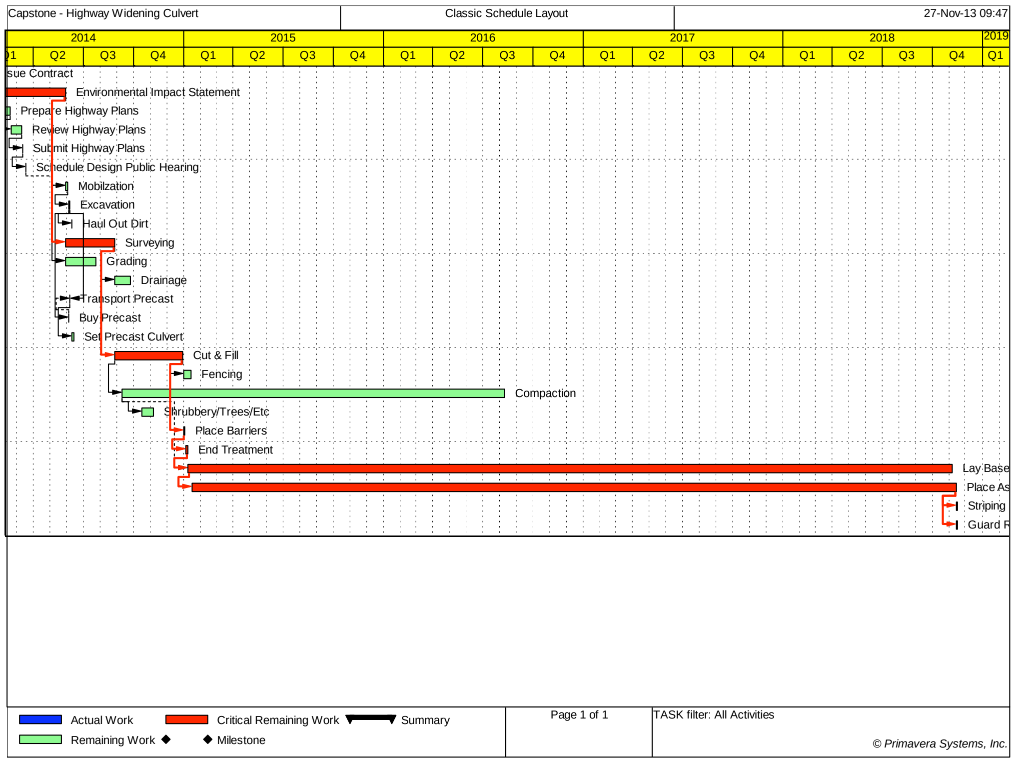
Criteria	LOS A	LOS B	LOS C	LOS D	LOS E
FFS = 75 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	75.0	74.8	70.6	62.2	53.3
Maximum v/c	0.34	0.56	0.76	0.90	1.00
Maximum service flow rate (pc/h/ln)	820	1350	1830	2170	2400
FFS = 70 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	70.0	70.0	68.2	61.5	53.3
Maximum v/c	0.32	0.53	0.74	0.90	1.00
Maximum service flow rate (pc/h/ln)	770	1260	1770	2150	2400
FFS = 65 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	65.0	65.0	64.6	59.7	52.2
Maximum v/c	0.30	0.50	0.71	0.89	1.00
Maximum service flow rate (pc/h/ln)	710	1170	1680	2090	2350
FFS = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	60.0	60.0	60.0	57.6	51.1
Maximum v/c	0.29	0.47	0.68	0.88	1.00
Maximum service flow rate (pc/h/ln)	660	1080	1560	2020	2300
FFS = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	55.0	55.0	55.0	54.7	50.0
Maximum v/c	0.27	0.44	0.64	0.85	1.00
Maximum service flow rate (pc/h/ln)	600	990	1430	1910	2250

Note:
The exact mathematical relationship between density and v/c has not always been maintained at LOS boundaries because of the use of rounded values. Density is the primary determinant of LOS. The speed criterion is the speed at maximum density for a given LOS.

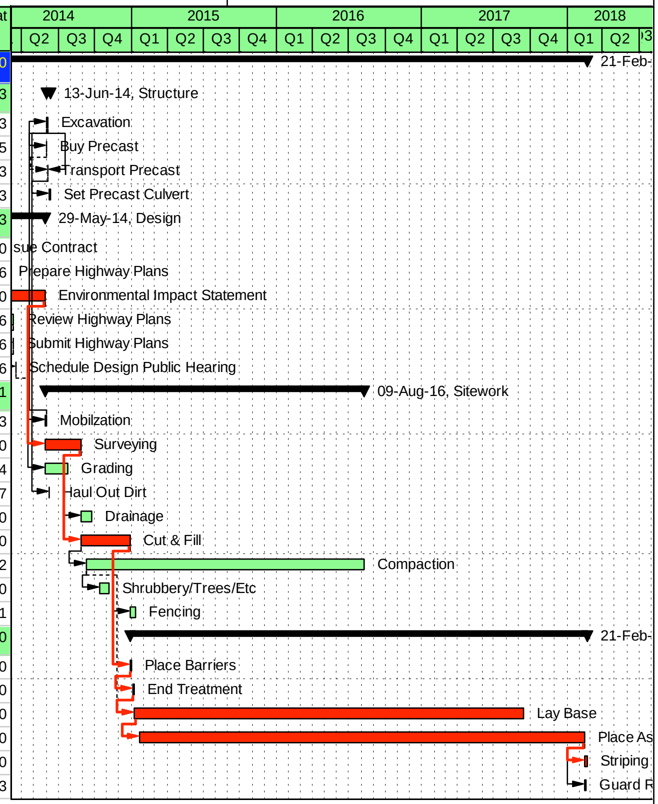
Figure 6C-1. Component Parts of a Temporary Traffic Control Zone



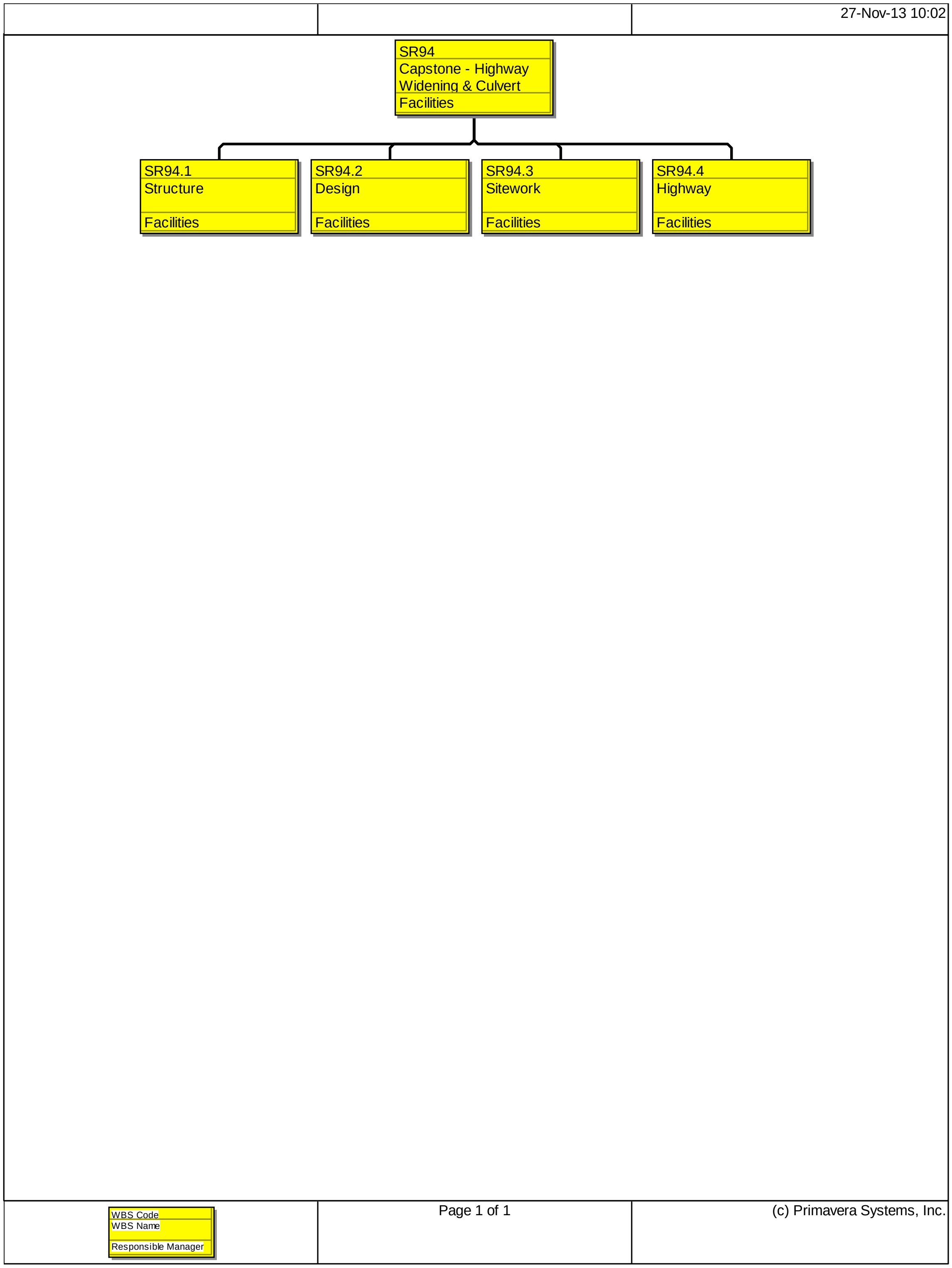
Appendix F – Construction



Capstone - Highway Widening Culvert		Classic WBS Layout			27-Nov-13 10:11
Activity ID	**Activity Name**	**Original Duration**	**Start**	**Finish**	**Total Float**
Capstone - Highway Wide		1078	06-Jan-14	21-Feb-18	0
Structure		9	03-Jun-14	13-Jun-14	963
SR1070	Excavation	4	03-Jun-14	06-Jun-14	963
SR1140	Buy Precast	1	03-Jun-14	03-Jun-14	965
SR1130	Transport Precast	1	06-Jun-14	06-Jun-14	963
SR1150	Set Precast Culvert	5	09-Jun-14	13-Jun-14	963
Design		104	06-Jan-14	29-May-14	963
SR1000	Issue Contract	1	06-Jan-14	06-Jan-14	0
SR1010	Prepare Highway Plans	30	07-Jan-14	17-Feb-14	1016
SR1005	Environmental Impact Stat	100	10-Jan-14	29-May-14	0
SR1020	Review Highway Plans	15	18-Feb-14	10-Mar-14	1016
SR1030	Submit Highway Plans	1	11-Mar-14	11-Mar-14	1016
SR1040	Schedule Design Public H	1	17-Mar-14	17-Mar-14	1016
Sitework		573	30-May-14	09-Aug-16	401
SR1060	Mobilzation	2	30-May-14	02-Jun-14	963
SR1100	Surveying	63	30-May-14	26-Aug-14	0
SR1110	Grading	40	30-May-14	24-Jul-14	934
SR1080	Haul Out Dirt	1	09-Jun-14	09-Jun-14	967
SR1120	Drainage	21	27-Aug-14	24-Sep-14	890
SR1160	Cut & Fill	90	27-Aug-14	30-Dec-14	0
SR1180	Compaction	500	10-Sep-14	09-Aug-16	72
SR1190	Shrubbery/Trees/Etc	16	15-Oct-14	05-Nov-14	860
SR1170	Fencing	10	31-Dec-14	13-Jan-15	811
Highway		821	31-Dec-14	21-Feb-18	0
SR1200	Place Barriers	3	31-Dec-14	02-Jan-15	0
SR1210	End Treatment	3	05-Jan-15	07-Jan-15	0
SR1220	Lay Base	700	08-Jan-15	13-Sep-17	0
SR1230	Place Asphault	800	22-Jan-15	14-Feb-18	0
SR1240	Striping	5	15-Feb-18	21-Feb-18	0
SR1250	Guard Rails	2	15-Feb-18	16-Feb-18	3



Actual Work	Critical Remaining Work	Summary	Page 1 of 1	TASK filter: All Activities
Remaining Work ◆	◆ Milestone			© Primavera Systems, Inc.


27-Nov-13 10:02
SR94
Capstone - Highway Widening & Culvert
Facilities
SR94.1
Structure
Facilities
SR94.2
Design
Facilities
SR94.3
Sitework
Facilities
SR94.4
Highway
Facilities
WBS Code
WBS Name
Responsible Manager
Page 1 of 1
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Capstone - Highway Widening Culvert

Report Date 27-Nov-13 09:53

Project Start 06-Jan-14
Project Finish 21-Feb-18
Data Date 06-Jan-14

SR-01 Classic Schedule Report - Sort by ES, TF

Activity ID	Activity Name	Original	Start	Finish	Late Start	Late Finish	Free Float	Total Float	WBS	Successo	Predeces
SR1000	Issue Contract	1	06-Jan-14	06-Jan-14	06-Jan-14	06-Jan-14	0	0	SR94.2	SR1010, SR1005	
SR1010	Prepare Highway Plans	30	07-Jan-14	17-Feb-14	29-Nov-17	09-Jan-18	0	1016	SR94.2	SR1020	SR1000
SR1005	Environmental Impact Statement	100	10-Jan-14	29-May-14	10-Jan-14	29-May-14	0	0	SR94.2	SR1100, SR1110, SR1060	SR1000
SR1020	Review Highway Plans	15	18-Feb-14	10-Mar-14	10-Jan-18	30-Jan-18	0	1016	SR94.2	SR1030	SR1010
SR1030	Submit Highway Plans	1	11-Mar-14	11-Mar-14	31-Jan-18	31-Jan-18	0	1016	SR94.2	SR1040	SR1020
SR1040	Schedule Design Public Hearing	1	17-Mar-14	17-Mar-14	06-Feb-18	06-Feb-18	53	1016	SR94.2	SR1060	SR1030
SR1100	Surveying	63	30-May-14	26-Aug-14	30-May-14	26-Aug-14	0	0	SR94.3	SR1160, SR1120	SR1005
SR1110	Grading	40	30-May-14	24-Jul-14	28-Dec-17	21-Feb-18	934	934	SR94.3		SR1005
SR1060	Mobilzation	2	30-May-14	02-Jun-14	07-Feb-18	08-Feb-18	0	963	SR94.3	SR1070	SR1040, SR1005
SR1070	Excavation	4	03-Jun-14	06-Jun-14	09-Feb-18	14-Feb-18	0	963	SR94.1	SR1080, SR1140, SR1130	SR1060
SR1140	Buy Precast	1	03-Jun-14	03-Jun-14	13-Feb-18	13-Feb-18	2	965	SR94.1	SR1130	SR1070
SR1130	Transport Precast	1	06-Jun-14	06-Jun-14	14-Feb-18	14-Feb-18	0	963	SR94.1	SR1150	SR1140, SR1070
SR1150	Set Precast Culvert	5	09-Jun-14	13-Jun-14	15-Feb-18	21-Feb-18	963	963	SR94.1		SR1130
SR1080	Haul Out Dirt	1	09-Jun-14	09-Jun-14	21-Feb-18	21-Feb-18	967	967	SR94.3		SR1070
SR1160	Cut & Fill	90	27-Aug-14	30-Dec-14	27-Aug-14	30-Dec-14	0	0	SR94.3	SR1180, SR1170, SR1200	SR1100
SR1120	Drainage	21	27-Aug-14	24-Sep-14	24-Jan-18	21-Feb-18	890	890	SR94.3		SR1100
SR1180	Compaction	500	10-Sep-14	09-Aug-16	19-Dec-14	17-Nov-16	0	72	SR94.3	SR1220, SR1190	SR1160
SR1190	Shrubbery/Trees/Etc	16	15-Oct-14	05-Nov-14	31-Jan-18	21-Feb-18	860	860	SR94.3		SR1180
SR1200	Place Barriers	3	31-Dec-14	02-Jan-15	31-Dec-14	02-Jan-15	0	0	SR94.4	SR1210	SR1160
SR1170	Fencing	10	31-Dec-14	13-Jan-15	08-Feb-18	21-Feb-18	811	811	SR94.3		SR1160
SR1210	End Treatment	3	05-Jan-15	07-Jan-15	05-Jan-15	07-Jan-15	0	0	SR94.4	SR1220	SR1200
SR1220	Lay Base	700	08-Jan-15	13-Sep-17	08-Jan-15	13-Sep-17	0	0	SR94.4	SR1230	SR1180, SR1210
SR1230	Place Asphault	800	22-Jan-15	14-Feb-18	22-Jan-15	14-Feb-18	0	0	SR94.4	SR1240, SR1250	SR1220
SR1240	Striping	5	15-Feb-18	21-Feb-18	15-Feb-18	21-Feb-18	0	0	SR94.4		SR1230
SR1250	Guard Rails	2	15-Feb-18	16-Feb-18	20-Feb-18	21-Feb-18	3	3	SR94		SR1230

Page 1 of 1

State Route 94 Culvert and Bridge Evaluation

Background

State Route (SR-) 94 is a two lane highway which passes through the community of Jamul in the southern portion of the County of San Diego (Figure 1). SR-94 divides the California Department of Fish and Wildlife's (CDFW) Rancho Jamul Ecological Reserve (RJER) from its Hollenbeck Canyon Wildlife Area (HCWA). These properties constitute a major portion of the County of San Diego's Multiple Species Conservation Plan - South County Subarea Plan Core Area. Core areas are intended to provide source populations and allow for genetic diversity to sustain those populations throughout the plan area for all species covered by the MSCP through connections to other core areas. CDFW considers the roadway which bisects this primary core area of the MSCP to be a significant impediment to wildlife movement.

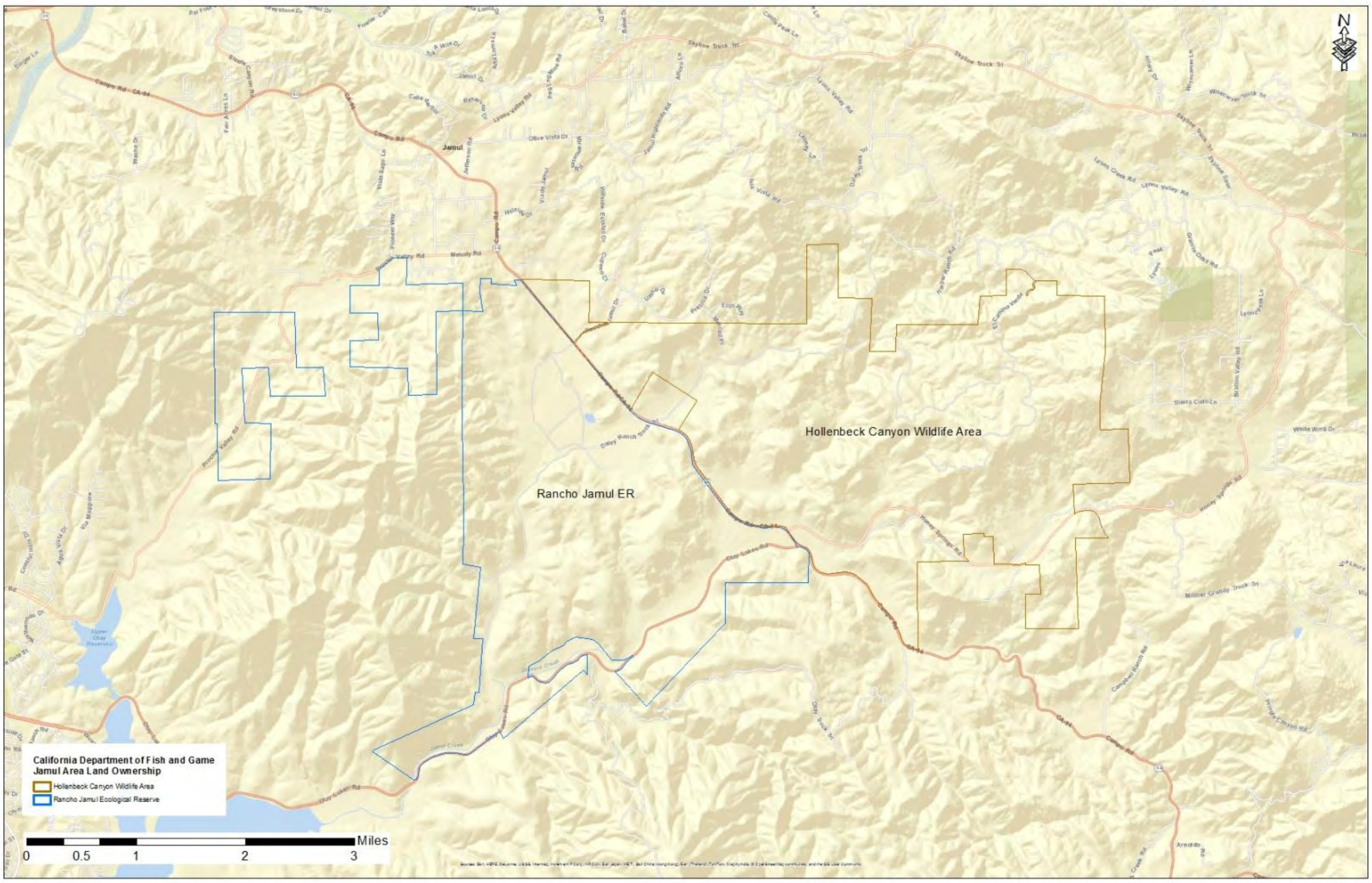

Figure 1. Vicinity Map.

Purpose

In order to facilitate potential enhancements to the State Route (SR-) 94 for wildlife movement, an initial assessment was performed to identify current road undercrossings which may be suitable for wildlife movement between Rancho Jamul Ecological Reserve (RJER) and Hollenbeck Canyon Wildlife Area (HCWA), between Otay Lakes Road at the South end of RJER and the Jamul Indian Village at the North end.

Methods for evaluating wildlife use

This assessment of culverts and bridges as potential wildlife crossings was performed by Senior Environmental Scientist (Specialist) Tim Dillingham on September 12, 2013 as a background study to determine the number of structures which could provide suitable opportunities for wildlife to safely cross under State Route 94 from the Rancho Jamul Ecological Reserve (RJER) and the Hollenbeck Canyon Wildlife Area adjacent to SR-94.

Each culvert and bridge was examined from both sides, and an attempt was made to look or pass through the undercrossing to determine connectivity. A 30 foot Stanley English unit tape measure was used to determine size of the culverts (diameter and length) and bridges (width, height and length). Photographs were taken with a Nikon digital format SLR camera at 14 megapixel resolution. Mile post locations were determined using the Caltrans Earth internet site.

This assessment contains photographs of the undercrossings, location information on each culvert and bridge within this segment of SR-94, a description of the structure, a professional opinion on the suitability of the crossings, and recommendations for improving the crossing, where possible.

Methods for evaluating safety issues

CDFW staff reviewed known accident information, observed traffic volume and vehicle speeds, and general observations relative to traffic volume, vehicle speeds, passing, and line of sight. Safety recommendations are based on staff experiences accessing and driving on Highway 94, and concerns expressed by visitors to the CDFW properties. No traffic studies were done.

Discussion

The structures are listed from north to south, starting at the entrance to the Jamul Indian Village property, and ending at the Otay Lakes Road intersection with SR-94. Caltrans Post Mile (PM) markers are listed for location purposes. The Dulzura Creek watershed includes Jamul Creek, Hollenbeck Creek, Dulzura Creek and all unnamed tributaries of those streams. All drainages flow from east to west towards Lower Otay Lake, Otay River and ultimately San Diego Bay.

Location 1 - PM 21.508 Daley Dip

a. Existing Conditions: The "Daley Dip" is an Arizona style crossing with three 3-foot diameter RCP pipes beneath the roadway. Fencing is a three strand barbed wire fence subject to storm flow damage.
b. Wildlife Evaluation: Wildlife crosses at this location at grade because sediment fills the culverts following most storm events and in generally maintained only immediately prior to a storm event. Numerous road kill events at this location both documented and observed prior to establishment of the road kill data base.
c. Safety Evaluation: Traffic slows for the dip crossing and often vehicles will tailgate slower vehicles. During storm events water flows over the roadway slowing traffic further, and occasionally stops traffic during heavy flood events. Vehicles may also swerve to avoid striking wildlife.
d. Recommendations: Raising the roadway to eliminate flooding would also allow better wildlife crossing if properly designed. Installation of a bridge would be the preferred alternative to minimize encroachment into habitat, although large culverts would provide a suitable crossing as well.

Figure 2. Looking west into RJER.

Figure 3. Looking west from HCWA. Note 3 foot diameter pipes almost entirely buried in sediment.

Figure 4. Looking east into HCWA.

Location 2 - PM 21.708: Culverts northwest of Rancho Jamul Road.

a. Existing Conditions: Three 4 foot diameter side by side culverts. Fencing is a 4 foot tall field fence topped with a single strand barbed wire.
b. Wildlife Evaluation: These culverts function somewhat as a small animal crossing. Camera traps show use by long tailed weasels and rabbits. Coyotes still tend to cross at grade, and improvements to the culvert approaches could increase use.
c. Safety Evaluation: Keeping wildlife off of the highway could prevent accidents caused by swerving to avoid wildlife.
d. Recommendations: Improve habitat on both sides of the roadway and maintain the culverts to provide clear approaches to the crossing.

Figure 5. Looking east from RJER.

Figure 6. Looking north from west side of SR-94 (RJER)

Location 3 - PM 21.877 Culvert southeast of Rancho Jamul Road.

a. Existing Conditions: a 24 inch culvert partially blocked with sediment and brush. Fencing is a 4 foot tall chain link fence with a gap on the bottom edge to allow debris flow.
b. Wildlife Evaluation: This culvert does not provide a functional crossing as the upstream entrance is within the roadway fencing, fencing does not direct wildlife into the culvert and the culvert is too small for most wildlife. The downstream end of the culvert is a diversion box which obscures visibility through the culvert, and often fills with sediment and debris.
c. Safety Evaluation: Keeping wildlife off of the highway could prevent accidents caused by swerving to avoid wildlife.
d. Recommendations: Remove the diversion box and redirect the flows to the adjacent field. A swale from historic flows still exists through the grassland. Enlarge the culvert to provide a small/medium animal crossing, extend the upstream end into HCWA and fence the approach to direct wildlife into the crossing. Improve habitat on both sides of the roadway and maintain the culverts to provide clear approaches to the crossing.

Figure 7. Looking north towards Rancho Jamul Road.

Figure 8. Looking east towards HCWA.

Location 4 - PM 22.353: Whoop-de-doos.

a. Existing Conditions: A segment of undulating roadway approximately 750 feet north of the RJER main gate without culverts or other crossings. Wildlife currently crosses the roadway at grade, and well developed game trails exist to the east and west. The fence is a six-foot chain link fabric recently repaired by CDFW.
b. Wildlife Evaluation: Wildlife previously crossed the roadway through gaps in the fencing caused by multiple vehicle accidents. Wildlife is likely to continue to attempt to cross the road in this location as a major water source exists on RJER in this area. A safe crossing should be installed, likely a dual basin undercrossing as the land is relatively flat on both sides of the highway.
c. Safety Evaluation: CDFW has repaired these fences numerous times following vehicle accidents. The undulations in the roadway hide oncoming traffic from those who are willing to illegally pass in this section, leading to vehicles swerving off of the highway to avoid head on collisions. Leveling the road and improving the line of sight in this section could help prevent these types of accidents.
d. Recommendations: Installing a culvert underneath this section and leveling the roadway would improve conditions for both wildlife and for public safety.

Figure 9. Looking west towards RJER.

Location 5 - PM 22.56: 500 feet north of RJER main gate.

a. Existing Conditions: A single 48 inch culvert which has a bend in the pipe somewhere underneath SR-94, with an outlet in a drainage ditch within RJER, and two inlets on either side of SR-94 consisting of grated drains, and a large inlet with steeply angled concrete sides. The fence is a six-foot chain link fabric recently repaired by CDFW.
b. Wildlife Evaluation: Wildlife previously crossed the roadway through gaps in the fencing caused by multiple vehicle accidents. Wildlife is likely to continue to attempt to cross the road in this location as a major water source exists on RJER in this area. The existing culvert provides little if any function for wildlife.
c. Safety Evaluation: CDFW has repaired these fences numerous times following vehicle accidents. The undulations in the roadway to the north hide oncoming traffic from those who are willing to illegally pass in this section, leading to vehicles swerving off of the highway to avoid head on collisions. Leveling the road and improving the line of sight in this section could help prevent these types of accidents. This is also an area CDFW identified in the RJER management plan as a public access point.
d. Recommendations: Installing a culvert underneath this section and leveling the roadway would improve conditions for both wildlife and for public safety. If CDFW develops a public parking area here, a slowing and turn lanes for school buses should be installed.

Figure 10. Looking south. This inlet is very steep and the sides are smooth concrete.

Location 6 - PM 22.376: RJER main gate.

a. Existing Conditions: Three side by side 12'x12' culverts approximately 40 feet long. On the west side of the highway, the RJER main gate is a six foot tall steel gate surrounded by five foot chain link topped by 3-strand barbed wire. On the east side there is a four foot tall chain link fence across the culvert.
b. Wildlife Evaluation: A bent fence post allows wildlife to move through the culvert but is limited to small and medium mammals.
c. Safety Evaluation: This is an access point for visitors to the reserve including school buses. Traffic often is traveling very fast and close. There has been a least one fatal accident at this location.
d. Recommendations: Creation of a slowing and turn lanes at this location would improve safety for the public and staff. Removal of fencing on the east side of the culverts would allow larger wildlife to move through, however the upstream channel restricts movement and should be returned to a natural channel where possible. This property is currently privately owned.

Figure 11. Looking east towards private residence.

Figure 12. Looking west towards RJER.

Location 7 - PM 23.373: Adjacent to Call Box 94-234, one half mile southeast of RJER main gate.

a. Existing Conditions: A single 24" culvert approximately 80 feet long with significant vertical drop on the eastern end. The culvert discharges into the gully at the bottom of the slope on the east side of the highway. Fencing is four foot tall field fencing partially buried and topped with three strand barbed wire.
b. Wildlife Evaluation: This culvert is small and has a steep drop through a very long pipe. It is non-functional.
c. Safety Evaluation: This is the beginning of the passing zone. Traffic is often traveling at a high rate of speed in either direction while attempting to complete a pass.
d. Recommendations: Placement of an over or an undercrossing at this location would greatly improve wildlife crossing opportunities and connect RJER to HCWA in a significant movement area. The turnout is a large fill slope with enough space underneath the roadway to install a large mammal crossing without significant modification of the road elevation.

Figure 13. Looking east at culvert set eight feet below road surface

Figure 14. Looking northeast. The culvert outlet is at the bottom of the slope. The truck on opposite side of the road is above the opening to the culvert (figure 4) on the west side.

Location 8 - PM 23.86: Hollenbeck Creek.

a. Existing Conditions: two 44 foot long side by side 5x5 foot culverts connect the good riparian habitat on either side of SR-94. Fencing is composed of three strand barbed wire.
b. Wildlife Evaluation: These culverts provide small/medium animal crossing, however a sharp drop on the downstream end of the culvert limits the suitability. The upstream end is within the Right of Way fencing and does not prevent wildlife from entering the roadway.
c. Safety Evaluation: This is the beginning of the passing zone. Traffic is often traveling at a high rate of speed in either direction while attempting to complete a pass. Public enters the wildlife area at this location, especially during hunting season. Deceleration and turn lanes would improve safety for public and staff.
d. Recommendations: Improvement to the entrances to the culverts to allow better access into the culverts is needed. Fencing to direct wildlife into the upstream end, elimination of the drop on the downstream end through the installation of a bench or other feature and better directional fencing would improve its use as a small/medium animal crossing.

Figure 15. Looking west from HCWA

Figure 16. Looking west from SR-94

Figure 17. Looking south along SR-94

Figure 18. Looking north along SR-94

Location 9 - PM 24.685: Otay Lakes Road Bridge.

a. Existing Conditions: The bridge consists of 3 bents, 6-15 feet tall, with 40 foot spans between bents. Fencing is composed of three strand barbed wire. A staging area has been expanded and public is beginning to use the area as a rest stop.
b. Wildlife Evaluation: The bridge is suitable for all species; however fencing along the road is three-strand barbed wire with numerous gaps in the length caused by vehicle accidents. Animals pass freely through the fence, and without significant upgrades to the entire fence it will not prevent animals from entering onto the roadway. The bridge also provide significant bat roost habitat for sensitive bat species.
c. Safety Evaluation: Damaged fencing from repeated minor and major vehicle accidents allows wildlife to enter the roadway.
d. Recommendations: Improve fencing along roadways to direct wildlife to the bridge crossing. Eliminate human access to the bridge except for necessary crews and law enforcement to reduce human disturbance to improve wildlife use.

Figure 19. Looking east from RJER towards HCWA

Figure 20. Looking north from south end of bridge