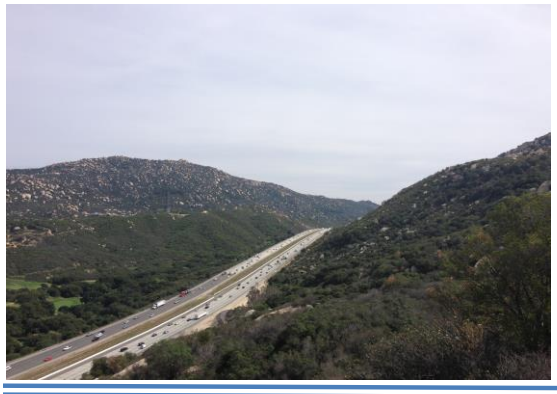

Assessment of Wildlife Crossing Sites for the Interstate 15 and Highway 101 Freeways in Southern California

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Prepared by (in alphabetical order):

Seth P. D. Riley, Ph.D., National Park Service
Trish Smith, The Nature Conservancy
T. Winston Vickers, Ph.D., UC Davis Wildlife Health Center

TABLE OF CONTENTS

Appendices

List of Tables

Page

List of Figures

Page

EXECUTIVE SUMMARY

Roads can cause significant mortality for wildlife, but large roads like freeways can also form major barriers to wildlife movement and gene flow. Freeways are ubiquitous in southern California, and two freeways, Interstate 15 and U.S. 101, have been found to be barriers to wildlife passage and gene exchange, especially for mountain lions, between the Santa Ana Mountains and the Palomar Mountains and other mountains to the east (separated by Interstate 15), and between the Santa Monica Mountains and the Simi Hills, Santa Susana Mountains, and others to the north (separated by the 101 Freeway). We used two sources of information with the goal of bridging the gap between connectivity science and conservation practice. In early 2015 we engaged an independent panel of connectivity experts to evaluate possible locations and concepts for wildlife crossings along stretches of both freeways. We also developed and implemented an evaluation tool based on landscape characteristics and wildlife data to help prioritize locations for wildlife crossing infrastructure. The experts were asked to evaluate stretches of each freeway where wildlife studies have indicated that some connectivity potential remains due to the presence of natural habitat on both sides of the road, but where new or enhanced structures are likely required to restore lost connectivity. Multiple specific sites were examined along these stretches of each freeway. For I-15, both the Landscape and Expert scoring indicated that retention and enhancement of function under the Temecula Creek Bridge, and construction of a new under or overpass south of the bridge, were both likely needed for long term connectivity. For the 101 Freeway, the Landscape and Expert scoring both strongly concluded that West Liberty Canyon is the best location for a new wildlife crossing structure, with several other locations being sites where enhancements or new construction could serve the role of providing secondary crossings. The experts indicated that an overpass, over both 101 and the parallel Agoura Rd, was the best option here to provide connectivity for a range of species. The experts agreed that accompanying measures, such as effective wildlife fencing to funnel animals to crossing points and appropriate vegetative cover on and near structures were also important. They also recommended that, over the long term, more than one crossing structure should be enhanced or created for each linkage to assure sufficient movement of wildlife to accomplish gene exchange between populations in entire mountain ranges. Increasing connectivity across both freeways is critical for the long-term viability of local wildlife populations, especially for wide-ranging species such as mountain lions, and this analysis provides a concrete way forward.

1. INTRODUCTION

The protection of habitat connectivity is arguably one of the most salient global conservation problems of our day – how to keep from fragmenting intact natural landscapes with areas of intense human land use, and how to halt and reverse the cascading impacts of habitat fragmentation resulting from past land use decisions.

The threat of habitat fragmentation to biodiversity is well recognized in southern California. Here, coastal, montane, and desert ecosystems intersect to create an area renowned for its unique and diverse biota (Myers et al. 2000). It also is an area of intense human development with a growing population of nearly 24 million that threatens the persistence of the region's natural habitats and species (State of California, Dept. of Finance 2017). Despite large expenditures of funds and effort to preserve biodiversity and conserve threatened or endangered species in the region, substantial challenges remain for persistence of some species.

The Santa Ana Mountains and Santa Monica Mountains are two of several large southern California landscapes (Figure 1) that, despite conservation investments in the hundreds of millions of dollars, remain at risk of isolation and fragmentation by roads and urban development (Riley et al. 2014, Ernest et al. 2014). Wildlife research studies have identified that major highways and associated development have severed connectivity between these coastal ranges and larger inland protected lands that are considered critical to protecting plant and animal species against climate change and other threats. Specifically, Interstate 15 (hereafter referred to as "I-15") in western Riverside County has seriously reduced connectivity between the Santa Ana Mountains and the inland eastern Peninsular Ranges (with the Palomar Mountains being the most proximate portion of the Peninsular Ranges to I-15), and US Highway 101 (hereafter referred to as the "101 Freeway") in northern Los Angeles County and Ventura County has seriously reduced connectivity between the Santa Monica Mountains and inland Santa Susanna and Sierra Madre Mountains to the north (Riley et al. 2014, Ernest et al. 2014). These concerns have been amplified by the findings of recent genetic analyses relating to both the Santa Ana Mountains' and Santa Monica Mountains' mountain lion *(Puma concolor)* populations, indicating significant genetic restriction and minimal evidence of migration into these populations in recent years. These studies indicate that genetic diversity for Santa Ana and Santa Monica mountain lions is very low (Riley et al. 2014, Ernest et al. 2014), lower than has been measured anywhere else in the west. Only in endangered Florida panthers, where severe genetic defects were present throughout the population before a genetic introgression program, has lower genetic diversity been found (Gustafson et al. 2017).

Both linkages have been prioritized for protection by the South Coast Missing Linkages Project, an effort to identify important landscape linkages throughout the State of California (Penrod et al. 2001). Subsequently, detailed linkage designs, including recommendations for highway crossing structures for the 101 and I-15 freeways, were developed (Penrod et al. 2006, South Coast Wildlands 2008). Both linkages were also identified as important in the California Essential Habitat Connectivity Project (2010), commissioned by Caltrans and the California Department of Fish and Wildlife.

Significant research and planning efforts have been conducted for both linkages to help address connectivity needs, which range from strategic land acquisition for conservation to the identification of locations and concepts for wildlife crossing structures for both freeways. Because of the rate and extent of past urbanization throughout southern California, opportunities for securing connectivity across

major freeways in both linkages are limited. Each of these areas presents unique challenges to accomplishing improved connectivity, with many improvements that have been proposed likely requiring significant financial investment, for both wildlife crossing structures and land protection, and significant political and public support.

As stated in the Wildlife Crossing Structure Handbook (2011): “There is currently an urgent need to provide transportation and other stakeholder agencies with technical guidance and best management practices on the planning and design of wildlife crossing mitigation measures. The siting of wildlife crossing structures is equally as important as their design. Identifying the proper location of crossing structures is critical for designing effective mitigation of the barrier effect caused by roads."

Given the challenges and level of financial investment required to secure connectivity for the Santa Ana to Palomar Mountains Linkage (Figure 2), and the Santa Monica to Sierra Madre Mountains Linkage (Figure 3), the National Park Service, The Nature Conservancy, and the UC Davis Karen C. Drayer Wildlife Health Center felt that both linkages would benefit from a collaborative effort to help bridge the gap between science and practice by: 1) engaging an independent panel of connectivity experts to evaluate possible wildlife crossing site locations and concepts for the I-15 and 101 Freeways; and 2) developing and implementing an evaluation tool based on landscape characteristics and wildlife knowledge to help prioritize locations for the siting of wildlife crossing infrastructure.

Figure 1. Regional map of the Santa Ana to Palomar Mountains Linkage and Santa Monica to Sierra Madre Linkage and other priority linkages in Southern California

Figure 2. Location map of Santa Ana to Palomar Mountains Linkage, including the area along I-15 evaluated for wildlife crossings.

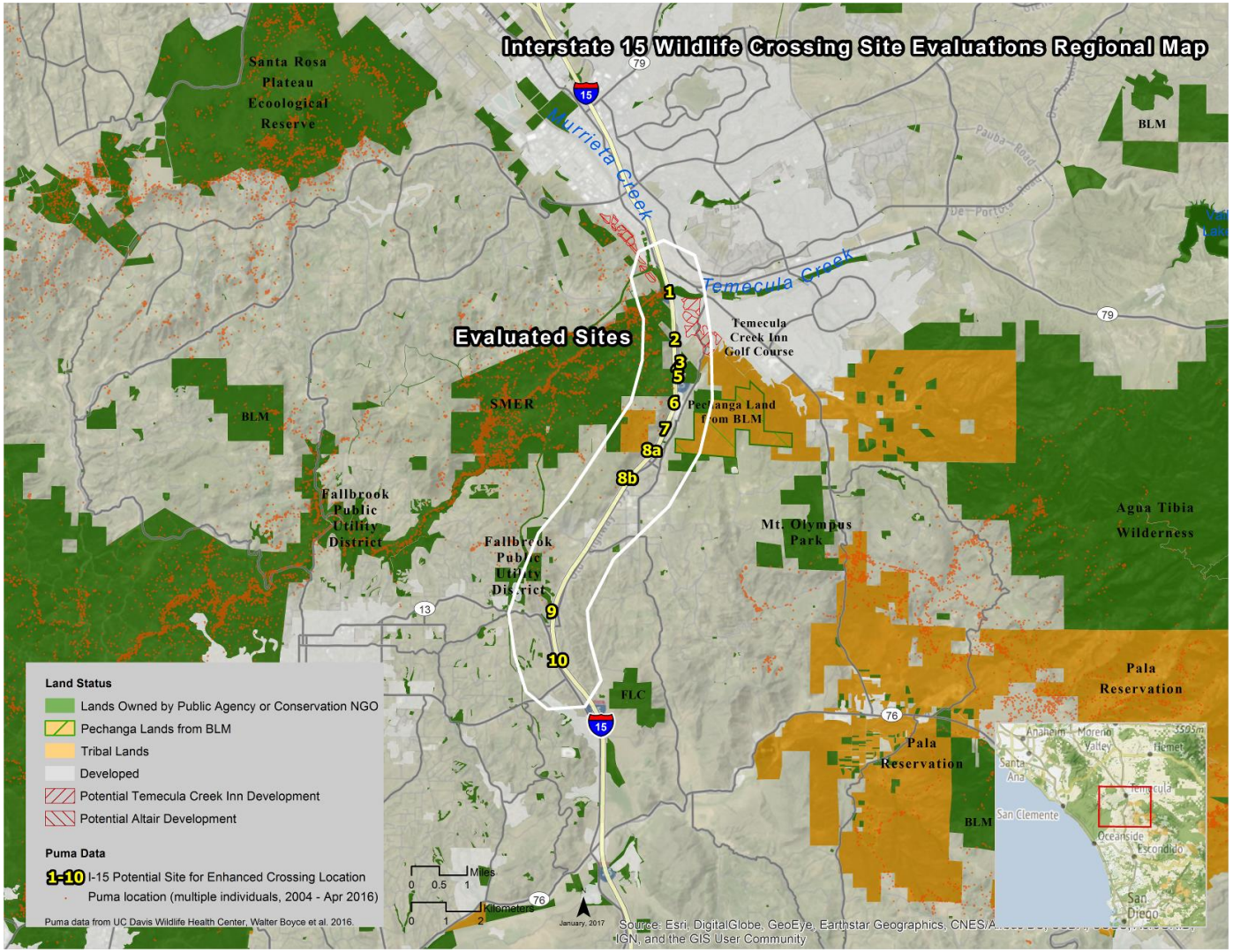
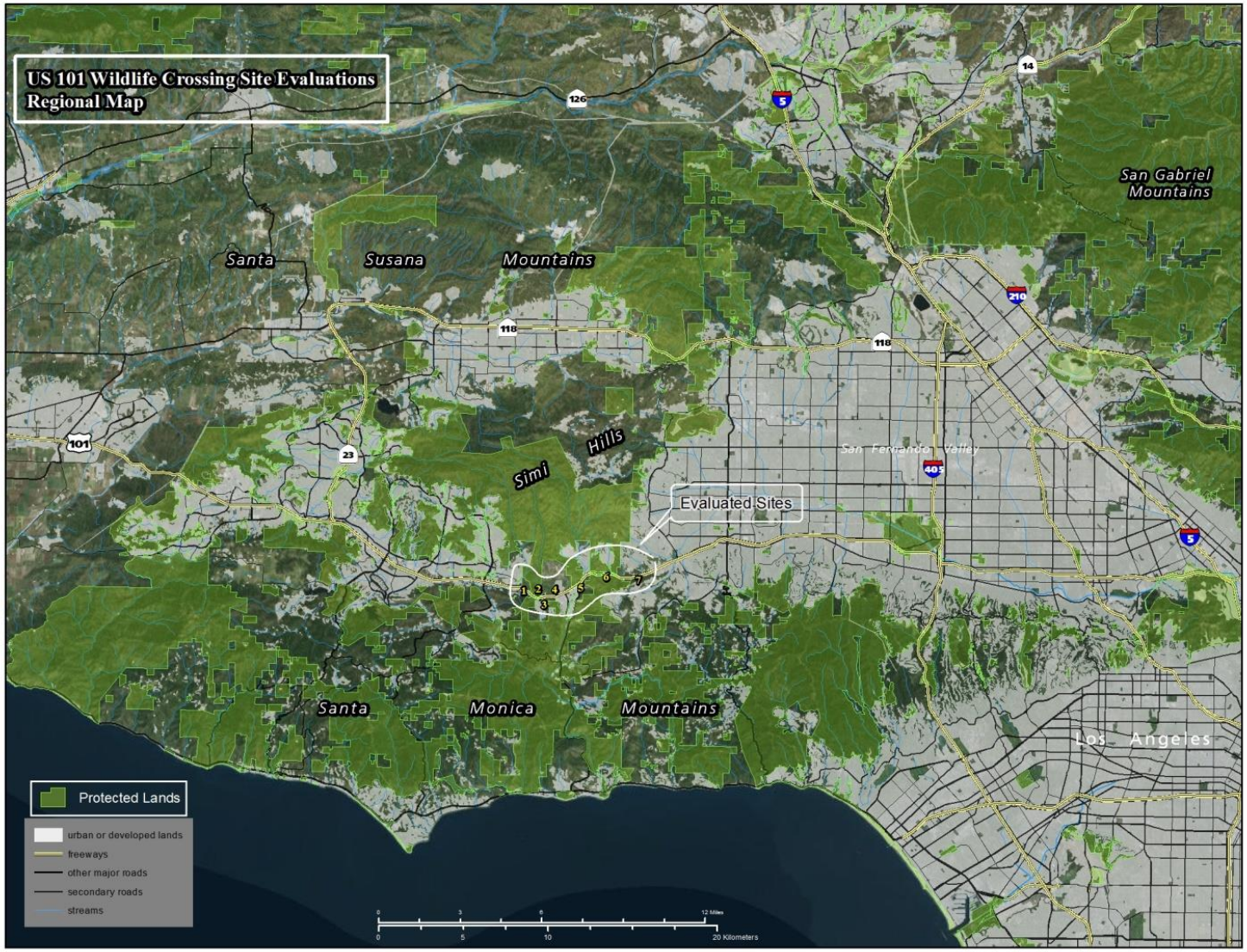


Figure 3. Location map of Santa Monica Mountains to Sierra Madre Mountains Linkage, including the area along 101 evaluated for wildlife crossings, and the intervening natural areas of the Simi Hills and Santa Susana Mountains.



Project Objective: The overall objective of this effort was to provide critical information to stakeholders involved in the development of new or improved wildlife crossing structures across the I-15 and 101 Freeways. Stakeholders that are expected to use this information include conservation agencies and organizations (governmental and non-governmental), highway agencies, local jurisdictions involved with land use decisions, wildlife agencies, and others in the region in their efforts to increase connectivity for wildlife.

Given the likelihood that these freeways negatively impact or block free exchange of genes for many wildlife species (documented for the 101 and I-15 Freeways for mountain lions, and for the 101 Freeway for bobcats, coyotes [Riley et al. 2006], and smaller vertebrates [Delaney et al. 2010]) and full use of available habitat by other wild species, assessment of potential crossing locations included the goal of providing potential movement pathways for large and medium-sized carnivores, mule deer, reptiles, amphibians, small mammals, and fish.

In relation to mountain lions specifically, the aim of crossing structure modification or new construction is to enhance the likelihood that juvenile mountain lions can move out of larger populations to the east of the Santa Ana Mountains and to the north of the Santa Monica Mountains, into the coastal mountain ranges. Without this in-migration of dispersing animals, including territory establishment and breeding, genetic diversity in these populations will continue to decline. Out-migration of animals from the Santa Ana Mountains and Santa Monica Mountains would also assure that overall genetic exchange between these populations was adequate for the health of both populations. In the Santa Monica Mountains, there have been repeated instances of close inbreeding between fathers and daughters, as well as extensive mortality from intraspecific fighting (Riley et al. 2014), both of which could likely be reduced by increasing migration out of the Santa Monicas.

This report presents background on both linkages, methods on how wildlife crossing points for each freeway were evaluated and scored through an expert review process and landscape evaluation, and summary results for each crossing point that was evaluated.

2. METHODS

The general areas of evaluation for the potential placement of wildlife crossing infrastructure for the I-15 and 101 Freeways were based on the local landscape configuration and detailed linkage assessments completed by South Coast Wildlands (Penrod et al. 2006, South Coast Wildlands 2008), and were further informed by wildlife movement studies and modelling efforts (Gibbons 2008, Tracey and Crooks 2011, Zeller et al 2015, Zeller et al. 2017a, Zeller et al. 2017b, Huber unpublished data).
Specific sites that were evaluated for the placement of wildlife crossing infrastructure along both freeways were identified using several parameters that indicate likely or at least potential use by wildlife if adequate crossing structures were present.

Parameters utilized for initial identification of potential crossing points for evaluation were:

1. Current presence of suitable habitat or pathways that could be restored to wild habitat on both sides of the potential crossing;
2. Evidence from GPS or radio tracking, camera traps, or other methods, of close approaches of mountain lions or other carnivores (e.g., bobcats and coyotes) to the freeway at that location;

3. Indication in movement or corridor models that mountain lions and other wildlife are likely to approach or cross the roadway at that point;
4. Documented crossing by mountain lions or other wildlife at that location previously (either through existing structures or at grade);
5. Occurrence of mountain lion mortalities from roadkill at that location.

Scoring of each location for ranking purposes was accomplished by use of two methods, with equal weight in final rankings assigned to each method.

Method 1: Expert Opinion

The following connectivity experts were assembled in January 2015 for a three-day workshop aimed at discussing, evaluating, and ranking locations and designs for infrastructure to improve connectivity (undercrossings, overcrossings, fencing, etc.) for the I-15 and 101 Freeways.

- Dr. Paul Beier, with Northern Arizona University, is a professor of wildlife biology who is widely recognized as one of the nation's leading experts on habitat connectivity and the design of wildlife corridors. He has studied the movements of mountain lions in southern California, has published numerous journal articles on designing, conserving, and managing functional corridors in urbanizing areas, and is the founder of CorridorDesign.org.
- Dr. Anthony Clevenger is a senior research scientist at the Western Transportation Institute, Montana State University who has been studying road effects on wildlife populations in Banff and the surrounding national and provincial parks in the Canadian Rocky Mountains since 1996. During his 20+ years of research, Dr. Clevenger's interests have been broad and ecologically based, but have been weighted towards the ecological effects of roads and the conservation of small remnant populations of carnivores.
- Dr. Patricia Cramer is a Research Assistant Professor at Utah State University. Her research focuses on transportation ecology, wildlife connectivity, and carnivore and ungulate movement. She is nationally renowned advocate for wildlife crossings, and has conducted extensive evaluation of wildlife crossing structures throughout North America and developed recommendations for their construction.
- Julia Kintsch is an ecologist specializing in conservation planning, road ecology, large landscape conservation, and collaborative problem-solving. She is recognized across North America as an expert in wildlife crossing siting and design, offering a unique understanding of the features that influence successful passage for species ranging from salamanders to deer to the elusive Canada lynx. Following an active career working for non-profit organizations such as the Nature Conservancy, Southern Rockies Ecosystem Project, and Freedom to Roam, she launched ECO-resolutions LLC in 2008.
- Dr. Patrick Huber is a Project Scientist with the Information Center for the Environment at the University of California, Davis. He earned a Ph.D. in geography at UC Davis and wrote his dissertation on spatial scale and conservation planning. His work focuses on conservation planning, landscape connectivity, and reserve design primarily in California.
- Kathy Zeller earned a PhD in Environmental Conservation at the University of Massachusetts. Her research is focused on designing wildlife corridors, modeled across a resistance-to-movement surface where the landscape is quantified in terms of the difficulty different landscape features pose to a moving organism. Her work includes methodological comparisons

for estimating resistance to movement and modeling corridors, using data from mountain lions in southern California and black bears in northern Idaho.

- Kelsey Stricker earned her Master's degree studying road impacts on wildlife along I-15 by utilizing remote camera arrays. She lives in the area and is the lead biologist for the Pechanga Tribe, a major landowner in the vicinity of the Santa Ana to Palomar Mountains Linkage.

The panel of experts was provided with available information relating to both linkage areas (aerial photos, maps, adjacent land conservation status, existing locations of culverts and bridges, data on crossing point use, modeling results, wildlife movement data) and participated in day-long field tours of each linkage area to evaluate various sites for the potential placement of connectivity structures. Field tours were then followed on the third day by an all-day workshop to discuss and rank sites and options for connectivity structures for each linkage. At this workshop, the experts were joined by transportation planners, wildlife agency representatives, and various local connectivity experts who have been involved in past assessments of wildlife connectivity status and options at these locations.

During the all-day workshop, the invited experts were asked to rank the crossing point locations, and in many cases expressed their opinions relating to the likely best types of structures that could be utilized at those locations. These expert opinions are noted in the report, however determining the most feasible or best type of structure that could be utilized at any crossing point was beyond the level of engineering expertise that was present at the workshop. Thus, this report is primarily focused on relating the ranking of crossing point locations and the type of structure, with specific structure feasibility assessments to occur in the future.

Rankings were converted into a point system that assigned a point score of 3 to each expert's first choice, a score of 2 to their second choice, and a score of 1 to their third choice. For the Santa Ana to Palomar Mountains I-15 Linkage crossing point assessments, some experts ranked more than one crossing point identically. In that case, both crossing points were given the same point score. Expert scores were then rescaled to a maximum score of 5 before combination with the Landscape scores (also scaled to 5).

Method 2: Assessment of Landscape Characteristics and Wildlife Use

In this method, points were assigned to each wildlife crossing location based on important characteristics that were scored categorically (Table 1). Possible points for each characteristic ranged from 0-1 based on the strength of that characteristic at the site. In some instances, fractional scores were given to reflect partial satisfaction of the listed condition (e.g., for Landscape pattern - broad scale, if connectivity was present in 3 of 4 directions, this would generate a score of 0.75). The maximum number of points attainable by any individual site was 5. Rankings from each method were then added together for a composite total score (maximum score of 10) which were used to determine overall rankings.

Table 1. Attributes used for Landscape scoring of crossing points in both linkage areas.

Attribute	**Score Guide**
1. Evidence of mountain lion use	
Confirmed crossing or roadkill, or close approach both sides	1
Approach within 100 meters (close approach) - either side	0.66
Approach within 500 meters (medium approach) - either side	0.33
No known approaches	0
2. Landscape pattern - broad scale *What is the overall landscape connectivity like, i.e., can animals effectively reach the vicinity of the crossing point?*	
Both sides have good connectivity	1
One side has good connectivity	0.50
Neither side has good connectivity	0
3. Landscape pattern - fine scale *Is the landscape in the immediate vicinity of the crossing conducive to wildlife movement - all the way to the crossing structure or freeway edge itself?*	
Both sides conducive to animals getting to and through the crossing	1
One side conducive to animals getting to and through the crossing	0.50
Neither side conducive	0
4. Land securement - broad scale *Is land generally continuously protected in larger blocks within 1 km of site?*	
Both sides protected	1
One side protected	0.50
Neither side protected	0
5. Land securement - fine scale *Is land protected leading to the crossing point from larger blocks of habitat, and at the crossing?*	
Both sides protected	1
One side protected	0.50
Neither side protected	0

3. RESULTS

Results are presented separately for each linkage. Background information on each linkage is followed by assessments of each crossing point, briefly in this section and then in more detail in the Appendices (Appendix A for Santa Ana to Palomar Mountains Interstate 15 Linkage, and Appendix B for Santa Monica to Sierra Madre Mountains 101 Freeway Linkage). Assessments for each crossing point include a summary of existing conditions related to habitat, conservation status, documented wildlife use, threats, and existing crossing structures. Assessments are then followed by a summary of the overall results based on the combination of the Expert and Landscape scores.

Note: Statements in this report regarding the potential for constructing various types of structures at each site are based on previous publications and discussions with wildlife agency personnel, other stakeholders and experts, and, in the case of the 101 Freeway crossings, preliminary engineering studies. To the authors' knowledge, no detailed engineering studies have been conducted relating to the I-15 sites to ascertain viability or costs of any options mentioned.

There are some general characteristics of successful wildlife crossings (Clevenger and Huijser, 2011; Vickers unpublished data) that have helped to inform the recommendations in this report:

1. Undercrossings that are intended to accommodate mule deer movement are generally larger than those required for most other wild species. Frequently crossings intended or with the potential for wildlife use may be judged on their "openness," which refers to the size of the opening relative to the length of the crossing, and specifically by the "openness ratio", arrived at by multiplying width times height in meters, and dividing by length in meters [(Height s x Width) / Length]. For ungulates in general, and mule deer specifically, the shorter and wider the structure the more likely mule deer are to use it. Although there is certainly variability between sites, between species, and even within species, previous research has indicated that an openness ratio of 0.6 m or greater is preferred; however, landscape character, adaptations to the highway, width relative to height, and other factors may be more important (Kitsch and Cramer 2011). This generally requires a bridge-type structure to carry the highway above the crossing, or a large arch culvert. Mule deer have been documented using arch-type culverts with lower openness ratios (0.25 – 0.3m) in situations where the terrain favors extensive deer use of the approaches to the structure (Vickers unpublished data), thus terrain modification near the crossing end points might allow for a somewhat smaller structure. In a study of 15 freeway crossings in the Santa Monica Mountains area (Ng et al. 2004), the two crossings with significant deer use were wide bridges with openness ratios of 5.2 (15 crossings) and 4.1 (9 crossings); one tunnel with a ratio of 0.37 but good natural vegetation on both sides had two crossings.

   Some proposals for enhancing connectivity have proposed a 4m round "jack and bore" culvert as the solution for the need for new crossings. For the 101 Freeway, tunnel length would likely be close to 100m, resulting in an openness ratio of 0.13m for a 4m diameter opening, less than 1/4 of the recommended value, making it not suitable for mule deer. Tunnel length for I-15 would vary depending on the site.

2. As in almost all effective wildlife crossing structures, animals must be able to see through the structure to the opposite end and the habitat cover at both ends needs to promote wildlife movement by the full range of species expected to use the structure. Arch culverts also allow for

the placement of internal structural components such as rocks, shelves, or water features that can effectively promote the movement of small rodents, reptiles, amphibians, etc. through the structure.

3. Mountain lions and other wildlife have been documented using round culvert structures that are smaller (~4 meters in diameter) than that required by mule deer (Clevenger and Waltho 2005, Kintsch and Cramer 2011, W. Vickers unpublished data). Thus, discussions of undercrossing designs and costs need to take these two different parameters into account, and the determination should be made early in the process whether connectivity for mule deer and other smaller species with more specific needs should be assured for any new or modified crossing structure to be judged successful.

4. In general, overcrossings for wildlife have several characteristics that are expected to enhance their use by a wider range of species than culverts. They are typically wide (50m or more), contain vegetation and natural substrates, have vegetation structure that accommodates the movement tendencies of multiple species, have structural elements that block sound and light from the roadway below, and incorporate modifications to the landscape and vegetation on the approaches that assist in funneling wildlife to the structure entrances.

5. In addition, high fencing (preferably 3- to 3.7-meter (10 – 12 ft.) high chain-link, buried to prevent animals digging underneath, and with barbed-wire outriggers) should be installed for long distances (up to a mile or more) in both directions along both sides of the roadway to funnel wildlife to any new or improved crossing structure (Huijser et al. 2016). This design is expected to minimize the likelihood of mountain lions, mule deer, and most of the smaller carnivores entering the roadway. Fencing of different designs and as low as 2.4 meter (8 ft.), such as "webwire" fencing without outriggers or burial, would be expected to restrict mule deer entrance to the highway but not mountain lions, smaller carnivores, or other wildlife.

Santa Ana to Palomar Mountains Linkage: Assessments of Interstate 15 Crossing Points

The Santa Ana to Palomar Mountains Linkage connects the Santa Ana Mountains and adjoining coastal lowlands with the Palomar Mountains and other inland portions of the Peninsular ranges primarily in San Diego County. The Santa Ana Mountains include over 120,000 hectares of protected chaparral, coastal sage scrub, grasslands, vernal pools, and oak and riparian woodlands. Lands that are protected as wildlife habitat are owned or managed by various public agencies including the National Forest Service, Department of Defense, California State Parks, the Counties of Orange, Riverside, and San Diego, San Diego State University, California Department of Fish and Wildlife, and a variety of water districts, non-profit entities, and others. The linkage has been studied by wildlife biologists for over 25 years and is widely recognized as critical for maintaining biodiversity in the Santa Ana Mountains, as it is the last option for securing connectivity between this coastal range and larger intact natural lands to the east (Figure 2). The linkage is necessary to maintain ecological processes and genetic diversity in the Santa Ana Mountains as they become more degraded and fragmented by development.

In practical terms, urban, rural, and agricultural development have limited the potential I-15 crossing area to an approximately 10-kilometer-long (6-mile) stretch of I-15 south of Temecula where wildlands and agricultural lands are present on both sides of the freeway (Figure 2; Luke et al 2004). The only

exception to this generalization is that, further south, the bridge over the San Luis Rey River provides safe passage for wildlife under I-15, but for mountain lions, an east to west crossing at that location requires that they follow the San Luis Rey River west through the cities of Fallbrook, Bonsall, San Luis Rey, Oceanside, and developed portions of Marine Base Camp Pendleton before reaching wild areas of the Santa Ana Mountains to the north of Oceanside. Thus, this pathway is not one that is expected to support regular movement of mountain lions in and out of the Santa Ana Mountains.

Urban and rural development remain a threat to what remains of the linkage, and I-15 and associated development, as well as secondary roads, have formed an apparent partial or complete barrier to east-west movement for wildlife and plants. One secondary road of concern is Rainbow Canyon Rd (Old Hwy 395), which runs parallel to the I-15 Freeway and is a lesser but likely significant barrier to wildlife movement that needs to be addressed as part of linkage planning.

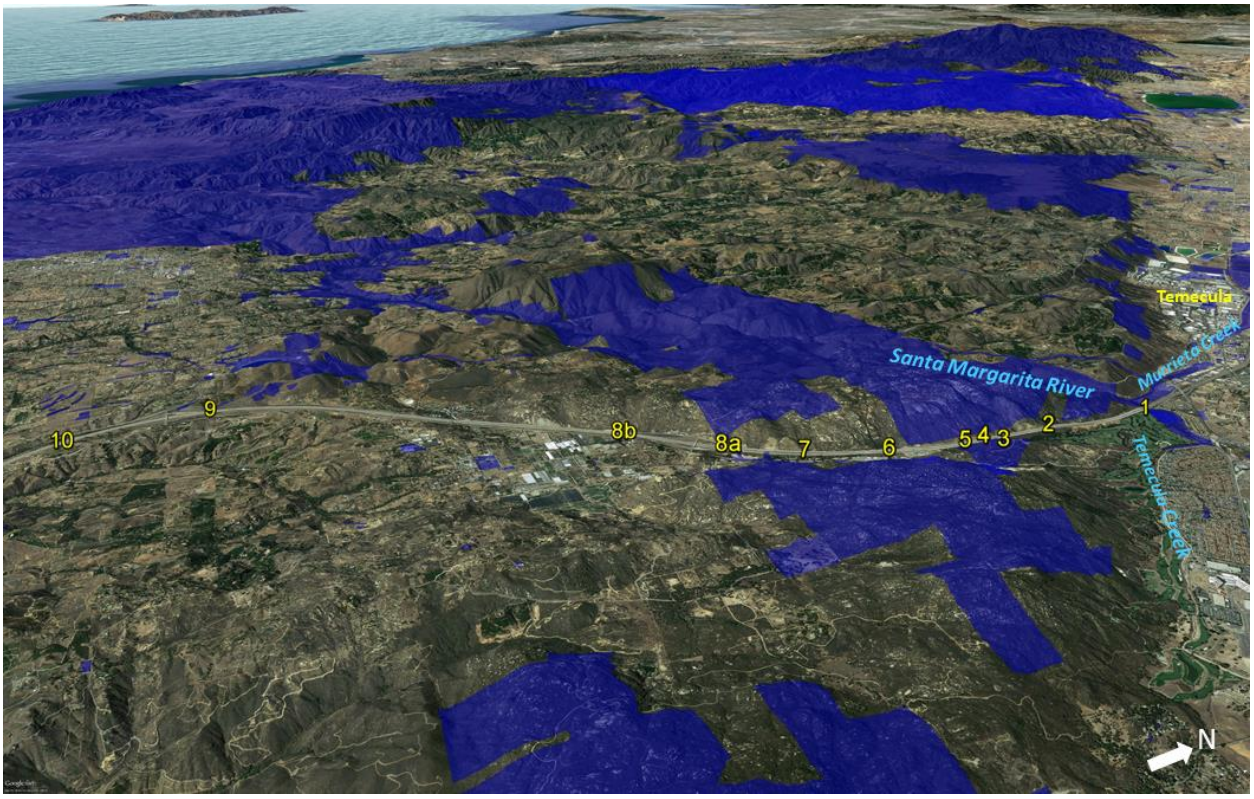
Two extensive mountain lion studies have been conducted in the region, both of which included multiple radio-collared and GPS-collared animals circulating in the Santa Ana to Palomar Mountains Linkage (Beier and Barrett 1993, Vickers et al. 2015). Mountain lion GPS points from the Vickers et al. (2015) study are depicted in Figure 2. In the Beier and Barrett study period, only two mountain lions were documented to have crossed I-15 (both west to east). In the Vickers, et al. (2015) study, only one GPS-collared animal was documented to have crossed the freeway (west to east. Based on that genetic analysis (Ernest et al. 2014), that animal (M86) did reproduce, potentially enhancing the gene pool in the Santa Ana Mountains lion population; however, few of his probable offspring have survived as of late 2016 in the population, and M86 was killed by a vehicle strike (Vickers and Boyce unpublished data). Genetic analyses from 146 sampled pumas indicate that seven pumas crossed I-15 over the last 15 years, including four males from west to east, and three males from east to west (Gustafson et al. 2017). Vickers et al. (2015) demonstrated that survival rates in the Santa Ana Mountains are lower than in most other mountain lion populations throughout the west, compounding the threat posed to the Santa Ana Mountain's population by genetic isolation.

At least five separate modelling efforts have been performed using available data (landscape and vegetation characteristics, existing culvert and bridge locations, and mountain lion movement data) to determine the best locations for wildlife crossing structures in the approximately 10-kilometer section of I-15 south of Temecula (Tracey and Crooks 2001, Gibbons 2008, Zeller et al. 2015, Zeller et al. 2017b, Huber unpublished data). These modelling efforts have indicated that several different locations have potential as sites for new or improved wildlife crossing structures. However, no consensus crossing point locations have emerged from these models, or from discussions between local wildlife agency personnel, county conservation agency personnel, other governmental representatives, and conservationists.

Crossing Point Assessments – Santa Ana to Palomar Mountains I-15 Linkage

A total of eleven potential crossings points along the roughly 10-kilometer (6-mile) segment of I-15 south of Temecula were evaluated as part of this project (Figure 3). Four of the eleven sites (Sites 8a, 8b, 9 and 10) were determined to be too highly constrained by existing development to be considered during the evaluation process. These four sites all received Landscape Scores (Table 3), but none were ranked by the experts as first, second, or third choices, possibly because of the extensive agricultural and human development on both sides of the freeway at those sites. Thus, those sites' scores were lower than any of the first seven sites described, and they are not described in depth in Appendix A, though more detailed maps of these sites are included there.

Figure 4. Eleven potential wildlife crossing points (1-8a,8b-10) along a 10-km (6-mile) stretch of I-15 in the Santa Ana to Palomar Mountains. Conserved lands are depicted in dark blue. View depicted is looking from the Palomar Mountains northwest to the Santa Ana Range with the Pacific Ocean to the west in the upper left corner.



Appendix A contains detailed information about each of the evaluated crossing points for the Santa Ana to Palomar Mountains I-15 Linkage, including: 1) a summary of existing conditions related to habitat, conservation status, documented wildlife use, threats, and existing crossing structures, if present, 2) Landscape Scores for the crossing based on available information about landscape structure and wildlife use, and 3) Expert Scores based on the experts' rankings of the location as a crossing.

Brief Crossing Point Site Descriptions and Scoring Results – Santa Ana to Palomar Mountains Interstate 15 Linkage

Site 1: Temecula Creek Bridge: This site is at the northern end of the linkage and consists of two separate span bridges for the north and south-bound traffic lanes of I-15. The bridge crosses over Temecula Creek, and each span is roughly 22 meters wide with a 15-meter separation between spans (60 meters total width). The bridge length is approximately 75 meters and the height is approximately 15 meters. Protected open space is located on either side of the bridge; however, proposed development threatens both the west and east side of this crossing. Residential uses and a civic use are proposed on a 76-hectare site just north of the west side of the bridge. In its current state, Site 1 received a Landscape Score of 4.25 out of 5 and an Experts' Score of 2.78, and ranked as the second highest priority crossing point location.

Note: Sites 2 through 4 all have steep up-slopes on the west side of the highway and downslopes on the east. All culverts noted as pre-existing are steeply sloped on their eastern ends making them unsuitable currently for regular wildlife use. It was beyond the expertise level of the group in this workshop to evaluate engineering factors that would determine whether any type of undercrossing could be constructed at these sites that would be adequately horizontal to allow for wildlife use.

Site 2: This site is the location of an existing 2m diameter culvert that drains from the west side of I-15 to the east. Intact but unprotected chaparral habitat is found on the west side of the freeway, while oak woodland and golf course development are found on the east side of the freeway at the base of the lightly vegetated downslope. Site 2 received a Landscape Score of 2.91 and an Experts' Score of 0.37 and ranked seventh overall.

Site 3: This site currently has a 2m culvert that drains west to east with intact chaparral habitat on both sides of the freeway. The property on the west side of the crossing point is currently being pursued for conservation, while the property on the east side of the culvert has been recently acquired for conservation. Site 3 received a Landscape Score of 3.33 and an Experts' Score of 1.67 and ranked fourth overall.

Site 4: This site has a 1.5m diameter culvert that drains from west to east across I-15. The west side is composed of an oak-lined drainage that is part of the Santa Margarita Ecological Reserve, while the east side of the culvert drains into intact chaparral habitat that was recently acquired for conservation. Site 4 received a Landscape Score of 3.83 and an Experts' Score of 2.59 and ranked third overall.

Site 5: This site is composed of a steep up-slope of varying height (approximately 15 - 30 meters) on both sides of the highway. The west side of the highway is protected habitat that is part of the Santa Margarita Ecological Reserve and supports rock outcrops and chaparral habitat. The east side is intact chaparral habitat that was recently acquired for conservation. Site 5 received a Landscape score of 5.0 and an Experts' score of 4.07 and was ranked as the highest priority location for a crossing structure, with the assumption by the experts that a wildlife bridge was the only type of structure that could be feasibly placed at that location.

Site 6: On the west side of I-15 at this site there are several small gullies with intact but unprotected chaparral, rock outcrops, and small oak trees. The east side includes a lightly vegetated down-slope that extends below the highway edge, and an adjoining open lot containing mixed native and non-native vegetation that is approximately 100 x 120 meters in size and bordered by commercial lots to the north and south and Rainbow Canyon Road to the east. The U.S. Border Patrol has a check station with off-ramp just north of the site where extensive light and human activity are present 24 hours a day. Site 6 received a Landscape Score of 2.33 and an Experts' Score of 0.74 and ranked sixth overall.

Site 7: The west side of I-15 at this location is a steep rocky up-slope adjoining a small canyon with intact chaparral, rock outcrops, and small oak trees. The east side includes a sparsely vegetated down-slope that extends below the highway edge and adjoins an open lot that is approximately 150 x 150 meters in size with scattered small buildings at the edge. This lot is bordered by commercial lots to the north and south and Rainbow Canyon Road to the east. Site 7 received a Landscape Score of 3.25 and an Experts' Score of 0.74 and ranked fifth overall.

Sites 8a, 8b, 9, and 10: These sites are all located along I-15 south of Site 7. All sites received Landscape Scores (Table 3), but none were ranked by the experts as first, second, or third choices because of the

extensive agricultural and human development on both sides of the freeway at these sites. Thus, the scores for these three sites were lower than any of the first seven sites described, and they are not described in depth in Appendix A, though more detailed maps of these sites are included there.

Table 2. Expert scores by crossing point in the Santa Ana to Palomar Mountains I-15 Linkage

Expert	**Expert Scores by Site**										
	Site1	**Site2**	**Site3**	**Site4**	**Site5**	**Site6**	**Site7**	**Site 8a**	**Site 8b**	**Site9**	**Site 10**
Paul Beier	1		2	2	3						
Patty Cramer	3		2	2	2	1	1				
Kathy Zeller	1		3	2	2						
Patrick Huber	2				3						
Julia Kintsch	1		2	2	3						
Tony Clevenger	2				3						
Kelsey Stricker	1	2				3	3				
Seth Riley	2			3	3						
Christy Brigham	2			3	3						
Cumulative scores unweighted	15	2	9	14	22	4	4	0	0	0	0
Cumulative scores normalized to scale of 0-5	2.78	0.37	1.67	2.59	4.07	0.74	0.74	0	0	0	0

Table 3. Landscape and Combined Expert-Landscape scores by crossing point in the Santa Ana to Palomar Mountains I-15 Linkage

Scoring components	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8a	Site 8b	Site 9	Site 10
1. Evidence of mountain lion or other wildlife use	1	0.66	0.33	0.33	1	1	1	1.0	1	0.33	0
2. Landscape pattern - broad scale	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.50	0.50	0.75	0.75
3. Landscape pattern - fine scale	0.75	0.75	1	1	1	0.50	0.75	0.50	0.50	0.75	0.75
4. Land securement - broad scale	0.75	0.75	0.75	0.75	0.75	0.75	0.75	.75.	0.50	0	0
5. Land securement - fine scale	1	0	0.50	1.0	1.0	0	0	0.50	0.50	0	0
Total landscape scores (0-5)	4.25	2.91	3.33	3.83	4.50	3.00	3.25	3.25	3.00	1.83	1.50
Expert Scores (from Table 2)	2.78	0.37	1.67	2.59	4.07	0.74	0.74	0	0	0	0
Total score (expert plus landscape, 0-10)	7.03	3.28	5.0	6.42	8.57	3.74	3.99	3.25	3.00	1.83	1.5
Overall rank	**2**	**7**	**4**	**3**	**1**	**6**	**5**	**8**	**9**	**10**	**11**

Summary of Results – Santa Ana to Palomar Mountains Interstate 15 Linkage

Site 5 ranked highest in the expert scoring with 6 out of 9 experts selecting it as the highest priority, and a wildlife bridge structure at this site was considered by the experts to be the most functional for the widest array of wildlife and plant species, including mountain lions and deer. Both the location and wildlife bridge concept are consistent with previous studies (Beier and Barrett 1993, Fisher and Crooks 2001, Luke et al. 2004). This site ranked first in the landscape scoring. The exact location where a bridge structure would be placed in the stretch of the freeway encompassed by Site 5 would be dependent on engineering feasibility studies.

All experts ranked Site 1, Temecula Creek Bridge, as one of the top three crossing point locations; however, eight of the nine experts ranked this site as second or third priority, with only one expert ranking it as the highest priority location. Experts pointed to the fact that this site currently has the highest existing potential for wildlife movement, but has significant challenges to its proper function due to road noise and human presence. They felt that road noise and human disturbances could be sufficiently mitigated to increase this location's functionality for species such as mountain lions and deer. Recommended improvements include substantial reduction of sound and light pollution from traffic crossing the bridge, removal of lighting at the pump station on the west side of the bridge, prohibition of human presence under the bridge and in the creek bed at night, prohibition of further human development and nighttime activity on the Temecula Creek golf course and near the confluence of Temecula and Murrieta creeks and the Santa Margarita River on the west side of the bridge. In addition, experts agreed that increased native vegetative cover should be established on the golf course to promote the use of the site by deer and other wildlife. Even if the proposed residential development moves forward, the experts felt that this crossing could still function for medium-sized carnivores, smaller wildlife and plants, but its function for mountain lions and mule deer would be further degraded.

Site 4 ranked third overall in the cumulative Landscape and Experts' score; however, like Site 5, making this crossing site functional would necessitate construction of a new structure. The experts were equally divided on whether the crossing structure for this location should be an overpass or an underpass.

Site 3, previously suggested by some county staff and wildlife agency personnel as a possible location for an underpass to accommodate mountain lions and medium-sized carnivores, ranked fourth overall, and was a second or third priority for four of the nine experts.

Sites 2, 6, and 7 ranked similarly low in the expert scoring, each only receiving one vote as a first, second or third priority, though site 7 ranked fifth overall due to the occurrence of two puma roadkills at that location, confirming as at some other sites that pumas would potentially use a crossing if constructed at that location.

Sites 8a, 8b, 9, and 10 did not receive any support from the experts, although 8a and 8b both had puma roadkill occur very near their locations. Due to the lack of support from the experts, the cumulative score for each of these crossing points were very low.

Discussion – Santa Ana to Palomar Mountains Interstate 15 Linkage

Overall, when combined, the Expert and Landscape scores for the Santa Ana to Palomar Mountains I-15 Linkage support Site 5 as the highest priority location for the placement of a ***new wildlife crossing structure***.

However, Site 1, Temecula Creek Bridge, received the second highest Landscape Score ***in its current state*** based on existing landscape structure and evidence of use by many species including those requiring water for connectivity, and it placed second in overall scoring. It was also recognized as the only site of the 11 evaluated that currently functions for any significant wildlife movement, and that function is threatened by a development proposal recently approved by the City of Temecula. It was also the site that the experts felt had the most economic viability with regards to near term improvement.

Sites 4 and 3 were the next highest ranked crossing sites, but like Site 5, both ***would require construction of a new crossing structure*** (either over or under crossing) to become viable wildlife crossings. It is notable that sites 3, 4, and 5 all lie within a short (~0.3 mi) section of I-15 and have similar vegetation structure on either side of the freeway, and similar large-scale connectivity potential. Because landscape structure does not favor one over the other enough to rule either of the others out, if funding for a new structure becomes feasible, the ultimate choice between these three may rest most strongly on engineering factors and whether the land is conserved where any new crossing structure would have its end points.

The expert consensus was that ***more than one structure should be constructed or enhanced*** to provide the best potential for improved connectivity for a variety of wildlife species. Relying on only one highway crossing structure to provide adequate connectivity, especially for a wide range of species, between two entire mountain ranges, was regarded by the experts as risky and likely to fail. Thus, ***retention and enhancement of function of the Temecula Bridge is indicated even if a new wildlife structure may someday be built at Site 3, 4, or 5.***

Additional measures recommended by the experts for any new or improved wildlife crossing structures include: 1) wildlife fencing along both sides of I-15 to help funnel wildlife to the crossing structures (Huijser et al. 2016), 2) habitat modification of dense chaparral slopes on either side of the roadway, such as the construction of wildlife trails, to facilitate wildlife movement through the habitat to a new or improved structure, and 3) construction of an additional wildlife crossing structure across Rainbow Canyon Road, a busy secondary road to the east of I-15.

The crossing point rankings and the recommendation for more than one crossing structure are consistent with the findings of local experts who have evaluated crossing options over the last 25 years. In the last five years, local agencies and experts have prioritized a wildlife undercrossing structure at Site 3, and a wildlife overpass at Site 5. Although a wildlife overpass is viewed by local experts as the best option to serve the widest variety of species, local government agencies have generally expressed greater interest in an undercrossing due to a lower perceived expense. However, relative expense levels have not yet been determined via engineering studies, and we urge that such studies be done in order that informed decisions may be made on this question.

Santa Monica to Sierra Madre Mountains Linkage: Assessments of Crossing Points for the 101 Freeway

Santa Monica Mountains National Recreation Area (SMMNRA) is the largest urban national park in the country. Its 150,000 acres of mountains and coastline in Los Angeles and Ventura counties are a network of local, state, and federal parks interspersed with private lands and communities. SMMNRA is part of a globally rare Mediterranean ecosystem that is exceptionally biodiverse, with more than 450 animal species and 84 distinct plant alliances.

The Santa Monica Mountains, which run east-west to the north of Malibu, to the west of the Los Angeles Basin, and to the south of the San Fernando and Conejo Valleys, are substantially cut off from other large natural areas to the north by the 101 Freeway. This freeway is 8-10 lanes and receives very heavy traffic: it is one of the busiest freeways in the world, and in fact the 101-405 Freeway interchange (about 19 kilometers, or 12 miles to the East of the study area) is the second most trafficked in the entire country. As a national park in the Los Angeles area, at Santa Monica Mountains National Recreation Area the National Park Service has always been interested in and concerned about the effects of urbanization and habitat fragmentation on natural resources, including wildlife populations, particularly for wide-ranging species such as mammalian carnivores.

For more than two decades, the park, along with other partner agencies in the region such as the Santa Monica Mountains Conservancy and California State Parks, has been concerned about habitat connectivity between the Santa Monica Mountains and other remaining natural areas in the region. These and other agencies and groups have worked hard and spent millions of dollars in land acquisition money to strategically acquire and conserve land near the 101 Freeway, especially in the Liberty Canyon area in Agoura Hills. It was easy to see from the beginning of these efforts, and it is easy to see on any current map of the region, that the Agoura Hills-Calabasas grade area, specifically from Palo Comado Canyon Rd. to Mureau Rd., is one of the last areas where wildlife connectivity would be possible across the 101 Freeway (Figure 3). This area is one of the few remaining places along the Freeway where there is natural habitat adjacent to it on both sides. Planners did not consider the connectivity needs of wildlife when it was built in this area in 1949, or in the ensuing decades, and thus there is urban development along the 101 Freeway throughout the San Fernando and Conejo Valleys. The one other place in the Santa Monica Mountains where there is remaining natural habitat on both sides of the road is in the Conejo Grade area, just east of Camarillo. This area is less desirable for a wildlife crossing primarily because north of the Freeway, connectivity to other large natural areas is seriously compromised by roads and development. This area is also at the far western end of the Santa Monica Mountains, making it less accessible to as many animals as areas in the middle of the Mountains. However, two sub-adult mountain lions did cross the 101 Freeway in the Conejo Grade area in 2015 (National Park Service, unpublished data). Multiple crossings and connectivity in multiple areas are both generally desirable, so creating a safe wildlife crossing in this area in the future would be optimal.

The consensus maps developed as part of the South Coast Wildlands Linkage Design show the 101 Freeway crossing near the Agoura Hills-Calabasas grade area as the best location for providing connectivity for multiple species (Penrod et al. 2006). Starting in 2011, multiple agencies in the region formed the Linkage Implementation Alliance (LIA) to develop and coordinate efforts to turn the linkage maps into conservation reality through land acquisition, easements, education, etc. This group continues to meet quarterly.

In 1996, the park began studies of mammalian carnivores, specifically bobcats and coyotes and later (in 2002) mountain lions as well, to better understand wildlife movement in the area and the effects of the major barrier of the 101 Freeway. These studies have found that while carnivores can and sometimes do use developed areas, they largely use remaining natural areas, subsist on natural foods, and are subject to regular mortality from anthropogenic sources such as vehicles and toxicants (Riley et al. 2003, Riley et al. 2007, Riley et al. 2010, Gehrt and Riley 2010, Beier et al. 2010). The 101 Freeway was found to be a major barrier to movement for all three species, and in fact was also found to be a barrier to gene flow, such that significant genetic differentiation was present across it (Riley et al. 2006, Riley et al. 2014, Serieys et al. 2015). For mountain lions, the barrier effects of 101, along with other freeways in the region such as 405 and 5, are particularly severe. Genetic diversity for Santa Monica mountain lions is very low (Riley et al. 2014), lower than has been measured anywhere else in the west and like that in the isolated Santa Ana Mountains population (Ernest et al. 2014). The barrier effects of the freeway are also likely contributing to close inbreeding between relatives (e.g., fathers and daughters) and potentially to increased mortality from intraspecific strife (adult males killing subadult males and females, and even an adult female) because of the severely restricted dispersal of subadults out of the Santa Monicas (Riley et al. 2014). A recent population viability model incorporating both demographic and genetic factors predicted a continued steep decline in genetic diversity, leading to likely quick extinction once inbreeding depression compounds the effects of the already small population (Benson et al. 2016). The model found that even modest increases in immigration greatly ameliorated both demographic and genetic problems. Finally, research on smaller, less mobile species has also documented the genetic effects of roads and urban development. Specifically, significant genetic differentiation related to habitat fragmentation was found for three different lizard species, western fence lizards, side-blotched lizards, and western skinks, as well as for a common chaparral bird, wrentits (Delaney et al. 2010).

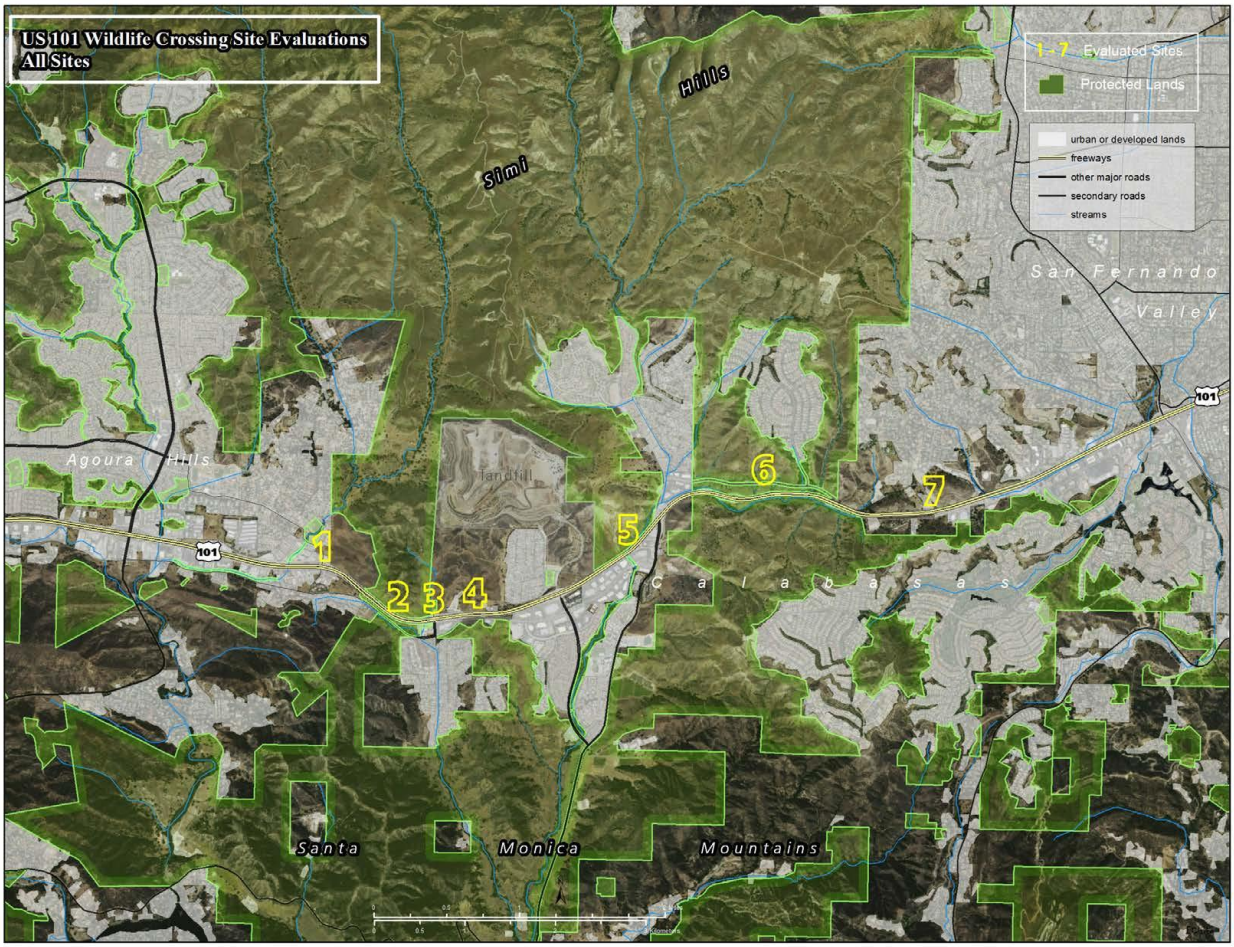
Overall, the mandate of the National Park Service, and the goal of the other open space agencies in the region, is to preserve the natural populations and communities present in the Santa Monica Mountains and the surrounding region as much as possible. The 101 Freeway, and the massive interruption in connectivity that it represents, is a significant impediment to this goal. Connectivity between natural areas is critical for all components of the natural communities, especially for wide-ranging species such as mountain lions or mule deer, but for all species of plants and animals as well. Over the long-term, we cannot hope to have naturally functioning ecosystems without increasing the effective connections between the Santa Monica Mountains and other natural areas to the north. Therefore, it has been a high priority to establish more connectivity across the 101 freeway for wild populations, particularly for wide-ranging animal species. Multiple agencies in the region, including the National Park Service, Caltrans, SMMC/MRCA, California State Parks, and others have been working towards this goal for more than two decades.

Specifically, for this workshop, the goal was to bring in experts who had experience with wildlife connectivity and road challenges around the country and the world, and to obtain their input on our situation here with the 101 Freeway and connecting the Santa Monicas to other protected areas to the north. In this report, the goal was also to integrate landscape information and current wildlife knowledge with the expert opinion to provide the fullest picture of the challenges and potential solutions.

Crossing Point Assessments – Santa Monica to Sierra Madre Mountains 101 Freeway Linkage

A total of seven potential wildlife crossing points along a 9.5-kilometer (5.9-mile) stretch of the 101 Freeway in the Agoura Hills-Calabasas area were evaluated as part of this analysis (Figure 5). A brief description of each of these potential crossing points is presented below.

Figure 5. Seven potential wildlife crossing points along a 9.5 km (5.9 mile) stretch of the 101 Freeway in the Agoura Hills-Calabasas area of the Santa Monica to Sierra Madre Mountains Linkage.



Appendix B provides more detailed information about each crossing location, including: 1) a summary of existing conditions related to habitat, conservation status, documented wildlife use, threats, and existing crossing structures, if present; 2) Landscape Scores for the location based on existing data related to landscape conservation status and wildlife use, particularly for mountain lions, and 3) Expert Scores based on their rankings of the crossing locations.

Brief Crossing Point Site Descriptions and Scoring Results – Santa Monica to Sierra Madre Mountains 101 Freeway Linkage

Site 1: Palo Comado Canyon Road Bridge. This farthest west site is a bridge for a two-lane paved road that receives moderate vehicle use, including entering and exiting freeway traffic. The bridge is immediately adjacent to residential development on both sides, although at the broader scale there is protected open space in three of four directions. The site received a Landscape score of 1.25 (6th) and a 0 from the experts, for a total score of 1.25 out of 10 (sixth overall).

Site 2: West Liberty Canyon. This site is just west of Liberty Canyon. It has natural vegetation on both sides, connects to protected open space both immediately adjacent to and farther away from the crossing location, and has extensive known use by wildlife including mountain lions and other carnivores. This was by far the best site, based on both Landscape scores (5) and Expert evaluation (5): it received a 10 out of 10 overall, while no other site had a landscape score above 3.33 or an overall score above 5.

Site 3: Liberty Canyon Road. This is the road underpass where Liberty Canyon Road passes under the freeway. It is well connected to open space on the north side, and broadly to the south, with known wildlife use. However, there is commercial development immediately adjacent on the south side, and the underpass itself is unvegetated and open with regular traffic entering and exiting the freeway. There was some underpass use by wildlife in a study from 1999-2000, but recent monitoring has found very little, despite extensive use of nearby areas by all species, including mountain lions. The overall score was 3.70, fourth out of seven.

Site 4: Agoura Road Pass. This site is east of Liberty Canyon, where there are hills rising above the freeway on both sides which could assist with overpass construction, and a mountain lion was killed on the freeway here. However, the land is not protected immediately to the north or south, and the broader connectivity is poor to the south. This site received a Landscape score of 3 (4th of 7), but was given no priority by the experts, for an overall score of 3.

Site 5: Las Virgenes Creek. This site is where Las Virgenes Creek goes under the freeway. It is a nice wide, natural underpass, with some documented use by wildlife including deer. Although it is well connected to natural and protected areas to the north, to the south the creek passes through intensive residential and commercial development for a long stretch before it connects with natural protected lands. This was the third highest ranked site for the experts, second in Landscape Score, and third overall (4.76 out of 10).

Site 6: Mureau Road Tunnels. This site includes multiple culverts for water passage in the vicinity of Mureau Rd (north of the freeway). The site is well connected and protected immediately adjacent to the crossing points, but at a broader scale there is development in some directions on both sides. There is also generally standing water on the south side of the culverts, decreasing their effectiveness. The experts felt this site had some potential (ranking second, with 1.95 out of 5), and it was second in Landscape Score at 3.08, ranking second overall (4.98 out of 10).

Site 7: Mureau Road Bridge. This is the farthest east site, another road bridge over the freeway where Mureau Road crosses it. It is one lane each way with a sidewalk on the east side and regular traffic between Hidden Hills and Agoura Hills to the north and Calabasas to the south. It is not well-connected

on either side at the fine or the broad scale, although there is some land protection to the southwest. This was the lowest ranked site by every measure, with a 0.75 out of 10 overall score.

Summary of Results – Santa Monica to Sierra Madre Mountains 101 Freeway Linkage

Overall, the results of the crossing point assessment for the 101 Freeway were very clear in terms of the best location for a new crossing structure, with the same conclusion coming from both the Expert and the Landscape Score assessments: West Liberty Canyon is the best location for a new wildlife crossing structure. As noted in the site descriptions and as is clear from Tables 4 and 5, on both sides this site has protected, natural habitat both adjacent to the freeway and farther away, and it has had known use nearby by multiple wildlife species including mountain lions and other carnivores. This site scored 5 out of 5 on the Landscape Score assessment, and was the unanimous top choice among the seven sites for the experts.

The Mureau Road culverts, Las Virgenes Creek, and Liberty Canyon Road all scored between 3.7 and 4.98 overall, reflecting some potential, but all were far behind West Liberty Canyon because of various problems. Liberty Canyon Road is an active road with traffic coming on and off the freeway, and it is completely open and unvegetated underneath the bridge. It also has development immediately adjacent to the road on the south side, both to the southeast and southwest. Recent monitoring with remote cameras has documented no confirmed crossings by wildlife in two years (through April 2017), despite detections of many species, including mountain lions, immediately adjacent to it (National Park Service, unpublished data). Las Virgenes Creek has a natural, vegetated crossing under the freeway and good direct connections to open space immediately on the north side, but to the south there is a long stretch of thin riparian vegetation through intense urban development (Fig. 5). The Mureau Road Culverts are across a major secondary road, Mureau Road, from large areas of open space, and many of them are small, dark, and have bends, so the other side is not visible. Of the two tunnels that do have line of sight all the way across, one has a large pool of standing water on the south side which would seriously impede use from either direction. All of these locations could have some value as redundant sites, especially with improvements (see below), but again, all are far inferior to the West Liberty Canyon site.

Table 4. Expert scores by crossing point for the Santa Monica to Sierra Madre 101 Freeway Linkage

Expert (Note: Expert Kathy Zeller was not able to visit this linkage)	**Expert Scores by Site**						
	Site 1 PC Canyon Road Bridge	**Site 2** West Liberty Canyon	**Site 3** Liberty Canyon Road	**Site 4** Agoura Road Pass	**Site 5** Las Virgenes Creek	**Site 6** Mureau Road Tunnels	**Site 7** Mureau Road Bridge
Paul Beier		3			1	2	
Patty Cramer		3			2		
Patrick Huber		3			2		
Julia Kintsch		3	2			1	
Tony Clevenger		3	2			1	
Winston Vickers		3				2	
Trish Smith		3			1	2	
Cumulative scores unweighted	0	21	4	0	6	8	0
Cumulative scores normalized to scale of 0-5	**0**	**5.0**	**0.95**	**0**	**1.43**	**1.90**	**0**

Table 5. Landscape and Combined Expert-Landscape scores by crossing point in the Santa Monica to Sierra Madre Mountains 101 Freeway Linkage

	Site 1 PC Canyon Road Bridge	**Site 2** West Liberty Canyon	**Site 3** Liberty Canyon Road	**Site 4** Agoura Road Pass	**Site 5** Las Virgenes Creek	**Site 6** Mureau Road Tunnels	**Site 7** Mureau Road Bridge
1. Evidence of mountain lion or other wildlife use	0	1	1	1	0.33	0.33	0
2. Landscape pattern - broad scale	0	1	0.50	0.75	1	0.75	0
3. Landscape pattern - fine scale	0.50	1	0.75	0.50	0.50	0.50	0
4. Land securement - broad scale	0	1	0.25	0.50	1	1	0.50
5. Land securement - fine scale	0.75	1	0.25	0.25	0.50	0.50	0.25
Total landscape scores (0-5)	**1.25**	**5.0**	**2.75**	**3.00**	**3.33**	**3.08**	**0.75**
Total score (expert plus landscape, 0-10)	**1.25**	**10.0**	**3.70**	**3.00**	**4.76**	**4.98**	**0.75**
Overall rank	**6**	**1**	**4**	**5**	**3**	**2**	**7**

Discussion - Santa Monica to Sierra Madre Mountains 101 Freeway Linkage

In terms of what kind of structure would be best, the consensus of the experts was that an overpass, over both 101 and Agoura Rd., at the West Liberty Canyon site would be the best solution for the most number of taxa. The experts agreed that an overpass just over the Freeway, which based on the site characteristics would need to end right next to Agoura Rd, would not be desirable because it would endanger animals coming off the structure, they would not be delivered across the road to nearby natural habitat, and it would be a bad precedent and perception both for this and future projects. Given the quality of the site, the next most effective solution would be a tunnel also at the Liberty Canyon West Site, although the tunnel also would not convey animals across Agoura Rd, south of 101. A tunnel, regardless of size, would also not be as effective for smaller species such as small mammals, reptiles, and amphibians. Both an overpass and a large tunnel were considered to likely be functional for all the medium and large mammals considered, including mountain lions and deer, although a tunnel large enough for deer under a freeway that wide (10 lanes of pavement) would pose serious engineering and traffic challenges, and therefore come at great monetary and social and political cost.

In the long run, multiple crossing structures should be available for a wide range of species to effectively cross the 101 Freeway between the Santa Monica Mountains and areas to the north. In terms of other sites, the existing Las Virgenes Creek underpass was thought to be functional for some species, including deer, smaller vertebrates, and aquatic species such as amphibians, since it has permanent water. However, though the area north of the freeway is natural and protected, connectivity south of the freeway is limited by the thin vegetated corridor that is surrounded by development for several hundred meters. In the past, the presence of invasive aquatic species, specifically crayfish, made this crossing less ideal for native aquatic species, although recent extensive efforts to remove crayfish in Las Virgenes Creek have reduced this concern. The second-best site in terms of expert opinion and total score was the Mureau Road Tunnels. This site is well connected to protected natural habitat near the Freeway, has some connectivity farther away, and has existing tunnels that could be improved. Although these tunnels are long and relatively small, they could be valuable for carnivores, and could serve to augment an overpass at West Liberty Canyon. A disadvantage here is that Mureau Road separates the crossing area from the open space to the north, so animals would have to cross four lanes of pavement and a median. This would be a significant barrier for many smaller species, and a potential mortality source for larger ones. Experts agreed that wildlife fencing should also be constructed in association with any new or improved structures to help funnel wildlife to the crossings (Huijser et al. 2016).

4. OVERALL CONCLUSIONS

Both the Santa Ana to Palomar Mountains and the Santa Monica to Sierra Madre Mountains Linkages in southern California have been a focus of regional wildlife research and conservation planning efforts for over 25 years. These two linkages are widely recognized as critical for maintaining biodiversity in the two largest coastal southern California mountain ranges, and both these linkages represent the last local opportunity for securing connectivity with larger intact natural lands.

For both linkages, the expert consensus was that, to maximize connectivity for multiple wildlife species, a diversity of crossing structures should be enhanced or constructed. While wildlife overpasses would likely serve the broadest suite of species, experts also pointed to the opportunities provided by enhancing existing creek crossings. Temecula Creek in the Santa Ana Mountains and Las Virgenes Creek in the Santa Monica Mountains might provide the best and most economical option for improving

connectivity for smaller mammals, amphibians, and fish. These are the only potential aquatic crossings for either the I-15 or 101 Freeways; however, both Temecula and Las Virgenes Creeks have urban edge issues of noise, exotic species, light, and human activity that would require mitigation and long-term management.

In addition to wildlife fencing to funnel wildlife to the crossing structures, some form of habitat modification would benefit both linkages. For the I-15 linkage, which has dense chaparral on both sides of the freeway, it was recommended that wildlife trails be constructed through the chaparral to attract carnivores and deer to the crossing structures. For the 101 Freeway, the restoration of coastal sage scrub in areas currently dominated by non-native grassland would provide needed cover for wildlife approaching the crossing, such as on the north side at the West Liberty Canyon site.

Participants also stressed that secondary roads that run parallel to both freeways – such as Rainbow Canyon Road in the I-15 Linkage and Agoura Road in the 101 Freeway Linkage - can be problematic for wildlife and that both linkages need to incorporate crossing structures for these secondary roads.

The authors recognize that assuring adequate connectivity for wildlife in these two areas will require significant public investment and political will, particularly because of significant costs associated with crossing structure construction and land protection. We hope that the results of this workshop will help guide all parties to a consensus opinion relating to crossing improvements, which can then allow progress towards improving wildlife connectivity at both critical locations.

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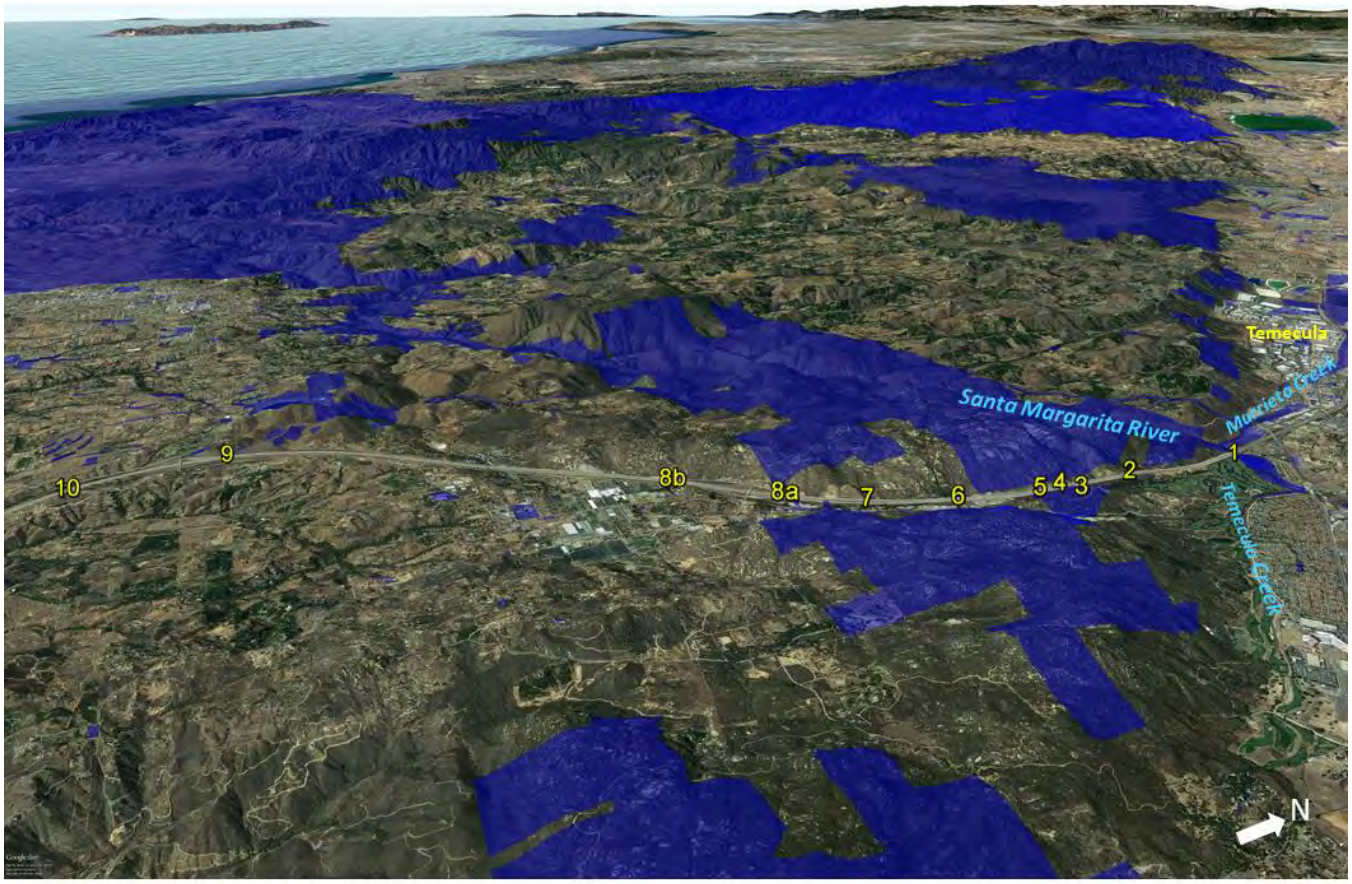
Appendix A
Detailed Site Assessments for the Santa Ana to Palomar Mountains I-15 Linkage

Certain structural parameters are recommended to be followed for any future undercrossing and overcrossing construction or improvements. These relate to structure length, size, incline, ability of the animal to see through the structure, associated fencing, sound and light blocking materials, etc., and are discussed in the main report so are not repeated in depth here.

It is important to note that a second roadway (Rainbow Canyon Rd. / Old Hwy 395) exists parallel to I-15, and is a lesser but still possibly significant barrier to wildlife movement. It is recommended that planners also address this issue and develop plans for crossing improvements or construction on that roadway to accompany any improvements to I-15 crossings.

Figure 1 (from main report). Eleven potential wildlife crossing sites (yellow numbers) Santa Ana to Palomar Mountains linkage. Conserved lands in blue. View looking northwest from Palomar Mountains toward Santa Ana Mountains.



Site 1/Temecula Creek Bridge

UTM COORDINATES: 487131.40E, 3703892.33N 11S (NAD 83)

Site 1 looking west: North end of Temecula Creek golf course is in lower left, and Temecula Creek is beneath bridge and lower center. Santa Margarita River Channel is in the upper center; Murrieta Creek runs from west of the bridge to the north parallel to I-15 in upper right. Proposed developments are west of Murrietta Creek in upper right, and on Temecula Creek golf course lower left.

1. SITE 1 DESCRIPTION:

Habitat: This wildlife crossing location is a relatively intact riparian linkage dominated by willow, cattails, and herbaceous plants. Water flow is year-round and partially fed by urban development.

West: Just west of the bridge crossing is the confluence of Temecula and Murrieta Creeks which are tributary to Santa Margarita River. The creek is protected and connects to the Santa Margarita Ecological Reserve, just west of I-15, which includes intact riparian, oak and chaparral habitats.

East: To the east, Temecula Creek is partially degraded by human encampments, residential and golf course developments, roads, and flood control maintenance activities. Pechanga Creek is tributary to Temecula Creek and is approximately 1 km upstream of the bridge on the east side, and may provide a potential westward connection to Temecula Creek Bridge from the east, though it too is bordered by residential development and the Temecula Creek Golf Course through the last mile of its length before joining Temecula Creek.

Documented Existing Wildlife Use: Multiple GPS-collared mountain lions that are part of the UC Davis study have approached within 100 meters of the bridge from the west in the Santa Margarita River drainage, and have utilized Murrietta Creek near the bridge, as well as the escarpment both north and south of the bridge. One mountain lion that was radio-collared by Beier (1993) east of the crossing appeared to have crossed from west to east under the bridge (based on tracks) before being captured in the Pechanga Creek channel. One of the Beier study's radio-collared mountain lions successfully crossed I-15 just south of this location. The Western Riverside County Regional Conservation Authority (RCA) has documented use of this crossing by bobcats,

coyotes, and raccoons. Evidence of deer utilizing the creek channel to travel under the bridge has been minimal in recent times. Arroyo chub have been documented in the creek at the bridge. The crossing is likely used by avian and invertebrate species.

Threats: Many human-related threats compromise the utility of this crossing location for large carnivores and deer.

Noise: Roadway noise at this undercrossing location is very high and is believed to interfere with wildlife use of this crossing.

Human Use: Unauthorized human uses include homeless encampments, graffiti, night use by teenagers, recreational use by hikers.

Light: Security lighting at nearby MWD pump station on the west side of the bridge is likely a deterrent for wildlife approaching the bridge crossing at night from the west.

Fencing: Fencing between the creek and golf course likely inhibits wildlife travel through golf course from upland habitat/Palomar Mountains

Proposed development: The recently approved Altair Development on the west side of bridge could further constrain this linkage and would likely disrupt some wildlife movement to the bridge in the Santa Margarita River channel and from the escarpment northwest of the bridge.

2. **EXISTING WILDLIFE PASSAGE INFRASTRUCTURE**

Temecula Creek Bridge is composed of two separate bridges for north and south-bound traffic lanes. Each span is roughly 22 meters wide, with a 15-meter separation between spans (60 meters total width). The bridge length is approximately 75 meters. Exact height is unknown, but approximately 15 meters.

3. LAND USE SECURITY

Fine scale protection status: This crossing is protected on the west side of the crossing structure (Santa Margarita Ecological Reserve (SMER)). The east side of the crossing structure is protected along the creek (Flood Control District) but from this point there is a 2800-meter distance to the nearest protected habitat at Temecula Mountain. The Temecula Creek Golf Course likely serves as a link to upland habitat for some species, however, it lacks the cover necessary to function fully as a corridor. Pechanga Creek could function as an important link directing wildlife from the Palomar Mountains westward to Temecula Creek bridge. However, its use may be restricted due to the presence of urban development (lights, noise, dogs) along one side.

4. TRANSPORTATION MITIGATION OPTIONS PREVIOUSLY PROPOSED BY WILDLIFE AGENCY STAFF OR OTHER ENTITIES

Design type: Underpass

Suggested Design Enhancements:

Land Use: Maintaining the golf course use for Temecula Creek Inn and enhancing it as wildlife habitat (through the addition of oak woodland and scrub/chaparral habitat) would improve this linkage.

Light: Shielding or removal of lighting at MWD pump station (high priority) could increase wildlife movement west of the bridge. Motion sensor cameras/lights and/or higher fence could be substituted as security measures.

Sound: Sound engineering measures to improve this crossing would include sound buffering, including possible installation of “Rhino Liner” type material on the under-side of bridge; sound walls along the sides of the roadway bridge were suggested by experts but may not be feasible due to driver safety issues. Fencing with

screening along the freeway leading to the bridge or sound walls would reduce light and noise pollution in the Temecula Creek and Santa Margarita River channels.

Human Disturbance: Removal and management of ongoing human encampments is a high priority. Possible transfer of the creek from the Flood Control District to RCA might improve habitat conditions. In addition, regular security presence is needed to prevent/disrupt human use.

Buffering of development along Pechanga Creek would enhance its function as a linkage.

Fencing: removal of fencing along golf course to facilitate wildlife use of golf course within the linkage.

Habitat Restoration:

- Restoration/enhancement of riparian vegetation in Temecula Creek to increase cover for wildlife.
- Restoration/creation of woodland and chaparral/scrub habitat patches within golf course to enhance use of golf course as part of the linkage, particularly for deer and mountain lions.

Prey Base: Experts agreed that we will need to increase native habitat cover on the golf course for deer to attract mountain lions.

Measures have been suggested by Beier (1993) to deter mountain lions from continuing eastward up Temecula Creek (a dead end for connectivity) beyond the golf course.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

This crossing likely currently functions well for birds, amphibians, small mammals, fish, and coyotes. Enhancements to this structure would improve its functionality for mountain lion, deer, and bobcat.

6. SCORING

Experts Score:

The Temecula Creek Bridge site was ranked as the highest priority crossing site by one expert. It was chosen as a second priority crossing site by four experts, and third priority crossing site by four experts. This was the only crossing location that received a score by all experts in attendance. Overall, this site was ranked second highest priority crossing by the experts.

Landscape Score

Site 1 received the second highest Landscape Score of 4.25 out of a possible 5.0.

Total score and ranking

Total of the Expert and Landscape Score for site 1 was 7.03, placing this site second overall.

Site 2

UTM COORDINATES: 487271.66E, 3702523.25N 11S (NAD 83)

Site 2 view from east. South end of Temecula Creek golf course is at bottom of picture.

1. SITE 2 DESCRIPTION:

Habitat:

West: Intact oak and chaparral habitat

East: Oak and chaparral habitat immediately east of I-15 transition to golf course and Old Hwy 395

Documented Existing Wildlife Use: Wildlife studies performed by Kelsey Stricker documented bobcat and grey fox entering culvert on the east side of highway. Paul Beier documented a collared mountain lion crossing at grade between this location and the Temecula Creek Bridge in the early 1990's.

Threats:

Human Use: The location of the culvert on the west side is approximately 15-20 feet below the roadway and is used by truckers as a rest stop.

Light: the angle of the existing culvert is such that light is not visible from one side to the other. The east side of the highway is lower than the west side, thus the culvert angles from west to east.

2. EXISTING PASSAGE INFRASTRUCTURE

This culvert is roughly 2 meters in height, and extends approximately 180 meters across I-15. It is made of corrugated metal. Light is not visible within the culvert because of its angled descent from west to east. From the west side, the culvert slopes slightly for nearly 120 meters and then dips steeply for approximately 60 meters leading to its exit on the eastern side. The culvert empties on the east side onto riprap, coast live oak

woodland, and the golf course. Both sides of the culvert are rather quiet despite its location next to the interstate. Very little artificial light pollutes the vicinity.

3. LAND USE SECURITY

Fine scale protection status: Land on the west side is held privately and are being pursued for conservation. This parcel directly adjoins SMER lands 120 meters to the west of Interstate 15.

Lands on the east side are occupied by a golf course owned by the Temecula Creek Inn. Distance between conserved habitat lands and eastern entrance to culvert is greater than 1500 meters.

4. TRANSPORTATION MITIGATION OPTIONS PREVIOUSLY PROPOSED BY WILDLIFE AGENCY STAFF OR OTHER ENTITIES

Design type: Underpass/Culvert

Design Enhancements: To improve this crossing to reduce the angle, the west side would need to be dug down below existing grade, and the east end would need to be elevated. The culvert would require a redesign or replacement that would allow visible light at each end. A light "sono tube" installed in the freeway median would allow some light to penetrate the structure. Elevation of the east end would result in its outlet being in the approximate middle of the fill slope rather than at the bottom where cover is present. Thus, modification of the vegetation on the fill slope and wildlife trail construction would likely need to be a part of this modification.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

Mountain lion, medium sized carnivores, small mammals, reptiles.

6. SCORING

Experts Scoring

This site only received one expert vote as a second priority crossing. Overall, this crossing location got the lowest overall score of the 7 that received any ranking by the experts.

Landscape Scoring

Site 2 received a score of 2.91 out of a possible 5.0. It scored lowest in fine scale protection, as neither side of the crossing location is in conservation ownership. In addition, the fine scale landscape pattern on the east side of the crossing is the Temecula Creek Inn golf course with minimal natural vegetation between the golf course and the culvert entrance. Zeller modeling indicated some support for this location due to the wooded canyon leading to the culvert on the west side.

Total score and ranking

Total of the Expert and Landscape Scores for site 2 was 3.28, placing this site seventh overall.

Site 3

UTM COORDINATES: 487335.40E, 3701806.84N 11S

Site 3 looking northeast with Temecula Creek Golf Course in the upper left

1. SITE 3 DESCRIPTION

Habitat:

West: A small drainage with intact oak woodland and chaparral habitat leads to the culvert on the west side.

East: Intact chaparral on east side extends for > 900 meters.

Documented Existing Wildlife Use: A mountain lion mortality was documented near this location on I-15 in the early 1990's.

Threats:

Light: Light is not visible from one side of the culvert to the other. This culvert is believed to segment off into many smaller culverts which exit to the other side, so its current utility is likely non-existent.

Noise: Roadway noise is likely an issue

2. EXISTING PASSAGE INFRASTRUCTURE

This culvert is roughly 2 meters in height, and extends approximately 140 meters across I-15. It is made of corrugated metal. Light is not visible within the culvert. Noise on the west side of the culvert is slightly buffered by a berm that separates it from the highway.

3. LAND USE SECURITY

Fine scale protection status: Private lands on the west side of the roadway are currently being pursued for conservation and extend for 180 meters before adjoining SMER. Lands on the east side of the roadway have recently been acquired for conservation and extend for approximately 600 meters before connecting to Pechanga Indian Reservation conservation lands.

4. TRANSPORTATION MITIGATION OPTIONS PREVIOUSLY PROPOSED BY WILDLIFE AGENCY STAFF OR OTHER ENTITIES

Design type: Culvert.

Design Enhancements: Construct a new culvert under the roadway. The constructability of this crossing is unknown but a new undercrossing structure constructed near the existing culvert would allow the existing culvert to remain for drainage purposes. In 2012, the USFWS investigated the placement of a 4-meter diameter "jack and bore" culvert just north of this location, which was determined to possibly be feasible but no extensive engineering studies have been done. Ideally, any new culvert to be placed should be of a type and size adequate to promote use by a wide range of species, including mule deer.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE ENHANCED

A 4-meter diameter culvert would likely function for mountain lions, medium sized carnivores, reptiles, and amphibians, but might not accommodate mule deer.

6. SCORING

Experts Scoring

Site 3 was ranked a priority crossing location by one expert, and as a second priority crossing location by three experts. Three experts identified this site as a potential location for an arched culvert, while one expert identified this general location for a potential overpass. Overall, this crossing site was ranked as a moderate priority by the experts. Total expert cumulative score was 1.67 out of 5.0.

Landscape Scoring

Site 3 scored a total of 3.33 out of a possible 5.0.

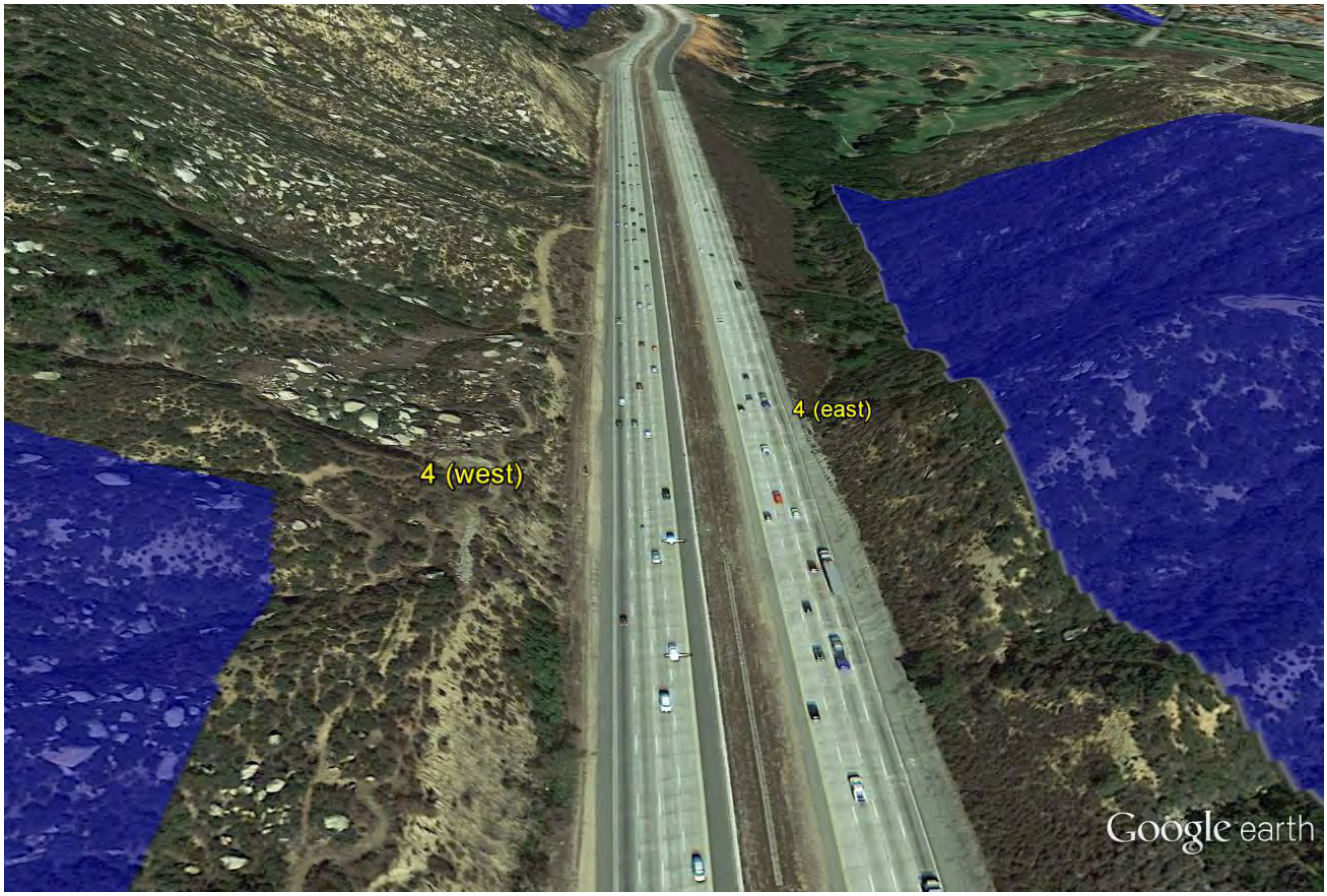
Total score and ranking

Total of the Expert and Landscape Scores for site 3 was 5.0, placing Site 3 fourth overall.

Site 4

UTM COORDINATES: 487358.87E, 3701702.04N 11S (NAD 83)

Site 4 looking north. Southern end of Temecula Creek golf course in upper right.



1. SITE 4 DESCRIPTION:

Habitat:

West: Intact chaparral, rock outcrops, and scrub habitat with a small oak lined drainage

East: The east side includes a mostly un-vegetated up slope that transitions downslope to chaparral, rock outcrops and scrub habitat. A small oak lined drainage flows to the north parallel to the roadway on the east side.

Documented Existing Wildlife Use: Mountain lion mortalities have been documented on I-15 near this location.

Threats:

Light: Light from the border patrol facility poses an issue. Light is not visible from one side of the culvert to the other. The culvert is situated on an angle to drain from west to east.

Noise: Roadway noise is likely an issue, but there is a berm on the west side between the culvert and the highway.

2. EXISTING PASSAGE INFRASTRUCTURE

A 1.5-meter culvert is located at this location, and like Sites 2 and 3, extends approximately 140 meters across I-15. It is made of corrugated metal. Light is not visible within the culvert. Noise on the west side of the culvert is slightly buffered by a berm that separates it from the highway.

3. LAND USE SECURITY

Fine scale protection status: Land on the west side is in conservation (SMER). Lands on the east side have recently been acquired for conservation.

4. TRANSPORTATION MITIGATION OPTIONS

Design type: Culvert

Design Enhancements: The existing culvert would require replacement with or the addition of a culvert that allows for light to penetrate from both ends and is of a design and size adequate to promote use by a wide range of species, including mule deer. The constructability of this crossing structure is not known but likely similar to sites 2 and 3.

A new culvert could have to be constructed at less of a slope angle than other crossing points to allow light to penetrate from both ends of the culvert. A light "sono tube" or other natural lighting device placed in the freeway median could also enhance light penetration within the culvert.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

This crossing would function for mainly upland species, including mountain lion, deer, medium-sized carnivores, small mammals, reptiles and amphibians.

6. SCORING

Experts Scoring

Site 4 was lumped with Site 5 as a priority overpass location by two experts, and a second priority overpass location by an additional two experts. Site 4 as an underpass/culvert crossing location was ranked as second priority by two experts. When including scores that were lumped with Site 5, the expert score was 2.59 out of 5.0.

Landscape Scoring

Site 4 scored 3.83 out of a possible 5.0.

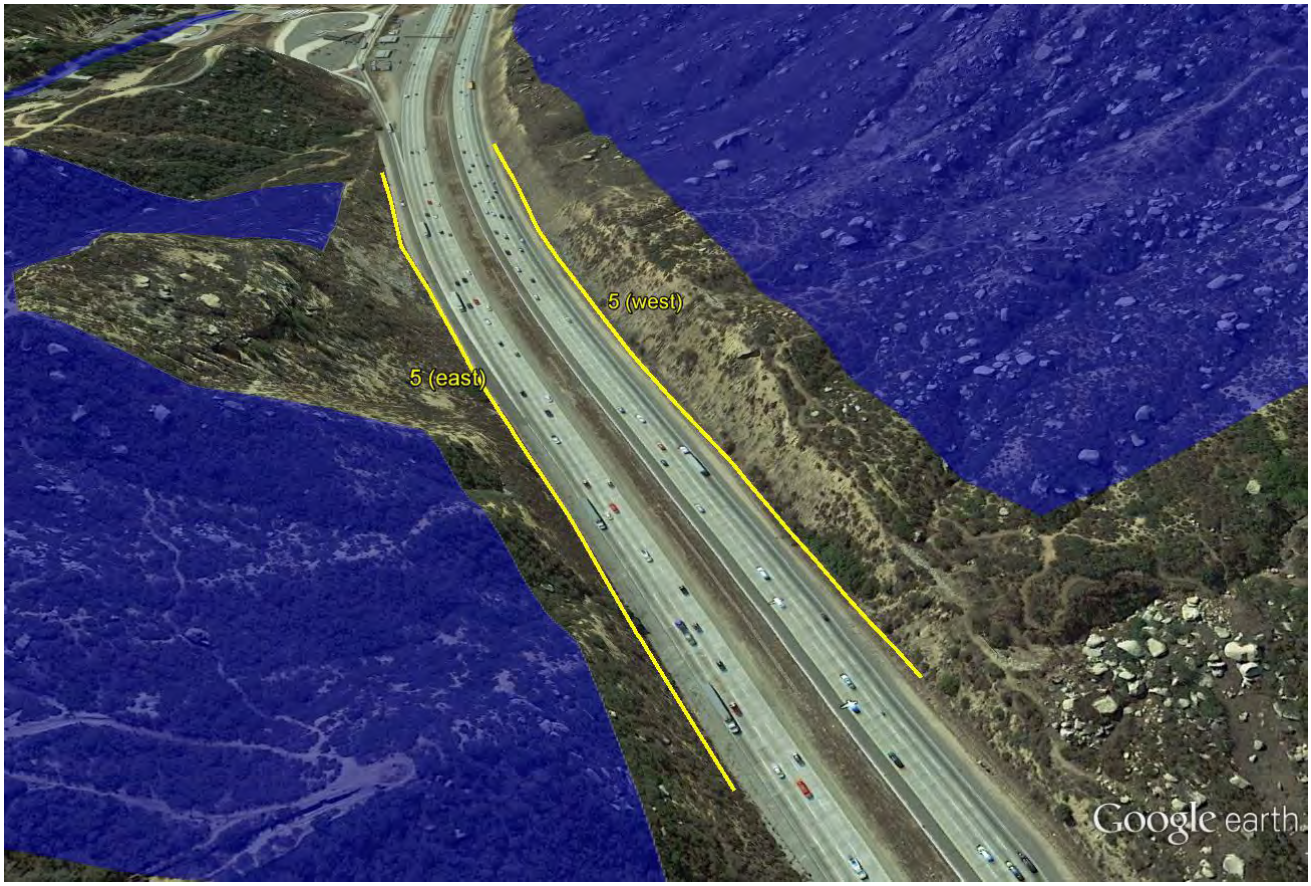
Total score and ranking

Total of the Expert and Landscape scores for site 4 was 6.42, placing this site third in the overall rankings.

Site 5

UTM COORDINATES: 487389.23E, 3701393.23N 11S (NAD 83)

Site 5 looking southwest. Actual overcrossing structure could potentially be located within limits of yellow lines dependent on engineering considerations



1. SITE 5 DESCRIPTION:

Habitat:

West: Revegetated cut slope that adjoins intact chaparral, rock outcrops, and scrub habitat

East: The east side includes a mostly un-vegetated cut slope that transitions to chaparral, rock outcrops and scrub habitat.

Documented Existing Wildlife Use: At least one mountain lion mortality has been documented on I-15 near this location.

Threats:

Light: Light from border patrol facility poses an issue.

Noise: Roadway noise likely an issue

2. EXISTING PASSAGE INFRASTRUCTURE

None

3. LAND USE SECURITY:

Fine scale protection status: Land on the west side is in conservation (SMER). Lands on the east side have recently been placed in conservation ownership. There also is one small parcel of land owned by Caltrans that is directly adjacent to the right-of-way.

4. TRANSPORTATION MITIGATION OPTIONS

Design type: This is a crossing site that has been identified in multiple studies for the construction of a wildlife overpass (Luke et al 2004, Beier and Barret 1993, Fisher and Crooks 2001). Although an overpass would be a substantial financial investment, this has been identified as the best location for such a crossing structure within the linkage area as it would serve a variety of wildlife as well as plants. Engineering studies would be required to assess its constructability.

Design Enhancements: The overpass should be vegetated with coastal sage scrub and chaparral plants native to the local area.

Fisher and Crooks (2001) recommended that the bridge be constructed at an angle from SE to NW to create more level crossing surface.

The steep vegetated terrain on the west side of the crossing should be modified to create trails that lead wildlife to the crossing structure.

Walls or berms should be constructed on the overpass to reduce noise, light and glare from the roadway and nearby Border Patrol Checkpoint.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

Upland species, including mountain lion, deer, medium-sized carnivores, small mammals, birds, reptiles, invertebrates and plants.

6. SCORING

Experts Scoring

Site 5 ranked as the highest priority crossing location (overpass) by six experts, and as a second priority crossing location (overpass) by two experts. The expert cumulative score for Site 5 was 4.07 out of a possible 5.

Landscape scoring

Site 5's Landscape Score was 4.50 out of a possible 5.0.

Total score and ranking

Total of the Expert and Landscape Scores for site 5 was 8.57, placing this site first in the rankings.

Site 6

UTM COORDINATES: 487263.95E, 3700692.60N 11S (NAD 83)

Site 6 looking northeast. Border check station is upper center; commercial operations are lower right.

1. SITE 6 DESCRIPTION:

Habitat

West: Natural slope and small gullies / canyons with intact chaparral, rock outcrops, small oaks, and scrub habitat.

East: The east side includes a lightly vegetated fill slope at the highway edge, and an adjoining open lot containing mixed native and non-native vegetation that is approximately 100 x 120 meters in size and bordered by commercial lots on both the north and south margins, and Rainbow Canyon Road on the east margin. On the east side of Rainbow Canyon Road from the open lot, another commercial operation is present slightly uphill from Rainbow Canyon Road.

Documented Existing Wildlife Use: At least one mountain lion has been documented approaching I-15 on the west side within 100 meters of this location.

Threats:

Light: Light from border patrol facility and human activity in the commercial facilities on the north, south, and east sides of the site.

Noise: Roadway noise and noise associated with commercial activities likely an issue. The proximity of Rainbow Canyon Road and noise from traffic on that road would also be an issue.

Proximity of buildings north, south, and east of the site (across Rainbow Canyon Road) and associated human activity would discourage movement of wildlife.

2. EXISTING PASSAGE INFRASTRUCTURE

Culverts are present at site 6 and just north and south of the site. These culverts are either too small or convoluted to be expected to be used by wildlife as crossing structures.

3. LAND USE SECURITY:

Fine scale protection status: Land on the west side is not conserved but conserved lands exist within approximately 150 meters north of the site. Lands on the east side are also held privately.

4. TRANSPORTATION MITIGATION OPTIONS

Design type: overpass or underpass

Design Enhancements: Restoration of wild habitat in the open ground on the east side would be needed. Fencing with screening or walls would be helpful to reduce impacts of light and noise from surrounding properties. Any overpass or underpass structure would have to be similar in design to those discussed for other sites.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

A vegetated overpass would likely function for all wildlife and plants. An underpass would function for mountain lion and medium-sized carnivores. Design enhancements of the undercrossing, such as ledges or rocks, could make it function for small wildlife, such as small mammals, reptiles, and invertebrates and plants.

6. **SCORING**

Experts Scoring

Site 6 was ranked as a first-priority crossing location (overpass) by one expert, and as a third priority crossing location (overpass) by one expert. Its score was 0.74 out of 5.

Landscape Scoring

Site 6 received a Landscape Score of 3.00 out of a possible 5.0.

Total score and ranking

Total of the Expert and Landscape Scores for site 6 was 3.74, placing this site sixth overall in the rankings.

Site 7

UTM COORDINATES: 487008.50E, 3699901.56N 11S (NAD 83)

Site 7 looking west. Scattered buildings are on lot at site 7 on east near freeway.

1. SITE 7 DESCRIPTION:

Habitat:

West: Steep rocky cut slope adjoining a small canyon and gullies with intact chaparral, rock outcrops, small oaks, and scrub habitat

East: The east side includes a lightly vegetated fill slope at the highway edge, and an adjoining open lot that is approximately 150 x 150 meters in size with scattered small buildings at the edge that contains mixed native and non-native vegetation and bordered by commercial lots on both the north and south margins, and Rainbow Canyon Road on the east margin.

Documented Existing Wildlife Use: At least one mountain lion has been documented approaching I-15 on the west side within 200 meters of this location.

Threats:

Light and Human Activity: Although there is a vacant property on the east side of the highway, it is adjoined to the north and south by commercial and private development that is a source of light pollution and human disturbance.

Noise: Roadway noise is likely an issue, both from I-15 and Rainbow Canyon Rd. / Old Hwy 395 on the east.

2. EXISTING PASSAGE INFRASTRUCTURE

A culvert is present at site 7. It is too angled to be expected to be used by wildlife as a crossing structure.

3. LAND USE SECURITY:

Fine scale protection status: Land on both sides of the highway is privately owned except for the narrow strips of right of way along both I-15 and Rainbow Canyon Road.

4. **TRANSPORTATION MITIGATION OPTIONS**

Design type: Vegetated wildlife overpass or underpass

Design Enhancements: Restoration of habitat in the open ground on the east side would be needed. Fencing with screening or walls would be helpful to reduce impacts of light and noise from surrounding properties. Any overpass or underpass structure would have to be similar in design to those discussed for other sites.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

Upland species, including mountain lion, deer, medium-sized carnivores, small mammals, birds, reptiles, invertebrates and plants.

6. SCORING

Experts Scoring

Site 7 was ranked as a priority crossing location (overpass) by one expert, and as a third priority crossing location (overpass) by one expert. It's experts score was 0.74 out of 5.

Landscape Scoring

Site 7 received a Landscape Score of 0.25 out of a possible total of 5.0.

Overall Score

Total of the Expert and Landscape Scores for site 7 was 3.99, placing this site fifth overall.

Sites 8a, 8b, 9 and 10

Sites 8a, 8b, 9, and 10 all received Landscape Scores (Table 3 of main report), but none were ranked by the experts as first, second, or third choices, possibly because of the extensive agricultural and human development on both sides of the freeway at those sites. Thus, those sites' scores were lower than any of the first 7 sites described, and they are not described in depth here, though more detailed maps of these sites are included below.

Site 8a looking west

Site 8b looking southwest

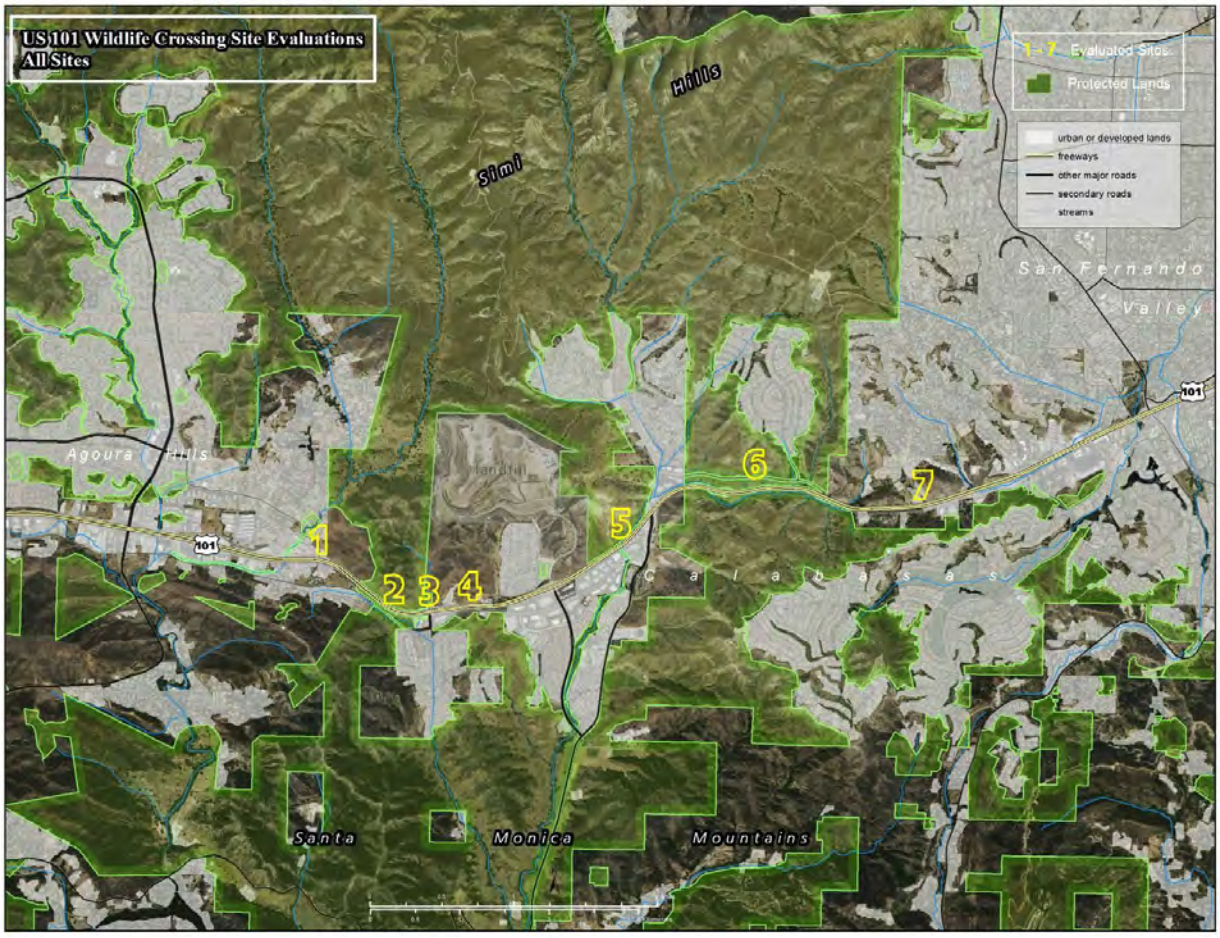
Site 9 looking northeast

Site 10 looking southeast

Appendix B
Crossing Site Assessments for the Santa Monica Mountains to Sierra Madre Highway 101 Linkage

A total of seven potential wildlife crossing sites along a 5.9-mile stretch of Highway 101 in the Agoura Hills-Calabasas area were evaluated as part of this Linkage analysis. Information on each of these potential linkage sites, including their rankings, is presented below.

Figure 1, the 7 evaluated sites with protected open space (within green border) and developed urban areas (gray).



Site 1: Palo Comado Canyon Road Bridge

UTM COORDINATES: 339,749/3779,392 WGS84

Site 1, Palo Comado Canyon Road Bridge, looking northeast. Green shaded line marks edge of protected open space. White circles are bobcat locations, red squares are coyote locations, yellow circles are mountain lion locations.

1. SITE 1 DESCRIPTION:

This is a two-lane vehicular bridge for Palo Comado Canyon Road over US 101. There is one lane in each direction, a shoulder on the east side, and a sidewalk on the west side. There is very little vegetation and almost no cover.

Habitat:
South: There is no natural habitat at this bridge on the south side. There is commercial and residential development between the bridge and Agoura Road, more residential development south of Agoura Road, and then open space south of this development, which is relatively thin (just one or two rows of houses). The open space on the hills to the south is visible from the bridge.

North: There is natural habitat between the bridge and the on- and off-ramps. There is natural habitat across the off-ramp to the northeast, although it is composed of introduced grassland, and there is not much in the way of shrub cover. To the northwest there is residential development.

Documented Existing Wildlife Use

There is no known wildlife use of this bridge. It has never been specifically monitored with cameras. There is no evidence that radio-collared bobcats in the open space south of Agoura Road have successfully crossed US 101 at this location, although a few animals to the east were able to successfully cross US 101, likely along Liberty Canyon Rd.

Threats

Human Use: There is a gas station at this intersection and heavy vehicle traffic and human presence. There is also high exposure to roadway mortality for animals that might attempt to cross this bridge, as the crossing structure is a busy road with little shoulder. It currently cannot support a safe pedestrian sidewalk or bicycle lanes, and Caltrans documents indicate it has a high traffic load during peak hours.

Light: There are street lights that are on at night illuminating the general area.

2. EXISTING INFRASTRUCTURE

The existing crossing infrastructure is a roadway bridge with a sidewalk on one side. It provides one 12-foot lane and 4-foot shoulder in each direction. A 5-foot sidewalk is provided on the west side of the overcrossing. The interchange is configured with tight diamond ramps on the northbound side and hook ramps on the southbound side. The southbound hook ramps connect with Dorothy Drive and Chesebro Road at a four-point intersection south of US 101. The southbound off-ramp is a one-lane exit that widens to two lanes at its terminus. The southbound on-ramp is a one-lane ramp throughout. The northbound ramps connect directly to Palo Comado Canyon Road (#2). The northbound on-ramp has two lanes starting from the Palo Comado Canyon Road intersection and tapers to a one-lane on-ramp before joining the freeway. The northbound off-ramp begins as one lane and widens to two lanes at its terminus. The interchange does not currently have any intersections with traffic signals. Palo Comado Canyon Road is a free-flowing street from Agoura Road in the south to Driver Avenue in the north, where the intersection is controlled by a four-way stop sign.

3. LAND USE SECURITY:

Fine scale protection status

All the land surrounding the bridge is privately owned and zoned for development. NPS (National Park Service) and MRCA (Mountains Recreation and Conservation Authority) lands exist to the north and east of the bridge.

Broad scale protection status

None.

4. TRANSPORTATION MITIGATION OPTIONS

Constructability

In order for this crossing to function, there would need to be a wildlife sidewalk with good cover and there would need to be connectivity from the bridge through the developed areas surrounding the bridge into open space on the north and south. The density of development, lack of open space, and

distance to protected open space, as well as the current design of the bridge all pose major engineering constraints, so its constructability is likely low.

Design type:
Combined vehicle and wildlife bridge

Design Enhancements:
In order to improve this crossing, the bridge would need to be widened to accommodate a screened, vegetated wildlife walkway on one side of the bridge. The design would also need to incorporate some fencing to funnel wildlife on to the bridge and safely across the on- and off- ramps on either side.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

All, including mountain lion, medium-sized carnivores, deer, small mammals, reptiles, and amphibians. There is very little functionality here at the moment, both for habitat connection and crossing suitability reasons. Both issues would need to be addressed to significantly improve the connectivity value, although making the bridge more wildlife friendly could improve use, at least from north to south, for carnivores and deer even without significant habitat changes. However, to reach open space to the south, animals would still need to travel through a significant area of development.

6. SCORING

Expert Scores

This site was not selected as a high priority by any of the experts, as they agreed that it was not optimal for wildlife movement. It received a 0 for expert score.

Landscape Score

The Palo Comado Bridge Crossing site received a Landscape Score of 1.25 out of a possible 5.0. It scored lowest in the area of fine and large scale protection, as neither side of the crossing location is in conservation ownership. In addition, landscape patterns on the north side of the crossing are not conducive to wildlife movement because of the busy vehicle traffic and human development.

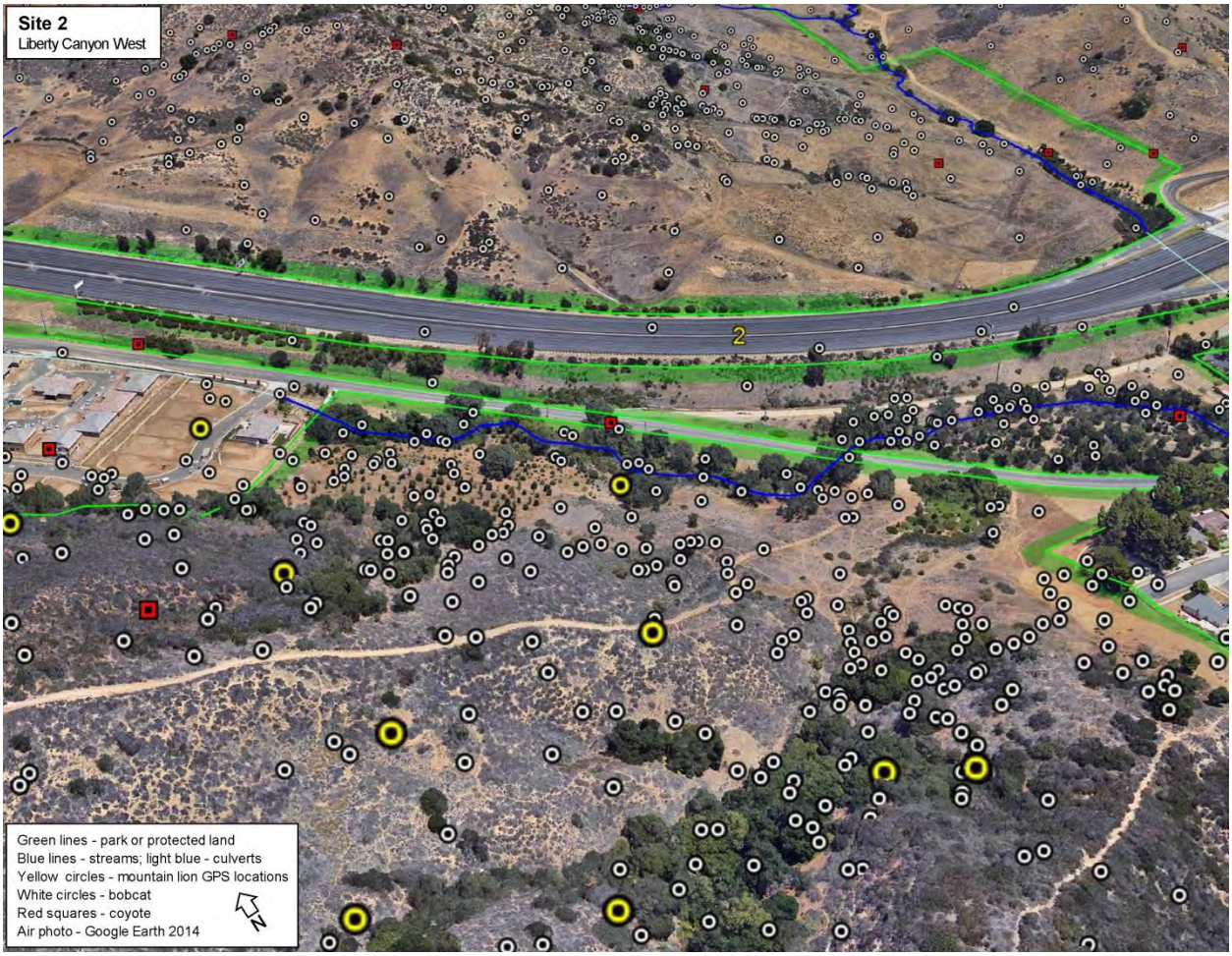
Overall Score

This was the lowest ranked crossing with a total score of 1.25 out of a possible total score of 10.

Site 2: West Liberty Canyon

UTM COORDINATES: 340,610/3778,829 WGS84

Site 2, West Liberty Canyon, looking northeast. Green shaded line marks edge of protected open space. White circles are bobcat locations, red squares are coyote locations, yellow circles are mountain lion locations.



1. SITE 2 DESCRIPTION:

This is the area just west of Liberty Canyon Road, and east of Chesebro Road, where there is protected open space on both sides of the freeway.

Habitat

South: Immediately south of the freeway there is a steep vegetated hillside which drops down to a road (Vendell Place) and then to areas of natural habitat between the freeway and Agoura Road. On the hillside the habitat is grassland, with some occasional shrubs, mostly *Baccharis*, and some exotic Eucalyptus and pepper trees. The area between Agoura Rd. and the freeway has been restored by SMMC (Santa Monica Mountains Conservancy), and includes coastal sage scrub and grassland under a canopy of valley and live oaks. South of Agoura Road is protected open space and natural, largely native coastal sage scrub and grassland habitat. A streambed (mostly dry) parallels Agoura Road here, crossing

under the road east of the intersection with Vendell Place and then running along the southwest side of Agoura Rd.

North: The north side of the freeway is protected open space and grassland habitat immediately adjacent to the proposed crossing area. In the Liberty Canyon streambed to the east, there has been significant scrub and riparian habitat restoration by SMMC/MRCA, specifically of scrub and riparian vegetation in and near the stream. Farther up on the hillsides there is more scrubland, including coastal sage scrub and chaparral. There is a large parcel of private property on the north side to the east of the SMMC property (between SMMC land and the Saratoga Hills development) that, if developed, could impact the crossing.

Documented Existing Wildlife Use

NPS research in this area going back to 1996 has documented extensive use by bobcats and coyotes, as well as some use by mountain lions, through VHF and GPS radio-tracking. Bobcats and coyotes have used the areas right up to the freeway on both sides, over many years, including between Agoura Rd and the freeway, where there is documented bobcat use. A number of bobcats and coyotes have crossed the freeway over the years, likely in this area, although it is unknown exactly how they crossed (likely using Liberty Canyon Road, see site #3).

Mountain lions have also been documented using both sides of the highway in this area on a number of occasions. Notably, the only collared mountain lion that was documented crossing the US 101 Freeway from north to south in the first 15 years of the NPS study, P12, crossed in this area in February 2009, although again it is not known whether he crossed US 101 at grade or crossed under the highway using Liberty Canyon Rd.

Threats:

Human Use

There is relatively little human use of this area, other than some recreational use of trails since the majority of the area is protected open space on both sides. There is a dirt parking lot and trailhead on the south side that leads to SMMC property and on to Malibu Creek State Park. This trail is mostly used by hikers. On the north side there is an old fire road that runs along Liberty Canyon creek, just north of Liberty Canyon Rd. This road continues on to private property, while the trail then runs across the creek to the west and then parallel to it going north through SMMC property towards the Calabasas Landfill and NPS property in Cheeseboro Canyon. This trail is used by hikers, and some by horseback riders.

Light

There is no development in this area, so there is very little light pollution. There are developments farther to the west and east along Agoura Rd, and these areas have more extensive street lighting. There are some streetlights along Agoura Rd, but it is largely dark at night. Radio collared animals have been documented in this area for many years.

2. EXISTING INFRASTRUCTURE

There is no current infrastructure for wildlife movement in this area. There is a double culvert that carries flows from Liberty Canyon Creek under the highway. These two culverts are long and bend before reaching the other side, and light is not visible on either end. An evaluation of their use by wildlife in 1999-2000 detected use only by raccoons and striped skunks.

In terms of overall transportation infrastructure, there is some Caltrans right-of-way fencing on both sides of the freeway. On the north side, the fencing runs parallel to the road at various distances, sometimes relatively close, but in some places it runs 100m or more away from the road. On the south side, the fence runs along the base of the hill leading up to the freeway, along Vendell Pl., and then along Agoura Rd., west of Vendell Pl.

3. LAND USE SECURITY:

Fine scale protection status

Land on both sides of the freeway in this area is protected open space. On the north side, the land is owned by SMMC/MRCA and farther north by the NPS. On the south side, the land is also owned by SMMC/MRCA, and farther south by California State Parks. MRCA has done extensive work to restore and revegetate the areas south of the freeway, between the freeway and Agoura Rd, and in the creek south of Agoura Rd, as well as to the north in Liberty Canyon Creek just above the freeway. There is a large parcel of private undeveloped land on the north side just east of the crossing area between SMMC land and the Saratoga Hills development.

Broad scale protection status

This site is within the area identified as the Santa Monica Mountains - Sierra Madre Linkage by South Coast Wildands, which was also identified as one of the highest priority linkages in southern California.

4. TRANSPORTATION MITIGATION OPTIONS

Multiple different mitigation options are being considered for this area, including an overpass over US 101 only, an overpass that includes both US 101 and Agoura Road, a 13x13 foot jacked tunnel, and a larger 32x15 foot tunnel. Neither of the tunnels would enable animals to avoid crossing Agoura Road, which the full overpass option would do.

a. Design type: 13x13-foot jacked tunnel

Constructability: This tunnel would be relatively easy to construct by jacking it under the freeway, allowing the freeway to remain functional during construction.

Design Enhancements: This tunnel would be long (about 300 ft) and not very large, so it would likely not be used by more sensitive species such as deer. It would also potentially not be very usable by small animals such as small mammals and herpetofauna, since it cannot be vegetated. The use of low structures and objects in the tunnel could make them feel more comfortable. A light “sono tube” installed in the freeway median would allow some light to penetrate the structure. Impermeable 8-14 ft high fencing along both sides of roadway would help to funnel wildlife to the crossing keep it off the freeway.

b. Design type: 32x15 foot cast-in-place rectangular tunnel

Constructability**:** This tunnel could not be jacked, since 13x13 is the largest culvert that can constructed using the tunnel-jacking method. Thus, this construction would be much more difficult and costly. In particular, it would have to be done by means of a "cut and cover" method, which means that the freeway would have to be closed for some period, which would significantly impact traffic on one of the busiest freeways in the world.

Design Enhancements: This tunnel would be much wider than the jacked 13x13 tunnel, so it would likely be more readily used by deer. However, since it is a tunnel, it would potentially not be very usable by small animals such as small mammals and herpetofauna, since it cannot be vegetated. Again, low structures and objects could increase use by smaller species. A light "sono tube" installed in the freeway median would allow some light to penetrate the structure. Impermeable 8-14 ft high fencing along both sides of roadway would help to funnel wildlife to the crossing keep it off the freeway.

c. Design type: Vegetated wildlife overpass over Hwy 101 and Agoura Rd.

Constructability**:** The overpass would entail significant construction, since it would cross over 10 lanes of freeway. On the north side it could connect with an elevated bench, but on the south side the overpass would have to come down at a steep angle to reach ground level before Agoura Road. If the overpass continued across Agoura Road, a tunnel would have to be built under the overpass to accommodate Agoura Rd. The overpass could be vegetated and would be wide, so it could be usable by the full range of wildlife species, including large and smaller carnivores, deer, and small vertebrates including small mammals, reptiles, and amphibians.

Design Enhancements: As mentioned, the entire overpass would be vegetated with a range of plants and vegetation types (grass, shrubs, trees). Again, fencing would also be installed on both sides of the freeway to funnel animals to the overpass. Sound walls would also be built along the overpass over the freeway, to reduce light and noise from the freeway on the overpass.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

The smaller tunnel would accommodate mountain lion and medium sized carnivores. The larger tunnel would accommodate mountain lion, medium-sized carnivores, and deer. The overpass would accommodate movement for all species, including small mammals, reptiles, and amphibians.

6. SCORING

Experts Score

The Overpass design for this site was ranked as the highest priority crossing by all the experts, with 7 of the 7 experts ranking this site as the first priority. This site scored a total of 5.0 out of a possible 5.0 points.

Experts largely agreed that the overpass should cross both Hwy 101 and Agoura Rd. The steep incline created by terminating the overpass at Agoura Road was identified as a potential issue for wildlife, and it was agreed that vehicular mortality of wildlife along Agoura Rd. was a concern.

Landscape Score

The Liberty Canyon Bridge Overpass also ranked highest in terms of the Landscape Score, with a total 5.0 out of a possible 5.0 points.

Overall Score

The Liberty Canyon Overpass ranked as the highest priority wildlife crossing overall, with a total of 10 out of a possible 10 points

Site 3: Liberty Canyon Road

UTM COORDINATES: 340,991/3778,817 WGS84

Site 3, Liberty Canyon Road, looking north. Green shaded line marks edge of protected open space. White circles are bobcat locations, red squares are coyote locations.

1. SITE 3 DESCRIPTION:

This is the location where Liberty Canyon Road passes underneath US 101. The road is regularly used to exit and enter the freeway. There are 3 lanes - one in each direction and a turn lane for going left to go eastbound from the north, or westbound from the south. There is also a wide dirt shoulder on either side of the road, under the freeway.

Habitat

South: To the south, there is urban development next to the underpass on both sides of Liberty Canyon Road. On the east side, there is a large office building, with plans for increased size and increased night lighting. On the west side, there is a smaller office building, with a second office building under construction closer to Agoura Road. Between the main office building and the freeway there is a thin, 10 m or so, corridor of natural habitat composed of grassland, coyote brush, and pepper trees, that leads

westward behind the office buildings and down to a natural area of oaks, scrubland, and riparian habitat that has been restored by MRCA.

North: There is natural habitat on the north side of the Liberty Canyon Rd underpass. To the east it is mostly exotic grassland, and much of it is still grazed, especially across Liberty Canyon Rd. to the east. To the west there is some exotic grassland, but the riparian area around Liberty Canyon Creek has been greatly restored by MRCA and includes coastal sage scrub and riparian trees (willows, oaks).

Documented Existing Wildlife Use: Twenty years of NPS carnivore research in the area has documented extensive use of both sides of the freeway by bobcats and coyotes. On the south side of the freeway, this has included use of the natural areas between Agoura Rd. and the freeway. However from 2002-2017, studying 61 mountain lions and recording more than 120,000 GPS locations, we never documented collared mountain lions using this area between Agoura Rd. and the freeway. We have also documented several radio-collared bobcats and coyotes crossing the freeway in the Liberty Canyon area (all at least 10 years ago), and although we don't know for sure how they did so, they may well have used Liberty Canyon Rd. The two cases of mountain lions crossing 101 in the central Santa Monica Mountains also occurred right in this area. For P12 in February, 2009, although we don't know for sure how he crossed, it was potentially at Liberty Canyon Rd. For P64 in early 2018, he crossed using the Liberty Creek culvert.

Finally, we have some monitoring data for the underpass itself. From 1999-2000, the crossing was monitored with gypsum powder for one week/month for a year. A few species were documented to use it, including coyotes (3 times), raccoons (2 times), deer (15 times), and rabbits (5 times), but mostly people (487 times). In April 2015, NPS began monitoring the underpass and areas just to the north and south with remote cameras, to determine the extent to which wildlife is using the road underpass and the nearby areas. As of April, 2017 we have documented extensive use of the areas just to the north and south of the crossing by multiple species including mountain lions, but we have very few detections of wildlife in the underpass itself, and we have not detected any confirmed crossings, i.e., animals detected at both ends, indicating a crossing. There is currently (late 2017-early 2018) a project to significantly improve the underpass, specifically planting vegetation and adding rocks. to make it seem like a dry stream bed. We hope that this will improve the suitability for wildlife use.

Threats:

Human Use: The biggest threat to this crossing is the fact that Liberty Canyon Road is an active road with significant traffic. Since there is almost no development to the north (there is just a small school at the terminus of Liberty Canyon Rd), there is certainly less traffic than there could be. However, there is substantial development along Liberty Canyon Rd down to Malibu Creek State Park to the south. Traffic from these neighborhoods and from other areas along Agoura Rd enters the freeway westbound here, thus driving along the underpass, and likewise traffic exiting the freeway must turn south along the passage. As mentioned above, there is also significant urban development on the south side between the freeway and Agoura Rd. Aside from traffic on Liberty Canyon Rd. itself, there are also freeway on and off ramps between the underpass and the adjoining areas, both north and south of the freeway.

Light: Although there is no lighting inside the underpass itself, there is lighting along Liberty Canyon Rd. as it goes south, and along all 4 of the on and off ramps.

2. EXISTING INFRASTRUCTURE

The existing underpass consists of Liberty Canyon Rd, and areas under the freeway along the road. The road itself consists of 3 lanes, since there is a lane in each direction and a turning lane for turning left onto the east and westbound onramps. There is a wide area of dirt on either side of the road as well, which is mostly unvegetated. There is a current project to restore vegetation as much as possible to areas adjacent to and, to the extent possible under, the underpass.

3. LAND USE SECURITY:

Fine scale protection status: The land to the northwest of Liberty Canyon Rd. and the freeway is protected open space owned by MRCA/SMMC. The area due north of the underpass, where there is a trailhead and fire road, is also owned by MRCA/SMMC. However, to the northeast of the underpass the land is privately owned, between there and the Saratoga development to the east. There have been various development proposals over the years for that parcel, including having houses on the ridge overlooking Liberty Canyon and even having the egress for the development come out onto Liberty Canyon Rd. Acquiring this parcel as open space should be a high priority for conserving connectivity in the area.

All the land on the south side of the freeway at Liberty Canyon Rd. is privately owned. There is a conservation easement for the thin area behind the office buildings to the southwest that leads over to the restored MRCA property.

Broad scale protection status: As with site 2, the Liberty Canyon Rd. site is within the area identified as the Santa Monica Mountains - Sierra Madre Linkage based on the SC Wildlands Linkage Design work.

4. TRANSPORTATION MITIGATION OPTIONS

Design Enhancements: As mentioned above, restoration is currently being done for this underpass area, including revegetating areas around it, and even under it, as much as possible and moving or removing fencing, especially on the north side, to funnel animals towards the crossing. On the south side, MRCA/SMMC has also worked with the landowners at the office building to remove a driveway and parking lot behind the office, and to build a vegetated berm that would separate the back of the building from the natural corridor that would run from Liberty Canyon Rd. west down to the MRCA/SMMC property between Agoura Rd. and the freeway.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

This crossing is unlikely to be used much by smaller vertebrates, small mammals, reptiles, and amphibians, because of the openness of the area and the lack of vegetation. The vegetation restoration that is planned may help somewhat, but it will depend on the effectiveness of restoration all the way underneath the freeway. The underpass itself is likely usable as is for carnivores, from large carnivores like mountain lions down to smaller ones like skunks, as well as for deer, given the large, open nature of it. The biggest issue is the traffic along the road, which may be an impediment for more sensitive species or individuals, and of course the lack of connection to natural habitat on the south side. The lack of confirmed crossings over the last two years of monitoring with remote cameras is not encouraging, but it will be interesting to see how the restoration affects use.

6. SCORING

Experts Score

This site was ranked as the fourth priority crossing by the experts overall, with 2 of the 7 experts ranking this site as second priority, and an additional 2 experts ranking it as a third priority crossing. This site received a total Experts' score of 0.95 out of 5.0.

While the existing undercrossing could be enhanced to promote wildlife use, experts agreed that the existing highway on- and off-ramps present an issue for safe wildlife movement.

Landscape Score

The Liberty Canyon undercrossing site also ranked fourth in the Landscape Score, with a total 2.75 out of a possible 5.0 points.

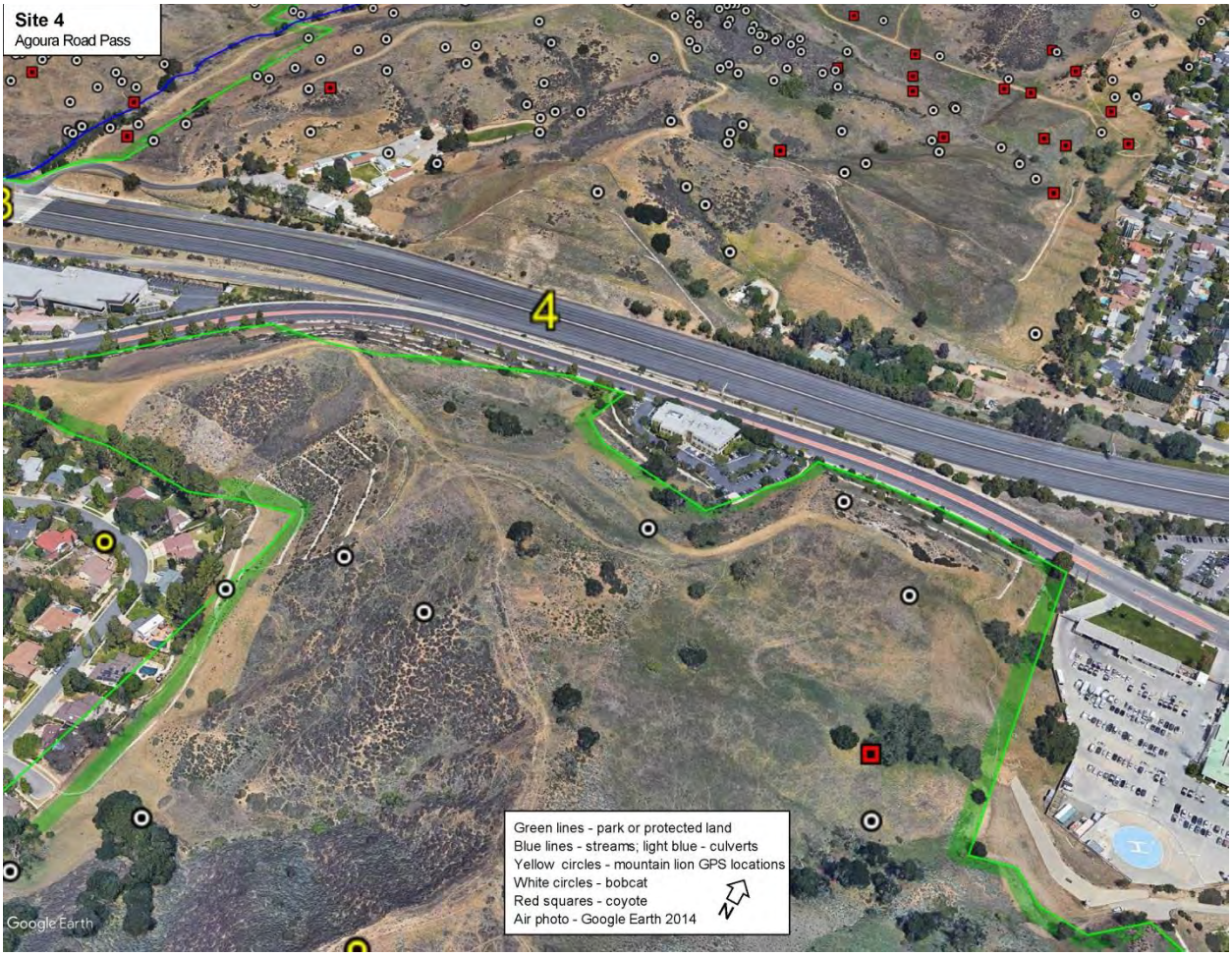
Overall Score

The Liberty Canyon Road undercrossing site ranked 4th overall, with a total of 3.70 out of a possible 10 points.

Site 4: Agoura Road Pass

UTM COORDINATES: 341,437/3778,868 WGS84

Site 4, Agoura Road Pass, looking west. Green shaded line marks edge of protected open space, although south of 101 this area is deed restricted but not under public ownership. White circles are bobcat locations, red squares are coyote locations, yellow circles are mountain lion locations.



1. SITE 4 DESCRIPTION

This is an area along the 101 freeway in Agoura Hills where you have steep embankments on both sides of the freeway, where Agoura Road comes right up to the 101 freeway across from just west of the Saratoga Hills Development. Both sides of the freeway are vegetated immediately adjacent to the freeway, but the south side consists of non-native shrubs (mainly some sort of ornamental Acacia) and the broader landscape connectivity to the south is not good.

Habitat:
South: Non-native landscaping shrubs, primarily Acacia sp.

North: Non-native grassland.

Documented Existing Wildlife Use: We have documented some use of the general area by bobcats and coyotes over the years, but none immediately adjacent to the site. In October, 2013, a young male mountain lion (P-H) was struck and killed by a vehicle in this area, where the southbound onramp from Liberty Canyon Rd. meets 101.

Threats:

Human Use: There is a roadway, Agoura Road, between the freeway and adjacent vegetation. There is a lot of development within close proximity of this location (see map – 150 meters from the crossing point to housing development). Although there does not appear to be high human use immediately at the site, there are people and lights nearby and Agoura Road has street lighting at this location.

Light: There are street lights on Agoura Road.

Vehicle Traffic: Animals could be hit trying to cross Agoura Road if the structure does not also go over Agoura Road.

2. EXISTING INFRASTRUCTURE

There is no existing infrastructure. Both sides of the freeway are cut slopes and are steep.

3. LAND USE SECURITY:

Fine scale protection status: Land on the north side is privately owned, although it is adjacent to SMMC owned lands. Lands on the south side are privately owned, although there is a deed restriction to open space that limits development there.

Broad scale protection status: As with site 2, the Agoura Rd. Pass site is within the area identified as the Santa Monica Mountains - Sierra Madre Linkage.

TRANSPORTATION MITIGATION OPTIONS

Constructability:
This would be an overpass between the two cut slopes.

Design type: Overpass

Design Enhancements: Native habitat could be restored on both sides of the freeway to increase cover and functionality. Fencing would also be required to direct animals to the crossing.

4. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

Mountain lions, medium-sized carnivores, small mammals, reptiles.

Other considerations: The connectivity on both the north and south sides is not as good as at other locations. The Calabasas Landfill and Saratoga Hills development present barriers on the north side of the freeway (the landfill blocks passage from the north and Saratoga Hills blocks access from the east). On the south side animals are funneled into a narrow piece of open space that is surrounded on three

sides by development and pinches down into a narrow corridor before connecting up with larger open space areas around Malibu Creek State Park.

5. SCORING

Experts Score
This site was not chosen as a priority crossing by any of the experts.

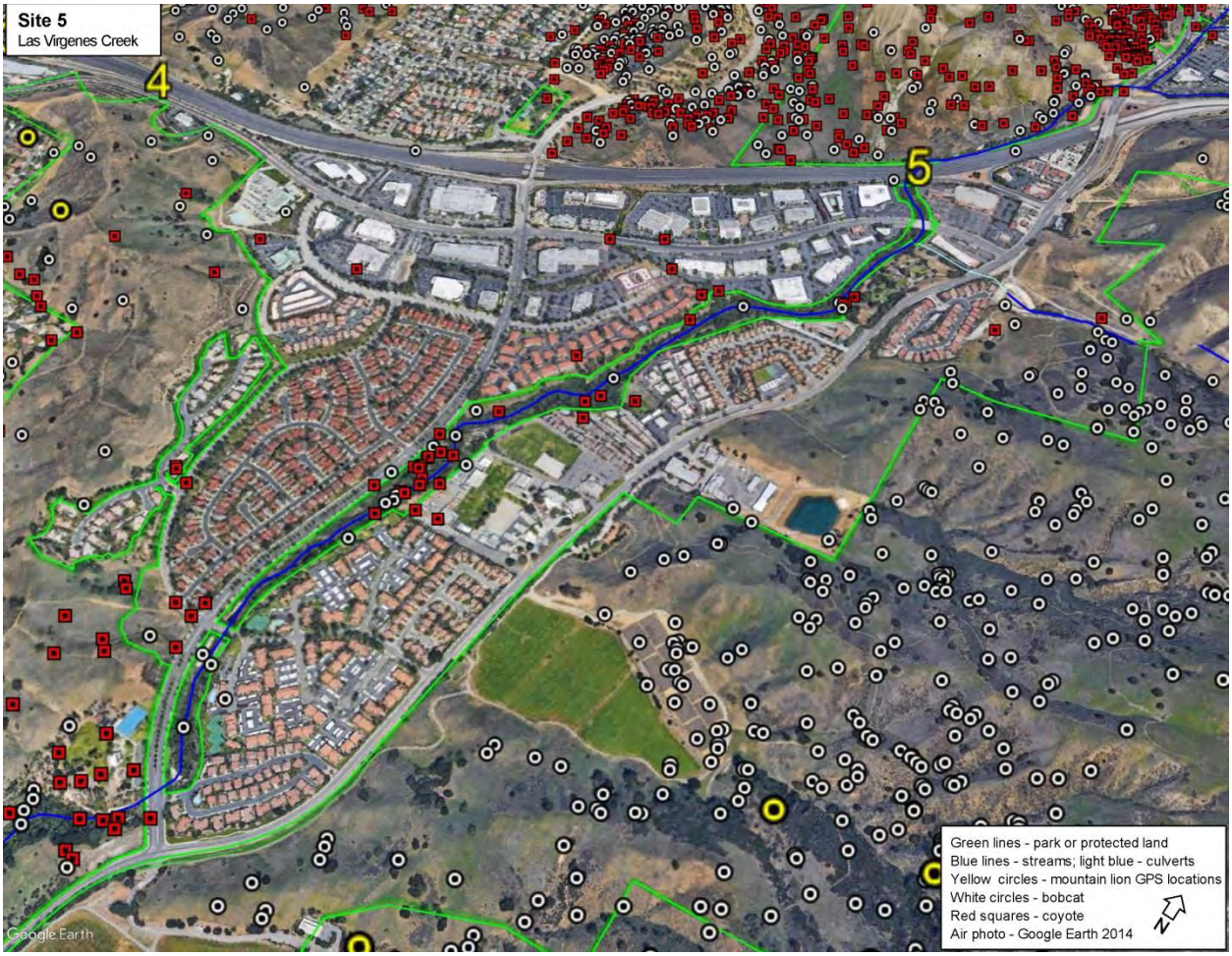
Landscape Score
The Agoura Road site ranked fourth in terms of the Landscape Score, with a total 3.25 out of a possible 5.0 points.

Overall Score
The Agoura Road crossing site ranked as a low priority, with a total of 3.25 out of a possible 10 points.

Site 5: Las Virgenes Creek

UTM COORDINATES: 343,113/3779,541 WGS84

Site 5, Las Virgenes Creek, looking north. Creek is visible running south, through intensely developed area. Green shaded line marks edge of protected open space. White circles are bobcat locations, red squares are coyote locations, yellow circles are mountain lion locations.



1. SITE 5 DESCRIPTION

This site is the underpass for Las Virgenes Creek under 101. There are three sections of the underpass, with cement walls in between them. There is permanent water in the creek and passing under the freeway. The creek is channelized to the north for 150 m or so, but in general there is good riparian habitat all along the creek north, south, and under the road.

Habitat:
South: The habitat to the south is good riparian habitat, including willows, oaks, and cottonwoods. However, the width of the natural, riparian habitat is quite narrow, as it passes between a commercial shopping area to the east and an office complex to the west. After the creek passes under Agoura Rd., it continues as natural, riparian vegetation, but the width is still quite narrow for more than 2 km to the south, until the creek crosses Lost Hills Rd. Historically, Las Virgenes Creek was also infested with

invasive crayfish (*Procambarus clarkii*), which have a large impact on native aquatic fauna, including amphibians. In the last couple of years, Mountains Restoration Trust (MRT) has done intensive trapping in many parts of Las Virgenes Creek to remove crayfish, and they seem to be absent from the Creek north of Agoura Rd. Moreover, after the huge rainyear of 2016-2017, a rare native amphibian moved into the main stem of Las Virgenes from a tributary, and the species is now present both north of 101 and south of 101, even below Agoura Rd. This means that this underpass was used by this amphibian species to cross the freeway.

North: The habitat to the north is also native riparian habitat, surrounded by exotic grassland and occasional scrubland south of the Calabasas Landfill. However this riparian habitat is in a cement channel for 150 m past the underpass to the north.

Documented Existing Wildlife Use: NPS research over the last 20 years has documented use of the Las Virgenes Creek corridor by bobcats and coyotes (see Map). Most of the data for the corridor south of the freeway are more than 10 years old, but we have documented radio-collared bobcats using the creek to the north and south of the freeway more recently. Through monitoring of the underpass itself with remote cameras between 1999 and 2000, we detected crossings by bobcats (2 times) and raccoons (15 times), as well as two detections, but not documented crossings, of mule deer.

Threats:

Human Use: There is extensive human use of the areas to the south of the underpass, especially in the commercial area to the east. There is also a new trail down from this commercial area and under the freeway, along the riparian area. It remains to be seen how much use this trail will receive. There is little human use north of the freeway currently, but this will also potentially increase now that the trail has been constructed.

Light: There is not much in the way of artificial light, either in the underpass or along the riparian areas, since there is thick riparian vegetation throughout.

1. EXISTING INFRASTRUCTURE

This underpass is very wide, to accommodate Las Virgenes Creek, although the value of the width is compromised somewhat by the fact that the underpass is divided into three separate sections by concrete walls. Each section is 5m in width, for a total width of about 20m (including wall widths).

2. LAND USE SECURITY:

Fine scale protection status**:** Land on the north side is owned by the Calabasas Landfill in conservation easement, and the area under the freeway itself is now a designated trail. Lands on the south side are owned by the various private landowners, in conservation easement along the creek.

Broad scale protection status**:** This site is within the area identified as the Santa Monica Mountains - Sierra Madre Linkage.

3. TRANSPORTATION MITIGATION OPTIONS

Constructability: The crossing itself here is likely relatively functional, although we have not documented a lot of use recently. The biggest issue with this crossing is the lack of connectivity to the south, where

the riparian habitat along Las Virgenes Creek is very thin for a long way south of the freeway. The crossing itself could be potentially improved by removal of one or both of the walls between the three sections under the freeway, but that is probably difficult or impossible structurally.

Design Enhancements: It is probably going to be difficult to substantially improve this crossing, since the biggest problem is the landscape configuration to the south, and the commercial and residential development has already occurred. For aquatic species, a significant issue has been the invasive aquatic species in Las Virgenes Creek, specifically crayfish. As mentioned above, MRT has already worked intensively to reduce crayfish populations in the creek, and in the Malibu Creek watershed, and has had significant success in Las Virgenes Creek generally, and especially north of Agoura Rd. The critical question will be whether crayfish can be kept out of the creek, or removed from areas farther south.

4. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

This site could be especially valuable for deer and reptiles and amphibians, since it relatively natural right up to the crossing on both sides, and because it has permanent water, making it valuable for amphibians. Historically, the presence of invasive exotic species reduced the potential value for native amphibians, but this has been changing recently, as mentioned above. This crossing could also be valuable for deer, and in fact was documented to receive some use by deer back in 1999-2000. However, the lack of a wide corridor of natural habitat to the south may also reduce the value for deer. More intensive monitoring of this site with remote cameras would be really valuable.

5. SCORING

Experts Score
The Las Virgenes Creek crossing was ranked as a second priority site by two experts, and a third priority by an additional two experts. It was observed that this crossing would provide a valuable linkage for amphibians and other small wildlife species. Overall, this site ranked third in priority by the experts, with a total score of 1.43 out of 5.0 points.

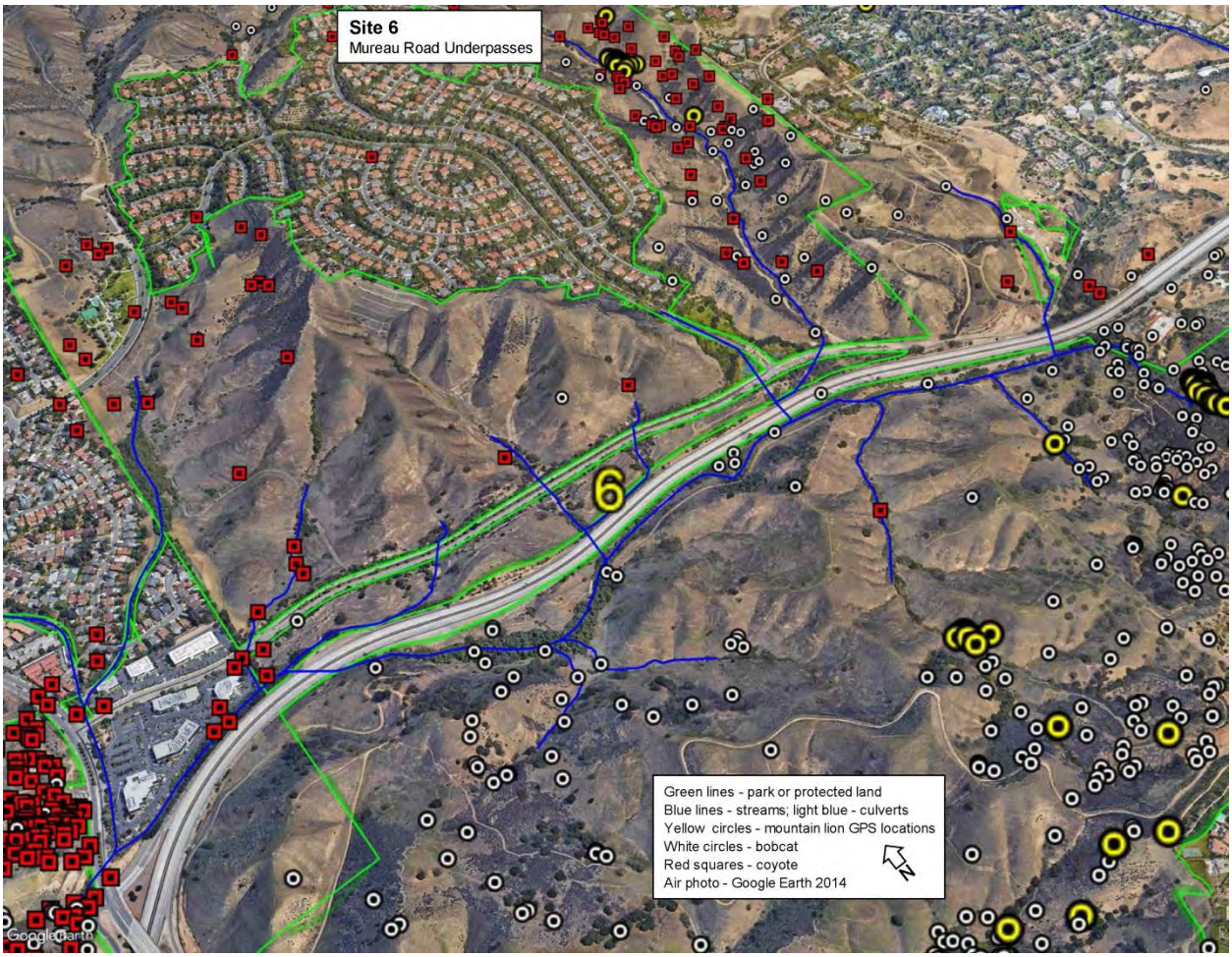
Landscape Score
This crossing ranked second in the Landscape scoring, with a total score of 3.33 out of 5.0. The fact that this site has not had a documented close approach by a mountain lion and only has good connectivity on the north side of the highway reduced its Landscape Score.

Overall Score
The Las Virgenes Creek crossing site ranked third overall with a total combined score of 4.76 out of a possible 10 points.

Site 6: Mureau Road Underpasses

UTM COORDINATES: Western pair of culverts: 344,538/3780,174 WGS84
Eastern pair of culverts: 345,067/3780,222 WGS84

Site 6, Mureau Road Underpasses, looking north. Green shaded line marks edge of protected open space. White circles are bobcat locations, red squares are coyote locations, yellow circles are mountain lion locations.



1. SITE 6 DESCRIPTION

There are multiple underpasses in this area, that move water from north to south under the freeway. The main crossing consists of two crossing points, each with two paired tunnels, with a clear view under the freeway for one of the tunnels but not for the other, as the other tunnel bends down or to the side. The tunnels that go straight through may end in standing water on the south side of the freeway.

Habitat:

South: Habitat to the south is mixed scrub and exotic grassland. There are also some wooded areas, especially along drainages, mostly live oaks.

North: Habitat to the north, specifically between Mureau Rd. and the freeway, is natural vegetation, although it is mostly exotic grassland and disturbed areas with some scrubland, and then landscaped vegetation along Mureau Rd.

Documented Existing Wildlife Use: We have never documented wildlife using these crossing structures, although we have also never had a chance to monitor them specifically. We have radio-tracked bobcats and coyotes in Crummer Canyon, Hidden Hills, and other areas nearby to the north, although in general animals did not ever come across Mureau Rd to the area between Mureau and the freeway (see map), that we know of. On the south side, we have seen some use of these areas by two GPS-collared bobcats as part of an aborted project with Caltrans to evaluate 101 crossing points. Neither of these animals crossed the freeway. We have seen relatively little use of any of these areas by mountain lions. P3 came down Crummer Rd. a couple of times early in the study, including making a kill. Collared mountain lions have rarely used the area to the south of these crossings, perhaps because much of this area, especially farther south from the crossings, is all exotic grassland and is still grazed, or has been recently, so it may not provide good deer habitat or hunting areas for lions.

Threats:

Human Use: There is not much in the way of human use of these areas or culverts. The biggest issue for these sites is the fact that they are separated from the main natural areas used by wildlife by another road, Mureau Rd., which has two lanes in each direction and a median. Mureau Rd. does not have significant traffic at night, but does during the day, and it is a wide and open area that presents a barrier, certainly to smaller species. The best solution would be to also have a crossing structure under Mureau, such as at Crummer Canyon.

Light: The underpasses under 101 are far down below Mureau, so there is not much artificial light affecting them.

2. EXISTING INFRASTRUCTURE

There are two sets of culverts under 101, each with two adjacent culverts. In each case, one culvert has direct sightlines all the way through to the other side of the freeway, and one does not, because it curves to the side or down. Depending on the amount of water present, the culverts end in standing water on the south side. The specifics on the two sets of culverts are:

Western Pair of Culverts: Both culverts are round and metal. The eastern one (to the left looking south) is 4 ft in diameter, and the western one (to the right looking south) is 5 ft in diameter. The eastern one has visibility all the way through it, although it is very long; the western one does not have visibility - it bends and is dark. As of August 2016, the entrance area was totally overgrown with willows, but the culverts were not silted in at all.

Eastern Pair of Culverts: For this pair, the eastern culvert is round and metal, 5 ft. in diameter. As of August 2016 there was water running through it, and it had visibility all the way through. This culvert is shorter than the eastern culvert in the Western Pair, and ended in a large pool of water that came 20 m up into the culvert. The western culvert is cement and rectangular, more than 6 ft. tall. It gradually turns a corner to the left, so there is no visibility all the way through, and there was 6 inches of standing water in it as of August 2016.

3. LAND USE SECURITY:

Fine scale protection status**:** Land on the south side is protected, recently acquired by MRCA/SMMC.

Lands on the north side, between Mureau Rd. and the freeway, are owned by the Mountain Gate community, except for areas within the Caltrans right-of-way for the freeway. On the north side of Mureau Rd., there are some natural areas that are in conservation status, owned by Mountain Gate, and then eventually, north of Mountain Gate, there are MRCA lands on the former Ahmanson Ranch.

Broad scale protection status: This site is within the area identified as the Santa Monica Mountains - Sierra Madre Linkage.

4. TRANSPORTATION MITIGATION OPTIONS

Constructability: In order for these crossings to function, especially for animals coming from the north, there would likely also have to be a good way for them to cross Mureau Rd. This would involve improved underpasses under Mureau Rd. Currently, there are culverts under Mureau Rd. in the drainages above each pair of culverts, but they are not very functional for wildlife. For example, the one above the western pair of culverts has a metal grate across it, preventing use by any larger animal. The one above the eastern pair of culverts does not have a grate, but it has a 4 ft. drop into a very deep pool of water (as of August 2016). Something also could be enhanced along Crummer Canyon, a bit farther east, which is known to be used by wildlife, specifically carnivores, on the other side of Mureau. Since Mureau Rd. is not too wide, and there are no developed areas on either side of Mureau here, making these kinds of changes could be relatively cost-effective. However, it would only be worth doing if the underpasses under 101 were effective.

In terms of increasing the effectiveness of these culverts under 101, it would be desirable to make sure they did not end in standing water on the south side, especially for use from south to north. For the western culverts that do not currently have visibility all the way through, more investigation would need to be done about whether they could have any value for wildlife movement, but the lack of visibility is not promising.

Design type: Enhancement of the culverts under Mureau Rd. Long-term elimination of standing water at culverts, on the south side of the freeway.

Design Enhancements: Fencing would be needed to guide animals to the underpasses, both under 101 and under Mureau.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

Mountain lions, medium-sized carnivores, small mammals, reptiles, possibly amphibians. These culverts are not likely to ever get much, or any, use by deer, given their long length and small cross-sectional area. Use by smaller vertebrates could potentially be enhanced by low structures on the bottom, although these could impede drainage. If they could stay moist throughout their length, they could be usable by amphibians, given that they are wet on the south side.

6. SCORING

Experts Score

The Mureau Road Underpasses crossing site was ranked as a second priority crossing by three experts, and a third priority crossing by an additional two experts. Overall, this site was ranked second in priority by the experts, with a total score of 1.90 out of 5.0 points.

Landscape Score

This crossing ranked third in the landscape scoring, with a total score of 3.08 out of 5.0. The facts that there is no documented approach of the crossing by mountain lions and that the overall landscape connectivity is low decreased its score.

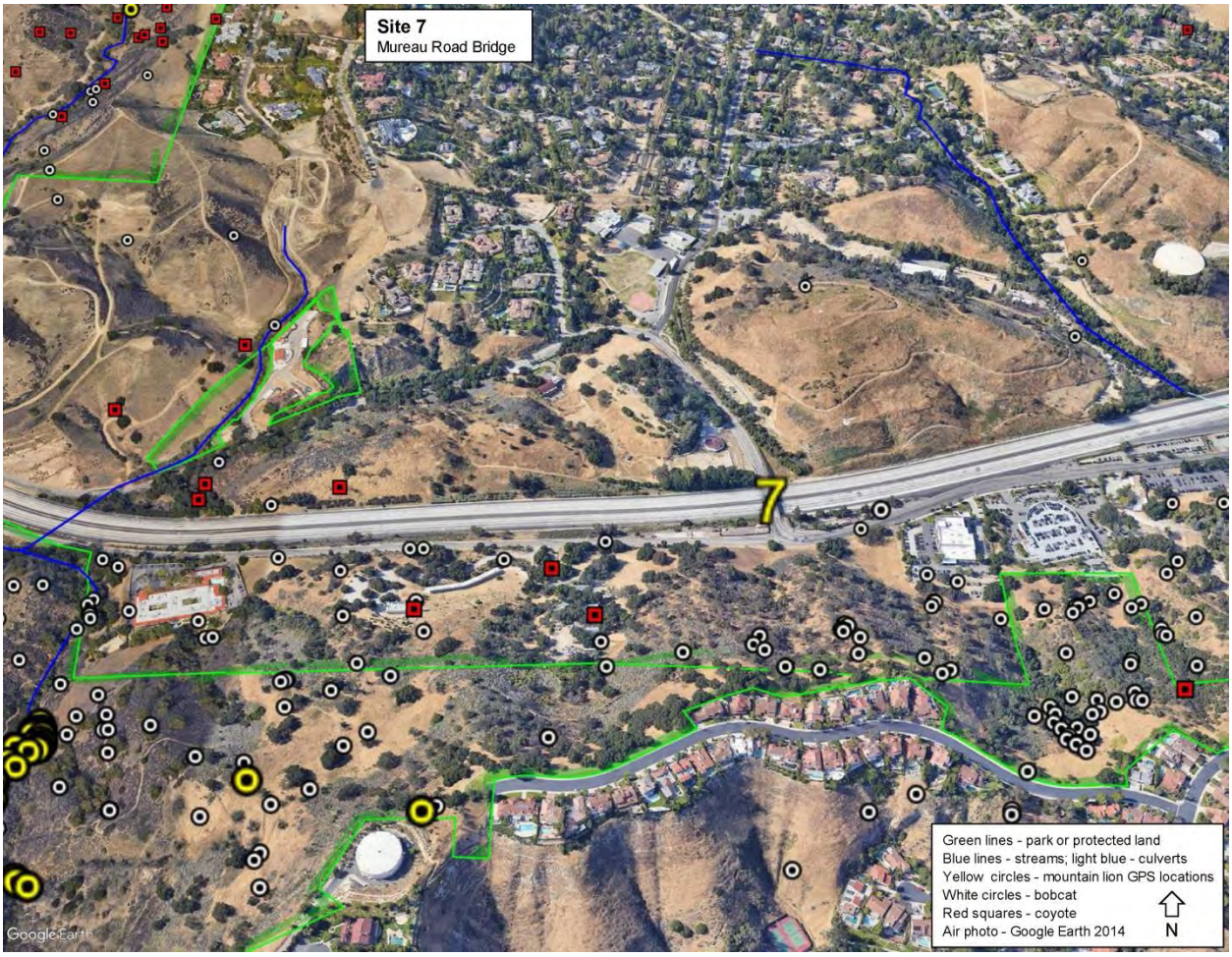
Overall Score

The Mureau Road tunnel crossing site ranked second overall with a total combined score of 4.98 out of a possible 10 points.

Site 7: Mureau Road Bridge

UTM COORDINATES: 346,519/3780,006 WGS84

Site 7, Mureau Road Bridge, looking north. Green shaded line marks edge of protected open space. White circles are bobcat locations, red squares are coyote locations, yellow circles are mountain lion locations.



1. **SITE 7 DESCRIPTION**

This is the road bridge where Mureau Road passes over the 101 Freeway, in Calabasas.

Habitat:
South: Dirt and non-native grassland immediately adjacent to where the bridge hits ground on the south side transitioning into scattered shrubs with some tree cover (live oaks) after crossing Calabasas Road.

North: Non-native grassland with scattered shrub cover.

Documented Existing Wildlife Use: We have documented some use of the general area by bobcats, coyotes, and mountain lions over the years, but none immediately adjacent to the site.

Threats:

Human Use: The actual crossing is a road that has relatively heavy traffic flow. There is a house just 60 meters from the bridge on the north side, and on the south side there is a secondary road (Calabasas Road) as well as a power station very near where the bridge ends after crossing the freeway.

Light: There are lights at the power facility on the south side of the bridge.

Vehicle Collisions: The crossing structure is a well-used road with no vegetation, cover, or other wildlife protections, and it ends on the south side at another road.

2. EXISTING INFRASTRUCTURE

The current structure is a bridge for cars with no vegetation. It has a cement sidewalk for people on the east side but not on the west side.

3. LAND USE SECURITY:

Fine scale protection status: Land on the north and south sides is privately owned.

Broad scale protection status: This area is close the Santa Monica Mountains - Sierra Madre Linkage, but is not within it, similar to the Palo Comado Bridge.

4. TRANSPORTATION MITIGATION OPTIONS

Constructability: In order for this crossing to function, areas on both the north and south side would need to be vegetated and the bridge would need to be expanded to include a fenced wildlife crossing area.

Design type: Bridge.

Design Enhancements: To make this bridge more effective as a wildlife crossing, it would need a wider space for wildlife crossing, ideally that is vegetated, as well as a taller wall blocking the view of the freeway.

5. SPECIES FOR WHICH CONNECTIVITY COULD BE IMPROVED

Mountain lions, medium-sized carnivores, deer, small mammals, reptiles.

Other Considerations: The connectivity to the north and the south are bad. On the north side the bridge is located in a small pocket of open space completely surrounded by development and cut off from larger habitat areas by areas of dense housing. On the south side, the bridge terminates in a small sliver of open space surrounded by development that parallels the freeway. On the south side this sliver of open space runs into Parkway Calabasas (another opportunity to get hit by a car) and to the west it is several miles before it opens into larger open space areas and is no longer bounded by dense development to the south.

6. SCORING

Experts Score

Like Palo Comado Bridge, the Mureau Road Bridge was not ranked as a priority by any of the experts, so it had an expert score of 0.

Landscape Score

This crossing was ranked second to lowest in the Landscape scoring, with a total score of 0.75 out of 5.0.

Overall Score

The Mureau Road Bridge crossing site ranked 7th out of 7 overall with a total combined score of 0.75 out of a possible 10 points.

Appendix C: January 15, 2015 Experts Workshop Attendees			
Last Name	**First name**	**Organization**	**E-mail**
EXTERNAL EXPERTS			
Beier	Paul	Northern Arizona University	Paul.Beier@nau.edu
Clevenger	Anthony		apclevenger@gmail.com
Cramer	Patty	Utah State	patricia.cramer@usu.edu
Huber	Patrick	UC Davis	prhuber@ucdavis.edu
Kintsch	Julia	Eco-Resolutions	julia@eco-resolutions.com
Stricker	Kelsey	Pechanga	kstricker@pechanga-nsn.gov
Zeller	Kathy	University of Mass.	kathyzeller@gmail.com
WORKSHOP INVITEES (BEYOND EXPERTS)			
Abelson	Eric	UCLA	eabelson@ucla.edu
Assef	Tania	Caltrans-District 12	tania.asef@dot.ca.gov
Basilavec	Chris	The Nature Conservancy	cbasilevac@tnc.org
Brehme	Cheryl	USGS-WERC	cbrehme@usgs.gov
Brigham	Christy	National Park Service	christy_brigham@nps.gov
Fisher	Robert	USGS-WERC	rfisher@usgs.gov
Fromer	Paul	San Diego Management and Monitoring Program	pfromer@gmail.com
Hofffman	Jen	Western Riverside County RCA	jhoffman@biomonitoringrca.org
Jennings	Megan	San Diego State University	mjennings@mail.sdsu.edu
Lyren	Lisa	USGS-WERC	llyren@usgs.gov
Marquez	Barbara	Caltrans - District 7	barbara.marquez@dot.ca.gov
Pert	Heather	California Department of Fish and Wildlife	heather.pert@wildlife.ca.gov
Pienkos	Charlotte	The Nature Conservancy	cpienkos@tnc.org
Principe	Zach	The Nature Conservancy	zprincipe@tnc.org
Randall	John	The Nature Conservancy	jrandall@tnc.org
Reppun	Erika	Caltrans - District 7	erika.reppun@dot.ca.gov
Riley	Seth	National Park Service	seth_riley@nps.gov
Rochester	Carlton	USGS-WERC	crochester@usgs.gov
Siepel	Nancy	Caltrans - District 5	nancy.siepel@dot.ca.gov
Sikich	Jeff	National Park Service	jeff_sikich@nps.gov
Smith	Trish	The Nature Conservancy	trish_smith@tnc.org
Stevens	Clark	Santa Monica Mountains RCD	cstevens@rcdsmm.org
Stricker	Kelsey	Pechanga	kstricker@pechanga-nsn.gov
Syzmanski	David	National Park Service	david_syzmanski@nps.gov
Vickers	Winston	UC Davis	twinstonvickers@gmail.com