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Via Electronic Mail Only

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Re: Comments on Draft EIR for Brea Boulevard/Brea Canyon Road Widening Project (IP 17-046) SCH # 2017051005

Dear Mr. Shannon and Mr. Morgan:

On behalf of Hills For Everyone, we have reviewed the Draft Environmental Impact Report ("DEIR") prepared in connection with the Brea Boulevard/Brea Canyon Road Widening Project ("Project"). Hills For Everyone has serious concerns about the environmental impacts of the Project as currently proposed. As discussed in more detail below, the DEIR substantially understates, and fails to adequately analyze or mitigate, the severity and extent of significant project-related effects on Aesthetics, Biological Resources, Hydrology, and Growth-Inducing Impacts. Furthermore, the alternatives considered do not meet basic requirements. The environmental documentation for the Project is thus inadequate as an informational document and violates the minimum standards of adequacy under the California Environmental Quality Act ("CEQA"), Public Resources Code § 21000 et seq., and the CEQA "Guidelines," California Code of Regulations, title 14, § 15000 et seq. The DEIR understates the impacts of the project and fails to identify adequate mitigation measures to reduce the Project's impacts, even though such measures are readily available and feasible. Moreover, there are myriad policy reasons to reconsider this project entirely.

The DEIR found that impacts to Aesthetics, Noise, and Transportation were significant and unavoidable. However, that does not allow the DEIR or the County to simply conclude that nothing else be done. CEQA requires that the most effective and feasible measures to reduce the impacts be adopted, even if they do not result in reducing the impacts to a less than significant level. This DEIR is woefully deficient in that regard.

Hills For Everyone was formed over 40 years ago with the specific mission to protect the unique, rare, and disappearing landscape in the Puente-Chino Hills. These hills lie at the juncture of four of Southern California's most populous counties: Los Angeles, Orange, Riverside, and San Bernardino. The group's first goal was the creation of the Chino Hills State Park. By designing the Park along ridgeline boundaries, Hills For Everyone originated a design strategy that protected the watershed and the viewshed. From its earliest history, Hills For Everyone has opposed projects that damaged the evolving Park and supported decisions, including the modification of potentially-harmful projects, that enhanced it.

The Project involves widening Brea Boulevard from two to four lanes (two lanes each direction) between Canyondale Drive and the northern end of the roadway corridor, replacing and widening three functionally obsolete bridges, installing traffic signals approximately 1,200 feet north of Canyon Country Road and at the intersection of Brea Boulevard and Tonner Canyon Road, replacing the existing signal at Canyon Country Road, modifying existing driveway ingress/egress, installing a new wildlife overpass/land bridge, adding open graded asphalt concrete paving (OGAC) at the southern end of the roadway corridor, and providing striping and installing new signage. Construction of these improvements would be conducted within permanent and temporary limits of disturbance along the roadway corridor (i.e., the project limits).

The DEIR is misleading about the County's options as it relates to construction along this roadway corridor. The County does not have to simply decide between the Project as proposed or no roadway improvements at all. The DEIR should study a project with reduced impacts such as rebuilding the three bridges with no expansion to roadway capacity. This would provide the safety improvements to the bridges desired by the County while minimizing impacts to sensitive biological, hydrological, and natural land resources in the Project vicinity. Furthermore, this alternative would cost a fraction of the estimated $181M for the full roadway widening.

I. The DEIR has Faulty or Insufficient Analyses, Lacks Valid and Enforceable Mitigation, and Therefore Violates the California Environmental Quality Act.

A. The DEIR Describes an Inaccurate Baseline Environmental Setting.

The environmental setting provides "the baseline physical conditions by which a lead agency determines whether an impact is significant." CEQA Guidelines § 15125(a). "Without a determination and description of the existing physical conditions on the property at the start of the environmental review process, the EIR cannot provide a meaningful assessment of the environmental impacts of the proposed project." *Save Our*

Peninsula Committee v. Monterey Cnty. Bd. of Supervisors (2001) 87 Cal.App.4th 99, 119.

This project began with the issuance of a Notice of Preparation (NOP) and Initial Study on May 2, 2017. Two years later, a new NOP and Initial Study for a revised project was published on May 17, 2019. Two and a half years after that, the Notice of Availability for the Draft EIR was published on December 1, 2022. CEQA provides that the date of the Notice of Preparation ("NOP") is "normally" the date upon which the DEIR's baseline conditions should be set. CEQA Guidelines § 15125. However, as the courts have emphasized, "the date for establishing the baseline cannot be a rigid one" and must be evaluated in light of other relevant factors. *Save Our Peninsula Committee,* 87 Cal.App.4th at 125.

In the case of this Project, the use of a different baseline for the purposes of assessing traffic-related impacts is not only acceptable, but imperative. There have been substantial changes to travel and commute patterns since 2019 that are critical to take into account in order to provide an informative and accurate analysis of environmental impacts. Most importantly, the COVID-19 pandemic and its fall-out—all of which post-date the issuance of the NOP—have fundamentally altered traditional commute patterns and typical five-day, in-office work weeks. These changes have in turn effected where office-based professionals are choosing to live, how they are able to connect with their workplace remotely, and how/when/if they are continuing the same (or varied) daily commute and travel patterns that were present before the seismic shift to remote work. Orange County's own Transportation Authority recognizes and documents these changes in its draft Long Range Transportation Plan.[1]

Despite these well-recognized changes in commute patterns, the DEIR relies exclusively on pre-pandemic daily trip volumes and level of service calculations from 2019. Specifically, the DEIR states that "[T]he traffic data collected for the traffic analysis included 7:00 to 9:00 AM and 4:00 to 6:00 PM peak hour turning movement and Average Daily Trips (ADT) counts conducted during the second week of September in 2019. The dates for the traffic counts are representative of typical conditions in the study area." *See* DEIR at 5.11-4.

The DEIR's use of 2019 baseline numbers ignores reality and virtually ensures that the resultant analysis is uninformative and inaccurate. Orange County and Caltrans publish Annual Traffic Volume Maps for key roadways throughout the County. The most

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[1] *See, e.g.,* Orange County Transportation Authority ("OCTA"), *Directions 2045, Long Range Transportation Plan* (January 2023 Draft) ("OCTA LRTP") at 2-28 (noting that the percentage of residents working from home increased from 11.5% in February 2020 to 46.5% at the height of the pandemic and that most residents indicated a continued desire to work from home after the pandemic). (reproduced at https://www.octa.net/pdf/LRTPJan2023DRAFT.pdf)

recent map (dated 2022) notes that ADT through Brea Canyon ranges from 13,000 to 16,000 vehicles.[2] The data represented on the map is based on traffic counts conducted in 2021. These traffic volumes are about 75% of the 2019 traffic volumes, and this newer, more relevant data calls into question the need for the road widening at all.

Accordingly, to provide a meaningful and accurate baseline, the County must conduct revised traffic counts to determine the current, actual baseline conditions in light of the fundamental changes to traffic due to the Covid pandemic. Only by doing so can the County provide a meaningful analysis of Project impacts. Moreover, as further explained below, an accurate, real world traffic count may show that the asserted need for the Project no longer exists or is substantially less than in pre-Covid times.

Another deficiency in the Project baseline is its failure to acknowledge or address the conservation easement that exists along the roadway corridor, which affects the land use setting. In approving the Tonner Hills Project in 2007, the County adopted a CEQA mitigation measure requiring the conservation of high quality habitat to mitigate for habitat losses caused by the project. To implement this mitigation, a conservation easement was dedicated on June 18, 2007, as shown in the Tonner Hills Conservation Easement Deed ("Conservation Easement"), attached as Exhibit A.

The Conservation Easement was established to provide "high quality habitat for the threatened California gnatcatcher as well as the opportunity for major habitat restoration and enhancement efforts that will benefit other species associated with coastal sage scrub, riparian, and walnut woodland communities." *See* Exhibit A at 1. The Conservation Easement specifically states that the conserved land will be enhanced ***to improve its habitat functions*** and values by removing low-quality non-native vegetation and replacing it with riparian vegetation of higher biological value consistent." *Id.* Exhibit B, Tonner Hills Mitigation and Conserved Areas map, illustrates the location of the Conservation Easement lands (shown in blue and green) and where the proposed Project will directly impact those lands. As detailed below, the DEIR's failure to acknowledge the existence of the Conservation Easement in the land use setting undermines its analysis of the biological impacts of the roadway widening, which will interfere with the purposes of the Conservation Easement.

B. The DEIR Mischaracterizes, Understates, and Fails to Mitigate the Project's Growth-Inducing Impacts.

The DEIR asserts that the Project would not induce substantial unplanned population growth in an area, either directly (for example, by proposing new homes and

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[2] Orange County 2022 Traffic Flow Map: https://www.octa.net/pdf/2022-ADT.pdf

businesses) or indirectly (for example, through extension of roads or other infrastructure). *See* DEIR at 4-5. It also asserts that because one of the objectives of the Project is to accommodate the existing ADT capacity by improving the roadway to be consistent with the County's Primary Arterial Highway classification per the MPAH, the Project is growth "accommodating," not growth inducing. *See* DEIR at 7-1.

However, neither the DEIR nor its appendices contain any evidence to support this conclusion. By contrast, numerous studies—and decades of experience—show just the opposite. This Project, like most roadway expansion projects, does indeed create "induced demand." The California Department of Transportation ("Caltrans") describes induced demand/induced traffic as resulting from projects that increase travel speeds, such as roadway capacity projects. *See* Exhibit C at 2 and Exhibit D. Such projects allow drivers to take new or longer trips, and to move from transit or other non-auto modes to driving. In addition, greater speeds spur land uses to spread out, increasing travel distances. After a while, that extra traffic again causes congestion, but the spread-out land uses remain, so travelers must spend more time and money reaching desired destinations, with greater emissions. *Id*.

Roadway expansions are textbook examples of infrastructure improvements that initially sound like they are "growth accommodating," but are actually "growth supporting." The Victoria Transport Policy Institute study on Generated Traffic and Induced Travel states "[u]rban economists have long realized that transportation can have a major impact on land use development patterns, and in many situations improved accessibility can stimulate development location and type." *See* Exhibit E at 13. Although the widened roadway will eventually be congested again, in the near-term, larger transportation infrastructure can set the stage for encouraging and inducing more intense and additional land uses that otherwise would not have occurred Also, because the City of Brea General Plan identifies the roadway as a Modified Secondary Arterial, and the Project is widening the roadway to Modified Primary Arterial standard, the infrastructure being proposed is necessarily more intense and growth-inducing.

The DEIR at p. 7-1 states "implementation of the Project would not result in the removal of an impediment to growth such as the establishment of an essential public service or the provision of new access to the area. No impact would occur." A roadway that is widened to provide more capacity is able to accommodate more vehicles, and provides more access between Brea and Hwy 57. The characterization of this as "no impact" is inaccurate and misleading. The DEIR states that the existing conditions are an ADT rate of 17,000-22,000 vehicles per day. As shown above, this conclusion is based on an outdated and misleading baseline; the actual baseline is almost certainly at least 25% lower. However, even using this artificially high baseline, Orange County is proposing to widen the roadway corridor to a Primary Arterial standard to accommodate up to 30,000 vehicles daily—thereby ***doubling*** the amount of traffic capable of travelling on the new roadway. By doubling the amount of traffic that can move through the area, the Project will remove a major impediment to access and thereby induce new growth in the area.

In sum, the DEIR's assertion that the Project will not have any growth-inducing impacts is inaccurate, misleading, and unsupported by any substantive evidence.

C. The DEIR's Analysis of and Mitigation for the Impacts of the Project are Inadequate.

1. The DEIR Fails to Adequately Address and Mitigate Impacts to Aesthetics (Scenic Resources, Light and Glare).

The City of Brea recognizes Brea Canyon Road/Brea Boulevard as a scenic resource and plans to preserve the hillsides in the vicinity of Brea Canyon Road to the maximum extent possible by maximizing the amount of hillside areas left in its natural state and limiting grading. *See* Brea General Plan at 4-36. The DEIR acknowledges that Brea Canyon Road is a roadway with high scenic quality. *See* DEIR at 5.1-1.

Despite this recognition of the unique scenic qualities of the area, the Project as proposed will have significant impact to scenic vistas and would substantially damage scenic resources, including within view of a State scenic highway. *See* DEIR at 5.1-7. In addition, visual impacts from Key Views 1 and 2 are also significant. The DEIR concludes that impacts to scenic resources are significant and unavoidable and offers no mitigation measures to attempt to reduce this impact.

The DEIR's failure to identify and analyze potential mitigation measures to limit these impacts violates CEQA. Where all available and feasible mitigation measures have been proposed, but are inadequate to reduce an environmental impact to a less-than-significant level, an EIR may conclude that the impact is significant and unavoidable. *See* CEQA Guidelines § 15126.2. If supported by substantial evidence, the lead agency may make findings of overriding considerations and approve the project despite its significant and unavoidable impacts. *Id*. at §§ 15091, 15093. However, the lead agency cannot simply conclude that an impact is significant and unavoidable and move on. A conclusion of residual significance does not excuse the agency from (1) performing a thorough evaluation and description of the impact and its severity before and after mitigation, and (2) proposing all feasible mitigation to "substantially lessen the significant environmental effect." CEQA Guidelines § 15091(a)(1); see also id. § 15126.2(b) (requiring an EIR to discuss "any significant impacts, including those which can be mitigated, but not reduced to a level of insignificance.") Furthermore, "[a] mitigation measure may reduce or minimize a significant impact without avoiding the impact entirely." Stephen Kostka & Michael Zischke, *Practice Under the California Environmental Quality Act* § 14.6 (2d ed. 2008).

In the case of impacts to scenic resources, potential mitigation measures could, for instance, include reducing the width of the road to lessen the need for hillside cuts, thereby lowering the height of retaining walls and minimizing the aesthetic impacts.

Another impact identified in the DEIR is light and glare generated by the Project. Construction of the Project will require periodic full closure of Brea Boulevard (from Friday at 8:00 pm to Monday at 5:00 am) due to bridge replacement-related work. During these times (up to a maximum 26 weekends with the full roadway closure), construction activities would occur outside the normal hours of construction, as crews will work extended hours, night shifts, and weekends. During night shifts and extended hours, construction lighting will be required. *See* DEIR at 5.1-11. While there may not be residences nearby that would be impacted by high-intensity construction lighting during the marathon weekend closures with night crews working, the light and glare will affect wildlife in the wildlife corridor and along Brea Creek. The DEIR did not analyze light and glare impacts on wildlife and is therefore inadequate in the conclusion that the light and glare impacts of the Project are less than significant. There may be measures that are not needed to minimize light and glare impacts to humans, but that are necessary and appropriate when minimizing light and glare impacts to wildlife. This issue needs to be analyzed, impacts assessed, and measures to reduce the impacts need to be identified.

2. The DEIR Fails to Adequately Identify and Mitigate Impacts to Biological Resources.

There have been substantial public and private investments in protecting the Puente-Chino Hills Wildlife Corridor from development and in creating connected natural spaces for wildlife to exist and thrive. At the local level, the City of Brea General Plan emphasizes that wildlife canyon corridors like Brea Canyon are key to supporting important biological resources, including several rare and endemic communities. "Wildlife corridors are considered an important declining resource in California because ongoing urbanization has separated remaining natural open space, interrupting wildlife movement and isolating populations. The primary threats to wildlife connectivity in the Southern California region include urbanization, ***roads***, invasive species, and agriculture. Scientific studies have shown that the isolation of habitat can lead to ecosystem collapse. Small, isolated areas of habitat simply cannot support as many species in a larger area." *See* Brea General Plan at 4-29 (emphasis added).[3] Other City General Plan policies

[3] https://www.ci.brea.ca.us/DocumentCenter/View/13951/Chapter-4---Community-Resources-2003

related to Brea Canyon that should be respected when considering any improvements to the road include: Policy CR-9.2, Preserve the integrity of blue line streams and riparian habitat areas; and Policy CR-9.5, Manage areas of diverse wildlife habitat as a natural resource and prevent major destruction or disruption.

The City of Brea has also undertaken several concrete efforts to implement these General Plan policies, further supporting the viability of the Puente-Chino Hills Wildlife Corridor. The City has secured a conservation easement on land in Brea Canyon and it is a founding member of the Wildlife Corridor Conservation Authority ("WCCA"), a JPA established to provide for the proper planning, conservation, environmental protection, and maintenance of lands within the Puente-Chino Hills corridor area. The WCCA's goal is to assure that sufficient continuity of habitat can be preserved to maintain a functioning wildlife corridor, which is made up of about 40,000 acres of land located between the Santa Ana Mountains and Whittier Hills.

The City is also a founding member of the Hillside Open Space Education Coalition ("HOSEC"), a regional city-based coalition formed to find ways to preserve strategic parcels of hillside open space from the threat of development, to prevent unwanted impacts on existing traffic congestion, schools, community infrastructure, and runoff pollution, as well as the regional wildlife and open space corridor. As these efforts illustrate, preservation of the wildlife corridor and preservation of Brea Canyon hillside open space is foundational to the City of Brea's planning and policy efforts, as reflected more generally in the General Plan, Municipal Code, and "Brea Envisions" Community Strategic Plan.[4]

The County should respect these efforts by its sister City as it considers transportation enhancements in the Brea Canyon Road corridor. As detailed below, the DEIR's analysis of biological impacts fails to do so.

The Puente Hills Habitat Preservation Authority ("Habitat Authority") prepared a comment letter on the Brea Boulevard Corridor Improvement Project DEIR (dated January 30, 2023) that we understand was submitted to the County. Hills For Everyone agrees with the concerns raised in that letter and incorporates them herein. Hills For Everyone also offers the following additional comments on biological resources.

The Project proposes to widen Brea Canyon Road from two to four lanes, effectively doubling the roadway's capacity, and eliminate several curves in the existing alignment. Both of these operational improvements would be undertaken with the specific intent of increasing roadway capacity and vehicular speeds. Increases in roadway

[4] Brea Envisions Community Strategic Planning effort: https://shapebrea.net/brea-envisions

capacity have the potential to cause a substantial increase in traffic volumes. The Victoria Transportation Policy Institute study describes this phenomenon: “If road capacity expands, peak-period trips increase until congestion again limits further traffic growth. The additional travel is called ‘generated traffic.’ Generated traffic consists of diverted traffic (trips shifted in time, route and destination), and induced vehicle travel (shifts from other modes, longer trips and new vehicle trips). Generated traffic often fills a significant portion of capacity added to congested urban road[s].” *See* Exhibit E at 1.

Increases in traffic volume and vehicular speed increase the risk of wildlife mortality as animals that end up on the roadway are navigating a wider road as well as one with faster-moving vehicles. Wildlife crossing/wildlife avoidance would become more difficult as animals struggle to cross a wider space, with a potential center median obstructing wildlife movement, thus making animals more susceptible to vehicle collisions. The abstract entitled “Effects of Roads and Traffic on Wildlife Populations and Landscape Function” (Exhibit F) notes that the effects of roadway construction and widening includes the loss and fragmentation of habitat, increased rates of wildlife mortality because of collision with vehicles, alterations to light, moisture and wind regimes due to the creation of edges, pollution from traffic, e.g., light, noise, and chemical, and facilitating the spread and dispersal of weeds and feral animals.” *See* Exhibit F at 2.

This problem will be exacerbated by any median barrier that is installed as part of the Project. Depending upon its height and length, such barriers could be difficult, if not impossible, for many animals to cross. The DEIR, however, is unclear on what the median configuration may be, noting that the Project will include a “median that is ***either*** 12 feet wide raised with limited landscaping, 6 feet wide with a concrete barrier, ***or*** striped of varying widths.” *See* DEIR at 1-3 (emphasis added). With this ambiguity, the DEIR should analyze the possibility that a concrete barrier might exist for the length of the Project. Nevertheless, the DEIR did not provide an analysis of the existing and expected wildlife mortality rate of the widened road. As a result, there is no basis for the DEIR’s conclusion that impacts to wildlife are being reduced to less than significant levels.

Increased traffic will result in increased vehicular noise, light, and glare once the roadway is expanded and fully operational. During the multi-year Project construction phases, the amount of noise generated from construction equipment and the light impacts from high-intensity nighttime lighting during marathon weekend closures with night crews working will be substantial. The DEIR analyzed the noise environment and noise expected to be generated by Project construction and determined that impacts would remain significant and unavoidable for construction noise generated at night and on Sundays during weekend construction periods. However, the DEIR’s noise assessments and noise thresholds only considered impacts to humans. It does not address noise impacts on wildlife along the roadway corridor. *See* DEIR Appendix N.

Given the location of this project in a wildlife corridor, many of the impacts created affect wildlife more than they do human beings. The DEIR's failure to mention, let alone analyze, disclose, and mitigate, these impacts violates CEQA. A revised EIR should be prepared to analyze these impacts and propose feasible and mitigation measures that avoid or minimize them.

The Federal Highway Administration's Wildlife Crossing Structure Handbook ("FHWA Handbook"), which is attached as Exhibit G, contains an informative summary of the impacts of roadways on wildlife: "Reduced landscape connectivity and limited movements due to roads may result in higher wildlife mortality, lower reproduction rates, ultimately smaller populations and overall lower population viability. These harmful effects have underscored the need to maintain and restore essential movements of wildlife across roads to maintain within population movements and genetic interchange." *See* FHWA Handbook at 14. "The fragmentation effect of roads begins as animals become reluctant to move across roads to access mates or preferred habitats for food and cover. The degree of aversion to roads may vary by age group and gender. The reasons why roads are avoided can generally be attributed to features associated with the road, e.g., traffic volume, road width or major habitat alterations caused by the road." *Id*.

One of the Project Objectives in the DEIR is to "[e]nhance safe wildlife movement across the roadway within the corridor." *See* DEIR at 3-5. While the wildlife overpass/land bridge proposed could be beneficial—if appropriately sized in accordance with federal recommendations—the proposed land bridge is wholly insufficient. The FHWA Handbook recommends a minimum width of 135-160 feet for wildlife-specific overpasses, while identifying 165-230 feet as optimal. *See* FHWA Handbook at 56. The proposed width of the land bridge, at 75 feet, is less than one-third of the optimal width, and will not adequately buffer noise and light from the traffic below, especially given that the adjacent Tonner Canyon/Brea Boulevard intersection will be signalized. Traffic will necessarily back up at this signal, beneath and on either side of the bridge, leading to prolonged light and noise that may dissuade wildlife from approaching and utilizing the bridge.

Our clients have informed us that they have regularly observed semitrucks using Brea Canyon Road as an informal spot to park and shelter for the night in their trucks with sleeping compartments. It is highly likely that Tonner Canyon—immediately adjacent to the proposed land bridge—will be within earshot of the constantly running tractor trailers, which will deter use of the wildlife bridge at night when animals tend to be most active.

The proposed location for the wildlife overpass/land bridge is highly problematic. Property on either side of the bridge is not only unprotected, but also privately-owned. Therefore, public agencies have limited control over any fencing, lighting or other obstacles installed on private property at either end of the wildlife bridge. These obstacles could easily present barriers to wildlife access to and use of the bridge. None of these potential conflicts were studied in the DEIR. *See* Exhibit H (map showing ownership of adjoining properties). Because the success of this wildlife corridor depends so heavily on where and whether fencing is located—and on how it is maintained—the EIR must be revised to provide details on how it will address this issue.

The Biological Resources section of the DEIR contains additional flaws and inconsistencies. There are three impact statements and associated mitigation measures that have no supporting evidence as to their effectiveness:

Impact 5.3.4.1: "Implementation of the Project has the potential to result in a substantial adverse effect, either directly or through habitat modifications, on species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations or by CDFW or United States Fish and Wildlife Service (USFWS)."

The DEIR proposes several mitigation measures that are ostensibly aimed at reducing the impacts of the Project on candidate, sensitive, and special status species. One of the species of particular concern is the western pond turtle (WPT). Mitigation Measure BR-4 proposes to reduce impacts to the WPT with the following requirements: "Brea Creek and riparian habitats shall be cleared of western pond turtle and any additional special-status reptiles or amphibian species which may occur (including western spadefoot), immediately before construction activities that would coincide with the creek and its riparian habitats is initiated, immediately before any equipment is moved into or through Brea Creek or riparian areas, and immediately before diverting any stream water, should diversions be required. The removal of western pond turtle, or any other reptile or amphibian species shall be conducted by a qualified biologist using procedures approved by CDFW, and with the appropriate collection and handling permits. Species shall be relocated to nearby suitable habitat areas that will not be disturbed by the Project. A Species Protection, Relocation, and Monitoring Plan including avoidance and minimization measures and relocation methods for western pond turtle shall be submitted to CDFW for review and approval prior to construction."

Mitigation Measure BR-4 misses the mark, though, by only addressing the impacts to WPT during construction. Due to the impacts to the creek (and deficient analysis thereof as outlined in the Hydrology section of this letter), it is expected that impacts to the water quality and habitat of WPT will be caused by the Project and therefore present long after construction is complete. The DEIR wholly fails to examine these operational (long-term) impacts of the Project on WPT habitat and fails to identify mitigation to minimize or eliminate the impacts. Mitigation Measure BR-4 is also lacking in identifying measures to re-establish WPT populations in Brea Creek once bridge construction has concluded after several years and the natural creek channel is allowed to re-establish unhindered by construction in and adjacent to the creek.

Impact 5.3.4.3: "Interfere Substantially with the Movement of any Native Resident or Migratory Fish or Wildlife Species or with Established Native Resident or Migratory Wildlife Corridors or Impede the Use of Native Wildlife Nursery Sites."

The wildlife corridor in the Puente-Chino hills is viable due to substantial public and community investment in land acquisition and habitat preservation. Exhibit I illustrates the amount and location of Publicly and Privately Protected Natural Lands that contribute to the existence of this wildlife corridor. The accompanying table (Exhibit J) identifies the monetary value of public agency investments in creating this wildlife corridor at over $227 million. Implementing the proposed Project will undermine these investments by creating a wider division and larger obstacle for the wildlife traversing the wildlife corridor.

Other proposed mitigation measures aimed at minimizing impacts to the use of wildlife corridors are ineffective and offer no performance metrics to measure or ensure success of the measure. Mitigation Measure BR-11, for example, notes that excavation and trenching activities shall include measures to prevent entrapment and injury to wildlife. For instance, steep-sided trenches may either be backfilled at the end of each workday, fenced, or include "escape ramps" for wildlife. This measure is to be implemented during construction. However, there are no mitigation measures that will prevent entrapment and injury to wildlife during long-term operations of the Project.

The DEIR notes that "there are multiple driveway access roads along the roadway corridor requiring control measures to prevent animal breaches of wildlife fencing. Control measures at these locations may include cattle guards/grates, swinging metal gates, or electrified mats imbedded into the pavement which safely deter wildlife entry. To address breaches of wildlife fencing, wildlife "jump-outs"/escape ramps will be provided to facilitate escape." *See* DEIR at 1-5. However, the DEIR does not provide any detail on the specific locations of the fencing or jump-outs or have any mitigation measure that requires their installation in accordance with any particular performance metrics or standards. The DEIR is largely silent on the details and offers no evidence that any of the mitigation measures will support the continued movement of wildlife through the Puente-Chino Hills Wildlife Corridor.

This glaring omission is particularly problematic with respect to the movement of mountain lions, which the DEIR does not even specifically address. As the Habitat Authority notes in its January 30, 2023 comment letter, the Southern California subspecies of mountain lion is a candidate species for listing under the California Endangered Species Act. The Authority noted that a collared male mountain lion (M317) has been documented in the project vicinity. More recent data shows that this individual has been present throughout the Puente-Chino Hills Wildlife Corridor from the 605 all the way down to Chino Hills State Park, crossing the 57 just north of the Project area several times. Exhibit K documents locations in which M317 has been tracked through GPS from March 2022 to January 2023. For wildlife that regularly travel through the wildlife corridor, expanding this roadway and limiting crossing locations to a single wildlife land bridge/overcrossing and three creek bridge undercrossings will diminish opportunities to move through the wildlife corridor. These impacts need to be analyzed in a revised DEIR that also thoroughly analyzes all potentially feasible mitigation to enable safe and unencumbered wildlife passage.

In addition, the DEIR fails to include sufficient mitigation to address both temporary and permanent disturbances of sensitive vegetative communities. The proposed 1:1 replacement ratio for coast live oaks is well below the California Department of Fish and Wildlife (CDFW) recommendations for mitigating the loss of oaks. For instance, CDFW recently reviewed a Mitigated Negative Declaration for a project in Mendocino County[5] and pointed out that the following measures should be included as project mitigation in accordance with Public Resources Code Section 21083.4: 1) maintaining mitigation planting for a minimum of seven years; and 2) requiring a range of oak replacement mitigation ratios (depending on removed tree diameter) ranging from 6:1 to 10:1. The DEIR falls far short of ensuring that oak tree replacements will be successful. The DEIR does not incorporate a tree survey with information on the number of trees that may need to be removed, and proposed Mitigation Measure BR-6 contains no information related to timing of measure implementation or any performance metrics, including the size of replacement trees, to determine successful compliance.

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[5] CDFW letter to the County of Mendocino re: Brutccao Vineyards Gateway House dated November 23, 2020. Accessed 2/2/2023: https://files.ceqanet.opr.ca.gov/261048-3/attachment/DVgyni_pLGvK6EKUbdJqlZbpWbBL5DiiTsZYKF2ckQ_xngJpMnugDYRoszldQc4AddVDoNHmdSgfkFBp0#:~:text=Of%20the%20suite%20of%20oak,15126.4(a)(2).

Impact 5.3.4.4: "Conflict with the Provisions of an Adopted Habitat Conservation Plan, Natural Community Conservation Plan, or Other Approved Local, Regional, or State Habitat Conservation Plan."

As noted above in the environmental baseline section, implementation of the Project will interfere with the 455 acre Conservation Easement dedicated in 2007 as mitigation for the County's approval of the Tonner Hills Project. The DEIR acknowledges this impact, yet defers identifying an appropriate mitigation measure to address it. Mitigation Measure BR-13 notes that OC Public Works will "coordinate with Tonner Hills SSP, LLC and the City of Brea, along with the Third-Party Beneficiaries (USFWS, USACE, and CDFW) of the Conservation Easement, to amend the Conservation Easement (via mutual written agreement) by adjusting the easement boundaries to include the existing Brea Boulevard right of way and necessary acquisitions (i.e., permanent road and retaining wall easements, temporary construction easement, etc.) associated with the Project, implement any need to transfer a portion of the Conserved Land and identify any subsequent compensatory actions or obligations pursuant to purposes of the Conservation Easement." *See* DEIR at 5.3-57.

However, the DEIR fails to analyze the impact of reducing or further fragmenting the Conservation Easement area, fails to quantify the amount of land currently under the Conservation Easement that will be utilized for the Project, and provides no details about any specific future action other than to collaborate with all stakeholders to work things out. Measure B-13 offers no timeframe in which any action will take place and does not identify any back-up plan in the event the County fails to secure the agreement of Parties to adjust the Conservation Easement boundaries. Given the nature, purpose, and scope of the easement, it is at the very least foreseeable that one or more parties might not consent to such a change.

3. The DEIR Fails to Adequately Identify Greenhouse Gas Emissions and Plan for Carbon Neutrality.

The DEIR concludes that Impact 5.6.4.2, Conflict with an Applicable Plan, Policy, or Regulation Adopted for the Purpose of Reducing GHG Emissions, is less than significant. However, the DEIR fails to explain how the Project is consistent with the 2022 CARB Scoping Plan, which is the State's roadmap to address climate change and cut greenhouse gas emissions by 85% to achieve carbon neutrality in 2045 as required by AB 1279. To reach this goal, all development should be at least carbon neutral, if not carbon offsetting. The DEIR must address how the Project is contributing to achieving this goal.

The 2022 CARB Scoping Plan specifically identifies roadway capacity expansions as an example of projects that do not contribute to carbon reduction efforts. "Regional efforts can support change too: energy and transportation systems that serve Californians do not stop at jurisdictional boundaries, and some local decisions can have ramifications for other communities. For instance, Metropolitan Planning Organizations (MPOs) can help to integrate local efforts by planning consistent with the Scoping Plan and Climate Action Plan for Transportation Infrastructure, including by removing polluting roadway capacity expansions from project pipelines and instead focusing on climate friendly solutions." *See* 2022 CARB Scoping Plan at 268.[6]

The DEIR also fails to explain how the Project is consistent with the Orange County Climate Action Plan and fails to describe what measures will be implemented at the project level. The DEIR offers no evidence that the Project will be compliant with the broader County efforts to reduce GHG emissions and move towards a carbon neutral future.

4. The DEIR Fails to Adequately Identify and Mitigate Impacts to Brea Creek (Hydrology).

The Hydrology section of the DEIR, along with related technical appendices, was reviewed by our expert consultant, Greg Kamman, Senior Ecohydrologist with CBEC EcoEngineering. Mr. Kamman's letter dated February 1, 2023, is attached as Exhibit L and is referenced below ("CBEC letter").

a. Potential changes to water flow in Brea Creek are under-estimated and mitigation will be required.

Impacts to Brea Creek and to the myriad species that live in and around the creek is one of the key concerns expressed by Hills For Everyone as well as the Habitat Authority in its comment letters on the Notice of Preparation of the DEIR in 2017 and 2019. In light of these clear expressions of concerns—and the several years the County has taken to prepare the EIR—it is disturbing and disappointing that the DEIR does not include any analysis of how constructing wider and taller replacement bridges will significantly increase storm flow velocity in the reaches upstream of replaced bridges. Changing the stream velocity capacity could create less desirable flow conditions for the western pond turtle and there may be secondary impacts (erosion and scour) that alter desirable habitat, destroy the benthic structure of the creek, and affect the fish and invertebrates adapted for the existing flow velocity.

[6] https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp.pdf

The CBEC letter identified three primary concerns regarding the insufficient creek impact analysis in this DEIR: (1) Impacts resulting from changes to the creek bed at bridges 2 and 3; (2) Impacts from increased creek flow conveyance through new, larger bridge openings; and (3) Incorrect peak flow estimate used for the hydraulic modeling, which would result in inaccurate conclusions and incorrect impact statements. These issues are explained in detail in the CBEC letter and are summarized below:

First, the replacement of Bridges 2 and 3 may promote channel incision. Replacing the concrete bottoms with a natural "soft" bottom will create the opportunity for the channel to incise during peak, high energy flows. The resulting incised channel can propagate upstream (head-cutting) as well as downstream from the former concrete bottom. The act of bed erosion and sediment transport will impair downstream water quality. Incised channels can also lead to over-steepened banks that become unstable and erode, further impacting downstream water quality. The resulting modifications to the channel form due to channel incision also could adversely alter the quality of existing aquatic and riparian habitat. *See* CBEC letter at 2.

Second, the Project results in increased potential for channel erosion upstream of the new bridges. The results of the hydraulic modeling completed for the DEIR (and included as Appendix M to the document) demonstrate how bridge replacement will increase flow conveyance capacity through the bridge crossings, resulting in lower peak flow water surface elevations at, and adjacent to, the new bridges. However, the creek flow velocities increase significantly at, and upstream of, the project bridges as compared to existing conditions. This has been demonstrated to result in increased erosion potential of natural channel bed materials and adversely impacting downstream aquatic conditions. *See* CBEC letter at 2.

Lastly, the DEIR relies on a Hydraulic Model Analysis that underestimated the 100-year peak flow rate. Using an inaccurate peak flow rate leads to inaccurate conclusions about the design safety of the bridges and what may happen in the event of a 100-year flood event. Therefore, the DEIR does not include potential ways to mitigate or avoid those impacts and the analysis is therefore flawed. *See* CBEC letter at 4.

b. Stormwater runoff into Brea Creek is insufficiently analyzed and impacts are unmitigated.

The DEIR concludes that "[T]he widened roadway would not substantially increase stormwater runoff, as localized stormwater runoff would continue to flow directly into the adjacent Brea Creek as it does under existing conditions." *See* DEIR at 5.8-8. However, the DEIR provides no quantification of the amount of increased stormwater runoff, so it is not possible to determine whether the impact is significant or not. *If* the calculations were provided and *if* the increase was not substantial, the DEIR should still demonstrate how to ensure that the stormwater runoff is clean and filtered adequately enough to flow into Brea Creek without causing potentially significant water quality impacts.

The DEIR should include mitigation measures to ensure that water flowing from the widened roadway is collected, treated, and filtered before it is released. The design sheets prepared by Mark Thomas (starting on PDF page 938 of DEIR Appendices Vol. 2) do not provide any best management practices or erosion control details. Under the "General Notes" on each of these sheets, Note 1. states, "All construction activities to be in compliance with all applicable regulation and/or mitigation measures identified in EIR Mitigation Monitoring and Reporting Program [MMRP]." However, the DEIR contains no mitigation measures in the Hydrology section, no MMRP for review, and no assurances that the impacts of stormwater runoff (either pollution or volume) will be less than significant. The DEIR does not set forth sufficient specific, measurable performance standards for the Stormwater Pollution Prevention Plan (for construction-related water quality impacts) or for the Water Quality Management Plan (for operational water quality impacts) that could potentially justify later formulation of mitigation methods targeted to meet water quality standards.

c. Impacts of construction dewatering and its impacts on aquatic resources is not quantified.

The DEIR refers to the fact that the creek will be dewatered in at least three places during the construction of the three new bridges, but offers no details on how the dewatering will take place or measures that should be in place to ensure that impacts are minimized. Without more specifics on the dewatering processes or protocols, it is impossible to determine if there will be detrimental impacts to the creek and aquatic habitat or if any impacts can be minimized or avoided.

5. The DEIR Fails to Adequately Address and Mitigate Impacts to Land Use and Fails to Disclose and Analyze the Project's Growth-Inducing Impacts.

The DEIR concludes that the proposed Project would not conflict with an applicable land use plan, policy, or regulation of an agency with jurisdiction over the Project adopted to avoid or mitigate an environmental effect. However, the DEIR fails to disclose that the Project is plainly inconsistent with Brea General Plan Policy CD-11.6 "Utilize creative methods to reduce congestion and improve circulation" and it fails to properly mitigate the impacts to the Conservation Easement as previously identified.

The DEIR asserts that the Project is consistent with Brea General Plan Policy CD-11.6, but road widening in an attempt to reduce congestion is not a creative or effective strategy. To the contrary, numerous studies show that while roadway widening has a ***short-term*** effect of easing congestion, the benefits do not last long and traffic congestion returns relatively quickly. It is well-recognized that road widening projects rarely solve for congestion in the long term, and for this reason policy experts and the public alike are increasingly calling for re-examination of this approach and of road widening projects included in previously adopted plans. A recent *New York Times* article highlighted the paradox of highway widening in nearby Los Angeles County and experts summarized the issue succinctly: "When a congested road is widened, travel times go down—at first. But then people change their behaviors. After hearing a highway is less busy, commuters might switch from transit to driving or change the route they take to work. Some may even choose to move farther away." *See* Exhibit M.

Similarly, the Victoria Transportation Policy Institute policy paper notes that "[t]raffic congestion tends to maintain equilibrium; traffic volumes increase until congestion delays discourage additional peak-period trips. If road capacity expands, peak-period trips increase until congestion again limits further traffic growth. The additional travel is called "generated traffic." Generated traffic consists of diverted traffic (trips shifted in time, route and destination), and induced vehicle travel (shifts from other modes, longer trips and new vehicle trips). Generated traffic often fills a significant portion of capacity added to congested urban road." *See* Exhibit E at 1.

For similar reasons, it is clear that the Project would have significant impacts due to inducing "substantial unplanned population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure). *See* DEIR at 4-5. The DEIR mischaracterizes this impact by suggesting that "[i]mplementation of the Project would not result in the generation of new permanent jobs and would not contribute to any substantial population growth. Therefore, Project implementation would not induce growth, either directly or indirectly. No impact would occur." *See* DEIR at 4-5. However, as detailed above, roadway widening is a textbook example of a growth-inducing project. The DEIR's conclusory suggestion that the roadway widening will not induce growth is contrary to all available evidence.

The Project is also inconsistent with the roadway classification for Brea Boulevard in the Brea General Plan. Brea identifies this roadway corridor as a "Modified Secondary Arterial" and states that "[t]he Modified Secondary Arterial classification best reflects the function Brea Canyon Boulevard serves during most travel hours. Only during the evening commute does the roadway experience heavy use, typically as an alternative to the crowded SR-57." *See* Brea General Plan at 2-46. However, the DEIR identifies Brea

Canyon Road/Brea Boulevard as a “Modified Primary Arterial” (*see* DEIR at 1-2), which is in conflict with Brea’s General Plan Circulation Element.

6. The DEIR Fails to Adequately Identify and Mitigate Impacts to Transportation.

The DEIR concludes that the Project has a less than significant impact and does not “[c]onflict with a program, plan, ordinance or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities.” However, the Project conflicts with the Brea General Plan in two ways. First, as just shown, the DEIR states that the Project will transform Brea Blvd./Brea Canyon Road into a Modified Primary Arterial, in conflict with the Brea General Plan provisions establishing this road as a Modified Secondary Arterial. Second the Project does not include—and could inhibit the future provision of—a Class 1 bike path as identified in the Brea General Plan. The DEIR states, “[O]verall, the Project does not remove or result in a degradation of existing bicycle or pedestrian facilities and is not expected to conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities. Therefore, impacts to transit, bicycle, or pedestrian facilities would be less than significant.” *See* DEIR at 5.11-30. The Project also conflicts with the ***County’s own*** General Plan Transportation Element Bikeways Plan, which also shows a future Class 1 bikeway along the Brea Canyon Road roadway corridor.[7] Therefore, the conclusion that no policy conflicts exist is incorrect.

The DEIR must be revised to disclose this impact. The revised DEIR must also address potential modifications to the Project to incorporate a Class 1 bikeway without further widening the roadway right of way.

D. The DEIR’s Analysis of Project Alternatives is Legally Inadequate.

CEQA Guidelines Section 15126.6(a) states that “An EIR shall describe a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project, but would avoid or substantially lessen any of the significant effects of the project and evaluate the comparative merits of the alternatives.”

CEQA provides that “public agencies should not approve projects as proposed if there are feasible alternatives . . . which would substantially lessen the significant environmental effects of such projects.” Pub. Resources Code § 21002. Critically, an EIR must consider a “reasonable range” of alternatives “that will foster ***informed*** decision-

[7] County of Orange Bikeway Plan, official map of the Transportation Element of the General Plan: https://ocds.ocpublicworks.com/sites/ocpwocds/files/import/data/files/115330.pdf

making and public participation." Guidelines § 15126.6(a) (emphasis added); *Laurel Heights Improvement Assn.,* 47 Cal.3d at 404 ("An EIR's discussion of alternatives must contain analysis sufficient to allow informed decision making.")

1. The DEIR Fails to Identify and Analyze an Adequate Range of Alternatives.

The DEIR identifies only two alternatives, other than the no-project alternative. Aside from the no project alternative, both of the alternatives have the same ***or greater*** environmental impacts as the proposed Project, has essentially similar elements, and would be constructed and operated in a similar manner. Alternative 2 contains most of the same elements, but would be even wider. The larger associated larger disturbance footprint and additional construction activity under Alternative 2 would result in greater impacts to aesthetics, air quality, biological resources, GHG emissions and energy, and land use and planning.

Alternative 3 is essentially the same proposal as the Project. It simply includes the possibility of an extended construction timeline that would result in incrementally degraded LOS at all intersections and roadway segments during construction when compared to the Project, including two additional potentially significant (temporary) intersection impacts. The incremental degradation of LOS and new intersection impacts are all due to the additional area traffic from planned development (if the construction timeline were to be extended under Alternative 3).

Disturbingly, neither Alternative 2 nor Alternative 3 would even potentially reduce ***any*** impacts of the Project. This violates both the letter and the spirit of CEQA. The central purpose of the alternatives analysis—which the courts have repeatedly described as the "heart" of CEQA—is to identify alternatives that could potentially ***reduce or avoid*** significant impacts. The EIR fails to identify any such alternative.

2. The DEIR Should have Considered an Alternative that Replaced the Assertedly Obsolete Bridges without Doubling the Road's Capacity.

The purpose of the alternatives analysis is to examine potential projects that can achieve the project objectives with lesser environmental impacts. In the case of this DEIR, none of the current alternatives serve these goals. By contrast, an alternative project that includes replacing the three bridges without widening the road to four lanes would reduce impacts to aesthetics, biological resources, noise, transportation, and would not be growth-inducing. Additionally, such an alternative would accomplish many of the key project objectives, including:

- Replace three functionally obsolete bridges over Brea Creek with bridges that meet current design standards;
- Increase flood conveyance of Brea Creek under the three bridges;
- Enhance safe wildlife movement across the roadway within the corridor;
- Minimize impacts to the surrounding habitat and wildlife; and
- Minimize impacts to above/underground utilities.

A revised DEIR should be prepared that analyzes such an alternative and its ability to reduce project impacts. In analyzing whether such an alternative would achieve project objectives, the County should also take into account the fact that many assumptions about the need for (and utility of) the road widening may no longer be valid in light of dramatically changed driving patterns and demand.

E. The DEIR Must Be Revised and Recirculated.

The present EIR cannot properly form the basis of a final EIR. CEQA and the Guidelines describe the circumstances that require recirculation of a draft EIR. Such circumstances include: (1) the addition of significant new information to the EIR after public notice is given of the availability of the DEIR but before certification, or (2) the draft EIR is so "fundamentally and basically inadequate and conclusory in nature that meaningful public review and comment were precluded." Guidelines § 15088.5.

Here, both circumstances apply. Decision-makers and the public cannot possibly assess the Project's true impacts or even its feasibility through the present DEIR, which is predicated on an improper baseline that results in an understatement of the Project's significant environmental impacts. The DEIR also repeatedly relies on mitigation measures that either omit required details or improperly defer specifics without providing any performance standards. To comply with CEQA—and to allow the public and decisionmakers to meaningfully assess the Project's actual impacts—the County must prepare a revised EIR that would necessarily include substantial new information. This revised EIR must then be recirculated for public review and comment.

II. The Project as Proposed is Unwarranted, Unnecessary, and a Misuse of Public Resources.

According to Brea City Manager Bill Gallardo as stated in a meeting on January 11, 2023 with our client, the Project is currently projected to cost $181 million. The actual expenses will likely be far higher given past overruns of cost projections for similar projects. As both a practical and policy matter, this expenditure is unjustifiable, particularly because there are currently no plans to widen the road further north into Los Angeles County. This means that any bottleneck that this roadway widening is meant to temporarily alleviate will simply be pushed 1.7 miles down the line. *See* Exhibit N, East San Gabriel Valley Mobility Action Plan, at 35, 37.

Moreover, the Project is based on the assertion that pre-pandemic traffic volumes warrant the widening. But without accurate, current traffic counts, there is no way of knowing whether that asserted need even exists. Likewise, the DEIR does not document safety hazards from the existing roadway to explain why the expansion may be needed. The number and frequency of accidents from 2014 to 2022 along Brea Canyon Road is less than eight per year. The existing roadway with the existing traffic volumes do not appear to present severe safety hazards and the existing alignment likely compels drivers to proceed more slowly than they could on a wider, less curvilinear roadway. *See* Exhibits O and P, map and table that quantify and locate traffic accidents along the roadway corridor.

Orange County Transportation Authority's 2022 Draft Long Range Transportation Plan (LRTP) recognizes that "[t]he age of addressing congestion through lane additions is coming to an end, and the focus is turning to strategies that help manage the number of trips taken each day, how those trips are made, and how transportation facilities are operated to get the most out of them."[8] *See* OCTA LRTP at 2-25. Orange County should reconsider its own policy positions as it relates to this Project and consider a different direction.

III. Conclusion.

For the reasons stated above, the DEIR violates CEQA in numerous respects and the project cannot be approved as proposed. Furthermore, there is no evidence that this Project is necessary to address any demonstrated need.

Given these realities, we urge the County to reconsider this Project in its entirety and to explore alternative projects that would spend valuable taxpayer resources more wisely and that would benefit a greater segment of Orange County's population of 3.2 million residents. The County's budget for this project can be better spent providing transportation improvements with climate- and resource-positive benefits in an area without such substantial and adverse environmental impacts.

[8] https://www.octa.net/pdf/LRTPJan2023DRAFT.pdf

Very truly yours,

SHUTE, MIHALY & WEINBERGER LLP

Robert "Perl" Perlmutter

Kristi T. Bascom, Urban Planner

cc: Hills For Everyone

Exhibits:

A: Orange County Clerk-Recorder, *Conservation Easement Deed.* (Dated June 18, 2007 and recorded on August 29, 2007)

B: Glenn Lukos Associates, Map of Tonner Hills Mitigation & Conserved Areas.

C: California Department of Transportation ("Caltrans"), *Rethinking How We Build So Californians Can Drive Less.* www.dot.ca.gov

D: Caltrans, *Bigger Roads, More Traffic* - Induced Travel Infographic. www.dot.ca.gov/programs/sustainability/sb-743

E: Litman, Todd, *Generated Traffic and Induced Travel – Implications for Transport Planning.* Victoria Transport Policy Institute. www.vtpi.org (November 2, 2022)

F: van der Ree, Rodney, Jaeger, Jochen A. G., van der Grift, Edgar A., & Clevenger, Anthony P. *Effects of Roads and Traffic on Wildlife Populations and Landscape Function: Road Ecology is Moving Toward Larger Scales.* Ecology and Society 16(1): 48. https://www.ecologyandsociety.org/vol16/iss1/art48/ (2011)

G: Clevenger, Anthony P. & Huijser, Marcel P. *Wildlife Crossing Structure Handbook – Design and Evaluation in North America.* Federal Highway Administration. (2011)

H: Hills For Everyone, Map of Brea Canyon Road and Neighboring Ownerships. (2022)

I: Hills For Everyone, Map of Natural Lands Within the Puente-Chino Hills Wildlife Corridor. (2023)

J: Hills For Everyone, Table of Public Agency Acquisition Investments in the Puente-Chino Hills Wildlife Corridor. (2022)

K: Map of GPS Points of M317 Through the Puente-Chino Hills Wildlife Corridor (March 2022 through January 2023).

L: Kamman, Greg, *Review of Draft Environmental Impact Report (SCH# 2017051005).* CBEC Eco-Engineering. (February 1, 2023)

M: Weingart, Eden. *Widening Highways Doesn't Fix Traffic. So Why Do We Keep Doing It?* New York Times. (January 6, 2023) https://www.nytimes.com/2023/01/06/us/widen-highways-traffic.html

N: County of Los Angeles Department of Regional Planning, *East San Gabriel Valley Mobility Action Plan.* (2022)

O: Hills For Everyone, Map of Brea Canyon Road Accidents (2014-2022).

P: Hills For Everyone, Table of Brea Canyon Road Accident Statistics (December 2014 - May 2022).

1612896.2

Exhibit A

RECORDING REQUESTED BY AND WHEN RECORDED MAIL TO:

Director,
Planning and Development Services
County of Orange
300 North Flower St.
Santa Ana, CA 92703

Recorded in Official Records, Orange County
Tom Daly, Clerk-Recorder
507.00
2007000535583 11:28am 08/29/07
106 207 E01 168
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CONFORMED COPY

Space Above Line for Recorder's Use Only

CONSERVATION EASEMENT DEED

(Including Third-Party Beneficiary)

THIS CONSERVATION EASEMENT DEED (this "**Easement**") is made this 18th day of June, 2007, by TONNER HILLS 680, LLC ("**Grantor**"), in favor of the COUNTY OF ORANGE ("**County**" or "**Grantee**"), with reference to the following facts:

RECITALS:

A. Grantor is the sole owner of the surface estate with respect to certain real property commonly known as the Habitat Conservation Area for the Tonner Hills Planned Community ("**Tonner Hills**"), in the City of Brea (the "**City**"), County of Orange, State of California (the "**Conserved Land**"). The Conserved Land consists of approximately 449 acres, being a portion of the real property legally described in Exhibit "A" attached hereto, as such portion is depicted in Exhibit "B" attached hereto (the "**Conserved Land**").

B. The Conserved Land currently provides some high quality habitat for the threatened California gnatcatcher as well as the opportunity for major habitat restoration and enhancement efforts that will benefit other species associated with coastal sage scrub, riparian, and walnut woodland communities. The Conserved Land will be enhanced to improve its habitat functions and values by removing low-quality non-native vegetation and replacing it with riparian vegetation of higher biological value consistent with the mitigation, monitoring, and management plans and agreements identified herein and the Approval Documents, defined below. The present and enhanced wildlife and habitat values of the Conserved Land are collectively referred to herein as "**Conservation Values**", which are of great importance to Grantee, the third-party beneficiaries to this Easement, and the people of the State of California.

C. Grantee is authorized to hold conservation easements pursuant to Civil Code section 815.3. Specifically, Grantee is a governmental entity identified in Civil Code section 815.3(b) and otherwise authorized to acquire and hold title to real property.

D. Active oil extraction operations are on-going within the boundaries of the Conserved Land. To the actual knowledge of Grantor and Grantee, all existing active oil operation areas exclusive of pipelines and electric utilities within the Conserved Land are shown on Exhibit "C" attached hereto and incorporated herein by this reference (**"Oil Operation Areas"**); provided, however, nothing set forth in this Easement shall constitute a warranty regarding such Oil Operation Areas. Oil operations are expected to continue until the oil reserves contained therein are exhausted. While operating, the facilities will require repair and maintenance, sometimes possibly under emergency conditions.

E. Pursuant to the Perpetual Management Plan for the Conserved Land attached hereto as Exhibit "E" (the **"Perpetual Management Plan"**), when oil operations are completed, the surface facilities within the Oil Operation Areas will be removed by the oil field operator and pipelines and fixtures outside of the Oil Operation Areas will be abandoned in place. The oil field operator will be responsible for any habitat restoration required as a result of applicable laws, rules, and regulations addressing oil field closure and cleanup activities. Habitat restoration occurring after the cessation of oil activities that is not the responsibility of the oil field operator will be the responsibility of the party in control of the Combined Endowment with funds from the Combined Endowment as provided for in the Perpetual Management Plan.

F. Grantor ultimately intends to transfer fee title to the Conserved Land to a conservation entity (**"Conservator"**), subject to an irrevocable offer of dedication of fee title to Grantee (the **"IOD"**). Upon transfer to Conservator and until Grantee exercises its rights under the IOD, if ever, Conservator and its successors and assigns shall assume all of the obligations and duties of Grantor specified herein, including without limitation the fiduciary duty to manage the Combined Endowment, except that should Grantor transfer its interest in the Conserved Land prior to the time that mitigation obligations are fulfilled, Grantor as the developer of the Project will remain responsible for the mitigation obligations of the Project until they are successfully implemented and completed per the success criteria set forth in the Mitigation Plans.

G. Alternatively, Grantor may transfer fee title to the Conserved Land to the Homeowner's Association (the **"HOA"**), subject to the IOD. Upon transfer to the HOA and until Grantee exercises its rights under the IOD, if ever, the HOA and its successors and assigns shall assume all of the obligations and duties of Grantor related to the Conserved Land specified herein, including without limitation the fiduciary duty to manage the Combined Endowment, except that should Grantor transfer its interest in the Conserved Land prior to the time that mitigation obligations are fulfilled, Grantor as the developer of the Project will remain responsible for the mitigation obligations of the Project until they are successfully implemented and completed per the success criteria set forth in the Mitigation Plans.

H. This Conservation Easement is designed to satisfy and is granted in satisfaction of: (1) U. S. Fish and Wildlife Service (**"USFWS"**) Biological Opinion FWS-OR-2347.5 (the **"Biological Opinion"**), (2) U.S. Army Corps of Engineers (**"ACOE"**) Section 404 Permit 199916501-DPS (the **"Section 404 Permit"**), and (3) California Department of Fish and Game (**"CDFG"**) Streambed Alteration Agreement #R5-2002-0114 (the **"Streambed Alteration Agreement"**). USFWS, ACOE and CDFG shall hereinafter be referred to individually as a **"Third-Party Beneficiary"** and collectively as the **"Third-Party Beneficiaries"**.

I. The Conserved Land provides mitigation for certain impacts of Tonner Hills pursuant to final Environmental Impact Report for the Tonner Hills Planned Community certified by the County of Orange (SCH No. 2001031137) and the Mitigation Monitoring and Reporting Plan created thereunder; the Tonner Hills Area Plan; the Tonner Hills Planned Community Text; the Biological Opinion, the Section 404 Permit, the Streambed Alteration Agreement, Vesting Tentative Tract Map No. 16642, the Development Agreement, the Section 401 Certification and the Water Quality Management Plan. The foregoing documents are collectively referred to herein as the "**Approval Documents**". The Approval Documents require certain improvements to the Conserved Land, as further described in Section 6.2 below and as depicted on Exhibit "D" attached hereto.

J. The mitigation for the impacts described in the Approval Documents also includes a number of habitat restoration and enhancement efforts that have been or will be described in that certain Coastal Sage Scrub Mitigation and Monitoring Plan for the Tonner Hills Planned Community attached hereto as Exhibit "F" (the "**Coastal Sage Scrub Mitigation Plan**"), and that certain Riparian and Walnut Woodland Mitigation and Monitoring Plan for the Tonner Hills Planned Community attached hereto as Exhibit "G" (the "**Riparian Mitigation Plan**") (collectively, the "**Mitigation Plans**").

K. CDFG has jurisdiction, pursuant to Fish and Game Code section 1802, over the conservation, protection, and management of fish, wildlife, native plants and the habitat necessary for biologically sustainable populations of those species.

L. USFWS has interest in the biological values of the Conserved Land in order to protect the California gnatcatcher as required by the federal Endangered Species Act and the Biological Opinion for this project area.

M. ACOE is the federal agency charged with regulatory authority over discharges of dredged and fill material in waters of the United States pursuant to section 404 of the Clean Water Act, and has an interest in protecting the functions and values of such aquatic resources.

N. Pursuant to the Biological Opinion, Grantor funded, or will fund, two separate endowments to fund the Perpetual Management Plan. The first endowment will fund the management of the Conserved Land while it is still under the control of Grantor ("**First Endowment**"). The First Endowment will be initially funded in the amount $270,000. If the First Endowment drops below $240,000, Grantor agrees to supplement it in order to maintain it above $240,000. Grantor has also established a second endowment in the amount of $100,000 ("**Second Endowment**"). The Second Endowment will accumulate interest until the Conserved Land is conveyed to Conservator, HOA, or Grantee pursuant to Grantee's exercise of the IOD as the case may be, at which time, the two endowments will be combined (the "**Combined Endowment**"). If the Combined Endowment at the time of such combination contains less than $700,000, Grantor agrees to provide a one-time supplement to ensure that the Combined Endowment is funded with $700,000, as it is anticipated that such amount will be sufficient for perpetual management of the Conserved Land. The First Endowment, the Second Endowment and/or the Combined Endowment shall collectively be referred to herein as the "**Endowment Funds**". Notwithstanding the foregoing, in the event that Grantor has not conveyed the Conserved Land to a Conservator, the HOA or Grantee within three (3) years of the date of the recording of this Easement, Grantor agrees to combine the two endowments and provide a one-time supplement to ensure that the Combined Endowment is funded with at least $700,000.

O. The Conserved Land is subject to that certain Tonner Hills Development Agreement dated November 19, 2002, which was recorded in the Official Records of the County of Orange as Instrument No. 2003000171873 (the "**Development Agreement**") by and between Grantee and Nuevo Energy Company ("**Nuevo**"), succeeded by merger by Plains Exploration & Production Company ("**Plains**"). Grantor and Tonner Hills SSP, LLC, a Delaware limited liability company ("**Tonner Hills SSP**") are the successors-in-interest to Nuevo and Plains with respect to the Development Agreement, and have assumed the obligations of Nuevo and Plains under the Development Agreement pursuant to that certain Assignment and Assumption Agreement dated as of December 7, 2004, and recorded in the Official Records of the County of Orange as Instrument No. 2004001123697 (the "**Assignment and Assumption Agreement**"). Tonner Hills SSP is the fee owner of the property subject to the Development Agreement proposed for improvement with residential housing.

P. The Development Agreement requires Grantor and Tonner Hills SSP to construct certain "**Public Facilities**" (as defined and identified in the Development Agreement). The Development Agreement further requires Grantor and Tonner Hills SSP to offer to dedicate to Grantee or its designee certain property for open space, recreation, and habitat conservation.

Q. This Easement is intended, in part, to satisfy the obligation of Grantor and Tonner Hills SSP to offer the open space, recreation, and habitat conservation areas as required by the Development Agreement. The grant of this Easement and the grant of a separate conservation easement over the fuel modification lots to be executed concurrently or substantially concurrently herewith is hereby declared to satisfy the obligations of Grantor and Tonner Hills SSP to offer for dedication to Grantee open space as required by the terms of the Development Agreement, including, without limitation, Exhibit "D" to the Development Agreement.

R. Prior to the date on which Grantor acquired title to the Conserved Land, Nuevo sold, transferred, and conveyed to BlackSand Partners, L.P., a Texas limited partnership ("**BlackSand**") all "**Oil Assets**" associated with the Conserved Land (i.e., oil, gas and other hydrocarbon substances, water, and minerals of every type and nature) along with the right: (i) to produce the Oil Assets from all then currently existing wells and those that might be newly drilled thereafter; and (ii) to remove the Oil Assets below five hundred (500) feet from the surface, as more fully set forth in that certain Purchase Agreement by and between Nuevo and BlackSand dated February 28, 2003.

S. Nuevo and BlackSand previously entered into that certain Mineral Payment and Performance Agreement dated February 28, 2003 (the "**Mineral PAPA**"), which sets forth certain duties of Nuevo and BlackSand with respect to a well abandonment and oil field accommodation program which Grantor, Nuevo and BlackSand are currently implementing (the "**Program**"). Grantor has agreed to complete the Program with respect to the Conserved Land, as further set forth in Section 4 below.

T. Aera Energy, LLC, a California limited liability company ("**Aera Energy**"), is an oil operator exercising the rights of BlackSand under one of the two oil and gas leases BlackSand holds within the Conserved Land.

U. Grantee agrees by accepting this grant, should Grantee elect to do so, to honor the intentions of Grantor stated herein to preserve and protect in perpetuity the Conservation Values of the Conserved Land in accordance with the terms of this Easement.

COVENANTS, TERMS, CONDITIONS AND RESTRICTIONS

For good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, and pursuant to California law, including Civil Code section 815, *et seq*., Grantor hereby voluntarily grants and conveys to Grantee a conservation easement in perpetuity over the Conserved Land, subject to acceptance by Grantee. This conveyance is subject to all prior conveyances (including, without limitation, the conveyance of the Oil Assets), covenants, restrictions, easements, leases, licenses, franchises, rights, encumbrances, exceptions, and reservations, that apply to the Conserved Land (collectively, the "**Exceptions**").

1. Purposes. The purposes of this Easement are to ensure that, subject to the Exceptions and the Reservations (as defined in Section 5 below), the Conserved Land will be preserved in perpetuity as open space and in a Natural Condition, defined hereafter, as required in the Approval Documents and as provided for in the Mitigation Plans and Perpetual Management Plan and, except for the Exceptions and Reservations, to prevent any use of the Conserved Land that will impair or interfere with the Conservation Values of the Conserved Land.

1.1. The term "**Natural Condition**" as used in this section shall mean the condition of the Conserved Land as it exists at the time this Easement is executed, as well as future enhancements or changes made to the Conserved Land that occur directly as a result of the following activities:

(a) Compensatory mitigation measures required by the Mitigation Plans;

(b) In perpetuity maintenance ("**Long-Term Maintenance**"), that occurs on the Conserved Land as described in Section 16 herein; or

(c) Activities described in Sections 4 and 6 herein.

1.2. The Natural Condition of the Conserved Land existing at the time this Easement is executed ("**Present Natural Condition**") is evidenced in part by: (1) an aerial photograph of the Conserved Land at an appropriate scale taken as close in time as possible to the date this Easement is executed with an overlay of the Conserved Land boundaries on such aerial photograph; (2) several on-site photographs showing all man-made improvements or structures and the major, distinct natural features of the Conserved Land; (3) the depiction of the Oil Operation Areas within the Conserved Land as shown on Exhibit "C" attached hereto, and (4) the depiction of the approved improvements within the Conserved Land as shown on Exhibit "D" attached hereto. If a controversy arises with respect to the Present Natural Condition of the Conserved Land, Grantor, Grantee, and the Third-Party Beneficiaries, or any designees or agents of Grantor, Grantee, and the Third-Party Beneficiaries, shall not be foreclosed from utilizing any and all other relevant documents, surveys, photographs, or other evidence or information to assist in the resolution of the controversy.

2. Grantee's Rights. To accomplish the purposes of this Easement, Grantor hereby grants and conveys the following rights and interests to Grantee, subject to acceptance by Grantee and subject to the Exceptions and Reservations. These rights are also granted to ACOE, CDFG, and USFWS as third-party beneficiaries of this Easement.

2.1. The right to preserve and protect the Conservation Values of the Conserved Land in conformity with the provisions of this Easement;

2.2. The right to enter upon the Conserved Land at reasonable times in order to monitor Grantor's compliance with and to otherwise enforce the terms of this Easement, and for scientific research and interpretive purposes by Grantee or its designees, provided that Grantee shall not unreasonably interfere with Grantor's authorized use and quiet enjoyment of the Conserved Land;

2.3. The right to prevent any activity on or use of the Conserved Land that is inconsistent with the purposes of this Easement and to require the restoration of such areas or features of the Conserved Land that may be damaged by any act, failure to act, or any use that is inconsistent with the purposes of this Easement;

2.4. All mineral, air, and water rights necessary to protect and to sustain the biological resources of the Conserved Land, except those previously granted and those required for the Reservations;

2.5. All present and future development rights appurtenant to, allocated, implied, reserved, or inherent in the Conserved Land; such rights are hereby terminated and extinguished, and may not be used on or transferred to any portion of the Conserved Land, nor any other property adjacent or otherwise; and

2.6. The right to enforce by any means the terms of this Easement, including, without limitation, injunctive relief.

3. Prohibited Uses. Subject to the Exceptions and Reservations, any activity on or use of the Conserved Land inconsistent with the purposes of this Easement, is prohibited. Without limiting the generality of the foregoing, the following uses by Grantor, Grantee, and their respective guests, agents, assigns, employees, representatives, successors, and third parties, are expressly prohibited, except as such activities may be within the Exceptions and Reservations and those required to implement the Approval Documents, Mitigation Plans, and Perpetual Management Plan:

3.1. Supplemental or unseasonable watering;

3.2. Use of fertilizers, pesticides, biocides, herbicides or other agricultural chemicals, or weed abatement activities, except as necessary to control or remove invasive, exotic plant species, or to control or advance the Conservation Values of the Conserved Land;

3.3. Incompatible fire protection activities;

3.4. Use of off-road vehicles and use of any other motorized vehicles except on existing roadways and emergency vehicle access roads or as may be necessary to undertake implementation of the Exceptions and Reservations;

3.5. Grazing or other agricultural activity of any kind;

3.6. Recreational activities including, but not limited to, horseback riding, biking, hunting, and fishing; except for recreational access within the Tonner Ridge Trail and an equestrian site up to one acre in size located adjacent to the Tonner Ridge Trail and within the former Green Waste Site shown on Exhibit "D" attached hereto (the "**Equestrian Site**") together with sufficient access thereto over an existing access road along the Tonner Ridge Trail; provided, however, all remaining portions of the former Green Waste Site must be revegetated pursuant to the terms of the Perpetual Management Plan following the cessation of oil activities and recreational access within the Equestrian Site is conditioned upon the County accepting, prior to January 10, 2031, the dedication of such site for use as an equestrian facility;~~.~~

3.7. Commercial, residential, retail, institutional, or industrial uses;

3.8. Construction, reconstruction, or placement of any building, billboard or sign, or any other structure or improvement of any kind, except those signs allowed under Section 4.5;

3.9. Depositing or accumulation of soil, trash, ashes, refuse, waste, bio-solids, or any other materials, except as may be temporarily required to implement the Exceptions and Reservations, the clean-up of which will be required following such temporary use;

3.10. Planting, introduction, or dispersal of non-native or exotic plant or animal species;

3.11. Filling, dumping, excavating, draining, dredging, mining, drilling, removing, or exploring for minerals, loam, soil, sands, gravel, rocks or other material on or below the surface of the Conserved Land;

3.12. Altering the surface or general topography of the Conserved Land, including building of roads;

3.13. Removing, destroying, or cutting of native trees, shrubs, or other vegetation;

3.14. Manipulating, impounding, or altering any natural watercourse, body of water, or water circulation on the Conserved Land, and activities or uses detrimental to water quality, including but not limited to degradation or pollution of any surface or sub-surface waters on the Conserved Land;

3.15. Any legal or de facto division, subdivision, or portioning of the Conserved Land; and

Notwithstanding anything set forth in this Section 3, nothing in this Easement shall require Grantor to undertake any action to prohibit any party that holds a property interest in the Conserved Land from undertaking any of the above-described prohibited uses, including without limitation, BlackSand and Aera Energy or any of their agents, contractors, invitees, and their respective successors and assigns, as Oil Assets of BlackSand and its continued rights to remove the same are expressly permitted pursuant to the terms of this Easement.

4. Grantor's Duties. To accomplish the purposes of this Easement as described in Section 1 herein, Grantor shall undertake the construction, maintenance and monitoring of mitigation areas pursuant to the Mitigation Plans and ensure the completion of the Program. The foregoing obligations may not be transferred to its successors and assigns. Grantor, its successors and assigns (including, without limitation, the Conservator or HOA should such party or parties take fee title to any portion of the Conserved Land and Grantee should Grantee exercise its rights under the IOD) shall:

4.1. Undertake all reasonable actions to prevent unlawful entry and trespass by persons whose activities are not in compliance with the purposes of this Easement or could degrade or harm the Conservation Values of the Conserved Land;

4.2. Cooperate with Grantee to protect the Conservation Values;

4.3. Perform Long-Term Maintenance of the Conserved Land as set forth in Section 16.

4.4. Install signs regarding unlawful entry; provided however, Grantor's fencing of Oil Operation Areas within the Conserved Land in accordance with the regulations of the Division of Oil, Gas and Geothermal Resources ("**DOGGR**"), shall not to be installed without the prior written consent of BlackSand and Aera Energy, and the posting of further signage regarding unlawful entry shall satisfy Grantor's obligations for this purpose.

4.5. Undertake all necessary actions to perfect Grantee's rights under Section 2 of this Easement, including without limitation, Grantee's water rights.

4.6. Repair and restore damage to the Conserved Land directly caused by Grantor, Grantor's guests, representatives, employees, or agents, and third parties, provided, however, Grantor shall not engage in any repair or restoration work on the Conserved Land without first consulting Grantee and the Third-Party Beneficiaries;

4.7. Set aside, hold, invest, and disburse the Endowment Funds in trust solely for the purposes of preserving the Conservation Values of the Conserved Land under this Easement in perpetuity; and

4.8. Have a fiduciary duty to ensure that the Endowment Funds held in trust for the Conserved Land are properly managed. The following principles of fiduciary duty shall apply:

(a) There shall be no commingling of the Endowment Funds with other funds. Funds may be pooled for investment management purposes only.

(b) Grantor shall have a duty of loyalty and shall not use the Endowment Funds for its own personal benefit.

(c) Grantor shall act as a prudent investor of the Endowment Funds.

(d) Grantor shall not delegate the responsibility for managing the Endowment Funds to a third-party, but may delegate authority to invest the Endowment Funds with Grantor's oversight. Grantor shall act with prudence when delegating authority and in the selection of agents.

(e) Grantor shall have an annual audit of the Endowment Funds performed by a licensed Certified Public Accountant. Grantor shall submit the auditor's written report to Grantee, ACOE, CDFG, and USFWS upon request.

5. Grantee's Duties. To accomplish the purposes of this Easement as described in Section 1 herein, the sole obligation of Grantee under this Agreement shall be to perform an annual compliance inspection of the Conserved Land, and make reports available to the Third-Party Beneficiaries upon request. Reasonable expenses of Grantee relating to the monitoring obligation set forth in this Section 5 shall be reimbursable from the First Endowment or the Combined Endowment. Additionally, Grantee shall have the right, but not the obligation, to transfer the monitoring obligation set forth in this Section 5 to the City, provided that Grantee provides prior written notice of such transfer to Grantor, ACOE, CDFG and USFWS. Notwithstanding the foregoing, in the event fee title to the Conserved Lands is held by the party responsible for the monitoring obligation set forth in this Section 5, such party shall delegate such monitoring obligation to a third party acceptable to ACOE, CDFG and USFWS.

6. Reservations and Permitted Uses. Grantor reserves to itself, and to its successors, assigns, agents and lessees, all rights accruing from its ownership of the Conserved Land, including the right to engage in or permit or invite others to engage in all uses of the Conserved Land that are not expressly prohibited or limited by, and are not inconsistent with the purposes of this Easement (collectively the "**Reservations**"). Without in any way limiting the foregoing, Grantor hereby reserves the all of the following rights, interests, and privileges:

6.1. Reasonable access through the Conserved Land to implement activities contemplated by the Mineral PAPA and the Program, the Mitigation Plans, Perpetual Management Plan, and to construct improvements as required or permitted by the Approval Documents. It is contemplated Grantor will ultimately convey all of the Conserved Land to the HOA or Conservator. The successor-in-interest will assume the roles and responsibilities of Grantor under this Conservation Easement, except that Grantor will remain responsible for the mitigation obligations until they are successfully completed as confirmed in writing by ACOE and CDFG. In the event Grantor conveys its interest in the Conserved Land prior to completion of all mitigation obligations, Grantor expressly reserves the right to enter the Conserved Land to perform such work thereon as is required to meet the mitigation obligations;

6.2. Pursuant to the Approval Documents and as further depicted in Exhibit "D" attached hereto, the right to complete all improvements described in the Approval Documents as further depicted in Exhibit "D" attached hereto, which includes the right to grade and manufacture slopes, emergency vehicle roads, the Tonner Ridge Trail, the Equestrian Site, reservoirs and detention and debris basins, install, maintain, repair and replace drainage devices and landscaping on manufactured slopes, emergency vehicle access roads, the Tonner Ridge Trail, the Equestrian Site, reservoirs and detention and debris basins, and improvements related to reservoirs and pump stations. The areas depicted in Exhibit "D" attached hereto represent Grantor's best effort to depict improvements permitted by the Approval Documents. However, Grantor makes no representation or warranty regarding the completeness of Exhibit "D" and expressly reserves any and all rights reserved in this Section 6.2 that are permitted by the Approval Documents, but not otherwise depicted in Exhibit "D";

6.3. The right to remediate and/or remove hazardous substances or conditions;

6.4. The right to remove trees, shrubs, and other native or non-native vegetation within the Conserved Land as required by law or as incidental to or appropriate for: (1) fire breaks and other emergency operations, including but not limited to emergency repair of gas, oil and water pipelines, electrical transmission lines and storm water conveyance structures; (2) maintenance of existing foot trails, roads, pipelines, power lines that have been subject to ongoing maintenance historically; (3) prevention or treatment of disease; (4) implementation of the Mitigation Plans and Perpetual Management Plan; and (5) the installation, repair, operation, maintenance, and removal of facilities such as wells, injection skids, test stations, manifolds, pipelines, within Oil Operation Areas. In the event that emergency operations must occur in areas outside waters of the United States under the jurisdiction of ACOE, Grantor will notify USFWS, ACOE and CDFG within a maximum of 72 hours of initiating impacts. In waters of the United States under the jurisdiction of ACOE, current law requires in most cases that even actions undertaken during emergency conditions must receive prior authorization from the Department of Army (through expedited procedures, if appropriate), if the action involves a discharge of dredged or fill material into jurisdictional waters of the United States and before any ground-disturbing activities occur on the Conserved Land.

6.5. The right to remove invasive or non-native vegetation as necessary by any reasonable means, including, but not limited to, the supervised use of Roundup or its chemical equivalent, mechanical means, or by hand;

6.6. The right to close or otherwise restrict public access at any time to the Conserved Land whenever Grantor determines it is necessary to do so in the interest of the preservation of the Conservation Values or for site security or public safety reasons; provided, however, except in the event of an emergency, Grantor shall not have the right to close or otherwise restrict public access to Tonner Trail without the City's express written consent, which consent shall not be unreasonably withheld, conditioned or delayed;

6.7. The right to perform any other rights under the BlackSand Purchase Agreement and/or the Mineral PAPA within the Oil Operation Areas shown on Exhibit "C" attached hereto, including without limitation, the right to perform oil and gas exploration, development, extraction, production, and related field maintenance and accommodation operations, including the drilling of new wells and the recompletion of existing wells. Additionally, the right to perform related maintenance and accommodation operations for existing wells and related oil facilities in areas outside the Oil Operation Areas shown on

Exhibit "C" attached hereto, including without limitation, the laying and replacement of gathering and transmission lines within the same footprint/existing alignment required to operate the field and to serve the wells, remediation activities including the removal and abandonment of certain existing gathering and transmission lines, oil field equipment, sumps, and access roads no longer required for the on-going operation of the oil field on or in the vicinity of the Conserved Land; provided however, the drilling of new wells and the installation of oil facilities not related to the maintenance of existing wells and related oil facilities is expressly prohibited outside the Oil Operation Areas shown on Exhibit "C" attached hereto. Additionally, the right to perform oil and gas exploration, development, extraction, production and related field maintenance and accommodation operations outside the Oil Operation Areas shown on Exhibit "C" attached hereto at a depth below 500 feet below the surface of the Conserved Land from access points within the Oil Operation Areas or other access points outside the Conserved Land;

6.8. The right of Grantor and its authorized agents and contractors to enter on, pass over, and egress from the Conserved Land as necessary to protect any right and to carry out Grantor's obligations or operations and to grant any additional licenses and/or easements which are consistent with the terms of the Exceptions and Reservations;

6.9. Subject to the prior conveyance of the Oil Assets to BlackSand, Grantor reserves from this Easement for the benefit of the owners, lessee(s), and operators of the mineral rights an estate in, on, and under the Conserved Land, any and all oil, oil rights, including: all rights to explore, develop and produce oil, gas or other minerals, including any such rights previously granted to any third parties, and including the right (previously conveyed or not) to convey in whole or in part, any and all oil, oil rights, minerals, mineral rights, gas, natural gas rights, and other hydrocarbons by whatsoever name known; geothermal steam and all products derived from any of the foregoing that may be within or under the Conserved Land, together with the perpetual right of drilling, mining, exploring, and operating therefore and storing in and removing the same from the Oil Operation Areas within the Conserved Land or lands other than the Conserved Land, including the right to whipstock or directionally drill and mine from Oil Operations Areas within the Conserved Land or lands other than the Conserved Land, oil or gas wells, tunnels and shafts into, through or across the subsurface of the Conserved Land and to bottom such whipstocked or directionally-drilled wells, tunnels, and shafts under and beneath or beyond the exterior limits thereof, and to redrill, retunnel, equip, maintain, repair, deepen, and operate any such wells or mines, provided, however, the drilling of new wells and the installation of oil facilities not related to the maintenance of existing wells and related oil facilities is expressly prohibited outside the Oil Operation Areas shown on Exhibit "C" attached hereto above the depth of 500 feet below the surface of the Conserved Land (i.e., no surface entry outside the Oil Operation Areas);

6.10. The right of the holders of prior conveyances, easements, leases, licenses, franchises, encumbrances, Exceptions and Reservations that apply to the Conserved Land, to exercise the rights and privileges granted or reserved within those instruments, including, without limitation, those rights set forth in Exhibit "H";

6.11. The right to implement and perform any and all obligations under the Development Agreement and the Mitigation Plans and Perpetual Management Plan;

6.12. The right to install signage pursuant to Section 4.5 herein;

6.13. Notwithstanding anything set forth herein to the contrary, nothing in this Easement is intended nor shall be applied to in any way to limit Grantor or any of Grantor's successors and assigns from: (1) constructing, placing, installing, and/or erecting any improvements upon the portions of Tonner Hills not constituting the Conserved Land; (2) installing and/or maintaining the subsurface infrastructure improvements, utility lines, landscaping (including irrigation and runoff), landscape mitigation, and/or similar non-structural improvements within the Conserved Land; and/or (3) developing property adjoining the Conserved Land for any purposes, except as limited by any local, state, or federal permit requirements for such development, and provided that for all of the above clauses (1), (2), and (3) neither such activity nor any effect resulting from such activity amounts to a use of the Conserved Land, or has an impact upon the Conserved Land, that is prohibited by Section 3 above.

6.14. Notwithstanding anything to the contrary set forth in this Section 6, Grantor shall obtain the prior written approval of ACOE and CDFG prior to Grantor engaging in any activity conducted pursuant to the Reservations not otherwise authorized by the Approval Documents within the areas of the Conserved Land outside the Oil Operation Areas; provide, however, Grantor shall not be required to obtain the approval of ACOE and CDFG for the following activities: (1) the implementation of the Program, (2) the implementation of the Mitigation Plans and (3) the implementation of the Perpetual Management Plan. Additionally, such approval of ACOE and CDFG shall not be unreasonably withheld, conditioned or delayed and, provided that Grantor's written request (email and first class mail) includes a notice that failure to respond within forty-five (45) days will result in the request being deemed approved, shall be automatically deemed granted by ACOE or CDFG in the event that such party does not respond to Grantor's written request within forty-five (45) days of its receipt thereof.

7. Grantee's Remedies.

7.1. Third-Party Beneficiary Enforcement Rights. Grantor, its successors and assigns grant to the Third-Party Beneficiaries a discretionary right to enforce this Easement in a judicial or administrative action against any person(s) or other entity(ies) violating or attempting to violate this Easement; provided, however, that no violation of this Easement shall result in a forfeiture or reversion of title. The Third-Party Beneficiaries shall have the same rights, remedies, and limitations as Grantee under this Section 7. The rights under this Section 7 are in addition to, and do not limit rights conferred in Section 2 above, the rights of enforcement against Grantor and its successors or assigns under the Approval Documents, or any rights of the various documents created thereunder or referred to therein.

7.2. Notice.

(a) If Grantee determines Grantor is in violation of the terms of this Easement or that a violation is threatened, Grantee may demand the cure of such violation. In such a case, Grantee shall issue a written notice to Grantor (hereinafter "**Notice of Violation**") informing Grantor of the violation and demanding cure of such violation.

(b) Grantor shall cure the noticed violation within fifteen (15) days of receipt of a Notice of Violation from Grantee. If said cure reasonably requires more than fifteen (15) days, Grantor shall, within the fifteen (15) day period, submit to Grantee for review and approval a plan and time schedule to diligently complete a cure. Grantor shall complete such cure in accordance with the approved plan. If Grantor disputes the Notice of Violation, it shall issue a written notice of such dispute (hereinafter "**Notice of Dispute**") to the Grantee within fifteen (15) days of receipt of the Notice of Violation.

(c) If Grantor fails to cure the noticed violation(s) within the time period(s) described in Section 7.2(b) above, or Section 7.2(d) below, Grantee may bring an action at law or in equity in a court of competent jurisdiction to enforce compliance by Grantor with the terms of this Easement. In such action, the Grantee may: (i) recover any damages to which they may be entitled for violation by Grantor of the terms of this Easement; (ii) enjoin the violation, ex parte if necessary, by temporary or permanent injunction without the necessity of proving either actual damages or the inadequacy of otherwise available legal remedies; or (iii) pursue other equitable relief, including, but not limited to, the restoration of the Conserved Land to the condition in which it existed prior to any such violation or injury. Grantee may apply any damages recovered to the cost of undertaking any corrective action on the Conserved Land.

(d) If Grantor provides Grantee with a Notice of Dispute, as provided herein, Grantee shall meet and confer with Grantor at a mutually agreeable place and time, not to exceed thirty (30) days from the date that Grantee receives the Notice of Dispute. Grantee shall consider all relevant information concerning the disputed violation provided by Grantor, and shall determine whether a violation has in fact occurred and, if so, whether the Notice of Violation and demand for cure issued by Grantee is appropriate in light of the violation.

(e) If, after reviewing Grantor's Notice of Dispute, conferring with Grantor, and considering all relevant information related to the violation, Grantee determines that a violation has occurred, Grantee shall give Grantor notice of such determination in writing. Upon receipt of such determination, Grantor shall have fifteen (15) days to cure the violation. If said cure reasonably requires more than fifteen (15) days, Grantor shall, within the fifteen (15) day period, submit to Grantee for review and approval a plan and time schedule to diligently complete a cure. Grantor shall complete such cure in accordance with the approved plan.

7.3. Conflicting Notices of Violation.

(a) If Grantor receives a Notice of Violation from Grantee, ACOE, CDFG, and/or USFWS that is in material conflict with one or more prior written Notices of Violation that have not yet been cured by Grantor (hereinafter "**Active Notice(s) of Violation**") such that the conflict makes it impossible for Grantor to carry out cure consistent with all prior Active Notices of Violation, Grantor shall give written notice (hereinafter "**Notice of Conflict**") to the agency or agencies issuing the later conflicting Notice(s) of Violation. Grantor shall issue said Notice of Conflict to the appropriate agency or agencies within fifteen (15) days of the receipt of each such conflicting Notice of Violation. A valid Notice of Conflict shall describe the conflict with specificity, including a description of how the conflict makes compliance with all Active Notices of Violation impossible.

(b) Upon issuing a valid notice of conflict to the appropriate agency, as described above, Grantor shall not be required to carry out the cure described in the conflicting Notice(s) of Violation until such time as the agency or agencies responsible for said conflicting Notice(s) of Violation issue(s) a revised Notice of Violation that is consistent with prior Active Notices of Violation. Upon receipt of a revised, consistent Notice of Violation, Grantor shall carry out the cure recommended in such notice within the time period(s) described in Section 7.2(b), above. Notwithstanding Section 7.4, failure to cure within said time period(s) shall entitle Grantee to the remedies described in Section 7.2(c).

(c) The failure of Grantor to issue a valid Notice of Conflict within fifteen (15) days of receipt of a conflicting Notice of Violation shall result in a waiver of Grantor's ability to claim a conflict.

(d) This Section 7.3 shall not apply to Section 7.4 below.

7.4. Immediate Action. If Grantee determines that circumstances require immediate action to prevent or mitigate significant damage to the Natural Condition or Conservation Values of the Conserved Land, Grantee may immediately pursue all available remedies, including injunctive relief, available pursuant to both this Easement and state and federal law after giving Grantor at least twenty four (24) hours' written notice before pursuing such remedies. So long as such twenty four (24) hours' notice is given, Grantee may immediately pursue all available remedies without waiting for the expiration of the time periods provided for cure or Notice of Dispute as described in Section 7.2(b). The written notice pursuant to this paragraph may be transmitted to Grantor by facsimile. The rights of Grantee under this paragraph apply equally to actual or threatened violations of the terms of this Easement. Grantor agrees that the remedies at law for Grantee for any violation of the terms of this Easement are inadequate and that Grantee shall be entitled to the injunctive relief described in this Section 7, both prohibitive and mandatory, in addition to such other relief to which Grantee may be entitled, including specific performance of the terms of this Easement, without the necessity of proving either actual damages or the inadequacy of otherwise available legal remedies. The remedies described in this Section 7.4 shall be cumulative and shall be in addition to all remedies now or hereafter existing at law or in equity.

7.5. Costs of Enforcement. Any costs incurred by Grantee, where Grantee is the prevailing party, in enforcing the terms of this Easement against Grantor including, but not limited to, costs of suit and attorneys' fees, and any costs of restoration necessitated by Grantor's violation or negligence under the terms of this Easement shall be borne by Grantor.

7.6. Enforcement Discretion. Enforcement of the terms of this Easement shall be at the discretion of the Grantee. Any forbearance by Grantee to exercise rights under this Easement in the event of any breach of any term of this Easement by Grantor shall not be deemed or construed to be a waiver by Grantee of such term or of any subsequent breach of the same or any other term of this Easement or of any of the rights of Grantee under this Easement. No delay or omission by Grantee in the exercise of any right or remedy upon any breach by Grantor shall impair such right or remedy or be construed as a waiver.

7.7. Acts Beyond Grantor's Control. Subject to Section 10, nothing contained in this Easement shall be construed to entitle Grantee to bring any action against or any injury to or change in the Conserved Land resulting from:

(a) Any natural cause beyond Grantor's control, including without limitation, fire not caused by Grantor, flood, storm, and earth movement;

(b) Any prudent action taken by Grantor under emergency conditions to prevent, abate, or mitigate significant injury to persons and/or the Conserved Land resulting from such causes; or

(c) Acts by Grantee, ACOE, CDFG, USFWS, or their employees, directors, officers, agents, contractors, or representatives.

7.8. Use of the Endowment Funds. If a court of competent jurisdiction determines that there has been a violation by Grantor of any term of this Conservation Easement:

(a) The Endowment Funds shall not be used to pay damages awarded as part of the judgment; and

(b) The Endowment Funds shall not be used to restore the Conserved Land to the condition in which it existed prior to the violation.

8. As-Is. Grantee acknowledges and agrees that Grantor has not made, does not make, and specifically negates and disclaims any representations, warranties, promises, covenants, agreements, or guaranties of any kind or character whatsoever, whether express or implied, oral or written, past, present, or future, of, as to, concerning, or with respect to: (1) the value of the Conserved Land; (2) the suitability of the Conserved Land for any and all activities and uses which Grantee may conduct thereon; (3) the manner, quality, state of repair, or lack of repair of the Conserved Land; (4) the nature, quality, or condition of the Conserved Land, including, without limitation, the water, soil, and geology; (5) the compliance of or by the Conserved Land or its operation with any laws, rules, ordinances, or regulations of any applicable governmental authority or body; (6) deficiency of any undershoring; (7) deficiency of any drainage; (8) the fact that all or a portion of the Conserved Land may be located on or near an earthquake fault line; or (9) with respect to any other matter, Grantee further acknowledges and agrees that having been given the opportunity to inspect the Conserved Land and review information and documentation affecting the Conserved Land, and except as otherwise expressly provided herein, Grantee is relying solely on its own investigation of the Conserved Land, and review of such information and documentation, and not on any information provided or to be provided by Grantor. Effective as of the date of this Easement, Grantee waives its right to recover from Grantor and from the members, employees, agents, assignees, and successors of Grantor (each a "**Grantor Party**") any and all damages, losses, liabilities, costs, or expenses whatsoever (including reasonable attorneys' fees and costs) and Claims therefor, whether direct or indirect, known or unknown, foreseen or unforeseen, which arise on account of or in any way grow out of or are connected with the physical condition of the Conserved Land or any law or regulation applicable thereto, including without limitation the Applicable Environmental Laws. This Section 8 does not affect Section 10 and Section 17.9.

9. Access. This Easement does not convey a general right of access to the public. This Easement will allow for access to the Conserved Land by ACOE, CDFG, USFWS, and third-party easement holders of record at the time of this conveyance at locations designated in easements and reservations of rights recorded in the chain of title to the Conserved Land at the time of this conveyance.

10. Costs and Liabilities. Subject to the Exceptions and to any obligations of any third parties under the Exceptions and any obligations arising by law on the part of Grantee as a result of the granting of this Easement by Grantor and the acceptance of this Easement, if applicable, by Grantee, and excluding any improvements installed by Grantee, Grantor retains all responsibilities and shall bear all costs and liabilities of any kind related to the ownership, operation, upkeep, and maintenance of the Conserved Land. Grantor agrees that Grantee and the Third-Party Beneficiaries shall not have any duty or responsibility for the operation or maintenance of the Conserved Land, the monitoring of hazardous conditions thereon, or the protection of Grantor, the public, or any third parties from risks relating to conditions on the Conserved Land. Subject to the foregoing, Grantor remains solely responsible for obtaining any applicable governmental permits and approvals for any activity or use permitted by this Easement, and any activity or use shall be undertaken in accordance with all applicable federal, state, local, and administrative agency statutes, ordinances, rules, regulations, orders and requirements.

10.1. Taxes; No Liens. Grantor shall pay before delinquency all taxes, assessments, fees, and charges of whatever description levied on or assessed against the Conserved Land by competent authority (collectively, "**taxes**"), including any taxes imposed upon, or incurred as a result of, this Easement, and shall furnish Grantee with satisfactory evidence of payment upon request. Grantor shall keep Grantee's interest in the Conserved Land free from any liens, including those arising out of any obligations incurred by Grantor or any labor or materials furnished or alleged to have been furnished to or for Grantor at or for use on the Conserved Land.

10.2. Hold Harmless.

(a) Grantor.

(i) Grantor shall hold harmless, protect, and indemnify Grantee and its directors, officers, employees, agents, contractors, and representatives and the heirs, personal representatives, successors, and assigns of each of them (each a "**Grantee Indemnified Party**" and, collectively, "**Grantee's Indemnified Parties**") from and against any and all liabilities, penalties, costs, losses, damages, expenses (including, without limitation, reasonable attorneys' fees and experts' fees), causes of action, claims, demands, orders, liens, or judgments (each a "**Claim**" and, collectively, "**Claims**"), arising from or in any way connected with injury to or the death of any person, or physical damage to any property, resulting from any act, omission, condition, or other matter arising from the breach of or default under this Easement by Grantor except that this indemnification shall be inapplicable to Grantee's Indemnified Parties with respect to any Claim arising from: (i) the breach of or default under this Easement by Grantee; (ii) the negligence or misconduct of Grantee, or any of its employees, agents, contractors, and/or representatives; and (iii) the existence or administration of this

Easement. If any action or proceeding is brought against any of the Grantee Indemnified Parties by reason of any such Claim, Grantor shall, at the election of and upon written notice from Grantor, defend such action or proceeding by counsel reasonably acceptable to the Indemnified Party. Following Grantor's conveyance of the Conserved Land, Grantor shall be released from all obligations and liabilities under this Easement, including without limitation, additional contributions to the Combined Endowment, except pursuant to Section 17.7.

(ii) Grantor shall hold harmless, protect and indemnify the Third-Party Beneficiaries and their respective directors, officers, employees, agents, contractors, and representatives and the heirs, personal representatives, successors, and assigns of each of them (each a "**Third-Party Beneficiary Indemnified Party**" and collectively, "**Third-Party Beneficiary Indemnified Parties**") from and against any and all Claims arising from or in any way connected with: (i) injury to or the death of any person, or physical damage to any property, resulting from any act, omission, condition, or other matter related to or occurring on or about the Conserved Land, regardless of cause, and (ii) the existence or administration of this Easement; provided, however, that the indemnification in this Section 10.2(a)(2) shall be inapplicable to a Third-Party Beneficiary Indemnified Party with respect to any Claim due solely to the negligence of that Third-Party Beneficiary Indemnified Party or any of its employees. If any action or proceeding is brought against any of the Third-Party Beneficiary Indemnified Parties by reason of any Claim to which the indemnification in this Section 10.2(a)(2) applies, then at the election of and upon written notice from the Third-Party Beneficiary Indemnified Party, Grantor shall defend such action or proceeding by counsel reasonably acceptable to the applicable Third-Party Beneficiary Indemnified Party or reimburse the Third-Party Beneficiary Indemnified Party for all charges incurred for services of the California Attorney General or the U.S. Department of Justice in defending the action or proceeding.

(b) Grantee. Grantee shall hold harmless, protect, and indemnify Grantor, Tonner Hills SSP, BlackSand, and Aera Energy, and their affiliates, respective members, officers, employees, agents, contractors, and representatives and the heirs, personal representatives, successors, and assigns (each a "**Grantor Indemnified Party**" and, collectively, "**Grantor's Indemnified Parties**") from and against any and all Claims, arising from or in any way connected with injury to or the death of any person, or physical damage to any property, resulting from any act, omission, condition, or other matter related to the exercise of the rights set forth in this Easement by any of the Grantee Indemnified Parties or the breach of or default under this Easement by Grantee. If any action or proceeding is brought against any of the Grantor's Indemnified Parties by reason of any such Claim, Grantee shall, at the election of and upon written notice from such Grantor Indemnified Party against which such action or proceeding was brought, defend such action or proceeding by counsel reasonably acceptable to such Grantor Indemnified Party or reimburse the Grantee Indemnified Party for all charges incurred for services of the County Counsel in defending the action or proceeding.

10.3. Condemnation. The purposes of this Easement are presumed to be the best and most necessary public use as defined at Code of Civil Procedure section 1240.680, notwithstanding Code of Civil Procedure sections 1240.690 and 1240.700.

11. Assignment. This Easement is transferable by Grantee upon written approval of ACOE, CDFG, and USFWS, which approval shall not be unreasonably withheld or delayed, but

Grantee shall give Grantor, ACOE, CDFG, and USFWS at least forty-five (45) days prior to written notice of transfer. Notwithstanding the foregoing, Grantee may assign its rights and obligations under this Easement to the City, provided that Grantee provides prior written notice of such assignment to Grantor, ACOE, CDFG and USFWS. Grantee may assign its rights and obligations under this Easement only to an entity or organization authorized to acquire and hold conservation easements pursuant to Civil Code section 815.3 and Government Code section 65965 (or any successor provision(s) then applicable) or the laws of the United States, and reasonably acceptable to ACOE, CDFG, and USFWS. Grantee shall record the assignment in the county where the Conserved Land is located. The failure of Grantee to perform any act provided in this section shall not impair the validity of the Easement or limit its enforcement in any way. Unless and until Grantor conveys fee title to the Conserved Land to Conservator or HOA, Grantor shall procure the assistance of an entity with the qualifications set forth in Section 12 below to manage the Conserved Land.

12. Subsequent Transfers. Grantor agrees to incorporate the terms of this Easement in any deed or other legal instrument by which Grantor divests itself of any interest in all or any portion of the Conserved Land, including, without limitation, a leasehold interest. Grantor agrees that the deed or other legal instrument shall also incorporate by reference the Approval Documents and any amendments thereto, and the Mitigation Plans and Perpetual Management Plan identified herein and any amendments thereto. Grantor further agrees to give actual notice to any transferee or lessee of the existence of this Easement and to give written notice to Grantee, ACOE, CDFG and USFWS of the intent to transfer any interest at least thirty (30) days prior to the date of such transfer. Grantee, ACOE, CDFG, and USFWS shall have the right to prevent subsequent transfers in which prospective subsequent claimants or transferees are not given notice of the covenants, terms, conditions and restrictions of this Easement. The failure of Grantor, Grantee, ACOE, CDFG, or USFWS to perform any act provided in this section shall not impair the validity of this Easement or limit its enforceability in any way. From and after the date of any transfer of all or any portion of the Conserved Land by Grantor and each transfer thereafter, (i) the transferee shall be deemed to have assumed all of the obligations of Grantor as to the portion transferred, as set forth in this Easement, (ii) the transferee shall be deemed to have accepted the restrictions contained herein as to the portion transferred, (iii) the transferor, as applicable, shall have no further obligations hereunder, and (iv) all references to Grantor in this Easement shall thereafter be deemed to refer to such transferee. Conservator must (i) have fulfilled legal requirements necessary for creation of a public or private entity, (ii) have demonstrated sufficient capability in terms of resources, available staff, and offices to provide sufficient management of the Conserved Land and to respond in a timely manner to issues that arise thereupon, (iii) have a site specific operations plan that is consistent with the Tonner Hills Perpetual Management Plan, (iv) have worked with members of the community and be accountable to the ACOE, CDFG and USFWS for Conservator's management of the Conserved Land and (v) have demonstrated either experience with managing native habitat, including coastal sage habitat occupied by the California Gnatcatcher, or the commitment to hire a subconsultant with such experience.

13. Merger. The doctrine of merger shall not operate to extinguish this Easement if the Easement and the Conserved Land become vested in the same party. If, despite this intent, the doctrine of merger applies to extinguish this Easement then, unless Grantor, Grantee, and the Third-Party Beneficiaries otherwise agree in writing, a replacement conservation easement or

restrictive covenant containing the same protections embodied in this Easement shall be recorded against the Conserved Land.

14. Notices. Any notice, demand, request, consent, approval, or communication that any party desires or is required to give to the other parties shall be in writing and be served personally or sent by recognized overnight courier that guarantees next-day delivery or by first class mail, postage fully prepaid, addressed as follows:

To Grantor:	Tonner Hills 680, LLC c/o Shea Homes 603 South Valencia Avenue, Suite 200 Brea, California 92823
and	Tonner Hills 680, LLC c/o Standard Pacific Homes 15326 Alton Parkway Irvine, California 92618-2338
With a copy to:	Allen Matkins Leck Gamble Mallory & Natsis LLP 1900 Main Street, Fifth Floor Irvine, California 92614 Attn: R. Michael Joyce, Esq.
and	Thompson & Knight LLP 1700 Pacific Ave., Suite 3300 Dallas, Texas 75201
and	Linn Western Operating, Inc. 650 Washington Road, 8th Floor Pittsburgh, Pennsylvania 15228
and	Aera Energy LLC 3030 Saturn Street, Suite 101 Brea, California 92821
To Grantee:	County of Orange 10 Civic Center Plaza Santa Ana, California 92701
To ACOE:	United States Army Corps of Engineers District Counsel 915 Wilshire Boulevard, Room 1535 Los Angeles, CA 90017 lawrence.n.minch@usace.army.mil
To CDFG:	Department of Fish and Game Office of the General Counsel

1416 9th Street, 12th Floor
Sacramento, CA 95814
Attn: General Counsel

and

Regional Manager
Department of Fish and Game
Region __

____
________, California ______

To USFWS:

United States Fish and Wildlife Service
6010 Hidden Valley Road
Carlsbad, California 92011
Attn: Field Supervisor

or to such other address as Grantor or Grantee may designate by written notice to the other parties, as may be necessary. Notice shall be deemed effective upon delivery in the case of personal delivery or delivery by overnight courier or, in the case of delivery by first class mail, five (5) days after deposit into the United States mail.

15. Amendment. This Easement may be amended by Grantor and Grantee only by mutual written agreement and subject to the written approval of ACOE, CDFG, and USFWS. Any such amendment shall be consistent with the purposes of this Easement and shall not affect its perpetual duration. Grantor shall record any amendments in the official records of Orange County, California and shall provide a conformed copy of the recorded amendment(s) to Grantee, ACOE, CDFG and USFWS.

16. Long-Term Maintenance. Grantor, its successors, and assigns shall be responsible for in perpetuity, ongoing, long-term maintenance of the Conserved Land. Such long-term maintenance shall consist of the following activities: (a) annual removal of trash or man-made debris; (b) annual maintenance of signage and other notification features pursuant to Section 4.5; and (c) annual repair, remediation, or restoration of the Conserved Land damaged by any activities prohibited by Section 3 herein. Grantor, its successors and assigns shall prepare a monitoring and maintenance report documenting activities performed under subsection (a) and (b) above, and shall make reports available to the Grantee, ACOE, CDFG, and USFWS upon request. When activities are performed pursuant to subsection (c) above, Grantor, its successors, and assigns shall retain a qualified Biological Monitor to prepare a Restoration Plan and to oversee/monitor such restoration activities. The Biological Monitor shall be an independent third-party consultant who is familiar with aquatic resources in the Orange County area and has at least a masters level education in the field of biology. Grantor shall submit the qualifications of the Biological Monitor to Grantee, ACOE, CDFG, and USFWS for their review and approval. Grantor shall have its Biological Monitor submit a draft Restoration Plan to the Grantee, ACOE, CDFG, and USFWS for review and written approval prior to its implementation. Upon completion of restoration as specified in the approved Restoration Plan, Grantor shall have its Biological Monitor prepare a detailed monitoring report, and Grantor shall make the report

available to the Grantee, ACOE, CDFG, and USFWS within thirty (30) days of completion of restoration activities. Grantor, its successors, or assigns and the Biological Monitor shall sign the monitoring report, and the report shall document the Biological Monitor's name and affiliation, the dates the Biological Monitor was present on-site, activities observed and their location, Biological Monitor's observations regarding the adequacy of restoration work by the Grantor, its successors, assigns, or contractors in accordance with the approved Restoration Plan, and recommended and implemented corrections.

17. General Provisions.

17.1. Controlling Law. The interpretation and performance of this Easement shall be governed by the laws of the United States and the State of California, disregarding the conflicts of law principles of such state.

17.2. Liberal Construction. Any general rule of construction to the contrary notwithstanding, this Easement shall be liberally construed to effect the purposes of this Easement and the policy and purpose of Civil Code section 815, *et seq*. If any provision in this instrument is found to be ambiguous, an interpretation consistent with the purposes of this Easement that would render the provision valid shall be favored over any interpretation that would render it invalid.

17.3. Severability. If a court of competent jurisdiction voids or invalidates on its face any provision of this Easement, such action shall not affect the remainder of this Easement. If a court of competent jurisdiction voids or invalidates the application of any provision of this Easement to a person or circumstance, such action shall not affect the application of the provision to other persons or circumstances.

17.4. Entire Agreement. This instrument sets forth the entire agreement of the parties with respect to this Easement and supersedes all prior discussions, negotiations, understandings, or agreements relating to this Easement. No alteration or variation of this instrument shall be valid or binding unless contained in an amendment in accordance with Section 15 of this Easement. To the extent that the terms of the Mitigation Plans and Perpetual Management Plan conflicts with the terms of this Easement, the terms of this Easement shall govern and control.

17.5. No Forfeiture. Nothing contained herein will result in a forfeiture or reversion of Grantor's title in any respect.

17.6. Successors. The covenants, terms, conditions, and restrictions of this Easement shall be binding upon, and inure to the benefit of, the parties hereto and their respective personal representatives, heirs, successors, and assigns and shall constitute a servitude running in perpetuity with the Conserved Land. The covenants hereunder benefiting Grantee shall also benefit ACOE, CDFG, and USFWS as Third-Party Beneficiaries.

17.7. Termination of Rights and Obligations. A party's rights and obligations under this Easement terminate upon transfer of the party's interest in this Easement or Conserved Land, except that liability for acts or omissions occurring prior to transfer shall survive transfer. Upon Grantor's transfer of its interest in the Conserved Land to Conservator or HOA or other entity, Grantor shall have no further obligations concerning the Conserved Land, including without limitation any obligations for the maintenance, management or monitoring of the Conserved Land, except as provided in Section 4 herein and except that Grantor shall remain liable for any damage to the Conserved Land caused by the Grantor prior to such transfer if Grantor would have otherwise been liable for such damage under this Restrictive Covenant.

17.8. Captions. The captions in this instrument have been inserted solely for convenience of reference and are not a part of this instrument and shall have no effect upon its construction or interpretation.

17.9. No Hazardous Materials Liability. Except with respect to those matters disclosed in the remedial action plan for Tonner Hills that was approved by the County of Orange Health Care Agency on December 17, 1999, Grantor represents and warrants that it has no knowledge or notice of any Hazardous Materials (defined below) or underground storage tanks existing, generated, treated, stored, used, released, disposed of, deposited or abandoned in, on, under, or from the Conserved Land, or transported to or from or affecting the Conserved Land. Without limiting the obligations of Grantor under Section 10.2, and notwithstanding Section 8, Grantor hereby releases and agrees to indemnify, protect and hold harmless the Grantee Indemnified Parties and the Third-Party Indemnified Parties (each as defined in Section 10.2) from and against any and all Claims (as defined in Section 10.2) arising from or connected with any Hazardous Materials or underground storage tanks present, alleged to be present, or otherwise associated with the Conserved Land at any time, except that (I) this indemnification shall be inapplicable to the Grantee Indemnified Parties with respect to any Hazardous Materials placed, disposed or released by Grantee, its employees or agents and (II) this indemnification shall be inapplicable to the Third-Party Indemnified Parties with respect to any Hazardous Materials placed, disposed or released by Third-Party Beneficiaries, their employees or agents; provided, however, that the indemnification shall be inapplicable to a Third-Party Beneficiary Indemnified Party with respect to any Claim due solely to the negligence of that Third-Party Beneficiary Indemnified Party or any of its employees or agents. This release and indemnification includes, without limitation, Claims for (i) injury to or death of any person or physical damage to any property; and (ii) the violation or alleged violation of, or other failure to comply with, any Environmental Laws (defined below). If any action or proceeding is brought against any of the Third Party Beneficiary Indemnified Parties by reason of any such Claim, Grantor shall, at the election of and upon written notice from the applicable Third-Party Beneficiary or Beneficiaries, defend such action or proceeding by counsel reasonably acceptable to the applicable Third-Party Beneficiary Indemnified Party or Parties or reimburse the applicable Third-Party Beneficiary or Beneficiaries for all charges incurred for the services of the United States or California Attorney General in defending the action or proceeding.

Despite any contrary provision of this Easement, the parties do not intend this Easement to be, and this Easement shall not be, construed such that it creates in or gives to Grantee or Third-Party Beneficiaries any of the following:

(1) The obligations or liability of an "owner" or "operator," as those terms are defined and used in Environmental Laws (defined below), including, without

limitation, the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (42 U.S.C. Section 9601 *et seq.*; hereinafter, "**CERCLA**"); or

(2) The obligations or liabilities of a person described in 42 U.S.C. Section 9607(a)(3) or (4); or

(3) The obligations of a responsible person under any applicable Environmental Laws; or

(4) The right to investigate and remediate any Hazardous Materials associated with the Conserved Land; or

(5) Any control over Grantor's ability to investigate, remove, remediate or otherwise clean up any Hazardous Materials associated with the Conserved Land.

The term "**Hazardous Materials**" includes, without limitation, (a) material that is flammable, explosive or radioactive; (b) petroleum products, including by-products and fractions thereof; and (c) hazardous materials, hazardous wastes, hazardous or toxic substances, or related materials defined in CERCLA, the Resource Conservation and Recovery Act of 1976 (42 U.S.C. Section 6901 *et seq.*; hereinafter "**RCRA**"); the Hazardous Materials Transportation Act (49 U.S.C. Section 6901 *et seq.*; hereinafter "**HTA**"); the Hazardous Waste Control Law (California Health & Safety Code Section 25100 *et seq.*; hereinafter "**HCL**"); the Carpenter-Presley-Tanner Hazardous Substance Account Act (California Health & Safety Code Section 25300 *et seq.*; hereinafter "**HSA**"), and in the regulations adopted and publications promulgated pursuant to them, or any other applicable Environmental Laws now in effect or enacted after the date of this Easement.

The term "**Environmental Laws**" includes, without limitation, CERCLA, RCRA, HTA, HCL, HSA, and any other federal, state, local or administrative agency statute, ordinance, rule, regulation, order or requirement relating to pollution, protection of human health or safety, the environment or Hazardous Materials. Grantor represents, warrants and covenants to Grantee and Third-Party Beneficiaries that activities upon and use of the Conserved Land by Grantor, its agents, employees, invitees and contractors will comply with all Environmental Laws.

17.10. Additional Easements. Except as provided in Section 6 above, Grantor shall not grant any additional easements, rights of way, or other interests in the Conserved Land (other than a security interest that is subordinate to this Easement), or grant or otherwise abandon or relinquish any water agreement relating to the Conserved Land, without first obtaining the written consent of Grantee, ACOE, CDFG, and USFWS. Grantee, ACOE, CDFG, and USFWS may withhold such consent in its sole discretion, if Grantee, ACOE, CDFG, and USFWS determine that the proposed interest or transfer is inconsistent with the purposes of this Easement or will impair or interfere with the Conservation Values of the Conserved Land. This Section 17.10 of this Easement shall not prohibit transfer of a fee or leasehold interest in the Conserved Land that is subject to this Easement and complies with Section 12 of this Easement. Grantor shall record any additional easements or other interests in the Conserved Land approved by the Grantee, ACOE, CDFG, and USFWS in the official records of Orange County, California and shall provide a copy of the recorded document to the Grantee, ACOE, CDFG, and USFWS.

17.11. Counterparts. The parties may execute this instrument in any number of counterparts, which shall, in the aggregate, be signed by all of the parties; each counterpart shall be deemed an original instrument as against any party who has signed it. In the event of any disparity between the counterparts produced, the recorded counterpart shall be controlling.

17.12. Incorporation of Recitals and Exhibits. The Recitals hereto and all Exhibits referred to herein and attached hereto and hereby incorporated herein by this reference.

17.13. Recordation. Grantor shall promptly record this Easement in the official records of Orange County, California and immediately notify Grantee, ACOE, CDFG, and USFWS through the mailing of a conformed copy of the recorded Easement.

17.14. Estoppel. Upon request, Grantee shall within fifteen (15) days execute and deliver to Grantor, its successors, and assigns any document, including an estoppel certificate, which certifies compliance with any obligation of Grantor, its successors, and assigns contained in this Easement and otherwise evidences the status of this Easement as may be requested by Grantor, its successors, and assigns.

17.15. Extinguishment. If circumstances arise in the future that render the purpose of this Easement impossible to accomplish, this Easement can only be terminated or extinguished, in whole or in part, by judicial proceedings in a court of competent jurisdiction.

17.16. Warranty. Grantor represents and warrants that there are no outstanding mortgages, monetary liens, or other monetary encumbrances which have not been expressly subordinated to this Easement, and that the Conserved Land is not subject to any other conservation easement.

17.17. Subordination. No breach, enforcement, or attempted enforcement of any of the terms, covenants, conditions, or restrictions of this Easement will defeat or render invalid the lien of any mortgage or deed of trust securing a loan made in good faith and for value with respect to the Conserved Land; provided, however, that all provisions of this Easement will be binding upon and effective against any subsequent owner of the Conserved Land whose title to the property or any portion of such is acquired by foreclosure, trust deed sale, or otherwise. Grantor hereby represents to Grantee that, as of the date of this Easement, the Conserved Land is not encumbered with any mortgage, deed of trust, or other monetary encumbrance except for liens for non-delinquent real property taxes and assessments.

17.18. Boundary Adjustments. The boundaries of the Conserved Land may be adjusted by Grantor provided that it obtains prior written approval from ACOE, CDFG, and USFWS and the adjustment will not affect, modify, or change the total acreage of "Natural Area Open Space" required under the Approval Documents.

IN WITNESS WHEREOF Grantor and Grantee have executed this Easement as of the day and year first above written.

GRANTOR:

Date: June 18, 2007

TONNER HILLS 680, LLC,
a Delaware limited liability company

By: Shea Tonner Hills, LLC,
a Delaware limited liability company,
its managing member

By: Shea Homes Limited Partnership,
California limited partnership,
its managing member

By: ______________________
Its: ______________________

By: ______________________
Its: ______________________

[THE SIGNATURE PAGE CONTINUES ON THE NEXT PAGE]

STATE OF CALIFORNIA)
) ss.
COUNTY OF ORANGE)

On June 18, 2007, before me, Joan Binder, a notary public, personally appeared Ron Metzler, personally known to me (~~or proved to me on the basis of satisfactory evidence~~) to be the person~~(s)~~ whose name~~(s)~~ is/~~are~~ subscribed to the within instrument and acknowledged to me that he/~~she/they~~ executed the same in his/~~her/their~~ authorized capacity~~(ies)~~, and that by his/~~her/their~~ signature~~(s)~~ on the instrument, the person(s), or the entity upon behalf of which the person~~(s)~~ acted, executed the instrument.

WITNESS my hand and official seal.

Signature ______________________ (Seal)

JOAN M. BINDER
Commission # 1614287
Notary Public - California
Orange County
My Comm. Expires Oct 18, 2009

STATE OF CALIFORNIA)
) ss.
COUNTY OF ORANGE)

On June 18, 2007, before me, Joan Binder, a notary public, personally appeared John Danvers, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument, the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

WITNESS my hand and official seal.

Signature ______________________ (Seal)

JOAN M. BINDER
Commission # 1614287
Notary Public - California
Orange County
My Comm. Expires Oct 18, 2009

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S7793-014/6-18-07/mrf/mrf

GRANTEE:

THE COUNTY OF ORANGE, CALIFORNIA,
a political subdivision organized and existing under the laws of the State of California

By: Chris Norby
Chairman of the Board of Supervisors

SIGNED AND CERTIFIED THAT A COPY OF THIS DOCUMENT HAS BEEN DELIVERED TO THE CHAIRMAN OF THE BOARD

By: ______________________
DARLENE J. BLOOM
Clerk of the Board of Supervisors,
County of Orange, California

APPROVED AS TO FORM:
COUNTY COUNSEL

By: ______________________

Date: 7-27-07

EXHIBIT "A"

LEGAL DESCRIPTION OF THE CONSERVED LAND

THE LAND REFERRED TO HEREIN BELOW IS SITUATED IN THE COUNTY OF ORANGE, STATE OF CALIFORNIA, AND IS DESCRIBED AS FOLLOWS:

PARCEL 1: (APN 306-012-35, 36 & 38; APN 306-031-21, 22, 24, 27 & 28)

LOTS 11, 12, 13, 16, 17, 18, 19 AND 21 OF TRACT NO. 16178, AS PER MAP FILED IN BOOK 853, PAGES 1 THROUGH 15, INCLUSIVE, OF MISCELLANEOUS MAPS, RECORDS OF ORANGE COUNTY, CALIFORNIA.

EXCEPTING THEREFROM ANY AND ALL OIL RIGHTS, MINERALS, MINERAL RIGHTS, NATURAL GAS RIGHTS AND OTHER HYDROCARBONS BY WHATSOEVER NAME KNOWN, GEOTHERMAL STEAM AND ALL PRODUCTS DERIVED FROM ANY OF THE FOREGOING (HEREINAFTER COLLECTIVELY REFERRED TO AS, THE "MINERALS"); TOGETHER WITH THE PERPETUAL RIGHT, AS LIMITED THEREIN, OF DRILLING, EXPLORING AND OPERATING THEREOF AND STORING IN AND REMOVING THE SAME, EXCEPTING THEREFROM THE MINERALS LYING FROM THE SURFACE TO FIVE HUNDRED (500') BELOW THE SURFACE OF THE PROPERTY AND GRANTEE SHALL HAVE NO RIGHTS TO DRILL FOR, EXPLORE, OPERATE, STORE AND REMOVE THE MINERALS FROM SAID RESERVED INTERVAL, PROVIDED, HOWEVER, GRANTEE SHALL HAVE THE RIGHT OF SUBSURFACE ENTRY THROUGH SAID INTERVAL TO EXPLORE, OPERATE, STORE OR REMOVE THE MINERALS LYING BELOW FIVE HUNDRED FEET (500') FROM THE SURFACE OF THE PROPERTY; AS CONVEYED TO BLACKSAND PARTNERS, L.P., A TEXAS LIMITED PARTNERSHIP, BY MINERAL GRANT DEED RECORDED FEBRUARY 28, 2003 AS INSTRUMENT NO. 2003000226060 OF OFFICIAL RECORDS.

PARCEL 2:

THOSE PORTIONS OF SECTION 1, TOWNSHIP 3 SOUTH, RANGE 10 WEST AND THAT PORTION OF SECTION 7, TOWNSHIP 3 SOUTH, RANGE 9 WEST, SAN BERNARDINO MERIDIAN, AS PER MAP FILED IN BOOK 51, PAGE 7 OF RECORDS OF SURVEY,

THAT PORTION OF SAID SECTION 1 MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT THE SOUTHWESTERLY CORNER OF SAID LOT 11;

THENCE ALONG THE SOUTHERLY BOUNDARY OF SAID LOT 11 NORTH 89°24'21" EAST 495.67 FEET TO THE SOUTHWESTERLY BOUNDARY OF A GRANT DEED TO METROPOLITAN WATER DISTRICT RECORDED FEBRUARY 10, 1967, IN BOOK 8173 AT PAGE 641 OF OFFICIAL RECORDS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE SOUTHEASTERLY ALONG SAID SOUTHWESTERLY BOUNDARY SOUTH 28°12'22" EAST 338.56 FEET TO THE NORTHERLY BOUNDARY OF TRACT NO. 12562 AS SHOWN ON A MAP FILED IN BOOK 579, PAGES 4 THROUGH 9 INCLUSIVE OF MISCELLANEOUS MAPS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE WESTERLY ALONG SAID NORTHERLY BOUNDARY SOUTH 89°24'21" WEST 659.12 FEET TO THE EASTERLY BOUNDARY OF TRACT NO. 9532 AS SHOWN ON A MAP FILED IN BOOK 454, PAGES 25 THROUGH 28 INCLUSIVE OF MISCELLANEOUS MAPS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE NORTHERLY ALONG SAID EASTERLY BOUNDARY NORTH 00°39'09" EAST 300.07 FEET TO THE POINT OF BEGINNING

ALSO TOGETHER WITH THAT PORTION OF SAID SECTION 1 MORE PARTICULARLY DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHEAST CORNER OF SAID LOT 11, SAID CORNER ALSO BEING ON THE WESTERLY BOUNDARY OF PARCEL A6471-4, AS CONVEYED BY A FINAL ORDER OF CONDEMNATION RECORDED SEPTEMBER 29, 1970, IN BOOK 9417, PAGE 364 OF OFFICIAL RECORDS, IN THE OFFICE OF THE COUNTY RECORDER OF SAID COUNTY;

THENCE SOUTHERLY ALONG SAID WESTERLY BOUNDARY SOUTH 10°52'43" WEST 306.11 FEET NORTHERLY BOUNDARY OF TRACT NO. 12563 AS SHOWN ON A MAP FILED IN BOOK 579, PAGES 10 THROUGH 15 INCLUSIVE OF MISCELLANEOUS MAPS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE WESTERLY ALONG SAID NORTHERLY BOUNDARY SOUTH 89°24'21" WEST 890.93 FEET TO THE

EASTERLY BOUNDARY OF A GRANT DEED TO METROPOLITAN WATER DISTRICT RECORDED FEBRUARY 10, 1967, IN BOOK 8173 AT PAGE 641 OF OFFICIAL RECORDS, IN THE OFFICE OP SAID COUNTY RECORDER;

THENCE NORTHERLY ALONG SAID EASTERLY BOUNDARY THE FOLLOWING COURSES:

NORTH 23°43'24" WEST 110.38 FEET TO THE BEGINNING OF A TANGENT CURVE CONCAVE EASTERLY AND HAVING A RADIUS OF 100.00 FEET;

NORTHERLY ALONG SAID CURVE 20.51 FEET THROUGH A CENTRAL ANGLE OF 11°45'15";

NORTH 11°58'09" WEST 182.51 FEET4TO THE SOUTHWEST CORNER OF SAID LOT 12;

THENCE LEAVING SAID EASTERLY BOUNDARY ALONE THE SOUTHERLY BOUNDARY OF LOTS 12, "B" AND 11 OF SAID TRACT NO. 16178, NORTH 89°24'21" EAST 1037.25 FEET TO THE POINT OF BEGINNING.

EXCEPTING THEREFROM ANY AND ALL OIL RIGHTS, MINERALS, MINERAL RIGHTS, NATURAL GAS RIGHTS AND OTHER HYDROCARBONS BY WHATSOEVER NAME KNOWN, GEOTHERMAL STEAM AND ALL PRODUCTS DERIVED FROM ANY OF THE FOREGOING (HEREINAFTER COLLECTIVELY REFERRED TO AS, THE "MINERALS"); TOGETHER WITH THE PERPETUAL RIGHT, AS LIMITED THEREIN, OF DRILLING, EXPLORING AND OPERATING THEREOF AND STORING IN AND REMOVING THE SAME, EXCEPTING THEREFROM THE MINERALS LYING FROM THE SURFACE TO FIVE HUNDRED (500') BELOW THE SURFACE OF THE PROPERTY AND GRANTEE SHALL HAVE NO RIGHTS TO DRILL FOR, EXPLORE, OPERATE, STORE AND REMOVE THE MINERALS FROM SAID RESERVED INTERVAL, PROVIDED, HOWEVER, GRANTEE SHALL HAVE THE RIGHT OF SUBSURFACE ENTRY THROUGH SAID INTERVAL TO EXPLORE, OPERATE, STORE OR REMOVE THE MINERALS LYING BELOW FIVE HUNDRED FEET (500') FROM THE SURFACE OF THE PROPERTY; AS CONVEYED TO BLACKSAND PARTNERS, L.P., A TEXAS LIMITED PARTNERSHIP, BY MINERAL GRANT DEED RECORDED FEBRUARY 28, 2003 AS INSTRUMENT NO. 2003000226060 OF OFFICIAL RECORDS.

APN: 306-031-30, 306-012-36, 306-012-38, 306-031-24, 306-031-28;306-012-35, 306-031-22 and 306-031-21

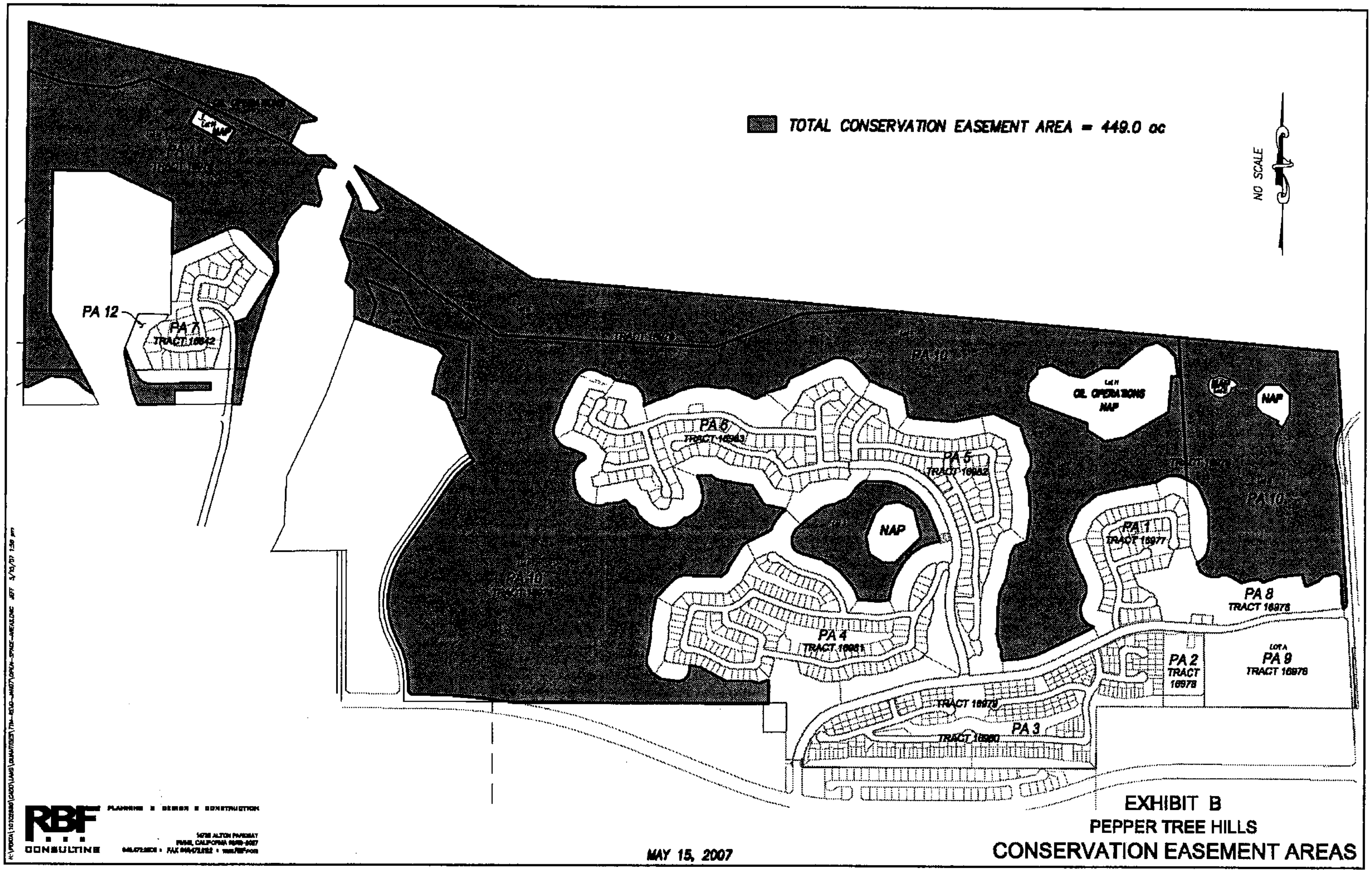

EXHIBIT "B"

-1-

812723.02/OC
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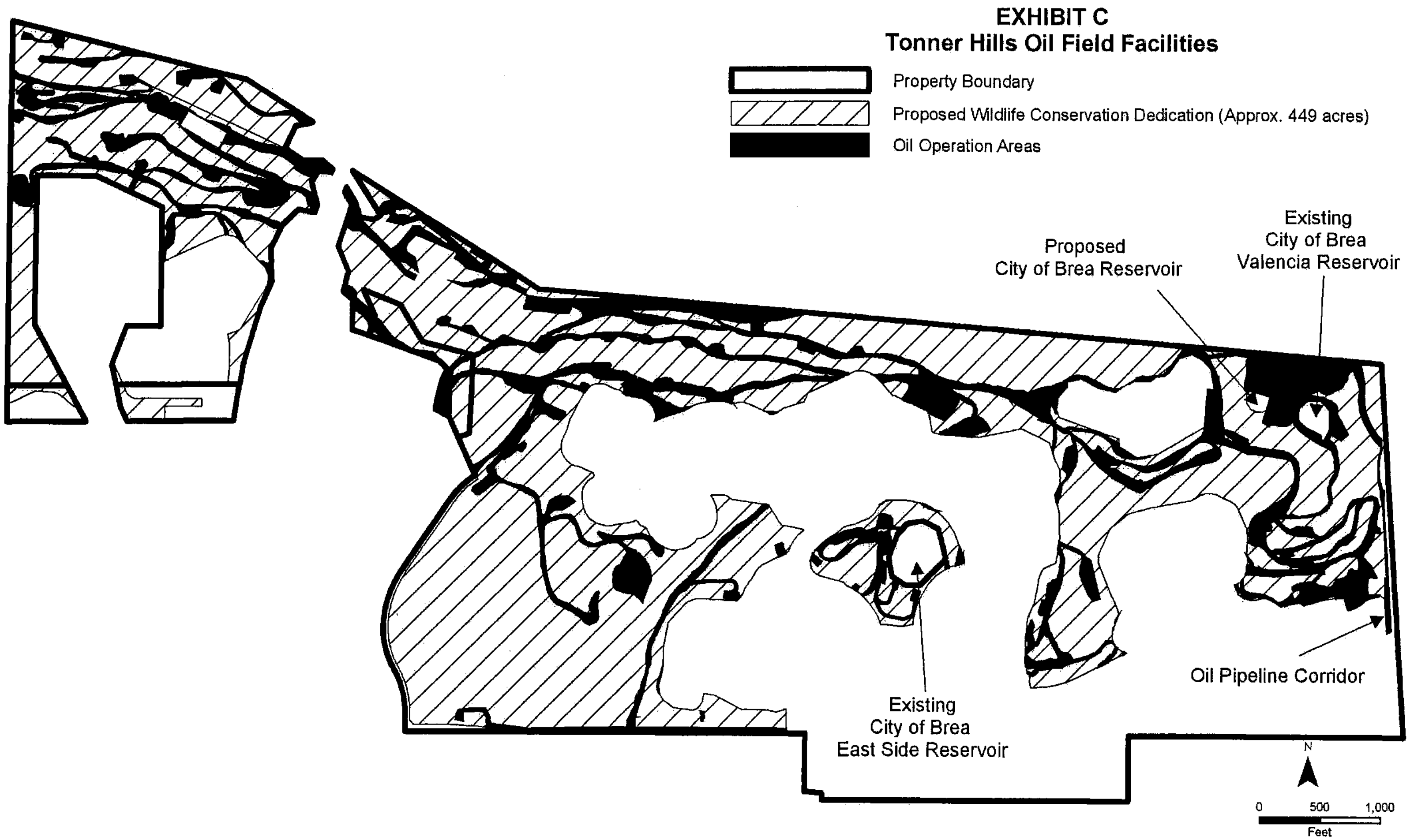
EXHIBIT C
Tonner Hills Oil Field Facilities
Property Boundary
Proposed Wildlife Conservation Dedication (Approx. 449 acres)
Oil Operation Areas
Proposed
City of Brea Reservoir
Existing
City of Brea
Valencia Reservoir
Existing
City of Brea
East Side Reservoir
Oil Pipeline Corridor
N
0
500
1,000
Feet

EXHIBIT "C"
-1-

EXHIBIT D
Tonner Hills Conserved Land:
Improvement Authorized by "Approval Documents"

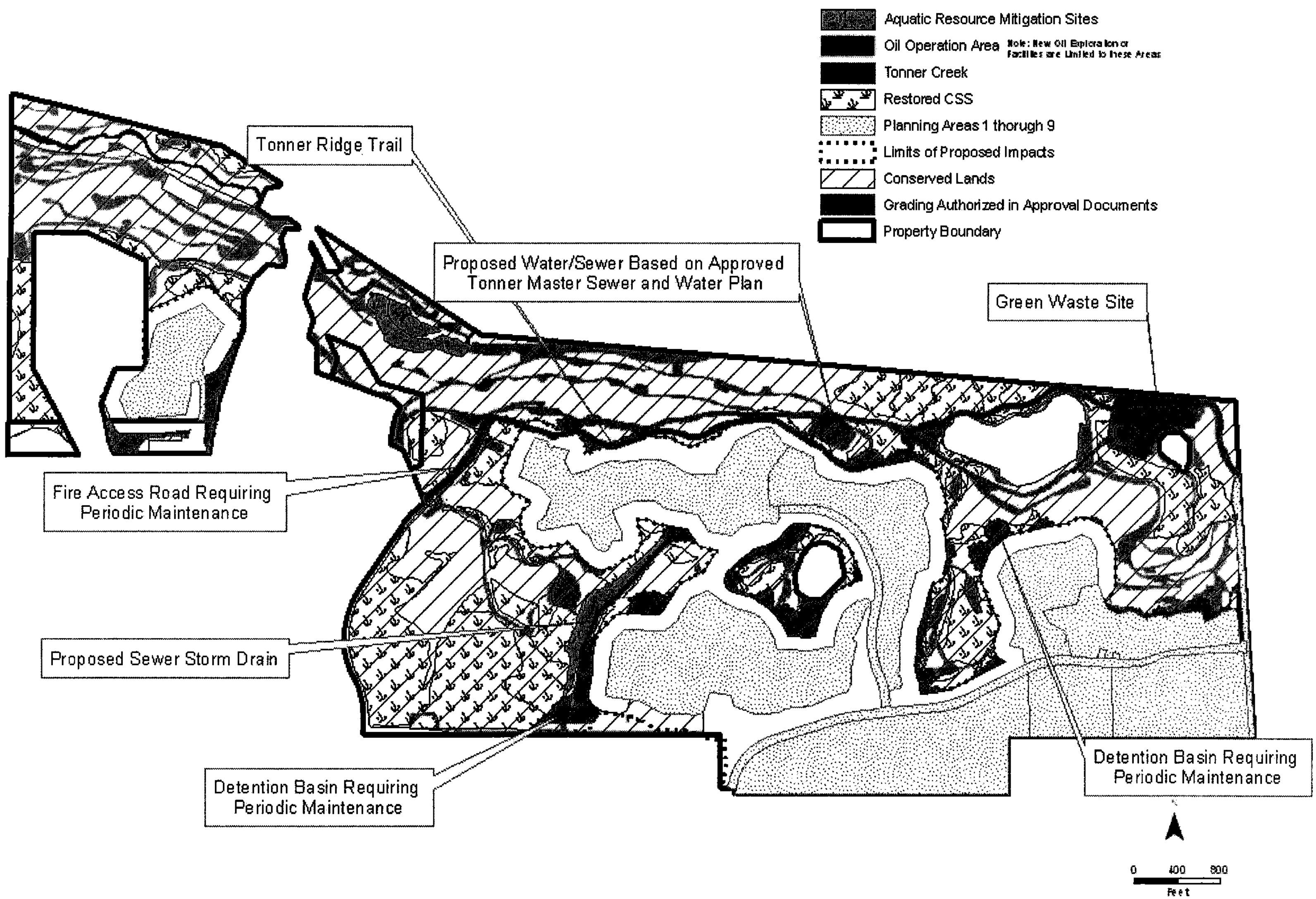

EXHIBIT "D"

812723.02/OC
S7793-014/6-18-07/mrf/mrf

EXHIBIT "E"

PERPETUAL MANAGEMENT PLAN

[See attached]

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TABLE OF CONTENTS (continued)

SECTION 1.0 – INTRODUCTION

The purpose of this Perpetual Management Plan (PMP) is to provide a plan that takes an adaptive management approach in the 449-acre Tonner Hills Conservation Easement area in order to ensure the long-term viability of the area as habitat for the federal-listed threatened California gnatcatcher and other sensitive species associated with coastal sage scrub. In addition, a secondary goal is to provide an effective management tool that will accomplish the first goal with a minimum of oversight by the County of Orange. The PMP is a requirement of the Biological Opinion issued by the U.S. Fish and Wildlife Service (USFWS) (FWS-OR-2347.5, December 31, 2002) for the Tonner Hills Planned Community project site. The development and funding of the long-term management plan will help to ensure that the conserved areas continue to provide habitat and regional connectivity for the coastal California gnatcatcher and other sensitive species and that these functions are not permanently compromised by invasive species, unauthorized use, fire, or other unforeseen events (USFWS 2002).

For the purposes of this PMP, the assumption is made that the success criteria established for each of the various habitat restoration areas have been met. The goal of the PMP is to provide enough information and guidance about the maintenance and monitoring of the Tonner Hills Conservation Easement area that the County of Orange and the resources agencies can be assured that the area will be effectively managed for the long-term. The time period for the PMP is assumed to start from the beginning of the sixth year after implementation of the habitat restoration projects (Implementation was completed in May of 2004), but no earlier than bond release following achievement of the necessary success criteria until the completion of oil extraction activities and the restoration of the oil extraction pads and access roads. At that time, the County of Orange or other management entity will either adopt this management plan or coordinate with the service to develop a new management plan that will ensure that the site is managed in perpetuity for the benefit of the native plant and animal life onsite, particularly coastal sage scrub and the coastal California gnatcatcher.

For reference, a summary table of the permit conditions and responsible parties is included in Appendix A.

In order to provide an easy guide to the contents of the PMP, the following table lists the components of the PMP along with the frequency of monitoring, reporting, and follow-up and the responsible parties.

Summary of Perpetual Management Plan Components
Monitoring, Reporting, and Follow-up

Task	Action Necessary	Frequency	Specific Reporting Requirements	Follow-up Requirements	Responsible Party
Education of Residents Regarding Conservation Area	Wildlife Education Pamphlet Reminder Memo Optional Newsletter	At point of home purchase Every three years Bi-annual	Copy of Pamphlet and reminder memo to USFWS and County Inspector	None	Master Community Association
Non-native Plant Species Eradication	Survey	Bi-annual	Memo	Survey and Verification Memo	Endowment Beneficiary
Conversion of oil rds/facilities	Survey	Upon cessation of oil field	Memo	Survey and Verification Memo	Endowment Beneficiary

		activities			

Summary of Perpetual Management Plan Components (continued)
Monitoring, Reporting, and Follow-up

Task	Action Necessary	Frequency	Specific Reporting Requirements	Follow-up Requirements	Responsible Party
Trash Removal	Survey	Quarterly	Memo	Survey and Verification Memo	Endowment Beneficiary
Recreational Impact Monitoring & Repair	Signage Survey	Initially and Ongoing Quarterly	Memo	Survey and Verification Memo	Endowment Beneficiary
Post Natural Catastrophe Monitoring & Repair	Survey	As-needed	Post Catastrophe Letter Report	Remedial Action Plan and Implementation	Endowment Beneficiary
Reclamation of Oil Pads and Roads	Survey, Vegetation Transects	At the Completion of Oil Extraction Operations	Initial Letter Report and Implementation Plan	Restoration Plan Implementation and Monitoring	Endowment Beneficiary
Focused Survey for California Gnatcatcher	Focused Survey According to USFWS Protocol	Years 2009, 2012, 2017, 2022, 2027, 2032, 2037, 2042, 2047	Focused Survey Report	None	Endowment Beneficiary
General Wildlife Survey	Survey	Years 2009, 2012, 2017, 2022, 2027, 2032, 2037, 2042, 2047	Included in Annual Summary Report	None	Endowment Beneficiary
Brown-headed Cowbird Trapping	Trapping Program	Frequency Determined by Presence of this Species	Trapping Report	None	Endowment Beneficiary
Annual Summary Report	Prepare Summary Report Submit to County Inspector and U.S. Fish and Wildlife Service	Annually by January 31 of Year Following When Activities Were Conducted	Brief Summary of Activities Conducted Throughout the Year	None	Tonner Hills 680 or Endowment Beneficiary

Note: Upon transfer of the property and the $650,000+ combined endowments to the approved management entity, no activity described above will be the financial responsibility of the applicant or the HOA unless specifically designated as such in this document. In the event that all endowment funding has been exhausted, no additional financial liability will rest with the landowner, applicant, or Tonner Hills Homeowner's Association.

SECTION 2.0 – PROJECT LOCATION

2.1 PROJECT LOCATION

The Tonner Hills Planned Community project site is an approximately 789.8-acre site located in the County of Orange, north of the City of Brea, California. The site is bounded by Lambert Road to the south, Tonner Creek to the north, Valencia Avenue to the east, and the 57 Freeway bisects the western portion of the site.

Regionally, the site lies within the northwestern portion of the Chino Hills and southeastern portion of the Puente Hills. Surrounding land uses include residential development to the south and west, similar native habitat within Tonner Canyon to the north, and oil production lands to the east and northwest. The project site comprises a series of low hills and ridges. It ranges in elevation from approximately 500 to 800 feet above sea level. The site is composed of several different vegetation communities. Many oil well pads and access roads are present throughout the site. The site is located on the U.S. Geological Survey (USGS) Yorba Linda and La Habra 7.5-minute topographic quadrangles.

The Conservation Easement area encompasses approximately 449 acres (as stated in the Amendment to the Biological Opinion) and the easement is held by the County of Orange, California. At present, the oil operations are continuing and the roads and oil well pads associated with the active oil extraction operation will continue to be used until the operations are completed (estimated 30 to 50 years or about 2045). At the completion of the oil extraction operations, a portion of the roads and all of the oil well pads will be reclaimed and restored with native habitat. At that time, these areas will become part of the Conservation Easement.

SECTION 3.0 – PROVISION OF EDUCATIONAL MATERIALS TO RESIDENTS

Educational materials related to the Conservation Area and the sensitive nature of the area shall be included in the CC&Rs and disclosures that are distributed to all new residents at the time they purchase their new homes in the Tonner Hills development. Because the CC&Rs may not be reviewed by residents on a regular basis, there is a need to frequently remind residents of the preservation and conservation activities associated with the Conservation Area. In addition, by educating the public about how they can help to protect the natural areas and the species that occur there, they are more likely to take an active interest in helping to protect the natural areas. Thus, the PMP provides guidelines for a continual public education program for the residents of the Tonner Hills development.

3.1 WILDLIFE EDUCATION PAMPHLET

A wildlife education brochure will be prepared by the Developer that will be distributed at the time of home purchase. This pamphlet will discuss the benefits and constraints associated with living adjacent to an undeveloped natural area. For example, the pamphlet will discuss the impacts of domestic animals on the gnatcatcher and other wildlife species occurring in the Conservation Area and request that homeowners not allow their domestic animals into the Conservation Areas. It will also caution homeowners about impacts of wildlife on domestic animals. The pamphlet will remind residents that the development is adjacent to natural open space and that encounters with wildlife are highly probable.

The pamphlet will caution against planting ornamental, potentially invasive species on conserved habitat and explain that the fuel modification zone has been approved by the Orange County Fire Authority and will be maintained by the Master Community Association. The pamphlet will identify any approved trails and appropriate activities that can take place on the trails and caution against hiking and biking through natural areas and discarding trash and other materials.

3.2 NEWSLETTER OR NOTIFICATION TO THE RESIDENTS

A reminder letter will be sent to residents at least once every three years because CC&Rs may not be viewed by residents on a regular basis. This letter will briefly summarize the information in the wildlife education pamphlet and could discuss the current status of the habitat, gnatcatcher, and wildlife observations or other relevant information. If there is a particular issue that needs to be addressed immediately, such as unauthorized clearing in the Conservation Area, a letter will be sent to the appropriate residents as needed.

An optional newsletter or specific mailing could be provided to the residents on a regular or occasional basis. Many homeowner's associations or community groups provide a newsletter to the residents to keep them informed of the happenings in the community. Quite often, residents will volunteer to write articles of interest for the community. It may be of value to solicit input from residents who are interested in the preservation of the natural areas or from biologists who are familiar with the sensitive resources at Tonner Hills. Interesting articles may include the status of the monitoring of the habitat areas, fencing, signage, and focused surveys for gnatcatchers, as well as the eradication of non-native plant species. In addition, this type of notification could also include a description of the activities that are detrimental to the natural areas, such as hiking and biking off of designated trails and discarding trash or other materials. These activities are incompatible with the integrity of the habitats and the species that occur there. Also, the materials could discourage the residents from planting any invasive, non-native plant species within the boundaries of their yards that may become a problem if they escape and become established the natural habitat areas and they could provide information regarding the success of the habitat restoration program and the general results of the wildlife and gnatcatcher monitoring.

One of the primary ongoing discussions in the education materials could include the devastating effect that pets (primarily cats) may have on the native wildlife. Cats have been known to have a severe impact on native birds that nest low to the ground and on small mammals and reptiles.

In addition, the public needs to be informed that the development exists within a natural area that supports a healthy population of large mammals (coyote, bobcat, and mountain lion) that may prey on domestic pets. Thus, in order to avoid any unpleasant altercations with wildlife, the public needs to be continually encouraged to keep their pets and their pet's food inside their homes or garages.

3.3 REPORTING

The Master Community Association shall be responsible for developing the original pamphlet and distributing them at the time the homes are purchased or resold. A copy of the wildlife education pamphlet must be provided to the U.S. Fish and Wildlife Service, the County Inspector, and the Endowment Beneficiary. Subsequent update/reminder letters to homeowners will be included in the annual report to USFWS.

SECTION 4.0 – FUTURE MAINTENANCE OF HABITAT RESTORATION AND PRESERVATION AREAS

Because the primary goal of the PMP is to provide guidance for ensuring that the Conservation Easement Area remains as habitat in perpetuity for the California gnatcatcher, a number of issues need to be addressed that could potentially degrade the preserved, enhanced, and restored habitat areas. These include the presence of invasive and non-native plant species, plant community succession to non-CSS plant community, accumulation of trash, human recreational impacts, and threats from domestic pets. The long-term maintenance and management of these issues is critical in order to assure that the preserved habitats and the restored coastal sage scrub, walnut woodland, and oak/riparian woodland habitats continue to thrive in the future. The control measures are described below.

4.1 PLANT SPECIES MAINTENANCE

4.1.1 Habitat Restoration Areas

The Habitat Mitigation and Monitoring Plans for the various habitat restoration areas (i.e., coastal sage scrub, walnut woodlands, and oak/riparian woodlands) include the measures related to maintenance and monitoring for the first 5 years after planting, or until the restoration areas meet the indicated success criteria. After the success criteria have been met (for cover and survival of the planted areas), then the sites would be expected to thrive. But, there will be a need for continued monitoring in these areas for the purpose of identifying areas that may become overrun with invasive, non-native plant species or denuded by unauthorized access. Target non-native plant species include, but are not limited to, the species listed in Table 4-1. It is important to note that, as the monitoring goes forward into the future, additional invasive plant species may be identified that should be added to this list.

Table 4-1
List of Non-Native Weed Species to be Removed

Common Name	Scientific Name
Tamarisk	*Tamarix ramossissima*
Giant reed	*Arundo donax*
Eucalyptus	*Eucalyptus* sp.
Castor bean	*Ricinus communis*
Pepper trees	*Schinus* sp.
Mustards	*Brassica* sp.
Tree tobacco	*Nicotiana glauca*
Fennel	*Foeniculum vulgare*
Italian thistle	*Carduus pycnocephalus*
Milk thistle	*Silybum marianum*
Non-native weedy thistles	*Cirsium* sp.
Non-native annual grasses	
Wild oats	*Avena fatua*
Slender wild oats	*Avena barbata*
Foxtail chess	*Bromus madritensis* ssp. *rubens*
Ripgut brome	*Bromus diandrus*
Soft chess	*Bromus hordeaceus*
Mediterranean barley	*Hordeum murinum*
Italian ryegrass	*Lolium multiflorum*
Annual beard grass	*Polypogon monspeliensis.*

Table 4-1 (continued)
List of Non-Native Weed Species to be Removed

Common Name	Scientific Name
Nonnative perennial grasses	
Pampas grass	*Cortaderia selloana*
Bermuda grass	*Cynodon dactylon*
Fountain grass	*Pennisetum setaceum*
Smilo grass	*Piptatherum miliaceum;*

A qualified botanist, who is familiar with the biology and ecology of southern California plant communities and who has experience in horticultural practices commonly used for habitat restoration and revegetation, shall conduct bi-annual site visits for the purpose of identifying problems. The botanist shall survey each of the habitat restoration areas and shall document any areas that have become denuded or overrun by non-native plant species to the extent that the future integrity of the target habitats may be compromised. In addition, the botanist shall also identify and document any other problems related to non-native plant species invasions, such as the re-sprouting of pepper trees within the restoration areas. It is anticipated that after the restoration and initial weeding efforts, the site will eventually become largely self-sustaining and will require less weeding. Therefore, if invasive species do not seem to pose a problem for the site after 5 years, the frequency of non-native plant species surveys and eradication efforts may be reduced to once per year, with approval of the USFWS.

4.1.2 Preserved Habitat Areas

The preserved habitat areas on the site contain both native and non-native plant communities. The long-term monitoring and maintenance of the preserved habitat areas is similar to that required in the habitat restoration areas in that the botanist shall conduct bi-annual visits in order to determine if problems are occurring, such as infestations of non-native plants. But, because much of the preserved habitat areas contain non-native grasslands and stands of ornamental trees (such as eucalyptus and pepper trees), the Homeowner's Association is not required to remove non-native plants in these areas to the same extent as in the restored habitat areas. Any existing non-native pepper or eucalyptus trees shall remain in place unless the botanist determines that they are having a significant detrimental effect on preserved coastal sage scrub or on the riparian habitat in Tonner Creek. During the bi-annual surveys, the botanist shall identify and document those areas that exhibit infestations of invasive, non-native species that may compromise the integrity of preserved native habitat areas.

4.1.3 Reporting and Follow-up

Following the bi-annual site visits, the botanist shall prepare a memorandum indicating the results of the surveys. Any problems that are identified shall be indicated on a map and described in the text. The memorandum shall be submitted to the Endowment Beneficiary and to a qualified landscape contractor who is familiar with native habitat restoration and who has been retained by the Endowment Beneficiary. The Endowment Beneficiary shall be responsible for making sure that the qualified landscape contractor performs the necessary maintenance (i.e., plant removal and/or reseeding) that has been suggested by the botanist within a reasonable amount of time (within 30 days or as seasonally appropriate). The botanist shall conduct a follow-up survey for the purpose of confirming that the necessary maintenance was completed. The botanist shall prepare a memorandum to the Endowment Beneficiary after the necessary maintenance has been completed. All memorandum prepared under this task shall be included in the annual report.

All non-native species shall be removed mechanically, except in cases where mechanical removal is ineffective. Mechanical removal of non-native species shall not occur in the restored or preserved habitat areas during the breeding season (March 1 through August 30). If mechanical removal is impractical or ineffective, then approved herbicides shall be applied utilizing the appropriate methodologies. The native vegetation landscape contractor, who must also have a certified applicator's license, shall determine the appropriate herbicide and application methodology. Application of herbicides shall not occur during the bird-breeding season (March 1 through August 30).

4.1.4 Periodic Review

The plant species maintenance program shall be reviewed on a periodic basis (every 5 years beginning in 2006) to determine whether additional plant species should be added to the removal list or if the monitoring and maintenance techniques need to be modified. For example, if better technology or control techniques are available, then those techniques should be reviewed and it should be determined whether or not they should be included in the eradication program. In the event that any methods are controversial or may be unproven, then the County of Orange, the USFWS, and the California Department of Fish and Game (CDFG) should be consulted for their concurrence.

4.2 ADAPTIVE ENHANCEMENT OF COASTAL SAGE SCRUB HABITAT

The PMP goal is to preserve the Tonner Hills Conservation Easement Area as habitat for the California gnatcatcher. The extensive habitat restoration program that was implemented as mitigation for the development project on the site was designed to create suitable breeding habitat for the gnatcatcher. Therefore, a qualified biologist who holds a Federal Fish and Wildlife Permit to survey for the California gnatcatcher shall conduct a survey of the habitat restoration areas and adjacent preserved coastal sage scrub every 3 years (See Summary Table in Section 1.0) beginning in 2006 for the purpose of identifying those areas that may require additional enhancement. For example, some areas may be denuded by unauthorized trail use, whereas other areas may become dominated by plant species not favored by the gnatcatcher. It is anticipated that some areas will support larger native bushes that may not be ideal gnatcatcher habitat but will contribute to habitat diversity, which is beneficial for wildlife in general. Nevertheless, in certain cases, selective thinning of native species to enhance the habitat value may be appropriate within the habitat restoration areas. Areas that may require supplemental enhancement such as selective thinning or planting will be identified and documented on a map by the biologist surveying the coastal sage scrub.

4.2.1 Reporting and Follow-up

Following the site visit, the biologist shall confer with the project botanist and they shall prepare a memorandum indicating the results of the survey. This memorandum can be combined with the report prepared by the botanist that addresses the non-native plant species on the site. Any problem areas that may need supplemental enhancement shall be indicated on a map and described in the text. The report shall be submitted to the Endowment Beneficiary, and to a qualified landscape contractor who is familiar with native habitat restoration and who has been retained by the Endowment Beneficiary. The Endowment Beneficiary shall be responsible for making sure that the qualified landscape contractor performs the necessary maintenance that has been suggested by the biologist within a reasonable amount of time (within 30 days or as seasonally appropriate). In the event that the proposed enhancement involves removal or thinning of native habitat, the U.S. Fish and Wildlife Service should be consulted for their concurrence. The botanist or gnatcatcher biologist shall conduct a follow-up survey for the purpose of confirming that the necessary enhancement was completed. The botanist or biologist shall prepare a memorandum to the Endowment Beneficiary after the necessary enhancement has been completed. All memorandum prepared under this task shall be included in the annual report.

4.3 TRASH REMOVAL

In order to identify trash accumulation problems in the preserved and restored habitat areas, a biologist shall conduct bi-annual site visits for the purpose of identifying and documenting trash that needs to be removed from the site. The biologist will also need to identify the appropriate timing and removal method for the trash removal. In other words, if an accumulation of trash is identified within gnatcatcher breeding habitat, the biologist needs provide guidance on when crews can enter the habitat areas to remove the trash and by what route they can access the trash. In this case, there will be restrictions on access into breeding habitat during the breeding season.

4.3.1 Reporting and Follow-up

Following the bi-annual site visits, the biologist shall prepare a memorandum indicating the results of the monitoring visit. This memorandum can be combined with other reports being prepared during the same period. Any problem areas that need trash removal shall be indicated on a map and described in the text. The memorandum shall be submitted to the Endowment Beneficiary and to a qualified landscape contractor who is familiar with native habitats and who has been retained by the Endowment Beneficiary. The Endowment Beneficiary shall be responsible for making sure that contractor performs the necessary trash removal that has been suggested by the biologist within a reasonable amount of time (within 45 days) The biologist shall conduct a follow-up site visit for the purpose of confirming that the necessary trash removal was completed. The biologist shall prepare a memorandum to the Endowment Beneficiary after the necessary trash removal has been completed. Noteworthy information from these memos (e.g., persistent problems or problems that result in habitat degradation) will be summarized in the annual reports.

4.4 CONTROL OF RECREATIONAL ACCESS INTO HABITAT AREAS

Human impacts related to recreation or trespass could potentially have a detrimental effect on habitat and the California gnatcatcher, as well as other species of wildlife. It is important to not only control access into the natural areas, but also to educate the public regarding the significance of the preserved habitat areas. The control of access must include signage that is designed to identify the conserved areas and remedial measures designed to eliminate further impacts or degradation of habitat in areas where access has already become a problem.

Appropriate signage that denotes the phrases "Conservation Area" and "Endangered Species Habitat" shall be placed in strategic locations throughout the project site to alert the public that the natural areas are considered sensitive areas. The signs should clearly state that access is not allowed in the natural areas. Signs should be placed at strategic locations where the public could potentially gain access into the natural areas. In addition, the signs should be placed close enough together to provide adequate coverage along potential access areas. These signs shall be installed prior to the first occupancy in each of the development phases. The sign locations shall initially be determined by a biologist and the installation of the signs, and timing of this installation, needs to be overseen by a biologist.

The sign locations shall be documented on a map of the site and the biologist/botanist will be responsible for determining if the signs are still in place during bi-annual monitoring visits in the Conservation Area. The biologist shall determine if additional signs need to be installed in problem areas or if signs need to be replaced because they have been damaged or removed. If problem areas are found, contingency measures will be employed to minimize future access. These measures, for example, may include the installation of constructed barriers (fencing), the placement of large boulders to control vehicle access, or the planting of noxious plants (poison oak or cactus, for example) to deter foot traffic. Those areas that are subjected to continual impacts related to human access may need to be assessed to determine if permanent barriers need to be installed.

None of the foregoing shall preclude activities associated with the installation, use, and maintenance of the Tonner Ridge Trial, which is a requirement of the Tonner Hills Area Plan.

4.4.1 Reporting and Follow-up

Following the bi-annual monitoring visits, the biologist shall prepare a memorandum indicating the results of the monitoring. This memorandum can be combined with other bi-annual memoranda when applicable. The memorandum shall document the problem areas and provide photographic documentation of impacts associated with unauthorized access into sensitive areas. Any problem areas that may need sign placement or replacement, or that may need remedial action to repair damage to habitat, shall be indicated on a map and described in the text. If remedial actions (repair of damaged habitat or placement of barriers) are necessary, then the biologist shall include a plan for repairing the problem areas in the memorandum. The memorandum shall be submitted to the Endowment Beneficiary and, if remedial actions are necessary, then it should also be submitted to a qualified landscape contractor who is familiar with native habitat restoration and who has been retained by the Endowment Beneficiary. The Endowment Beneficiary shall be responsible for making sure that the qualified landscape contractor performs the necessary maintenance or remedial measures that are suggested by the biologist within a reasonable amount of time (within 30 days). The biologist shall conduct a follow-up monitoring visit for the purpose of confirming that the necessary maintenance or remedial actions were completed. The botanist or biologist shall prepare a memorandum to the Endowment Beneficiary after the necessary maintenance or remedial actions have been completed. Noteworthy information from these memos (e.g., persistent problems or problems that result in habitat degradation) will be summarized in the annual report.

4.5 CONTINGENCY MEASURES IN CASE OF NATURAL CATASTROPHES (FIRE, ETC.)

In the event of a major fire or severe rainfall event or other disturbance that substantially damages the habitat, the condition of the site shall be assessed as soon as the area is safe (e.g., threat of fire has passed, etc.). The agencies shall be notified immediately and a damage assessment shall be conducted by a qualified habitat restoration specialist. This assessment shall include an estimate of the acreage of damaged habitat and a determination of the severity of the impacts. The habitat restoration specialist shall determine a plan of action for managing or repairing the damaged habitat. Because many native plant species are adapted to periodic fires, the habitat areas may be able to recover on their own with a minimal weed control effort. For those areas that are more severely damaged, there may be a need for seeding with native species or planting of container plants and irrigation of these plants. In addition, there may also be a need for erosion control measures. The goal of the plan shall be to encourage the habitat to recover to the pre-catastrophe habitat conditions. The cost of any necessary remedial measures will be paid for by the designated endowments. Upon transfer of the property and the $650,000+ combined endowments to the approved management entity, no additional financial liability will rest with the landowner, applicant, or Tonner Hills Homeowner's Association.

4.5.1 Reporting and Follow-up

Following the post-catastrophe site visit, the habitat restoration specialist shall prepare a memorandum indicating the results of the assessment. This memorandum shall document the post-catastrophe conditions and provide photographic documentation of the impacts. The damaged areas shall be indicated on a map and described in the text. The memorandum shall also contain the recovery plan for repairing or assisting in the recovery of the damaged habitat, for controlling future erosion problems (if necessary), and a schedule for when the actions should take place. The memorandum shall be submitted to the Endowment Beneficiary and the U.S. Fish and Wildlife Service for review and approval, and, if remedial actions are necessary, then it should also be submitted to a qualified landscape contractor who is familiar with native habitat restoration and who has been retained by the Endowment Beneficiary. The restoration specialist shall be responsible for making sure that the qualified landscape contractor performs the necessary maintenance or remedial measures within a reasonable amount of time (within 30 days or according to the schedule provided by the restoration specialist). The restoration specialist shall conduct the follow-up monitoring that has been set forth in the recovery plan. The restoration specialist shall include a description of the necessary remedial actions, monitoring, and maintenance that were performed in the next annual report.

4.6 RESTORATION OF OIL PADS AND ROADS

After areas currently used for oil operations are retired and the required investigations and clean-up activities are conducted (estimated 30-50 years), the well pads and roads will be dismantled and reseeded with coastal sage scrub or other native vegetation, as appropriate, and incorporated into the conservation easement area. It is understood that some of the existing access roads will need to be maintained as roads for future access requirements. The locations of the retained roads will be determined at the time that the oil operations are completed. These retained roads will not be subjected to habitat restoration activities but any future maintenance of these roads shall avoid disturbing the native habitats occurring adjacent to the roads.

The revegetation of the reclaimed roads and oil well pads will consist of removing any non-native invasive species on these sites and preparing the soil by ripping or by some other appropriate method. Prior to revegetation, a habitat restoration specialist or botanist who is familiar with the biology and ecology of southern California plant communities will perform surveys of transects in the existing coastal sage scrub and/or other target native plant community in the vicinity of the proposed restoration areas. Appropriate seed mixes and planting ratios will be developed from these survey transect results. The roads and pads designated for restoration will be seeded with the native plant seed mixes. Seeded areas will need to be maintained for three years to ensure that non-native plant species do not out-compete native plant species. During the three-year maintenance and management period, which will be conducted as described in Section 4.1.2. Because this management plan is projecting so far into the future, the restoration that will occur in these areas will need to use the best available technology at the time, i.e., if there is a technique other than the procedure described above.

4.6.1 <u>Reporting</u>

Documentation for the reclamation and restoration of the oil pads and roads will include a memorandum that serves as a mini-habitat restoration plan. The memorandum shall document the results of the vegetation transects, the seed palette, the methods for non-native plants removal, soil preparation, planting methods, success criteria, and maintenance and monitoring requirements. This memorandum shall be submitted to the Endowment Beneficiary and the U.S. Fish and Wildlife Service for review and approval, and a qualified landscape contractor shall be selected to implement the plan. The habitat restoration specialist shall ensure that the plan is implemented correctly and that the designated monitoring and maintenance schedule is adhered to. After the implementation of the restoration the restoration specialist shall prepare a memorandum documenting the work that was completed. This memorandum and any other memoranda prepared as a result of any maintenance and monitoring that may be required should be provided to the Endowment Beneficiary. Any further reporting shall be determined as part of the mini-habitat restoration plan. Generated related to the reclamation and restoration of the oil pads and roads shall be included in the annual reports that are generated each year.

4.7 DESIGNATION OF AUTHORIZED FUEL MODIFICATION LIMITS

The limits of fuel modification, in many cases, are coincident with the 449-acre preservation area. In these cases, fuel modification limits will be marked with clearly visible poles.

SECTION 5.0 – MANAGEMENT OF THE SITE FOR CALIFORNIA GNATCATCHERS AND OTHER WILDLIFE SPECIES

5.1 GNATCATCHER POPULATION MONITORING

The conservation area will be preserved in perpetuity for the California gnatcatcher. As part of the long-term management of the site for this purpose, the onsite coastal California gnatcatcher population will be monitored every three years from year 6 through 10 and every five years from year 11 through the end of oil production. The protocol for conducting the focused surveys shall follow the most current USFWS guidelines and the surveys shall be conducted by biologists who hold the appropriate federal U.S. Fish and Wildlife Service Permit to survey for the California gnatcatcher. Prior to the conducting the surveys, USFWS should be contacted in order to obtain the most current protocol. If the gnatcatcher is de-listed, then the USFWS shall be contacted regarding the cancellation of the requirement for focused surveys for this species~~.~~

5.1.1 <u>Reporting</u>

The results of the gnatcatcher surveys shall be documented in a focused survey report. The report shall contain a description of the protocol used to conduct the survey, a description and map of the locations of where gnatcatchers were observed, and a discussion of the behaviors observed. The report shall also contain copies of the field notes and a list of wildlife species noted during the surveys. In addition, if the gnatcatcher biologist observes any problem areas within the gnatcatcher habitat areas (recreational impacts, etc.), then these should be noted in the report. The gnatcatcher report shall also contain a summary of the activities that have occurred at the site (maintenance, trash removal, etc.) in the period since the previous gnatcatcher survey report. The biologist will also record the number and location of any cowbirds or nest parasitism observed during gnatcatcher surveys. This information will be used in determining whether it is necessary to implement brown-headed cowbird trapping. The report shall be submitted to the UWFWS in accordance with the protocol guidelines. The report shall also be included as part of the annual report in the year's when the gnatcatcher surveys are conducted.

5.2 GENERAL WILDLIFE SPECIES MONITORING

Reconnaissance-level wildlife surveys will be completed every three years from year 6 through year 10 and every five years from year 11 through the end of oil production. A qualified wildlife biologist that is familiar with southern California fauna will survey the site to determine the wildlife species using the habitat. Evidence of use of the site for reproduction will include the direct observations of amphibian larvae, breeding tree frogs, presence of territorial males during breeding season, bird or mammal nests, litters, or young of the year. Evidence of food chain support will include direct observations (e.g., documented observation of heron eating gopher or frog, white-tailed kite taking vole, rabbit-browsed rushes, caterpillar-eaten herbs) and indirect observations (e.g., scat, owl pellets, presence of appropriate or target species within created habitat).

5.2.1 <u>Reporting</u>

The reports that are prepared during the years that gnatcatcher surveys are conducted shall include the records of the wildlife species observed on the site during the monitoring visits, as well as evidence of reproduction and food chain support. The records of wildlife use will be recorded on a form for each survey. The wildlife survey form will be attached to the gnatcatcher survey reports. In addition, the locations of any sensitive species noted during the surveys shall be shown on a map of the site.

5.3 BROWN-HEADED COWBIRD TRAPPING

The brown-headed cowbird *(Molothrus ater)* is a nest parasite, meaning this species does not build its own nest or tend to its own young. Instead, female cowbirds deposit one or more eggs into a host species' nest, often removing or destroying some of the host eggs. The brown-headed cowbird has a variety of target host species, and has been recorded as successfully parasitizing 144 of 220 species in whose nests its eggs have been observed (Ehrlich et al. 1988). Some host species include threatened or endangered species such as the coastal California gnatcatcher, least Bell's vireo (*Vireo bellii pusillus*), and southwestern willow flycatcher (*Empidonax traillii extimus*). Although the majority of cowbird eggs and nestlings fail to reach adulthood (approximately 97 percent), cowbird parasitism affects host species by reducing the number of successful young. Furthermore, nest abandonment by the host species results in zero production for that breeding pair and therefore the reproductive effort will be significantly lower than that of an unparasitized species (Ehrlich et al. 1988). While brown-headed cowbird parasitism poses a major threat to many species of songbirds, some host species, including the California gnatcatcher, least Bell's vireo, and southwestern willow flycatcher, have also had to contend with habitat loss and fragmentation, which increase the risk of being parasitized (Harris 1991; Laymon 1987; Mayfield 1977; Stafford and Valentine 1985).

Cowbird traps were first used as a localized control in the early 1970s in Michigan, and by the mid-1980s were in widespread use in southern California and Texas, mostly in programs associated with the protection of threatened or endangered bird species. These traps proved to be so successful at reducing cowbird numbers and levels of parasitism in the study areas that the USFWS began to require cowbird removal as mitigation for a variety of development projects.

If during the course of the onsite California gnatcatcher population monitoring or general wildlife species monitoring, the biologists detect an abundant brown-headed cowbird population or if evidence of nest to parasitism is observed (e.g., a fledgling cowbird food-begging from a non-cowbird or an adult cowbird attempting locate a songbird nest), then a brown-headed cowbird trapping and removal program should be implemented. If cowbird trapping becomes necessary, trapping data will be assessed annually by a qualified biologist to determine if the program needs to continue.

A qualified biologist knowledgeable in brown-headed cowbird trapping protocol will implement a trapping and removal program according to the most current methods, using the best available technology at the time. Currently, Griffith Wildlife Biology's (GWB) brown-headed cowbird trapping protocol has been adopted by the USFWS, however, prior to implementing the trapping and removal program, the biologist should contact USFWS in order to obtain the most current trapping protocol and obtain appropriate agency authorization. Currently, brown-headed cowbird trapping and removal programs are operated in conjunction with CDFG and USFWS. The standard southern California trapping period is March 15 through July 15 (GWB 1994), however, the exact number and location of traps and the duration of the trapping effort should be determined if and when the trapping becomes necessary.

5.3.1 Reporting

In the event that cowbird trapping is conducted in the Conservation Area, then a report shall be prepared at the completion of each year's trapping program. The report shall include a description of the methods used, the locations of the traps, and the results of the trapping program. The report must be provided to the resources agencies (USFWS and CDFG) following the completion of the program. The report shall also be included in the annual report in those years that the trapping program is implemented.

SECTION 6.0 – ENDOWMENTS AND OFFER OF DEDICATION

6.1 ESTABLISHMENT OF WASTING ENDOWMENT

Prior to initiating CSS impacts, two separate endowments will have been established to fund the perpetual management plan. The first funds the management of the easement area while it is still under the control of the Permittee. This wasting endowment initially will have been funded in the amount $270,000. If this wasting endowment drops below $240,000, the Permittee will supplement the endowment to maintain it above $240,000. Proof of transfer of monies into the endowment will be submitted to the Carlsbad Fish and Wildlife Office with the submittal of the PMP (see Appendix A). All remaining funds in the wasting endowment after 30 years will convert to a non-wasting endowment discussed below.

6.2 PROVISIONS FOR OFFER OF DEDICATION TO COUNTY OF ORANGE

The conservation easement will be placed on Lots 11, 13, 18, and 19 of Tract Map No. 16178. The County of Orange will be the holder of this easement. While this will provide interim oversight and protection of the land for conservation purposes, this protection will cease when the property is donated to the County of Orange. Such donation is to occur with the cessation of oil operations and completion of the required cleanup. At the time of the transfer to the County of Orange, a non-wasting endowment will be provided and is discussed below.

There will need to be an additional mechanism recorded on the title to the land to ensure that the land is protected for conservation purposes in perpetuity. The County cannot hold the easement and own the land. Therefore, a restrictive covenant or deed restriction also should be placed on the land. If the County fails to take the property, the additional deed restriction will not be needed. However, the other management entity would need to be approved by the USFWS.

When the conserved land is offered for dedication to the County of Orange or another management entity approved by the USFWS, the new management entity will either adopt this management plan or coordinate with the USFWS to develop a new management plan that will ensure the site is managed in perpetuity for the benefit of the native plant and animal life onsite, particularly the coastal sage scrub and coastal California gnatcatcher.

6.3 ESTABLISHMENT OF NON-WASTING ENDOWMENT

In addition to the initial wasting endowment, the Permittee will have established a second endowment, initially in the amount of $100,000. The non-wasting endowment will accumulate interest until the property is turned over to the County of Orange or other appropriate management entity. At that time, the two endowments will be combined. If the combined endowments total less than $650,000, the Permittee will provide a one-time supplement to raise the level of the endowment above $650,000. After the Permittee turns the property over to an approved management entity, they will no longer be responsible for maintaining the endowment, as it is anticipated that the funding amount will be sufficient for perpetual management of the property. Evidence that the endowments have been established, as described, will be submitted to Carlsbad Fish and Wildlife Office 60 days prior to initiating any impacts to coastal sage scrub (see Appendix A).

SECTION 7.0 – REPORTING REQUIREMENTS

7.1 REPORTING REQUIREMENTS

The results of all of the monitoring visits, focused surveys, and remedial actions shall be summarized both in an annual summary report and in the reports that are prepared during the years that the gnatcatcher surveys are conducted. The annual summary report can be a brief 2 to 4 page report that describes the activities that have been conducted throughout the year and has relevant memos attached. The gnatcatcher reports will be prepared in 2009, 2012, 2017, 2022, 2027, 2032, 2037, 2042, and 2047. If oil production continues beyond 2047, then reports will continue to be prepared every 5 years until oil production is completed. The reports shall be submitted to the U.S. Fish and Wildlife Service and the County Inspector in the Environmental Planning Department of the County of Orange. The reports shall be due to the County and USFWS by January 31 and shall include all of the letter reports or memoranda prepared after monitoring was completed, focused survey reports, and any other follow-up memoranda that were prepared for the year ending the previous December 31. The reports shall address the status of site monitoring and maintenance, summarize the actions taken, and include recommendation measures for each issue area. All memoranda prepared during the monitoring period shall be included in the appendices of the gnatcatcher reports.

SECTION 8.0 – REFERENCES

California Department of Fish and Game (CDFG)
2003 Streambed Alteration Agreement #R5-2002-0114.

California Regional Water Quality Control Board (CRWQCB)
2003 Clean Water Act Section 401 Water Quality Standards Technically Conditioned certification for the Proposed Tonner Hills, Orange County, (ACOE Reference Number 199916501-DPS).

Chambers Group, Inc. (Chambers)
2001 Draft Conceptual Mitigation and Monitoring Plan.

2004 Coastal Sage Scrub Mitigation and Monitoring Plan for the Tonner Hills Planned Community.

2004 Tonner Hills 2.49-Acre Riparian Native Revegetation Project As-Built Assessment.

2004 Tonner Hills 2.49-Acre Riparian Native Revegetation Project Annual Inspection.

2004 Tonner Hills 14-acre Coastal Sage Scrub Revegetation Project As-Built Assessment.

2004 Tonner Hills 20-acre Coastal Sage Scrub Revegetation Project As-Built Assessment.

Ehrlich, P., D. Dobkin, and D. Wheye
1988 *The Birder's Handbook.* Simon and Schuster, Inc. New York, NY.

Griffith Wildlife Biology (GWB)
1994a Brown-Headed Cowbird Trapping Protocol. Unpublished document prepared by Jane C. Griffith and John T. Griffith, Griffith Wildlife Biology, Calumet, Michigan.

Harris, J. H.
1991 Effects of Brood Parasitism by Brown-Headed Cowbirds on Willow Flycatcher Nesting Success Along the Kern River, California. *Western Birds* 22:13-26.

Laymon, S. S.
1987 Brown-Headed Cowbirds in California: Historical Perspectives and Management Opportunities in Riparian Habitats. *Western Birds* 18:63-70.

Mayfield, H. F.
1977 Brown-Headed Cowbird: Agent of Extermination? *American Birds* 31:107-113.

Stafford M. D. and B. E. Valentine
1985 A Preliminary Report on the Biology of the Willow Flycatcher in Central Sierra Nevada. Cal-Neva Wildlife Transactions 66-77.

U.S. Army Corps of Engineers (ACOE)
2000 Nationwide Permit 38: Cleanup of Hazardous and Toxic Waste (200001421-YJC).

2003 Individual Permit, Pursuant to Section 404 of the Clean Water Act (199916501-DPS).

U.S. Fish and Wildlife Service (USFWS)
2002 Formal Section 7 Consultation for Nuevo Energy's Proposed Tonner Hills Planned Community, County of Orange, California.

EXHIBIT "F"

COASTAL SAGE SCRUB MITIGATION PLAN

[See attached]

COASTAL SAGE SCRUB
MITIGATION AND MONITORING PLAN FOR THE
TONNER HILLS PLANNED COMMUNITY

Prepared for:

NUEVO ENERGY COMPANY
201 South Broadway
Orcutt, California 93455
(805) 934-8239

Prepared by:

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February 2004

Chambers Group®

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SECTION 1.0 – INTRODUCTION AND PROJECT DESCRIPTION

1.1 INTRODUCTION

Chambers Group, Inc., (Chambers Group) was retained by Nuevo Energy Company (Nuevo), Bakersfield, California, to develop a Final Coastal Sage Scrub Mitigation and Monitoring Plan (Mitigation Plan) for the Tonner Hills Planned Community. This mitigation plan describes the methods to be used to restore and enhance coastal sage scrub within the project's approximately 473.2-acre habitat conservation area. The project site is located in the County of Orange, north of the City of Brea. The mitigation plan is based on literature reviews, reconnaissance-level biological surveys, sensitive plant surveys, focused surveys for the California gnatcatcher (*Polioptila californica californica*), and a previous draft revegetation plan that was included as an appendix to the Draft Biological Assessment for Tonner Hills (Chambers Group Inc., January 2002)

The mitigation plan is one of the mitigation measures to offset impacts to coastal sage scrub habitat associated with the development of the project site. Organization of and information in this mitigation plan follows the *Habitat Mitigation and Monitoring Proposal Guidelines*, issued in June 1993 and revised in January 2003, adopted by the United States Army Corps of Engineers (Corps) Los Angeles District Regulatory Branch.

1.2 PROJECT LOCATION

The Tonner Hills Planned Community project site is an approximately 789.8-acre site located in the County of Orange, north of the City of Brea, California (Figure 1-1). The site is owned by Nuevo Energy Company. The site is bounded by Lambert Road to the south, Tonner Creek to the north, Valencia Avenue to the east, and the 57 Freeway bisects the western portion of the site (Figure 1-2).

Regionally, the site lies within the northwestern portion of the Chino Hills and southeastern portion of the Puente Hills. Surrounding land uses include residential development to the south and west, similar native habitat within Tonner Canyon to the north, and oil production lands to the east and northwest. The project site comprises a series of low hills and ridges. It ranges in elevation from approximately 500 to 800 feet above sea level. The site is composed of several different vegetation communities. Many oil well pads and access roads are present throughout the site. The site is located on the USGS Yorba Linda and La Habra 7.5-minute topographic quadrangles.

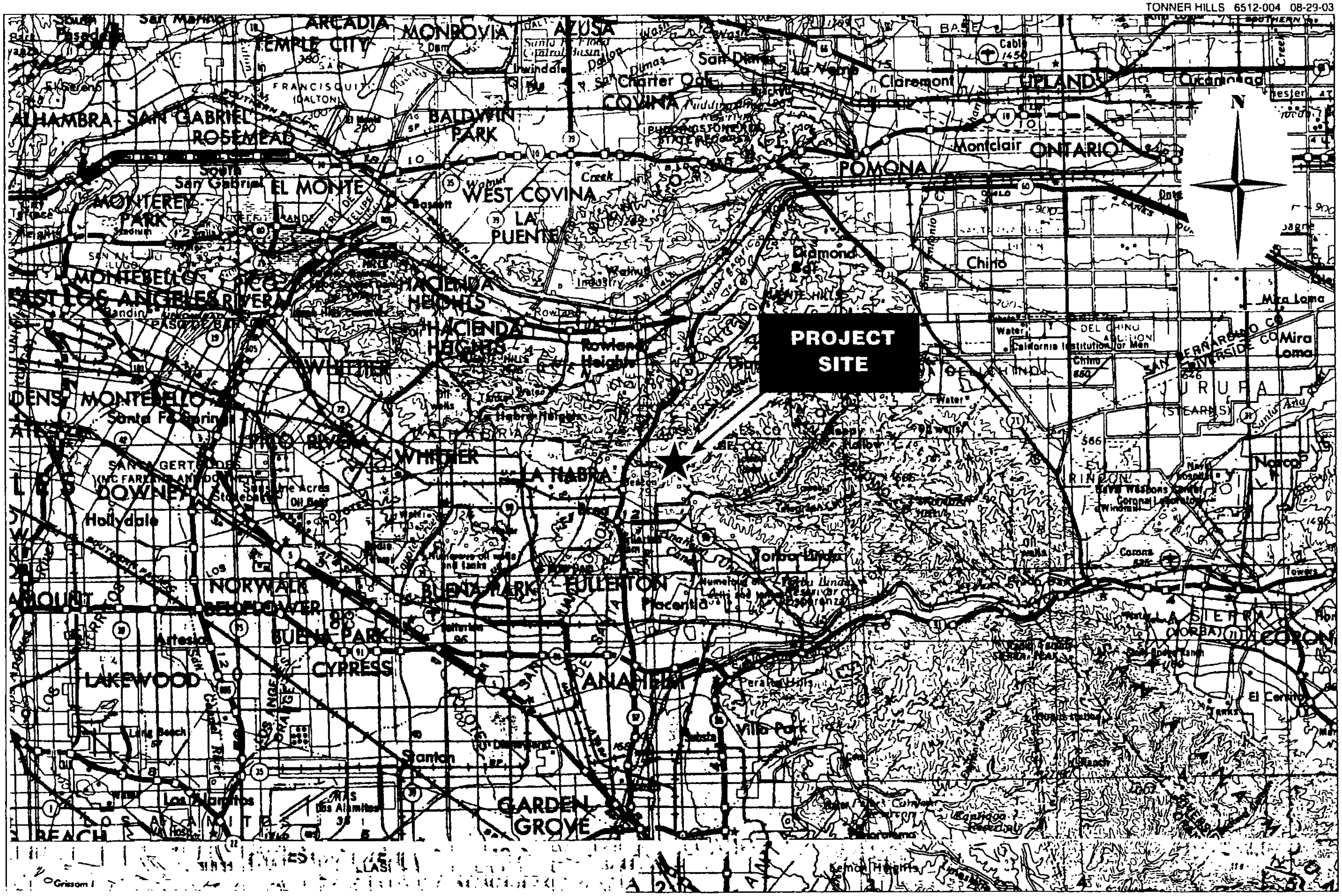
1.3 BRIEF SUMMARY OF OVERALL PROJECT

The proposed Tonner Hills project includes the development of a master planned community on approximately 180.0 acres. The project proposes the development of up to 795 residential units distributed in 7 distinct neighborhoods on 180.0 acres, 14.6 acres to be developed for neighborhood park use, 21.5 acres for public use areas, 19.2 acres for public streets, 16.3 acres to remain exclusively as oil and gas development.

The Tonner Hills project includes an extensive habitat restoration and enhancement program. At least 473.2 acres will be designated as habitat conservation area. This area is to support native plant communities. In addition, the habitat conservation area is designed to provide an east-west corridor for the movement of wildlife between areas west of the 57 Freeway and those located north and east of the Tonner Hills project site.

Following the revegetation and enhancement program, the conservation area will contain approximately 340.7 acres of native habitats including 227.4 acres of mature coastal sage, 11.6 acres of disturbed coastal sage scrub, 44.2 acres of undisturbed walnut woodlands, 24.2 acres of disturbed walnut woodlands, 11.7 acres of walnut/oak woodlands, 3.5 acres of oak woodland, 14.79 acres of willow

TONNER HILLS 6512-004 08-29-03



Miles

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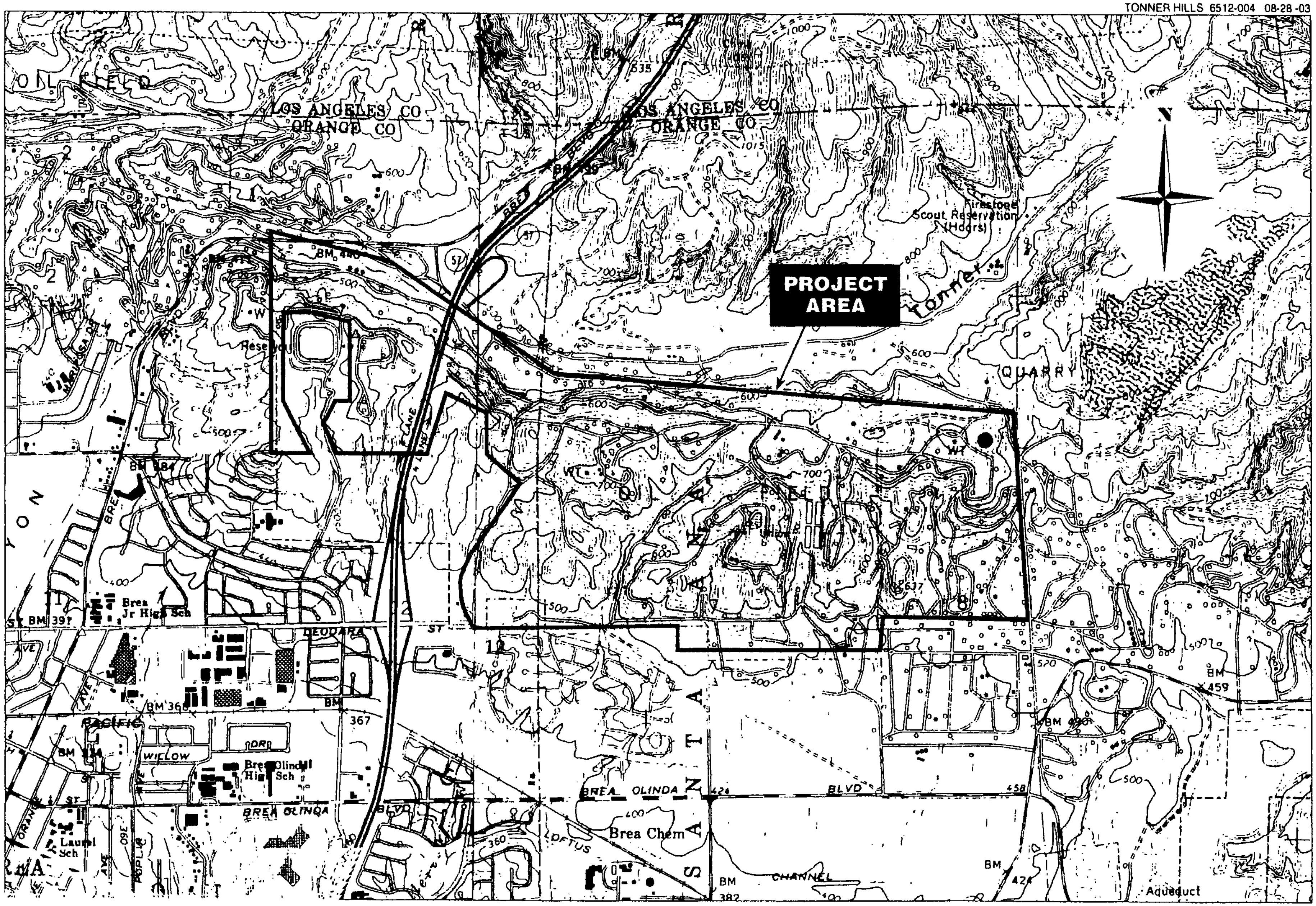
Base Map Source: USGS 1:250,000
Santa Ana, Long Beach, Los Angeles, San Bernardino, CA

Chambers Group

PROJECT VICINITY MAP
TONNER HILLS
Figure 1-1



Base Map Source: USGS 1: 24,000
La Habra, Yorba Linda, CA

Chambers Group

PROJECT LOCATION MAP
TONNER HILLS
Figure 1-2

woodland, and 3.3 acres of other assorted native habitats. The remainder of the conservation area contains non-native habitats (ornamentals, etc), ruderal areas, and areas that weren't included as part of the habitat restoration program.

A total of 116.6 acres of coastal sage scrub will be revegetated prior to and during project implementation. Furthermore, approximately 19.1 acres of disturbed coastal sage scrub will be enhanced by removing exotic species (e.g., castor bean, Italian thistle, fennel, and pepper trees). The locations of the habitat creation and enhancement areas are shown on Figure 1-3.

During the preparation of this mitigation plan, Bon Terra provided input regarding the planting density for Revegetation Areas A and B. Appendix A includes Bon Terra's justification for the suggested planting density and photographs of a similarly planted project that Bon Terra has implemented. Bon Terra is the consultant hired by the purchaser of the Tonner Hills project site.

1.4 RESPONSIBLE PARTIES

Nuevo will be responsible for the implementation of this mitigation plan. The contact person is:

Mr. John Ullom
Ullom Associates
16149 Redmond Way, Suite 401
Redmond, WA 98052
(425) 836-2728
(425) 836-2870 facsimile

The preparer of the mitigation plan is Chambers Group, Inc.. The contact person is:

Ms. Mari Schroeder
Chambers Group, Inc.
17671 Cowan Avenue, Suite 100
Irvine, CA 92614
(949) 261-5414
(949) 261-8950 facsimile

Restoration Specialist

A qualified Restoration Specialist shall supervise implementation of the mitigation plan. That person shall be a qualified Biologist/Restoration Ecologist familiar with the biology and ecology of southern California plant communities and shall have experience in horticultural practices commonly used for habitat restoration and revegetation. The Restoration Specialist's name, address, telephone number, and email address (if available) shall be provided to all permitting agencies.

The Restoration Specialist or an approved biological monitor also shall be present at all preconstruction and pregrading meetings and shall be onsite during all construction activities involving removal of vegetation resulting from project implementation to ensure compliance with resource-related mitigation measures and conditions of approval contained in the permits.

SECTION 2.0 – APPROACH, RATIONALE, AND METHODOLOGY FOR PROGRAMS

Section 2.0 provides guidelines and specifications for implementing the restoration and enhancement programs.

2.1 RATIONALE FOR EXPECTING IMPLEMENTATION SUCCESS

The selection of plant materials for the revegetation site at Tonner Hills was based on the slope aspect, substrate characteristics, and the expected ecological conditions. Native species selected for the revegetation areas include those present in undisturbed coastal sage scrub habitat elsewhere on the property.

Success of the Mitigation Plan is expected based on the following rationale:

- Plant materials (seeds and container plants) to be used for the revegetation site are carefully selected for their adaptability to the site conditions.
- The sites are highly disturbed non-native communities adjacent to areas supporting coastal sage scrub habitat. The existence of coastal sage scrub immediately adjacent to the restoration sites, and the presence of remnant individuals of coastal sage scrub plant species, supports the premise that a restored community can sustain itself and support native species.
- The revegetation sites will be planted with container plants at a relatively high density and seeded with a native herbaceous seed mix that inhibits the recolonization of invasive non-native plant species.
- A strict maintenance and maintenance-monitoring plan will be implemented to ensure the success of the plantings.

2.2 RESPONSIBLE PARTIES

Nuevo will be responsible for the implementation of this mitigation plan. The contact person is:

Mr. John Ullom
Ullom Associates
16149 Redmond Way, Suite 401
Redmond, WA 98052
(425) 836-2728
(425) 836-2870 facsimile

The Restoration Specialist shall supervise implementation of the restoration and enhancement programs and shall be responsible for oversight of the monitoring program. This person, aided by a team of approved biological monitors, shall be responsible for tracking and preparing all progress reports for submittal to the agencies. A qualified revegetation contractor experienced in the installation and maintenance of native restoration projects shall be responsible for actual implementation of the specifications of the mitigation plan and shall direct all the activities associated with the plan. The Restoration Specialist shall coordinate closely with the revegetation contractor to ensure that the specifications of the Mitigation Plan are properly implemented. In addition, a biologist who is permitted to survey for the California gnatcatcher shall be available on an as-needed basis to ensure that restoration activities do not adversely effect gnatcatchers located adjacent to the restoration areas. Where this is most appropriate is in the existing disturbed coastal sage scrub habitat areas that will be subject to enhancement through weed removal activities. In addition, as the revegetated habitat areas begin to mature and resemble habitat that may be occupied by gnatcatchers, the Restoration Specialist shall coordinate with the gnatcatcher biologist as to what activities and the timing of activities that may take place in these areas.

2.3 PHASING AND IMPLEMENTATION SCHEDULE

The revegetation and habitat enhancement programs will be completed in two phases. Phase 1 includes the revegetation of approximately 14 acres of coastal sage scrub (designated as Revegetation Area A) located adjacent to Planning Area 7 on the west side of the 57 Freeway. Phase 2 includes the revegetation of approximately 102.6 acres in the remaining habitat conservation areas located east of the 57 Freeway. Phase 2 includes a 20 acres area (designated as Revegetation Area B) located west of Planning Area 4 and the remaining 82.6 acres (designated as Revegetation Area C) that are scattered in various locations around the remainder of the Planning Areas. Enhancement of approximately 19.1 acres of disturbed coastal sage scrub is also included in Phase 2. Enhancement of 5.5 acres of disturbed walnut woodlands in Cable Canyon will begin with the removal of exotic trees in Phase 1 and will be completed with planting during Phase 2.

Phase I revegetation was initiated in April 2003 with preliminary weed abatement. Completion of the Phase I revegetation program is scheduled for the Fall/Winter of 2003/2004. Implementation of Phase 2 revegetation was originally scheduled to occur during the initial phase of development construction but it is now expected to be initiated in 2003/2004. The implementation of these phases is being accelerated so that all revegetation and enhancement efforts will be underway prior to the initiation of construction. Table 2-1 provides the schedule guidelines for Phase 2 revegetation and enhancement activities at Tonner Hills.

Table 2-1
Preliminary Schedule Guidelines For Revegetation Activities

Site Preparation for Phase 2 (Area B) (August 2003 through January 2004)
➢ Contract for plant and seed materials
➢ Contract with landscape contractor
➢ Contract with earthmovers, if required
➢ Restoration Specialist attends pre-construction meeting(s)
PRESERVATION, REMOVAL, AND ACCESS AREAS DELINEATED WITH CONSTRUCTION FENCING
➢ Install temporary irrigation system
➢ Pre-treat site for weeds
Planting of Phase 2 (Area B) (November 2003 through June 2004)
➢ Schedule plant materials delivery date and planting crew
➢ Layout planting scheme for landscape contractor
➢ Container plants installed
➢ Seed application
➢ **Site Preparation for Phase 2 (Area C) (October 2003 through January 2004)**
➢ Contract for plant and seed materials
➢ Contract with landscape contractor
➢ Contract with earthmovers, if required
➢ Restoration Specialist attends pre-construction meeting(s)
➢ Preservation, removal, and access areas delineated with construction fencing
➢ Install temporary irrigation system
➢ Pre-treat site for weeds

Table 2-1 (Continued)
Preliminary Schedule Guidelines For Revegetation Activities

Planting of Phase 2 (Area C) (January 2004 through January 2005)
➢ Schedule plant materials delivery date and planting crew
➢ Layout planting scheme for landscape contractor
➢ Container plants installed
➢ Seed application
Enhancement of Existing Coastal Sage Scrub (January 2004 through January 2005)
➢ Contract with landscape contractor (August)
DELINEATION OF ENHANCEMENT AREAS WITH FLAGGING OR CONSTRUCTION FENCING
RESTORATION SPECIALIST ATTENDS PRE-CONSTRUCTION MEETING(S)
WEED ABATEMENT COMMENCES IN ENHANCEMENT AREAS
Maintenance and Monitoring
➢ Conduct As Build Assessments for each area
➢ Coordinate and install replacement plantings, if necessary, monitored by Restoration Specialist
➢ Initiate project maintenance and maintenance monitoring program
Performance Monitoring and Documentation
➢ Initiate Performance Monitoring Program following completion of installation ➢ Restoration Specialist submits annual report to Agencies by January 1 each year following implementation

2.4 SPECIAL CONDITIONS TO PRESERVE HABITATS AND PROTECT SENSITIVE SPECIES DURING PROJECT IMPLEMENTATION

The following measures shall be implemented to protect the biological and aesthetic values of the natural habitats and sensitive species present within the site.

- A biological monitor shall be present during any removal of native vegetation on the site. The monitor shall be an experienced biologist, and shall be approved by USFWS prior to initiation of vegetation removal on the site. The monitor shall supervise grubbing and/or grading equipment operations to ensure that California gnatcatchers are not killed or injured during vegetation removal activities. The monitor shall have the authority to halt or suspend any activity until appropriate corrective measures are completed to protect sensitive species. The monitor shall prepare a daily monitoring report outlining observed activities and indicating compliance with the approved mitigation plan. The daily report shall also contain recommendations concerning remedial actions needed to correct any identified deficiencies. The monitor shall report any observed violations to USFWS and CDFG within 24 hours.

- In general, removal of non-native species shall occur outside of the nesting season (approximately August to February 15th). By avoiding the removal of non-native species in the breeding season, impacts to nesting bird species will be avoided, and this action will also avoid violation of the Migratory Bird Treaty Act. In those instances during the breeding season, when weed infestations in the revegetation or enhancement areas reach a stage where weed control is essential, the Restoration Specialist will coordinate with the gnatcatcher biologist in order to ensure that weed removal activities will not result in adverse effects on the gnatcatcher.

- All removal of existing coastal sage scrub habitats shall occur outside of the breeding season of the gnatcatcher (February 15 through August 30). If any construction activity is necessary within 500 feet of preserved coastal sage scrub habitat during gnatcatcher breeding season, the biological monitor shall implement nest-monitoring surveys in the adjacent habitat to determine whether nesting activity is being substantially disrupted. If the biological monitor determines that gnatcatcher nesting activity is substantially disrupted, the monitor shall halt or suspend all work in the vicinity of the nest until the young have fledged, the nest has been determined to be a failure, or a minimization plan approved by the USFWS has been implemented to reduce noise to 60 dBA in occupied habitat. During this time, the biological monitor shall provide USFWS with weekly summaries, via facsimile transmission, of all gnatcatcher monitoring activities.

- Preserved and/or protected areas shall be identified by the Restoration Specialist and delineated with construction lath, fencing, or similar materials prior to any clearing or grading activities. Protected areas include existing woodland and coastal sage scrub adjacent to revegetation areas and individual trees and patches of native habitat to be preserved within revegetation areas.
- Vehicles shall not be allowed to operate within the dripline of any preserved trees.
- Erosion control measures, including silt fencing, shall be installed as necessary at the discretion of the Restoration Specialist to contain sediments within graded or restoration areas. If erosion becomes a problem, then, at the discretion of the Restoration Specialist, silt fencing shall be semi-permanently installed at the boundary between upland revegetation areas and existing native habitats until vegetation is sufficiently established in the revegetation zone to prevent erosion. Maintenance of the erosion control measures is included as part of the maintenance program.
- Maintenance and refueling of construction equipment shall be limited to areas specified by the Restoration Specialist. Storage of potentially hazardous materials, including but not limited to fuel, paint, stains, pesticide, herbicides, solvents, oils, and solvents, shall not be permitted within 50 feet of any preserved native habitat or riparian zone. During project implementation, disposal of such materials shall occur in a controlled area that is physically separated from potential storm water runoff.
- The Restoration Specialist shall institute measures to prevent fire and leakage from vehicles used in the revegetation efforts on the project site. Such measures shall include designated no smoking zones and parking areas. Construction equipment will be restricted to designated areas and roads approved by the Restoration Specialist. The fire station located immediately adjacent to the Tonner Hills site will be notified in case of a fire emergency and will provide fire protection services on the site.

2.5 GENERAL IMPLEMENTATION GUIDELINES

Construction Fencing and Signage

Construction lath, orange plastic snow fencing, or other similar device shall be used to define limits of clearing and access routes at the Tonner Hills site. Where possible, fencing shall be located no closer than 15 feet from habitat to be protected.

Access

Access to the Tonner Hills site shall be from the Kramer Avenue gate. Vehicles and other equipment shall be restricted to approved routes within the sites.

Spoils, Trash and Debris Removal

Spoils shall be immediately removed from each site and transported to offsite locations. Garbage and debris shall also be removed from all areas of the site and transported to an appropriate offsite disposal facility. The removal of dead or downed wood will eliminate important microhabitats for small vertebrates and invertebrates, and reduce the reintroduction of organic materials into the soil. Therefore, dead or downed wood of native species shall be salvaged wherever possible except as required for safety reasons, flood control, or fuel modification (i.e., fire prevention).

Erosion Control

The erosion control plan that is developed for the construction project on the Tonner Hills shall be reviewed by the Restoration Specialist prior to the implementation of construction. Only nonvegetative erosion control measures shall be used in areas with native vegetation or in construction areas that drain into areas that support native vegetation. Such erosion control measures may include sandbags, silt fencing, slope breakers, trenches, or dissipaters. Erosion control measures that may contain materials that would contaminate the sites (e.g., hay bales or non-rice straw mulch, etc.) shall not be allowed on the site. These measures preclude the introduction of non-native weedy species into the seed bank of areas with native vegetation.

Drainage and sedimentation control devices shall be routinely cleaned, maintained, and repaired prior to and during the rainy season. All repairs to these systems shall be immediately executed to minimize erosion problems.

2.6 COASTAL SAGE SCRUB REVEGETATION PROGRAM

2.6.1 Overview

Restoration is intended to create a plant community where none currently exists by the planting of native vegetation. The goal of the revegetation effort is to create viable coastal sage scrub community in areas currently supporting non-native grass or ruderal vegetation on the site. Approximately 116.6 acres of coastal sage scrub shall be created on slopes and other areas on the site. This section describes the project and the various tasks required to prepare the areas for planting and to install container plants and seed materials.

2.6.2 Locations and Phasing of Revegetation

Approximately 116.6 acres of coastal sage scrub will be created onsite in areas outside the fuel modification limits of the project. The areas outside of the impact zone of the project that currently support non-native grasslands and agricultural areas will be revegetated with coastal sage scrub. The Tonner Hills revegetation and enhancement programs were originally designed to be completed in 3 phases, installed prior to and during construction of the development project. The implementation of the revegetation and enhancement phases of the project are being initiated prior to construction in order to avoid all temporal losses of habitat value. All revegetation and enhancement programs will be implemented prior to initiation of construction activities for the development project.

The revegetation program will be completed in two phases. Phase 1 includes the revegetation of 14 acres of coastal sage scrub in Revegetation Area A located west of the 57 Freeway. Phase 2 includes the revegetation of the remaining 102.6 acres in areas located east of the 57 Freeway. The revegetation areas east of the 57 Freeway are delineated into two distinct areas. Revegetation Area B is a 20-acre high-density planting area situated in the south-central portion of the property. Revegetation Area C comprises the remaining 82.6 acres of revegetation areas located east of the 57 Freeway. The 19.1 acres of habitat enhancement areas are located in preserved habitat adjacent to Revegetation Areas B and C. A 5.5 acres area in Cable Canyon will also be enhanced by the removal of non-native plant species and by planting of additional walnut trees. The locations of the revegetation and habitat enhancement areas are shown on Figure 1-3.

2.6.3 Site Preparation

Pre-Planting Weed Control

Weed control at the revegetation sites must be addressed at least 3 months before planting activities are initiated. Effective herbaceous weed eradication requires initial stimulation of weed growth. This allows a larger crop of weeds to be eradicated and reduces the weed seed bank in the soil. Weed farming method of removal will be used in revegetation sites where problem invasive weeds are established. Weed farming includes a cycle of irrigation, weed germination, and weed removal that may be repeated up to 12 times or more as a means of removing the weed seed bank in existing soils. Mechanical clearing, mowing, and non-residual herbicides (Rodeo® and/or Roundup®) may also be used to remove weed and exotic species. The weed farming methods are described below.

1. The site will be cleared of weeds by mechanical mowing. Cut vegetation of noxious weed species (including stems and flowering heads) will be removed from the site and disposed of at an appropriate offsite location.
2. In the absence of natural rainfall, the revegetation area will be irrigated two times per week for a two-week period using a temporary irrigation system. Soils should be saturated to a depth of at least 3 inches during each irrigation.
3. Germinated weeds will be mowed and/or treated with an appropriate post-emergent herbicide at the end of the first two-week irrigation cycle. Dead vegetation of noxious weed species will be removed from the site and disposed of at an appropriate offsite location.
4. The cycle of irrigation and weed removal as described in items 3 and 4 above will be repeated 3 times, including the initial cycle. The cycle will be repeated during different seasons to ensure the removal of annuals. The Restoration Specialist will determine if further treatment is required to reduce the weed seed bank.

At the time of planting, the planting contractor and the Restoration Specialist will assess whether any undesirable vegetation has become established in the mitigation planting areas and whether additional eradication is necessary. Wherever feasible, pre-planting weed control will use mechanical methods such as removal by hand or string trimmers. If effective weed control cannot be attained through mechanical means, appropriate systemic non-residual herbicides may be applied by a licensed applicator under the supervision of the Restoration Specialist. Weed species to be removed may include, but are not limited to, the following species:

Common Name	Scientific Name
Tamarisk	*Tamarix ramossissima*
Eucalyptus	*Eucalyptus* sp.
Castor bean	*Ricinus communis*
Pepper trees	*Schinus* sp.
Mustards	*Brassica* sp.
Tree tobacco	*Nicotiana glauca*
Fennel	*Foeniculum vulgare*
Italian thistle	*Carduus pycnocephalus*
Milk thistle	*Silybum marianum*
Nonnative weedy thistles	*Cirsium* sp.
Nonnative annual grasses	
Wild oats	*Avena fatua*
Slender wild oats	*Avena barbata*
Foxtail chess	*Bromus madritensis* ssp. *rubens*
Ripgut brome	*Bromus diandrus*
Soft chess	*Bromus hordeaceus*
Mediterranean barley	*Hordeum murinum*
Italian ryegrass	*Lolium multiflorum*
Annual beard grass	*Polypogon monspeliensis*
Nonnative perennial grasses	
Pampas grass	*Cortaderia selloana*
Bermuda grass	*Cynodon dactylon*
Fountain grass	*Pennisetum setaceum*
Smilo grass	*Piptatherum miliaceum*

Exotic Tree Removal

Exotic trees will be removed from the revegetation areas during preplanting weed control activities. Exotic trees on the site include Peruvian pepper (*Schinus molle*) and eucalyptus (*Eucalyptus* spp.). These trees are common throughout the site and are particularly abundant in Revegetation Area B. Exotic tree removal will generally be conducted outside of the breeding season for birds (approximately August 30 to March 1). If trees need to be removed during the breeding season, then a biological monitor will verify that raptor nests and other bird nests are not present in these exotic trees prior to removal. Approximately 1 acre of pepper trees will be removed from an area of high quality coastal sage scrub in the western portion of the Tonner Hills site (east of SR57). This area of tree removal is included in the total for coastal sage scrub enhancement areas per a conversation with Jonathan Snyder at USFWS.

The exotic trees will either be removed completely or will be removed by cutting and treating the stump with an appropriate herbicide. Rodeo®, a glyphosate herbicide approved for use in aquatic systems, must be used in areas in close proximity to riparian systems (e.g., Cable Canyon, Tonner Creek). The Restoration Specialist will determine the habitat limits within which the herbicide used will be restricted to Rodeo®. All trees will be cut to within 6 inches of the ground. Cut material will be removed from the site the day it is cut and disposed of at an offsite location. Undiluted herbicide (Round-up® or Rodeo® as directed by the Restoration Specialist) will be applied to the entire stump surface immediately after cutting. Treated plants will be inspected prior to initiating planting activities. If any treated stumps show evidence of new growth, or if any new plants are found, additional cutting and/or herbicide treatment will be performed. All applications of herbicide will occur outside of the bird-breeding season (March 1 through August 30).

2.6.4 Plant Materials

The plant materials for the coastal sage scrub revegetation and enhancement projects include container plants and a seed mix obtained from a commercial supplier experienced in the propagation of native plant materials.

Revegetation Area A (14 acres) and Revegetation Area B (20 acres) will be planted with a high density of container plants (approximately 1775 individuals per acre) to achieve the structure and density of native species required for the foraging and nesting activities of the California gnatcatcher in a relatively short period of time. Revegetation Area C will be planted with a moderate density of container plants (approximately 600 plants per acre. Areas B and C will be planted with container plants and may also be hydroseeded with a native plant seed mix. Some portions of Area C may only be subjected to a hydroseed treatment because these areas typically consist of small, isolated patches. Figure 1-3 shows the locations of the Revegetation Areas.

Container Plant Materials

Installation of container plants provides the following four important functions in revegetation:

- allows established plants that are past the vulnerable sapling stage to be introduced onsite,
- provides the means to introduce species that do not establish well from seed and are best propagated from cuttings,
- provides diversity of age structure and thus speeds natural regeneration, and
- provides an efficient method to introduce beneficial soil fungi (mycorrhizae) onsite.

Mycorrhizae can be reintroduced onsite by providing inoculated host plants. This process is often very slow (Miller 1985). Container plants that have been inoculated with mycorrhizae shall be used as the prime method for spreading these beneficial fungi. In addition to spreading the mycorrhizae onsite, inoculation of container-grown plants may increase transplant success, growth, and reproductive success.

The shrubs shall be obtained from a local supplier experienced in the propagation of native plant species. If possible, container plant materials shall be derived from cuttings, divisions, rhizomes, or seed of native plant materials obtained from north Orange County (Puente Hills or Chino Hills). In all cases where materials utilized for propagation of container stock is obtained from other areas, the materials supplier shall demonstrate that the stock is genetically suitable for this site. Use of materials propagated from materials originating from areas other than north Orange County shall be approved in advance by the Restoration Specialist. Prior to delivery, the root systems of the plants shall be inspected by the Restoration Specialist of the revegetation contractor to ensure that roots are straight and well established. Plants with coiled roots (rootbound) shall not be accepted.

The following specifications shall be included in the commercial collector/supplier's growing contract for the plantings:

- All plants shall be hardened to frost/drought.
- All plant species that would normally host mycorrhizal fungi shall be inoculated.
- Plants shall not be grown with excessive fertilization.
- Plant root systems must fill the containers, but not be root-bound at time of delivery.
- Plant materials shall be properly labeled as to genus, species, subspecies, and source.
- Trees shall be tagged with metal forestry tags stating the species and size at time of delivery to facilitate tracking of growth during the monitoring phase.
- Plant materials shall be provided in quantities and sizes specified.
- Plants shall be ready for planting during specified planting period.
- No plants showing signs of serious pest infestation or disease shall be accepted.
- All plant substitutions shall require written approval from the Restoration Specialist.
- Plants shall not be subjected to breakage or desiccation during transport. Any broken or desiccated plants shall be rejected.
- Plant materials shall be inspected and approved by the Restoration Specialist prior to delivery.
- Upon delivery to the mitigation sites, plants shall be stored in a shaded location, evenly spaced, and upright; and watered as needed until planting. All materials shall be protected from adverse weather, vandalism, or other conditions that may be detrimental to the product.

Substitutions of species or adjustments of specified quantities shall not be allowed without the express approval of the Restoration Specialist. Table 2-2 shows the container plant palette for the coastal sage scrub plant community.

Table 2-2
Coastal Sage Scrub Container Plant Palette

Scientific Name	Common Name	Size	1,775 Plants per Acre (high density treatment)	600 Plants per Acre (moderate density treatment)
Artemisia californica	California sagebrush	1 gallon	835	285
Baccharis pilularis	Coyote brush	1 gallon	50	25
Encelia californica	California bush sunflower	1 gallon	130	25
Eriophyllum confertiflorum	Golden Yarrow	1 gallon	35	10
Eriogonum fasciculatum	California buckwheat	1 gallon	235	65
Isocoma menziesii	Goldenbush	1 gallon	90	25
Leymus condensatus	Giant wild rye	1 gallon	15	10
Salvia mellifera	Black sage	1 gallon	225	65
Nassella pulchra	Purple needle grass	1 gallon	40	20
Mimulus aurantiacus	orange bush monkey flower	1 gallon	90	30
Malosma laurina	Laurel sumac	1 gallon	10	10
Rhus integrifolia	Lemonadeberry	1 gallon	10	10
Opuntia littoralis[1]	prickly pear cactus	Salvaged pads and 1 gallon	40	20
		Total number of plants per acre	**1775**	**600**
*** south-facing slopes**				

Seed Collection

Seeds collected from North Orange County (Puente Hills or Chino Hills) shall be supplied by a qualified commercial seed collector/supplier with experience in native seed collections. Seeds shall be cleaned to a commercially acceptable grade, tested, and labeled with the species name, weight, purity, and germination rate. Seeds shall be stored in a cool, dry environment until delivery for hydroseeding.

Because availability of seed may be limited, flexibility in species selection and application rates will be necessary. Actual amounts of seed necessary for the revegetation plan will ultimately be determined by the Restoration Specialist based on the purity and germination rates of the available seed. Seed shall not contain more than 0.5 percent weed seed by volume. Seed types shall be as specified in the seed palette and shall be applied at the rates indicated. Seed shall be received by the revegetation contractor in separate containers specifying kind, quality, purity, germination, and source. The revegetation contractor shall provide the Restoration Specialist with each seed bag label used in the installation. Seed suppliers shall be experienced in native plant seed propagation and collection, and shall be approved by the Restoration Specialist. Table 2-3 lists the understory seed palette for the revegetation areas

Table 2-3
Mixed Coastal Sage Scrub Seed Mix

Scientific Name	Common Name	Minimum Purity/Germination	Pounds of Seed per Acre [1]
Shrub and perennial species			
Artemisia californica	California sagebrush	15/50	5.50
Encelia californica	California encelia	40/60	3.00
Eriogonum fasciculatum var. *fasciculatum*	California buckwheat	10/65	3.50
Eriophyllum confertiflorum	golden yarrow	30/60	1.25
Isocoma menziesii	goldenbush	30/30	3.00
Lotus scoparius var. *scoparius*	deerweed	90/80	5.00
Mimulus aurantiacus	orange bush monkeyflower	5/70	1.50
Salvia leucophylla	purple sage	70/70	0.50
Salvia mellifera	black sage	70/50	0.50
Herbaceous and grass species			
Aristida purpurea	purple three-awn	60/45	2.50
Bromus carinatus	California brome	95/80	1.50
Dichlostemma capitatum	blue dicks	95/50	0.50
Gnaphalium californicum	California everlasting	2/50	2.00
Hemizonia fasciculata	tarweed	10/25	1.00
Layia platyglossa	tidy tips	80/75	1.50
Leymus condensatus	giant wild rye	70/80	2.00
Lupinus bicolor	small-leaf lupine	98/80	0.50
Nassella pulchra	purple needlegrass	70/60	8.00

[1] **Final specifications for the seed mix will be developed after tests for purity and seed germination for each species.**

2.6.5 Planting Methods

All planting shall occur in late fall through early winter to take advantage of winter rains, unless irrigation is provided.

Container Plant Methods

The Restoration Specialist shall oversee and supervise placement of the container specimens in accordance with the planting plan. Plantings shall be distributed in a natural pattern, with some plants grouped together and others spread farther apart. No large shrub plantings shall be planted closer than 8 feet on center.

Container shrub species shall be planted before hydroseeding is applied. No pruning of plant materials shall be allowed unless specified by the Restoration Specialist. The roots of the container stock shall be protected from drying during planting. Prior to planting, holes shall be hand-augered (twice the width and depth of each container) and then the holes shall be filled with water, backfilled with native soil, and refilled with water to create a moisture reserve in the soil.

Containers shall be gently cut or slid away from the rootball. Plants shall be placed in the premoistened holes with the root crown 1 to 2 inches above the surrounding soil. Backfill of native soil shall be gently tamped in around the rootball.

A small berm shall be constructed around the perimeter of the plant, effectively forming a watering basin. In level areas, excavated material shall be used to form a berm, creating an 18- to 24-inch diameter watering basin around the plant. The basin shall be filled with water, allowed to drain, and filled again.

No plantings shall be staked unless staking is considered necessary by the Restoration Specialist at the time of planting. Any staking shall be with a single wood post, with loose ties holding the trunk to the post. The ties shall be loose enough to allow the plant to flex without snapping or bending over excessively.

Seeding Methods

The seed mix shall be planted using hydroseed/hydromulch methods. Hydroseeding/hydromulching shall take place after the container plants have been installed to avoid disturbing the seeds. Container plants shall be avoided or otherwise protected during hydroseeding to prevent potential damage.

Hydroseeding shall consist of a hydraulic application of a slurry mixture containing water, organic soil stabilizer, cellulose wood fiber, mycorrhizae, and seed. Hydroseed mulch shall be manufactured from 100 percent virgin wood fiber and shall not contain growth or germination inhibitors. When mixed with water, the mulch shall remain in uniform suspension and when blended with the seed and other approved additives, form a homogeneous slurry. A non-phytotoxic wetting agent shall be added to the slurry mixture. A water-soluble, non-toxic green dye shall be added in sufficient quantity to clearly delineate the planted areas. The following materials shall be applied in a one-step hydroseed/hydromulch operation:

- virgin cellulose wood fiber: 1,000 pounds per acre;
- organic soil stabilizer: 160 pounds per acre on slopes; and
- seed mix as shown on Table 2-3.

Prior to loading the specified materials, the Restoration Specialist will conduct a visual inspection of the hydroseed equipment to ensure that the equipment is clean of contaminant seed or products. The hydroseed mix will be applied within one hour of mixing. The hydroseed equipment mixing apparatus will remain in constant motion during application of the materials until the tank is emptied.

2.6.6 Temporary Irrigation

Because the goal of revegetation is to create a self-sustaining site, no permanent irrigation system will be installed in the native plant communities at the revegetation site. Supplemental irrigation will be necessary, however, during the establishment period.

Therefore, a temporary, above-ground, overhead system will be installed to provide supplemental irrigation in sufficient amounts, as conditions require, to keep the container plants healthy and growing. Irrigation shall be accomplished in such a manner as to encourage deep root growth (i.e., periodic, deep irrigation as opposed to frequent, light irrigation). During the maintenance period, the Restoration Specialist will monitor soil moisture conditions to ensure sufficient water is delivered to the container plants. This supplemental irrigation shall be tapered back and the plants weaned over the first 2 years following planting. The native plants will adapt to site conditions after establishment and will survive on rainfall as a source of moisture. The supplemental irrigation will be discontinued when the Restoration Specialist determines the revegetation plantings are established and self-sustaining.

2.6.7 As-Built Conditions

An "As-Built Assessment" shall be conducted to document the actual project conditions on the site immediately upon completion of the installation. This assessment shall be performed by the Restoration Specialist. The Restoration Specialist will check the site for compliance with the Mitigation Plan's technical design criteria, permit conditions, and project objectives. Data pertaining to the following factors shall be collected by the Restoration Specialist and compared with the detailed construction documents:

- site location;
- site topography;
- substrate (soil source, texture);
- dates planted;
- quantity and locations of each species plants; and
- plant health and coverage.

Any differences found between the original design and the as-built conditions shall be fully assessed and documented by the Restoration Specialist through field maps, photographs, and descriptive text. It is expected that some modifications of the original plan will be deliberate and some will be due to unforeseen site conditions that became evident during construction. Any deliberate changes in the plan shall be justified to, and accepted in writing by, the Restoration Specialist and the revegetation contractor before the as-built conditions are approved. Recommendations for corrective measures shall also be made by the Restoration Specialist at the conclusion of the as-built assessment.

A report of the "As-Built Conditions" shall be submitted to the agencies within 6 weeks of completion of site preparation and planting, describing as-built status of the restoration project. The report shall include a map or diagram showing the mitigation area and the locations of the plantings and other installation items.

2.7 COASTAL SAGE SCRUB ENHANCEMENT PROGRAM

Approximately 19.1 acres of disturbed coastal sage scrub on the site will be enhanced by removing exotic species and reseeding with the same species described for the coastal sage scrub revegetation plan. The coastal sage scrub enhancement areas are shown on Figure 1-3. Target species to be removed include the species listed in Section 2.6.3, among others. The Restoration Specialist will identify the target species to be removed in each enhancement area.

Care will be taken not to damage the surrounding coastal sage scrub community during the eradication process. Woody species will be cut close to the soil surface and treated with an appropriate herbicide as described in the preplanting weed control section. Cut vegetation will be removed and disposed of at an off-site location the day it is cut. Non-woody species may be treated with a foliar application of herbicide. Herbicide application will not be applied during the breeding season for native birds.

Follow-up application of herbicide to control resprouting woody weed species is described in Section 3.0, Maintenance and Maintenance Monitoring Plan.

SECTION 3.0 – MAINTENANCE AND MAINTENANCE MONITORING PLAN

3.1 MAINTENANCE DURING THE MONITORING PERIOD

Maintenance of the site shall occur during the five-year monitoring period. The maintenance period shall begin when the installation work has been accepted as completed by the Restoration Specialist. Maintenance shall be performed by a qualified restoration contractor experienced in the care of native plant communities. During the first-year maintenance period, sufficient personnel and equipment shall be allocated to perform landscape maintenance of all planted areas. Maintenance visits shall be conducted at a minimum of once monthly during the first year after installation is complete, and quarterly thereafter. The need for additional maintenance visits shall be determined by the Restoration Specialist depending on site conditions. The required maintenance items shall include, but are not limited to, the following items:

<u>Erosion Control Devices</u>

Drainage and sedimentation control devices shall be routinely cleaned, maintained, and repaired as necessary. The maintenance contractor shall also install additional erosion control devices where necessary as indicated by the Restoration Specialist. Once sufficient vegetative cover has developed to prevent erosion, the erosion control devices shall be removed at the direction of the Restoration Specialist.

<u>Weed Control</u>

Weeds shall be controlled in the revegetation and enhancement areas for a minimum of 5 years or until native plantings are well established to prevent detrimental competition of invasive species with the mitigation plantings for water, nutrients, light, and space. Target non-native species include, but are not limited to, the species listed in Section 2.6.3. All weeds shall be removed mechanically, except in cases where mechanical removal is ineffective. Herbicides then shall be applied utilizing the appropriate methodologies. The Restoration Specialist shall determine the appropriate herbicide and application methodology in consultation with the native vegetation landscape contractor.

Follow-up foliar application of herbicide shall be applied to any resprouting stems of exotics in the revegetation and enhancement areas approximately 5 to 7 weeks after the initial treatment. At a minimum, quarterly inspections and reapplication of herbicide, if necessary, shall be conducted for a period of 5 years to ensure weed control. All application of herbicide should occur outside of the bird-breeding season (March 1 through August 30).

<u>Trash and Debris Removal</u>

Following rain events, trash and debris may enter the site. Following initial removal of the trash during site preparation, additional trash and debris shall be removed by the maintenance contractor during maintenance activities. Dead or downed wood of native species shall not be removed except as required for safety reasons or for flood control purposes. Garbage, debris, and noxious weed biomass shall be removed from all areas of the sites and disposed of at an offsite location.

<u>Irrigation</u>

The maintenance contractor shall be responsible for irrigating the restoration plantings as directed by the Restoration Specialist throughout the installation and maintenance periods. The maintenance contractor shall be responsible for maintaining all components of the temporary irrigation system installed at the site.

Vandalism

The maintenance contractor shall note any instance of vandalism and report occurrences to the Restoration Specialist within 24 hours. Recommendations for the replacement of damaged plants and their protection shall be developed by the Restoration Specialist. Such remedial measures will be undertaken as recommended in a timely manner. A description of all remedial actions will be included in the annual reports.

Replacement Plantings and Seeding

Any significant bare areas due to low seedling germination or establishment shall be reseeded. Prior to reseeding, soil compaction and soil chemical analyses may be required in the bare areas to identify any site-specific characteristics that may require specialized procedures or seed mixes. If indicated by the soil analyses, the Restoration Specialist shall develop specific site preparation and/or seed mixes.

Similarly, significant loss of container plant material shall require plant replacement. Replacement shall depend on the overall coverage of seedling plants and the relative frequency of the species in comparison to the performance criteria set forth in Section 4.0.

All reseeding and replanting should be conducted from October through December of each year, as necessary, unless irrigation is provided.

3.2 MAINTENANCE MONITORING

Maintenance monitoring of the site shall be performed with the knowledge and oversight of the Restoration Specialist. After installation is completed, maintenance activities shall be conducted on the sites as described in Section 3.1. The Restoration Specialist shall be responsible for overseeing maintenance of the sites and preparing maintenance reports. The person conducting maintenance monitoring inspections shall be a professional (e.g., biologist, landscape architect, horticulturist) knowledgeable of the physical requirements of native vegetation and experienced in installation and maintenance of native habitats.

3.2.1 Schedule of Maintenance Monitoring Inspections

The Restoration Specialist shall be responsible for inspecting the mitigation sites on a regular basis and, if necessary, providing recommendations to the maintenance contractor for changes in the maintenance program. At minimum, the following schedule of maintenance inspections for all plantings areas shall be implemented:

- monthly inspections during the first year following completion of installation,
- quarterly inspections during the second year following planting, and
- semi-annual inspections after the second year through the 5th year or until performance standards have been met.

After each maintenance monitoring visit, the Restoration Specialist shall submit a report to the project applicants summarizing the conditions observed at the site. The maintenance monitoring reports shall be included as an appendix to the Annual Performance Monitoring Report submitted to the agencies. The Annual Performance Monitoring Report shall be submitted to the agencies by January 31 of each monitoring year following completion of the installation.

SECTION 4.0 – PERFORMANCE MONITORING PLAN

4.1 INTRODUCTION

Performance monitoring shall be conducted to document the growth rates, coverage, and other general "success" attributes of the planted and enhanced areas. In addition, protocol wildlife surveys shall be conducted in a portion of revegetation areas to document use of the restored habitat by the coastal California gnatcatcher. Monitoring of the restored and enhanced vegetation communities shall be performed by the Restoration Specialist, plant ecologist, native landscape horticulturist, or other professional qualified to assess the performance of the habitat establishment efforts and recommend corrective measures, if needed.

The goal of the mitigation program is to progress toward the performance standards detailed below. Performance standards are based on the progress of the mitigation toward achieving targets developed from existing habitat for vegetation percent cover, tree height, frequency of distribution, and species diversity. The project applicant is responsible for performance monitoring. Performance monitoring will occur for a minimum period of 5 years or until the performance standards are achieved, whichever comes first.

Aspects of the performance standards set forth in the plan include the following:

1. Performance standards may be waived by the Corps, USFWS, or CDFG in any area if monitoring indicates that good growth and functional habitats are otherwise achieved.

2. If performance standards cannot be met because of adverse soil or other unmanageable site conditions, an alternative or auxiliary mitigation plan may be submitted to the Corps, USFWS, or CDFG for approval.

4.2 DEVELOPMENT RESTRICTIONS

Initiation of construction in Planning Area 7 and in a portion of Planning Area 4 is contingent on the success of the revegetation effort in Revegetation Areas A and B, respectively. Table 4-1 provides a summary of the specific success criteria that shall be met prior to initiation of construction of these Planning Areas.

Table 4-1
Summary of Development Restrictions

Development Area	Associated Revegetation Area/Description	Success Standards to be Achieved Prior to Initiation of Development
Planning Area 7,	Revegetation Area A 14-acre high-density	1. 75% Vegetative Cover 2. Documentation of breeding gnatcatchers within revegetation area
Planning Area 4	Revegetation Area B 20-acre high-density	1. 75% Vegetation Cover 2. Habitat must represent occupiable conditions for the California gnatcatcher.
Planning Areas 1, 2, 3, 5, & 6	Planting Area C 82.6 moderate-density and seeded portions	None

Planning Area 7: Success Criteria for the 14-Acre High-Density Planting in Revegetation Area A

Revegetation Area A comprises the 14-acre high-density planting located west of the 57 Freeway and immediately adjacent to Planning Area 7. According to the U.S. Fish and Wildlife Service Biological Opinion and the U.S. Army Corps of Engineers 404 permit for the Tonner Hills project, prior to impacting vegetation for the development of Planning Area 7, the restored coastal sage scrub in Revegetation Area A shall meet the final performance criteria for vegetation cover and survival described in Section 4.3. The goal of the mitigation plan is to establish breeding and foraging habitat for resident (and migratory) bird and wildlife species. In particular, the coastal California gnatcatcher is the target wildlife species for the project. Prior to initiating construction activities for the development of Planning Area 7, the project applicant shall provide evidence that any portion of the revegetated coastal sage scrub installed in Revegetation Area A is utilized as part of the territory of breeding gnatcatchers. Occupied is defined as a pair of gnatcatchers including any portion of the revegetation area within their breeding territory or one or both individuals of a gnatcatcher pair utilizing any portion of the revegetation area during the breeding season for foraging, collecting nesting material, territory defense, collecting prey for feeding nestlings, or foraging with fledglings. If the 75% cover criteria is met and the site is deemed to be occupied by gnatcatchers prior to the 5th monitoring year, then the site monitoring will be considered complete.

Planning Area 4: Success Criteria for the 20-Acre High-Density Planting in Revegetation Area B

Revegetation Area B comprises the 20-acre high-density planting area located in the south central portion of the property immediately adjacent to Planning Area 4. According to the U.S. Fish and Wildlife Service Biological Opinion and the U.S. Army Corps of Engineers 404 permit for the Tonner Hills project, prior to initiating construction activities in the western portion of Planning Area 4, the 20-acre high-density planting of coastal sage scrub installed in Revegetation Area B shall meet the final vegetation performance criteria described in Section 4.3. If the 20-acre site reaches the 75% cover prior to the 5th monitoring year and the site represents occupiable conditions for the gnatcatcher, then the site monitoring will be considered complete.

Planning Areas 1, 2, 3, 5, and 6

Initiation of construction for these Planning Areas are not subject to demonstrated success in any portion of the revegetation areas.

4.3 VEGETATION PERFORMANCE STANDARDS

Coastal sage scrub is the target vegetation community for this mitigation program. Listed below are the cover and survival standards that apply to all container plantings and seeding efforts.

4.3.1 Cover and Survival

Container plantings shall have a minimum of 100 percent survival the first year and 100 percent survival thereafter, and/or will attain 75 percent cover after 5 years. Areas treated with native seed mixes shall achieve 20 percent cover the first year and 50 percent cover after 3 years. During performance monitoring, density and cover will be quantified using standard vegetation transect methods. Representative areas within the mitigation areas will be also photographically documented from fixed stations. If the survival and cover requirements have not been met, replacement plantings shall be implemented, as necessary, to achieve the required standards. Replacements will be monitored with the original plantings during the 5-year monitoring period with the same survival and growth requirements as the plantings.

The survival and cover standards for the coastal sage scrub plantings are summarized in Table 4-2.

Table 4-2
Vegetation Cover and Survival Standards

Species	1st Year	3rd Year	5th Year[1]
Shrubs	100% survival	100% survival	75% cover
Seed Mixes[2]	20% cover	50% cover	75% cover[3]

[1] Performance standards during Year 5 must be attained without human interference (irrigation, rodent control).
[2] If adequate germination is not attained to prevent erosion or exclude weed infestations, reseeding may be necessary.
[3] Percent cover of seed mix is in combination with shrub and/or tree cover

4.3.2 Native Species Richness

Maximum potential species richness is one of the goals of restoration. In addition to the wide range of species included in the plant palettes, natural recruitment of native species may contribute to the overall diversity within the revegetation areas. A minimum of 80 percent of the species planted (or a combination planted and naturally recruited native species) will be represented in the revegetation areas after 3 years. If species richness requirements have not been met, the Restoration Specialist will make recommendations for remedial reseeding (i.e., species to be reseeded).

4.3.3 Evidence of Natural Reproduction

It is expected that natural reproduction of a variety of seeded and planted species will be evident by the third year after planting. If the Restoration Specialist notices any areas that are deficient in the recruitment of native species, appropriate remedial actions will be taken to remedy the situation.

4.3.4 Non-Native Species

Weeds shall be controlled in the revegetation and enhancement areas for 5 years or until plantings are well enough established to prevent detrimental competition between the non-native, invasive species with the revegetation plantings for water, nutrients, light, and space. The percent cover measurements shall be based on native plant species only; non-native plant species shall not be counted as cover in the percent cover measurements. Revegetation and enhancement areas shall have a goal of a maximum 5 percent cover of invasive weed species after 5 years.

4.4 VEGETATION PERFORMANCE MONITORING METHODS

Monitoring will be performed by the Restoration Specialist or a qualified biologist with appropriate experience in site monitoring and vegetation transect measurements. Performance monitoring of vegetation within the mitigation areas will generally include detailed analysis of growth, cover, height and viability using quadrant and point intercept methods. In Revegetation Areas A and B, a minimum of one randomly placed 50-meter transect per acre will be established. A minimum of ten 50-meter transects will be placed in Revegetation Area C. Permanent photo-documentation stations shall be established to record the progress of each site over the 5-year period. Photographic records shall be kept of all mitigation areas for purposes of comparing earlier and later stages of plant establishment and growth.

Plant vigor, recruitment, and patterns of growth within created and enhanced sites will be noted and documented along with the quantitative performance data. Aggregations of individual plants or species into stands or zones can provide important information relating to (1) gradients in physical parameters within the site, or (2) interactions with neighboring species (including wildlife).

Data collection Methodology

Quantitative vegetation data shall be collected on a minimum of 10 permanent 50-meter transects at the site, following point-intercept methodology modified from the California Native Plant Society (Sawyer and Keeler-Wolf 1995). Transect locations shall be randomly selected. The location of each transect shall be recorded using a GPS unit to find the coordinates for each end of the transect line.

Plant species touching a vertical line at 0.5 m-intervals along each 50-m transect shall be recorded as "hits" and used to estimate cover by species. Species shall be categorized by layer in the vegetation as "herb/ground," "shrub," and "tree." Data shall be recorded separately for each 0.5-m interval in order to accurately assess vegetative cover. In addition to the cover data, densities of perennial woody plants shall be sampled on each transect by censusing each tree and shrub species within a 500 m^2 (10m x 50m belt along the transect length) area.

4.5 WILDLIFE MONITORING SURVEYS

The use by wildlife of the site shall constitute evidence that the revegetation site is proceeding and providing good habitat values. Reconnaissance wildlife surveys and focused protocol surveys for the coastal California gnatcatcher shall be conducted by a permitted wildlife biologist in Revegetation Areas A and B during the 5-year monitoring period or until these two revegetation areas have achieved the final success criteria. In addition, reconnaissance wildlife surveys shall be conducted in Revegetation Area C on an annual basis. The Annual Reports shall include the records of the wildlife species and gnatcatchers observed in each revegetation area during the monitoring visits.

4.6 SCHEDULE OF PERFORMANCE MONITORING

Quantitative vegetation performance monitoring and wildlife surveys shall be conducted annually beginning approximately one year following completion of installation. Quantitative vegetation sampling shall occur during the spring and shall continue through the 5th year after installation is complete or until vegetation performance standards have been met. Focused wildlife surveys shall be conducted annually during the appropriate seasons to detect the presence of breeding gnatcatchers. Focused protocol gnatcatcher surveys shall be conducted in Revegetation Areas A and B each year during the 5-year monitoring period or until these two revegetation areas have achieved the final success criteria.

4.7 ANNUAL REPORTS

The Restoration Specialist shall prepare an annual report for submittal to the agencies. Reports shall be submitted by January 31 of each monitoring year beginning approximately one year after installation is complete. Monitoring reports shall present an overview of the revegetation effort and specifically address monitoring methods, plant survival, percent cover, and number of each species replanted. These reports shall include the following:

- a list of names, titles, and companies of all persons who prepared the content of the annual report and participated in monitoring activities for that year;
- a description of the existing conditions of the site;
- the results of the reconnaissance and focused wildlife surveys;

- an analysis of all qualitative and quantitative vegetation monitoring data;
- copies of all monitoring photographs;
- maps identifying monitoring areas, transects, planting zones, and so forth as appropriate;
- discussion and recommendations; and
- A copy of the permits, and any special conditions or letters modifying the original permit conditions.

4.8 NOTIFICATION OF COMPLETION

The applicant shall notify the agencies of the completion of the 5-year monitoring period in conjunction with submittal of the 5th year annual report. The Restoration Specialist shall be present during all field visits requested by the agencies to verify permit conditions have been satisfied. Earlier notification and request for release may be submitted to the resource agencies by the Restoration Specialist if the mitigation sites have met the established performance standard of 75% shrub cover and occupied for the 14 acres coastal sage scrub area and occupiable for the 20 acres coastal sage scrub area. Based on the plant densities placed in these two restoration areas, it's very likely that the success criteria will be met prior to the 5th monitoring year.

4.9 CONTINGENCY MEASURES

If at any time planting functions in restored areas do not appear to be meeting the performance standards set forth in the mitigation plan, Nuevo will be responsible for taking action and timely remedial actions (as determined by the Restoration Specialists) to ensure compliance with the performance standards.

<u>Replacement Plantings and Seeding</u>

Any site with significant bare areas due to low seedling germination or establishment shall be reseeded. Prior to reseeding, soil compaction and soil chemical analyses may be required in any bare areas to identify any site-specific characteristics that may require specialized procedures or seed mixes. If indicated by the soil analyses, the Restoration Specialist shall develop specific site preparation and/or seed mixes.

Similarly, significant loss of container plant material shall require plant replacement. Replacement shall depend on the overall coverage of seedling plants and the relative frequency of the species in comparison to the performance criteria set forth in Section 4.0.

In the event of a major fire or flood event or other disturbance that substantially damages the revegetation plantings, the condition of the site will be assessed as soon as the area is safe (e.g., threat of flood has passed, etc.). Assessment of the site shall be conducted by the Restoration Specialist and shall be documented in a letter report, which shall include photographic documentation. At a minimum, exotic species abatement practices will be increased to encourage natural recovery processes. If evidence of natural recovery is not observed within 3 months of the disturbance, or if the recovery is deemed inadequate to meet the stated goals of the project, the project applicants shall prepare an analysis detailing the cause of the failure and shall enter into consultation with the agencies to determine an appropriate remedial action or alternative mitigation program. The project applicant shall also consult with the agencies regarding remedial action if the site does not meet the project's established performance criteria.

SECTION 5.0 – REFERENCES

Harvey & Stanley Associates, Inc.
1983 *Revegetation Manual.* Prepared for Alameda County Flood Control ard Water Conservation District. Hayward, CA. June 1983.

Hickman, J.C. (Editor)
1993 *The Jepson Manual: Higher Plants of California.* University of California Press. Berkeley, CA.

Holland, R.
1986 *Preliminary Descriptions of the Terrestrial Natural Communities of California.* Nongame Heritage Program, State of California Department of Fish and Game.

Miller, R. M.
1985 Overview Mycorrhizae. Restoration and Management Notes 3:14-20.

Munz, Philip A.
1974 A Flora of Southern California. University of California Press, Berkeley, CA.

Skiyirs, J. and M.F. Allen
1985 Use of Mycorrhizae for Land Rehabilitation. MIRCEN - *Journal of Applied Microbiology and Biotechnology* 2(1):161-176.

Society for Ecological Restoration (SERCAL)
1992 *Restoration/Revegetation Planning: The Basics.* Proceedings for workshops held November 13, 1992, Sacramento, California. Sponsored by SERCAL, California Chapter.

United States Army Corps of Engineers
2003 Mitigation Guidelines and Monitoring Requirements. Special Public Notice, January 27, 2003.

APPENDIX A

BON TERRA'S INFORMATION

August 18, 2003

Ms. Beth Martinez
Vandermost Consulting Services, Inc.
27312 Calle Arroyo
San Juan Capistrano, CA 92675

VIA FACSIMILE AND EMAIL
(949) 489-0309

Subject: Recommended Planting Density for the 14-Acre Pre-Mitigation Site (PA-7) for the Tonner Hills Development

Dear Ms. Martinez:

BonTerra Consulting has evaluated the Draft Conceptual Mitigation Plan (Chambers Group, Inc.) (draft plan) for the Tonner Hills Development with respect to planting density within the 14-acre coastal sage scrub (CSS) pre-mitigation site. As the result of this evaluation, a field assessment of the 14-acre site, and recent meetings with key parties associated with the project [Chambers Group Inc., Lockhart & Associates, Nuevo Energy Group, Nature's Image Inc., Odle & Associates, Ullom Associates, Vandermost Consulting Inc. (consultant to Shea Homes), and BonTerra Consulting], BonTerra Consulting is submitting the following recommendations concerning the proposed planting densities for the 14-acre site.

As background, the Biological Opinion issued by the U.S. Fish and Wildlife Service for this development project requires that two performance criteria be met within the 14-acre site prior to construction implementation (clearing/grubbing). The first performance criterion includes the documented utilization of the 14-acre pre-mitigation site by coastal California gnatcatchers (*Polioptilia californica* ssp. *californica*). The second performance criterion includes the achievement of the five-year performance standard for overall native plant percent coverage. The draft plan includes a five-year native plant coverage standard of 75%.

As the result of coordination with key parties, it was determined that the target plant coverage for CSS restoration within the 14-acre site is 80%. In addition, it was determined that 100% plant survival relative to the initial planting quantities would be accomplished through ongoing replacement planting of any dead plants.

Attached is a document entitled *Container Planting Densities to Achieve Target Coverage* (BonTerra Consulting). This document sets forth in simple graphical and mathematical models the required initial container planting densities to achieve target plant coverage. Using these objective guidelines, it will be necessary to plant 1,775 plants per acre to achieve project performance goals. Following is a simple calculation, based on the models provided in the attached document, for determining this planting density:

1) CSS container shrubs are assumed to have an average diameter of five feet.
2) Each shrub, therefore, has an average area of 19.63 square feet (sf).
3) There are 43,560 sf in one acre.
4) Therefore, 43,560 sf/19.63 sf x 0.80 (% cover) = 1,775 plants.

Also attached is photo-documentation of a CSS mitigation site designed and monitored by BonTerra Consulting. The Peninsula Point CSS mitigation site in Rancho Palos Verdes was planted at a density of 2,090 plants per acre, at an approximate spacing of five feet on center, using drip irrigation throughout. Planting at this site was completed in April 2002. The year one quantitative survey, performed in April 2003, measured 64% overall native plant coverage. Recent qualitative surveys indicate that the overall coverage is now substantially higher, with large areas of contiguous shrub coverage and occasional gaps in vegetative cover to mimic natural conditions. Plant health is excellent, with all species assuming natural growth habits and no evidence of disease, stunted growth, or other stress. The 2.5-acre Peninsula Point CSS mitigation site is located adjacent to pre-existing CSS occupied by the gnatcatcher. Wildlife utilization of the restored CSS area is high.

Federally permitted gnatcatcher biologist Michael C. Couffer (permit # TE-782703-4) made an incidental observation of a female coastal California gnatcatcher and three fledglings foraging within the restored Peninsula Point CSS area on August 18th, 2003. The detection of the birds in the restored area indicates utilization of the created CSS habitat approximately 15 months after plant installation. Formal documentation of the gnatcatchers' utilization of the Peninsula Point CSS restoration area is pending, in scheduled quarterly and annual mitigation performance assessments for the project.

It is likely that restoration performance similar to that achieved in the Peninsula Point site can be attained within the 14-acre pre-mitigation site at Tonner Hills, assuming dense container planting (1,775 plants per acre), the use of high quality plant material, proper installation techniques, effective ongoing maintenance including weed control and irrigation, and no disadvantageous soils or other inherent site conditions.

BonTerra Consulting also recommends that high-density container planting (minimum 1,775 plants per acre, 100% plant survival through ongoing replacement of dead container plants) be conducted within the 20-acre pre-mitigation site (PA-4) at Tonner Hills, to facilitate the achievement of project performance standards.

BonTerra Consulting looks forward to reviewing the detailed mitigation plans for both PA-4 and PA-7, and to participation in project implementation. Please call us at (714) 444-9199 if you have any questions regarding these recommendations.

Sincerely,
BONTERRA CONSULTING

Melissa A. Howe
Associate Principal, Restoration Ecology

Richard B. Lewis, III
Senior Restoration Ecologist

Attachments: Container Planting Densities to Achieve Target Coverage
Photo-Documentation

R:\Projects\Vander\J024\14-Acre1.doc

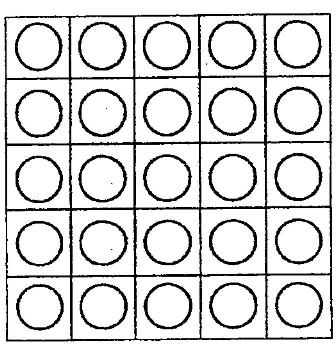
Cc: Mari Schroeder, Chambers Group, Inc.
Pam DeVries, Chambers Group, Inc.
Sharon Lockhart, Lockhart & Assoc.
John Deacon, Nuevo Energy Company
Robert Odle, Odle & Assoc.
John Ullom, Ullom Associates
Ann Johnston, BonTerra Consulting
Brian Daniels, BonTerra Consulting
Sandra Leatherman, BonTerra Consulting

Container Planting Densities to Achieve Target Coverage

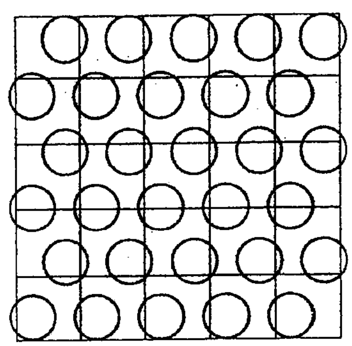
These guidelines present simple graphical and mathematical models to display the coverage of mature plants provided by planting at various initial densities. These guidelines were prepared specifically to evaluate coastal sage scrub (CSS) restoration; hence, an average mature shrub diameter of five feet (19.63 ft^2) typical of most CSS species, is used as the basis for the models.

Data is provided to indicate the approximate number of plants for a given sample layout (e.g., a 30' x 30' area), the approximate number of plants per acre, and the approximate overall mature shrub coverage for each model, assuming ongoing replacement of all dead plants. The models are shown at varying scales to display 30 plants per layout for comparison.

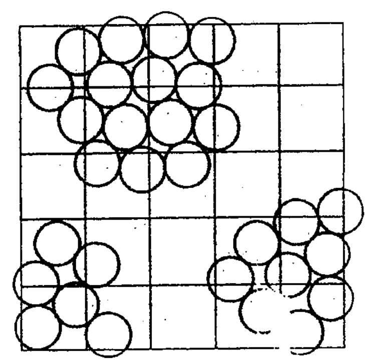
It is anticipated that most restoration projects will attempt to mimic natural conditions, i.e., random plant groupings rather than a linear, 'agricultural' planting scheme, or a linear hexagonal grid layout (higher density). Both 'hex grid' and grouped layouts are displayed for several models (note: the overall coverage remains the same whether a hex grid or grouped configuration is used, assuming no overlap).



Linear



Hexagonal Grid



Grouped

Habitat mitigation programs typically include a plant survival performance standard of 70-80%, and a target plant coverage of 70-85+%. Therefore, initial planting densities should reflect the allowed plant die-back to achieve target coverage, assuming no other source of shrub cover such as concurrent seed installation or natural seedling recruitment within a mitigation area.

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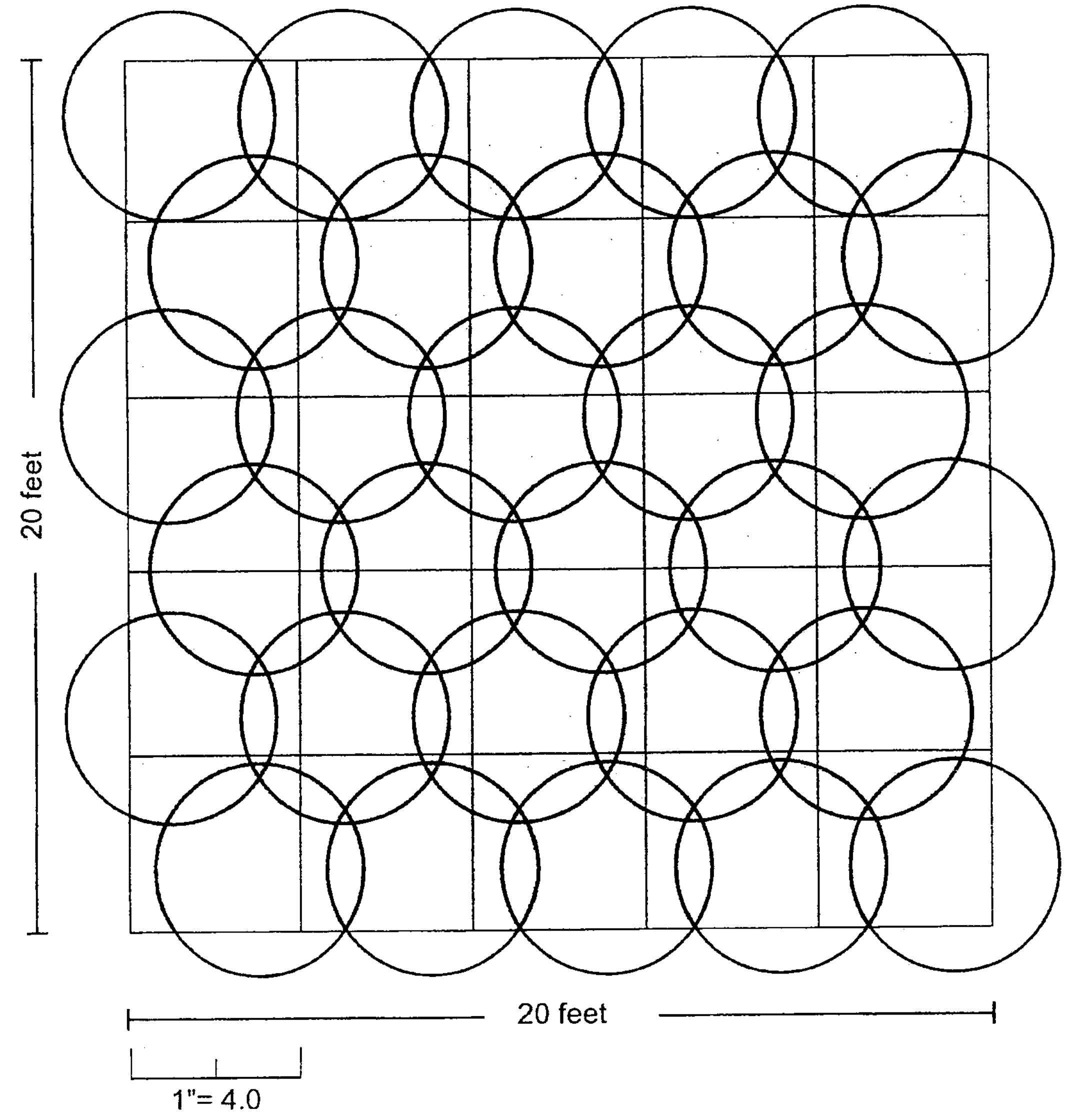

Sample layout of plants on 4-foot centers
(assuming 5-foot average plant diameter)

Approx. 29 plants per 400 square feet (overlap)

Mature shrub coverage: 141% (100%)

3,133 plants per acre

4-foot Centers

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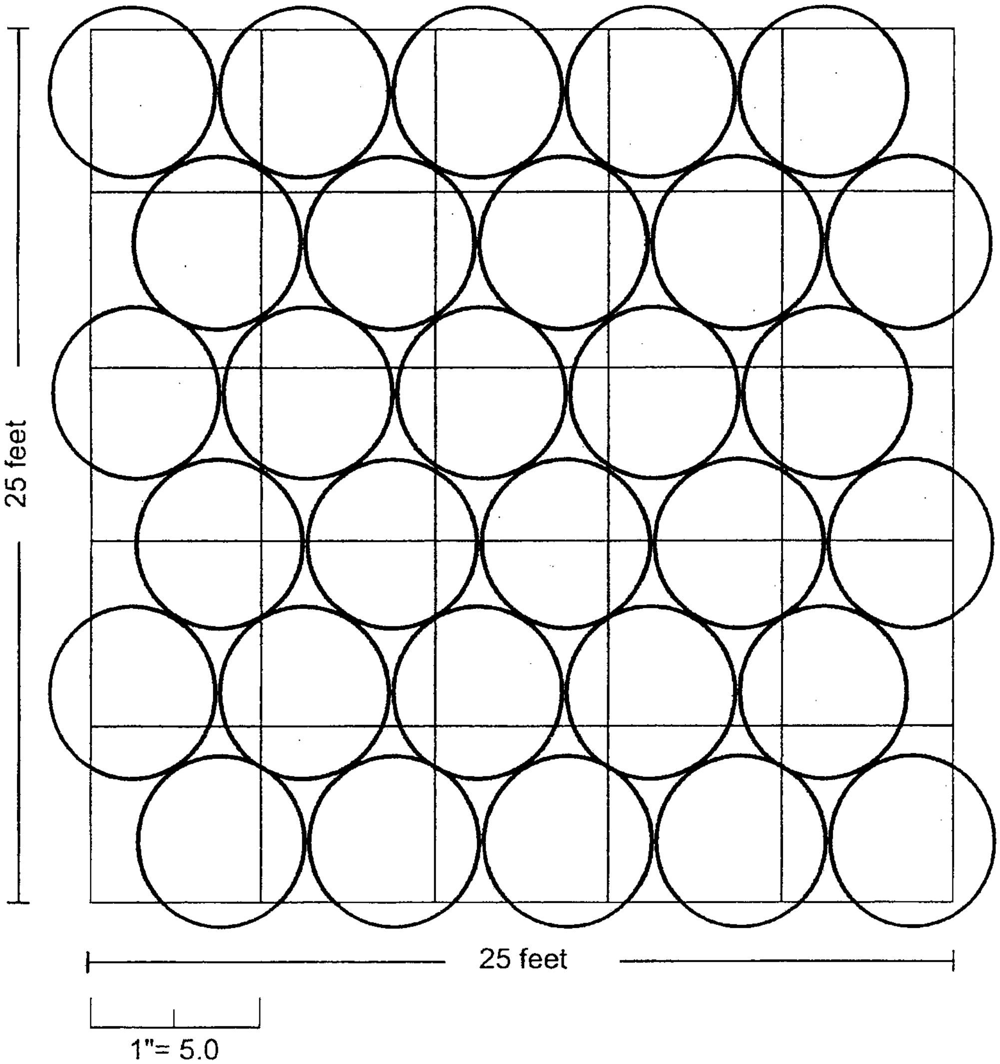

Sample layout of plants on 5-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 625 square feet

Mature shrub coverage: 91%

2,012 plants per acre

5-foot Centers

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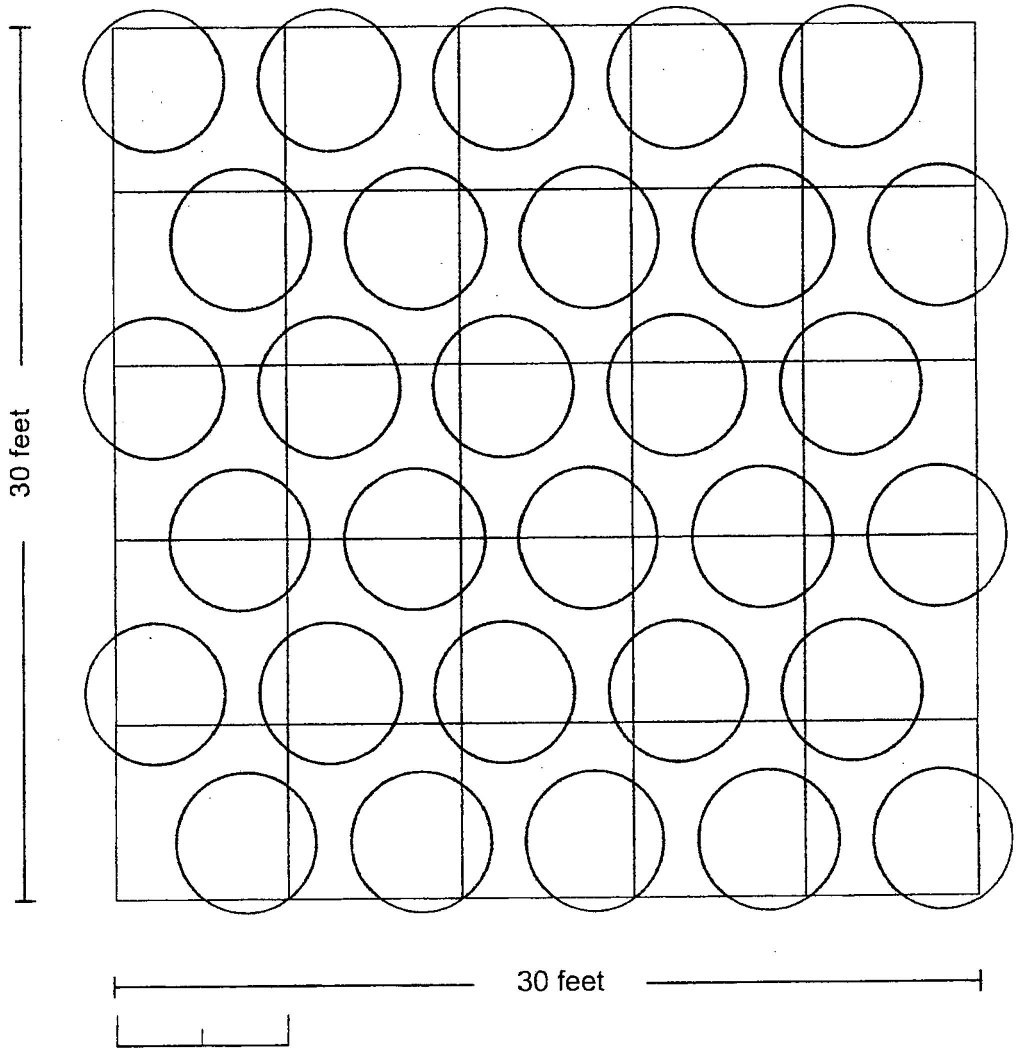

Sample layout of plants on 6-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 900 square feet

Mature shrub coverage: 63%

1,397 plants per acre

6-foot Centers

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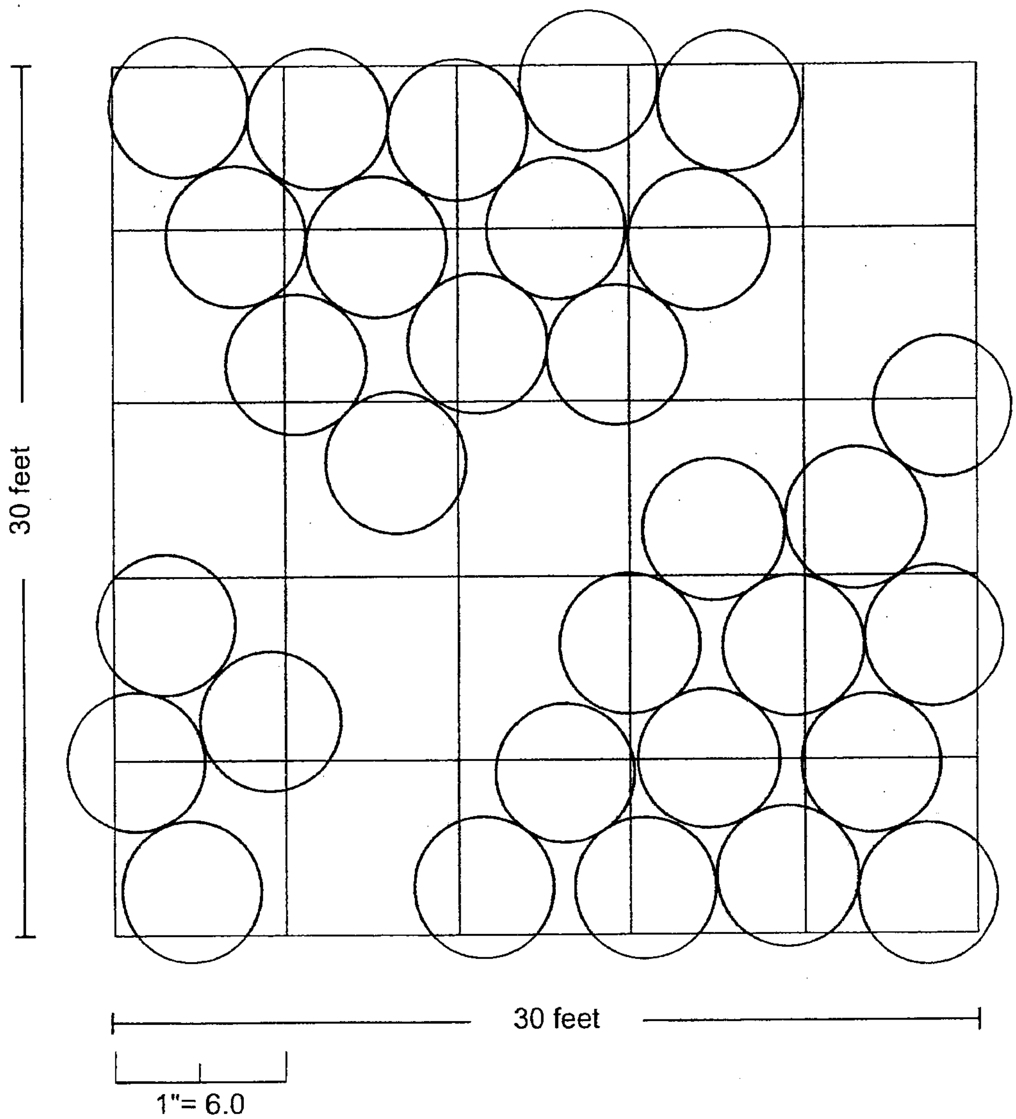

Sample layout of plants on 6-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 900 square feet

Mature shrub coverage: 63%

1,397 plants per acre

6-foot Centers, Grouped

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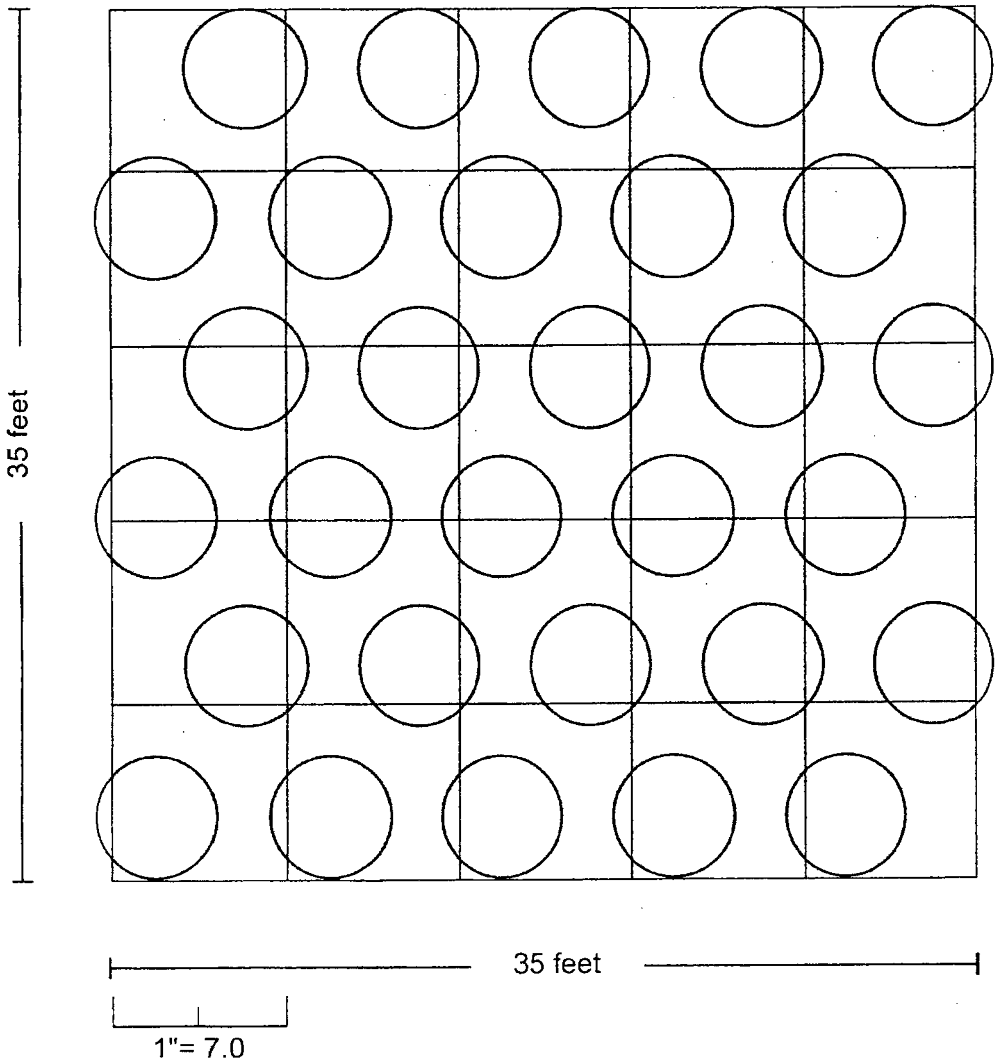

Sample layout of plants on 6-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 1,225 square feet

Mature shrub coverage: 46%

1,027 plants per acre

7-foot Centers

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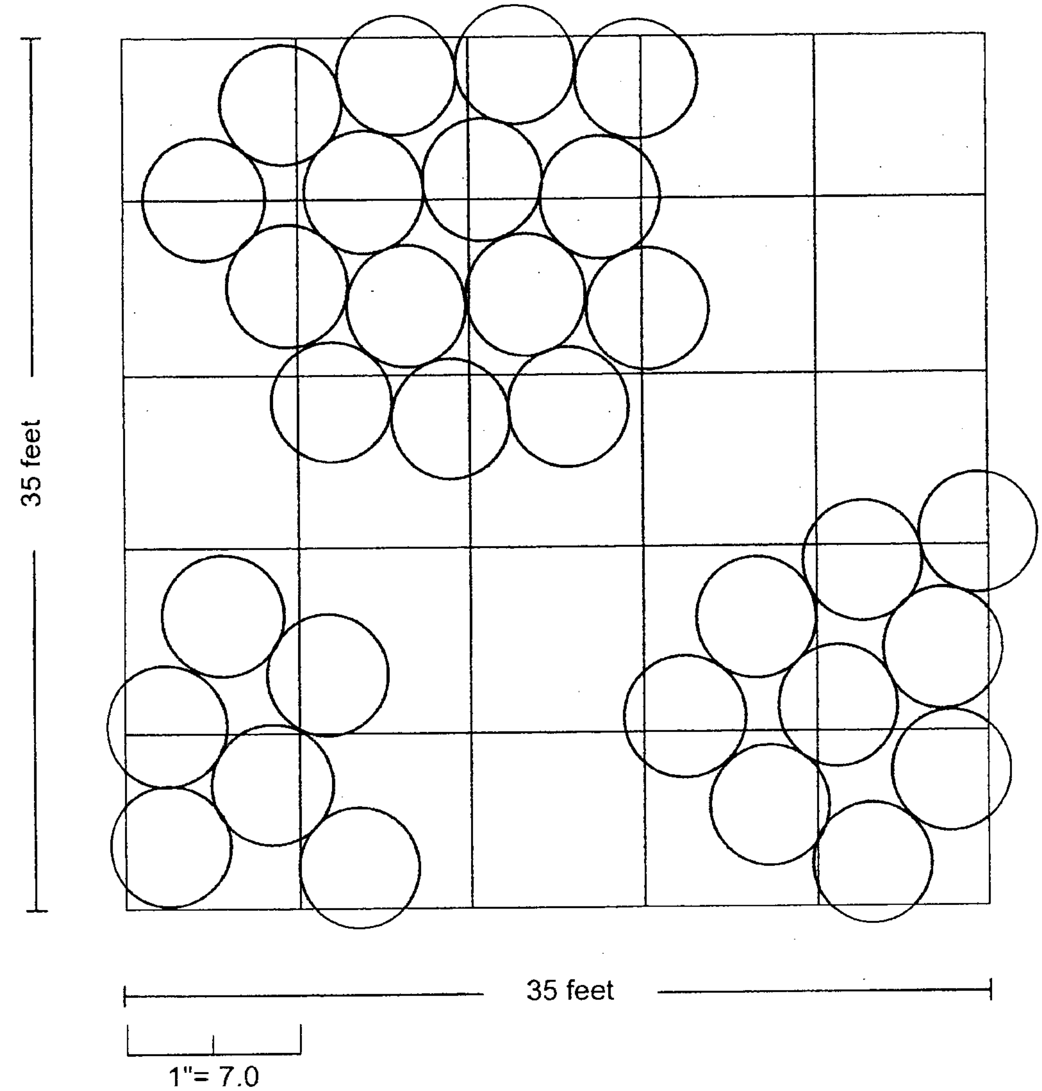

Sample layout of plants on 6-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 1,225 square feet

Mature shrub coverage: 46%

1,027 plants per acre

7-foot Centers, Grouped

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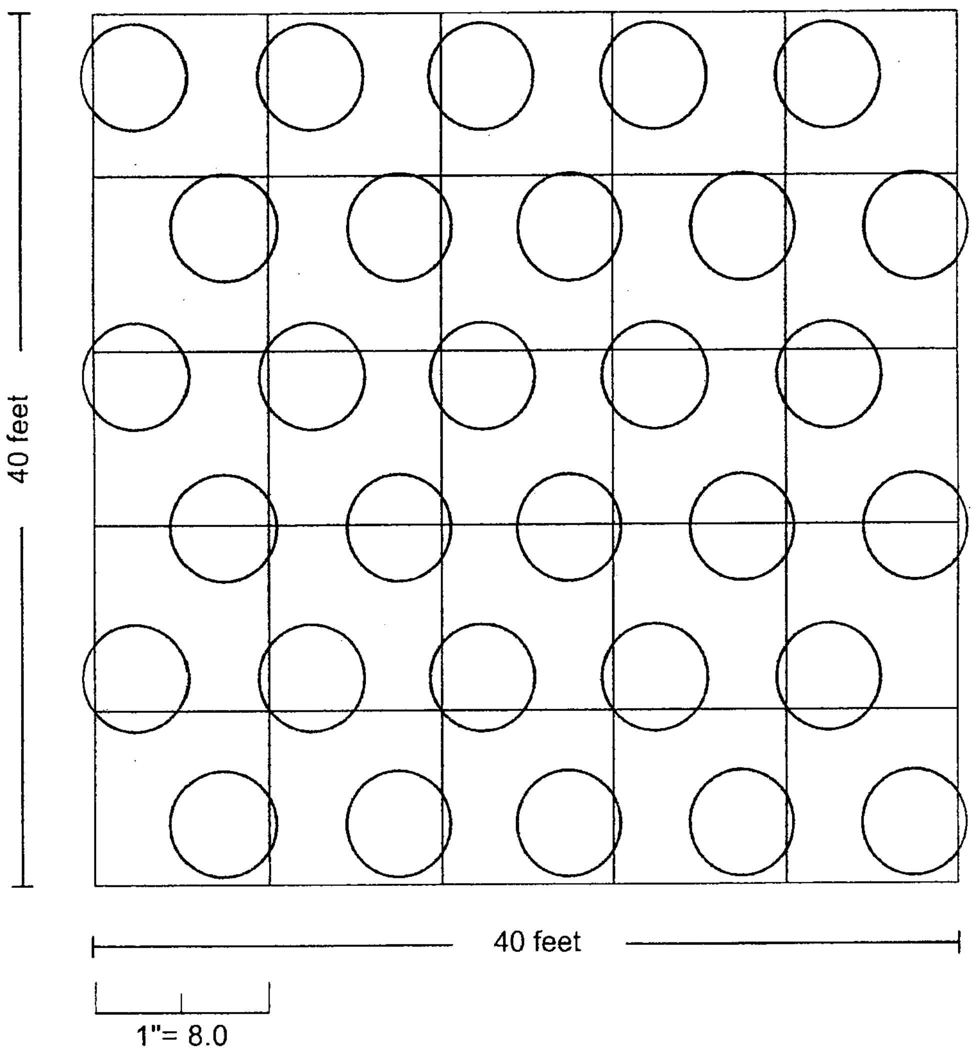

Sample layout of plants on 8-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 1,600 square feet

Mature shrub coverage: 35%

786 plants per acre

8-foot Centers

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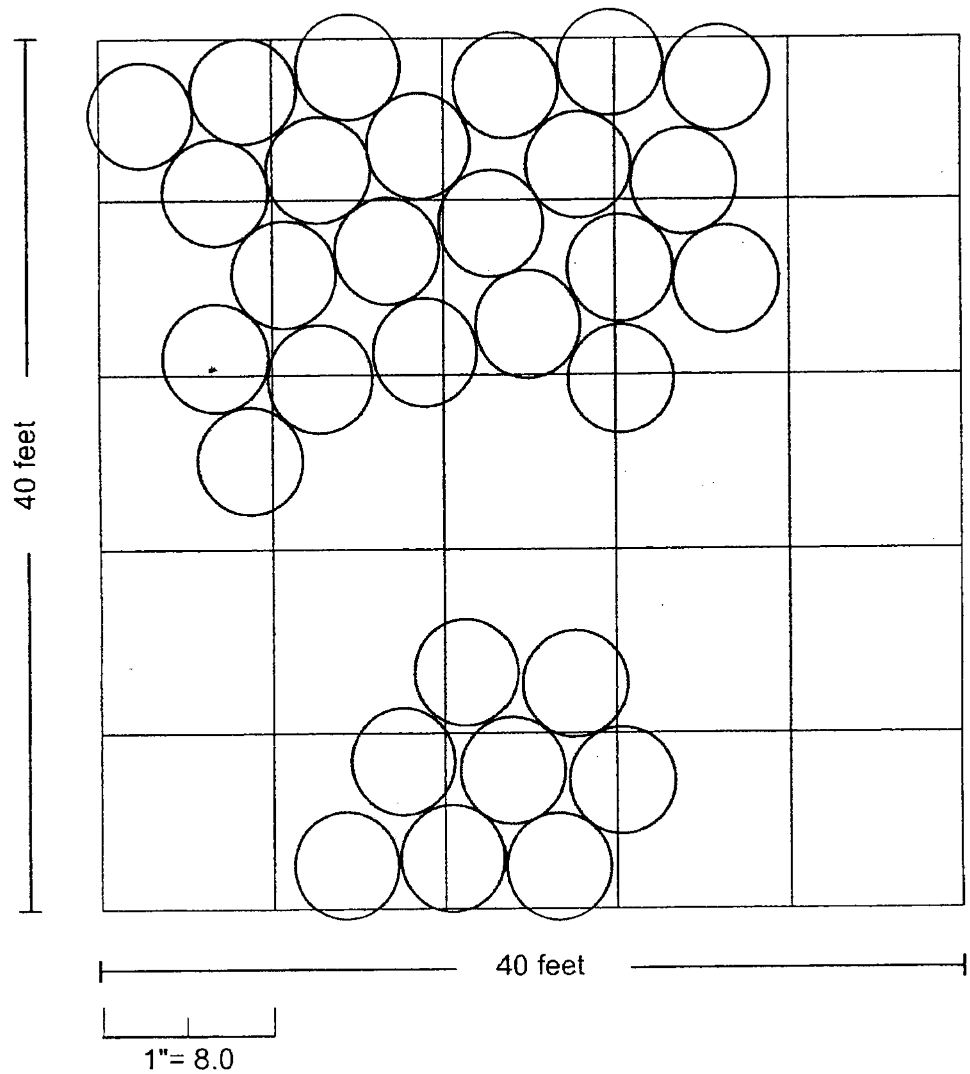

Sample layout of plants on 8-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 1,600 square feet

Mature shrub coverage: 35%

786 plants per acre

8-foot Centers, Grouped

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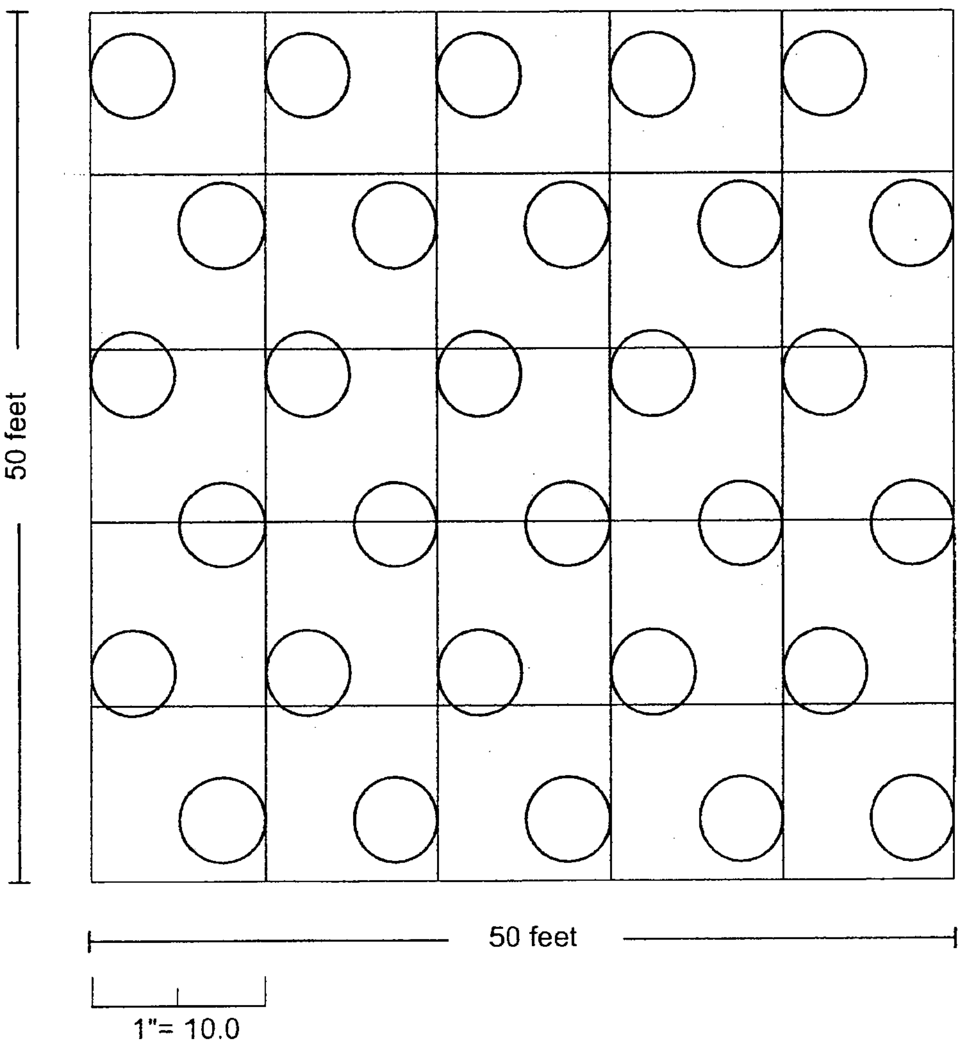

Sample layout of plants on 10-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 2,500 square feet

Mature shrub coverage: 23%

503 plants per acre

10-foot Centers

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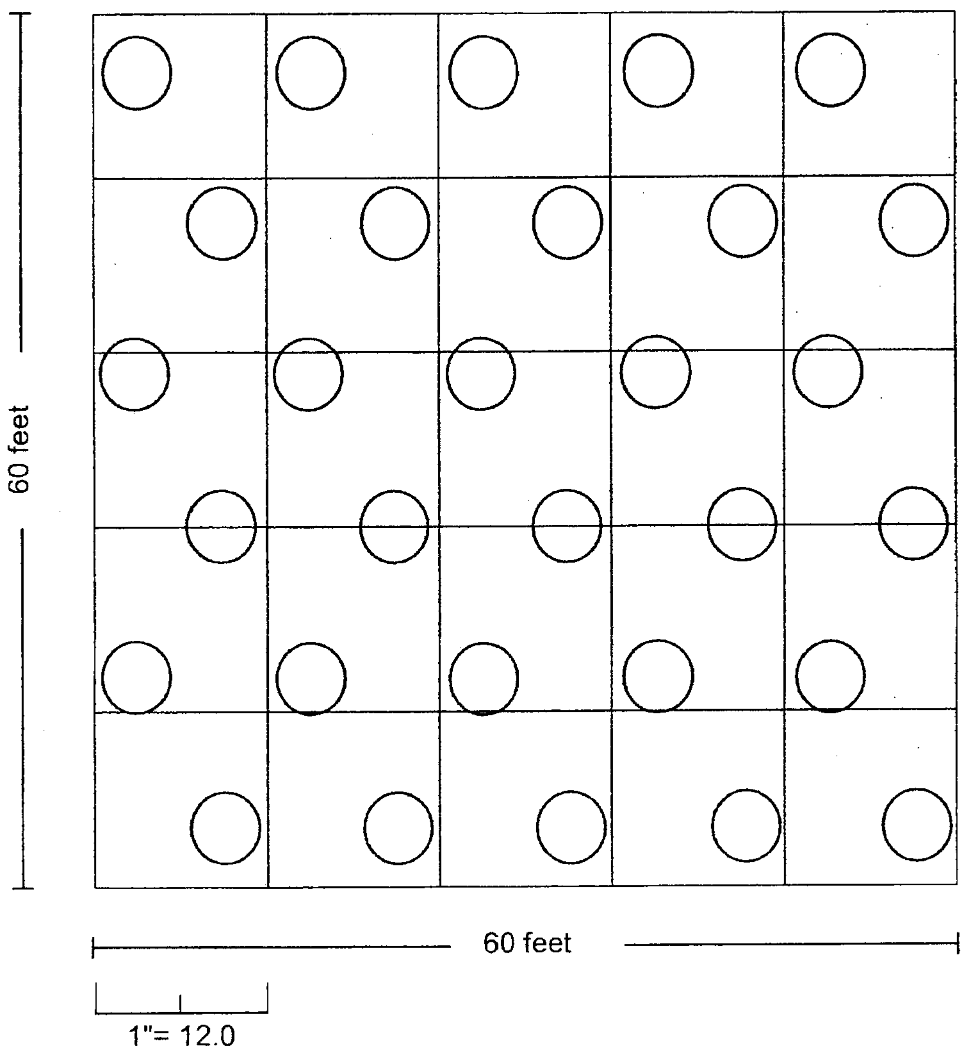

Sample layout of plants on 12-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 3,600 square feet

Mature shrub coverage: 16%

349 plants per acre

12-foot Centers

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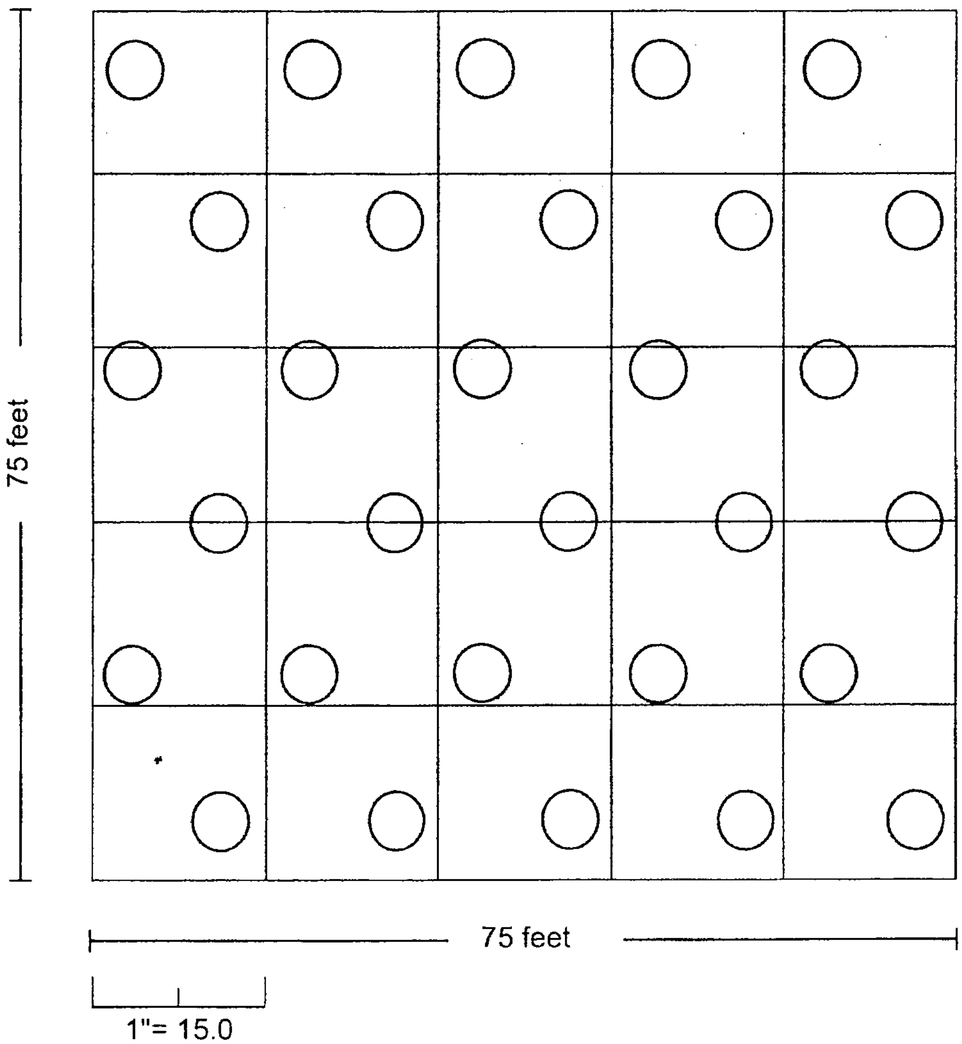

Sample layout of plants on 15-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 5,625 square feet

Mature shrub coverage: 10%

224 plants per acre

15-foot Centers

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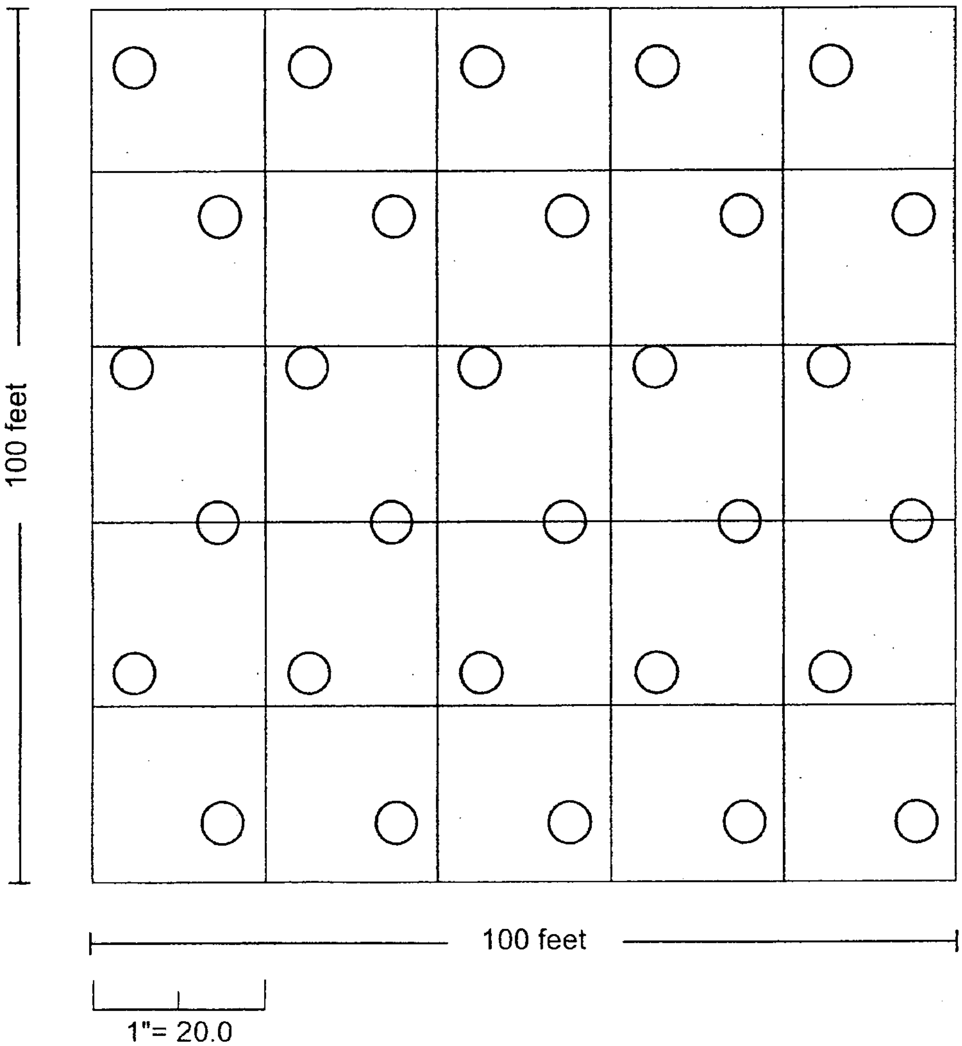

Sample layout of plants on 20-foot centers
(assuming 5-foot average plant diameter)

Approx. 30 plants per 10,000 square feet

Mature shrub coverage: 6%

126 plants per acre

20-foot Centers

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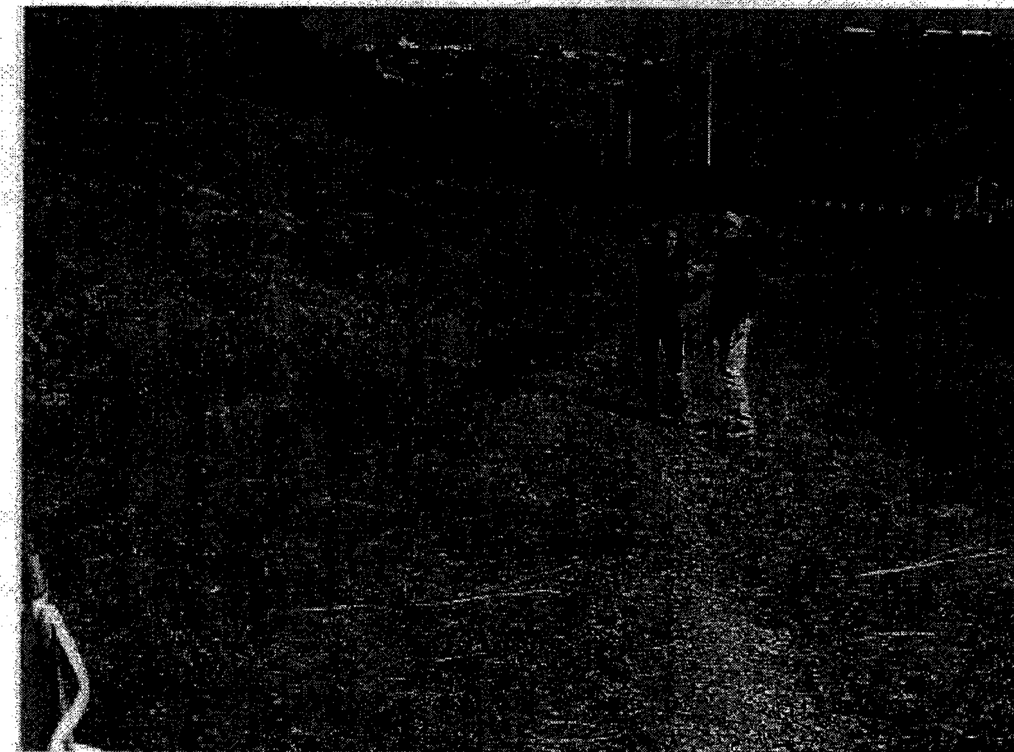
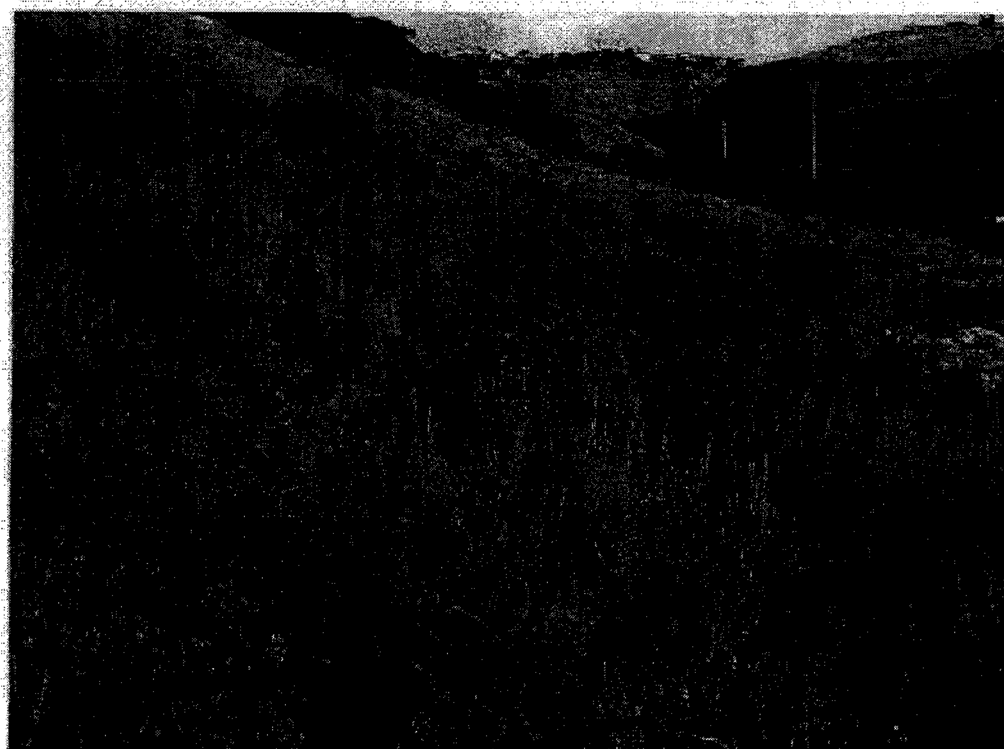




Coastal Sage Scrub Restoration: Before, and After One Year **Exhibit 1**

Peninsula Point Development
Coastal Sage Scrub Mitigation Program

BonTerra CONSULTING

Coastal Sage Scrub Restoration: Before, and After One Year **Exhibit 2**

Peninsula Point Development
Coastal Sage Scrub Mitigation Program

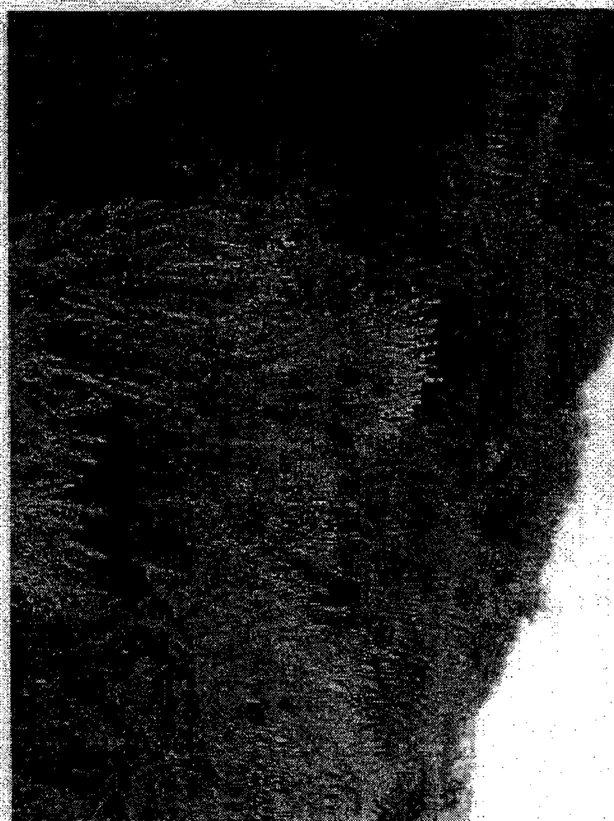
BonTerra CONSULTING


Peninsula Point CSS Restoration–BonTerra Consulting_01


Peninsula Point CSS Restoration–BonTerra Consulting_02


Peninsula Point CSS Restoration–BonTerra Consulting_03


Peninsula Point CSS Restoration–BonTerra Consulting_04



Peninsula Point CSS Restoration–BonTerra Consulting_05

Peninsula Point CSS Restoration–BonTerra Consulting_06

Peninsula Point CSS Restoration–BonTerra Consulting_07

Peninsula Point CSS Restoration–BonTerra Consulting_08

Peninsula Point CSS Restoration-BonTerra Consulting_09

Peninsula Point CSS Restoration-BonTerra Consulting_10

Peninsula Point CSS Restoration-BonTerra Consulting_11

Peninsula Point CSS Restoration-BonTerra Consulting_12

EXHIBIT "G"

RIPARIAN MITIGATION PLAN

[See attached]

SCANNED

FINAL
RIPARIAN MITIGATION AND MONITORING PLAN FOR THE TONNER HILLS PLANNED COMMUNITY

Prepared for:

SHEA HOMES
603 S. Valencia Ave.
Brea, California 92823
USA
(714) 792-2508

Modified and Updated by:

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29 Orchard,
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Original Prepared by:

CHAMBERS GROUP, INC.
17671 Cowan Avenue, Suite t00
Irvine, California 92614
(949) 261-5414

Modified May 2005
U.S. Army Corps Permit Number 199916501
Original Prepared November 2003

* *All changes from the 2003 HMMP are indicated with italics*

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SECTION 1.0 - INTRODUCTION AND PROJECT DESCRIPTION

1.1 INTRODUCTION

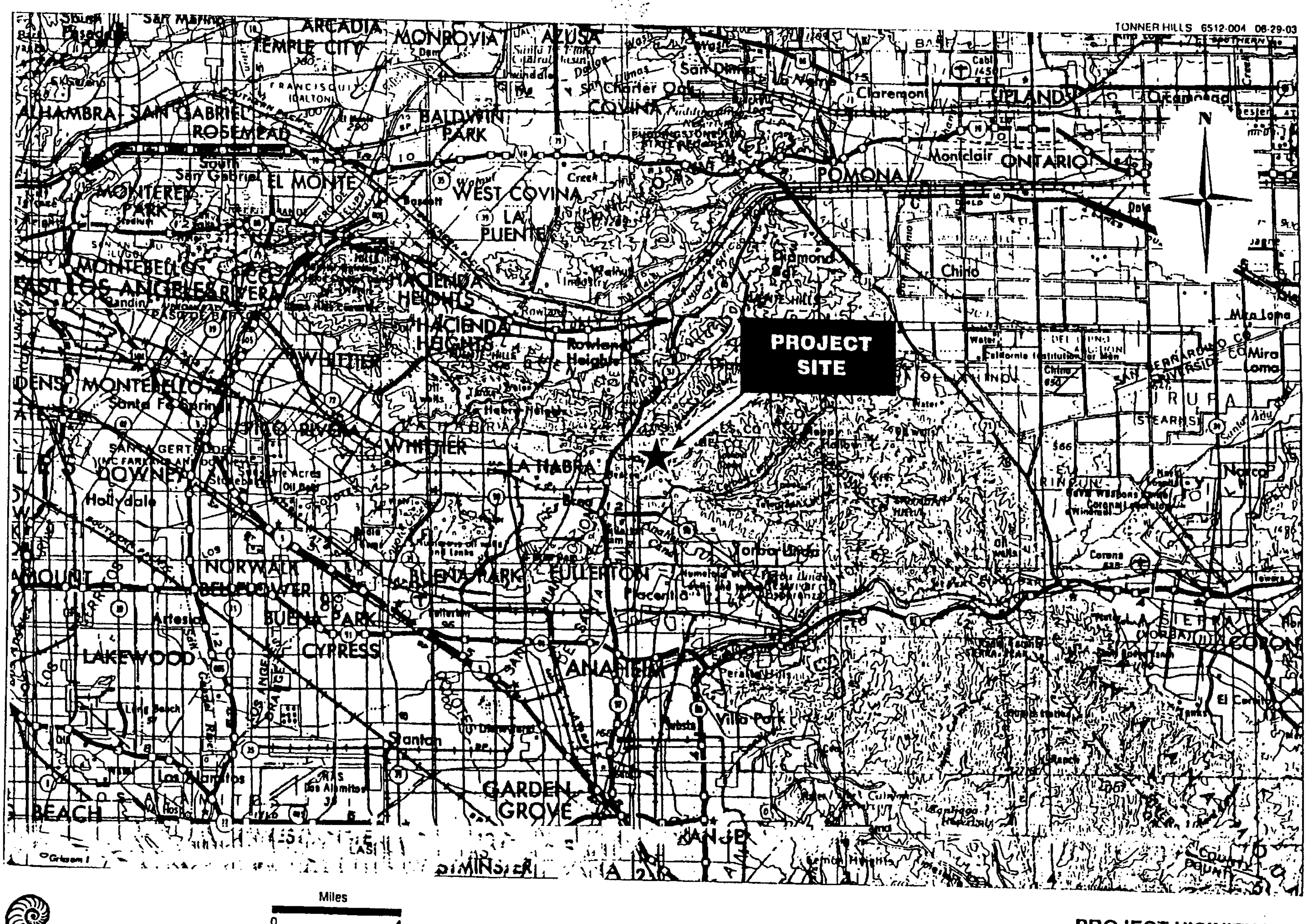
Glenn Lukos Associates was retained by Shea Homes to update and modify the Tonner Hills Planned Community Final Riparian Mitigation and Monitoring Plan (US Army Corps Permit Number 19991650), *originally prepared by Chambers Group, Inc. (Chambers Group) for Nuevo Energy Company (Nuevo), Bakersfield, California, to reflect changes requested by Dan Swenson (Corps) for the.* The HMMP is based on literature reviews, reconnaissance-level biological surveys, wetland/waters of the United States verification surveys, sensitive plant surveys, and a previous draft riparian restoration and enhancement plan.

The original HMMP prepared by Chambers Group incorporated the mitigation plan for soil remediation activities within Drainage 5 that were authorized by US Army Corps Permit Number #200001421-YJC. Per the Corp's request, the mitigation required by Permit Number #200001421-YJC will be kept under separate cover and is not further addressed in this plan. The HMMP describes the mitigation proposed to offset unavoidable impacts to State and federal jurisdictional drainages associated with the development of the Tonner Hills Planned Community. The HMMP follows the Habitat Mitigation and Monitoring Proposal Guidelines, issued in June 1993 and revised in January 2003, issued by the United States Army Corps of Engineers (Corps) Los Angeles District Regulatory Branch.

1.2 PROJECT LOCATION

The Tonner Hills project site is an approximately 789.8-acre site located in the County of Orange, north of the City of Brea, California (Figure 1-1). *The site is owned by Shea Homes with oil lease rights retained by BlackSands and Aera Energy.* The site is bounded by Lambert Road to the south, Tonner Creek to the north, Valencia Avenue to the east, and the 57 Freeway bisects the western portion of the site (Figure 1-2). Regionally, the site lies within the northwestern portion of the Chino Hills and southeastern portion of the Puente Hills. Tonner Creek is located along the northern boundary of the project site. The riparian restoration site is located adjacent to Tonner Creek. Nine drainages flow down the south facing slopes of the project site. The largest of these drainages is in Cable Canyon. The riparian enhancement project is located in Cable Canyon.

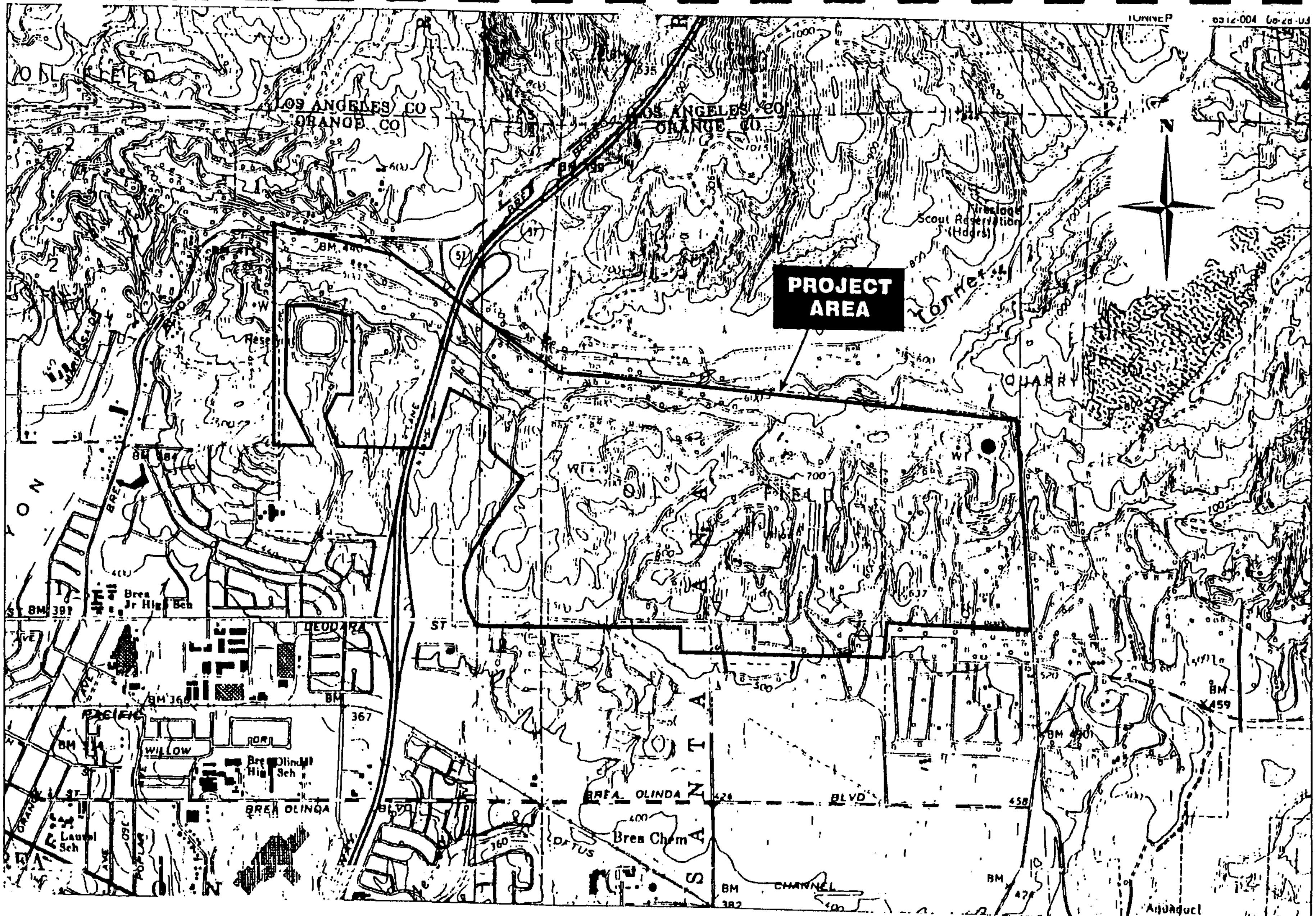
The project site comprises a series of low hills and ridges, and ranges in elevation from approximately 500 to 800 feet above sea level. The site is composed of several different vegetation communities, and many oil well pads and access roads are present throughout the site. Surrounding land uses include residential development to the south and west, similar native habitat within Tonner Canyon to the north, and oil production lands to the east and northwest. The project site is located on the USGS Yorba Linda and La Habra 7.5-minute topographic quadrangles.



Chambers Group

Base Map Source: USGS 1: 250,000
Santa Ana, Long Beach, Los Angeles, San Bernardino, CA

PROJECT VICINITY MAP
TONNER HILLS
Figure 1-1



Feet

0 2000

Base Map Source: USGS 1: 24,000
La Habra, Yorba Linda, CA

Chambers Group

PROJECT LOCATION MAP
TONNER HILLS
Figure 1-2

1.3 BRIEF SUMMARY OF OVERALL PROJECT

The proposed Tonner Hills project includes the development of a master planned community on approximately 191.2 acres of an existing oil field. The Tonner Hills project proposes residential, commercial, and recreational uses on the property. The project proposes the development of up to 795 residential units distributed in 7 distinct neighborhoods on 180.0 acres, 14.6 acres to be retained as Wildcatters Park, 21.5 acres for public use areas, 19.2 acres to be retained as P[illegible] Roadway System, and 77.0 acres to remain as oil and gas development and associated pads and roads. Some oil field facilities are scheduled to remain in place. Others will be abandoned or relocated.

The proposed Tonner Hills project includes an extensive habitat restoration and enhancement program within the approximately 514.1 acres, as required by the County of Orange to be designated as habitat conservation area. This area will support native plant communities. In addition, the open space areas are designed to preserve the wildlife corridor between areas along Tonner Creek west of the 57 Freeway and areas located north and east of the Tonner Hills project site.

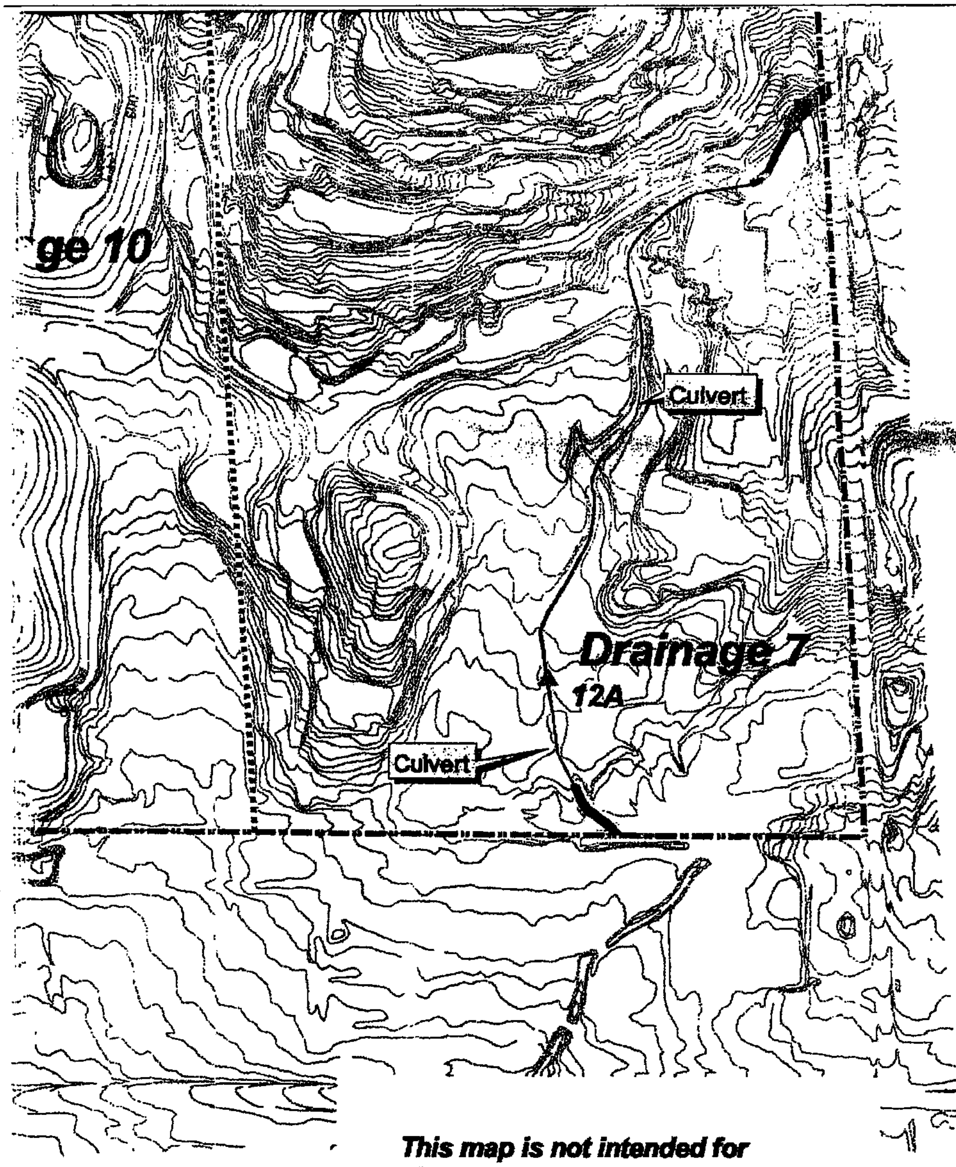
The applicant proposes to preserve all of Tonner Creek, which is part of the wildlife movement corridor in Tonner Canyon. Most of Cable Canyon, the largest north/south drainage on the south side of the ridge that delineates Tonner Canyon, also would be preserved. Cable Canyon contains a large concentration of California walnut trees (i.e., 5.5 acres) but the habitat also contains a large percentage of exotic plant species. Approximately 5.5 acres of riparian habitat will be preserved within Cable Canyon. The approximately 5.5 acres of the native communities in Cable Canyon will be enhanced by the removal of the exotics and planting of native riparian woodland species.

This HMMP provides for the enhancement of preserved habitat in Cable Canyon. This project will augment the ecological integrity of the area and in turn, support local and migratory wildlife.

1.4 EXISTING RESOURCES

Wetlands and Waters of the United States

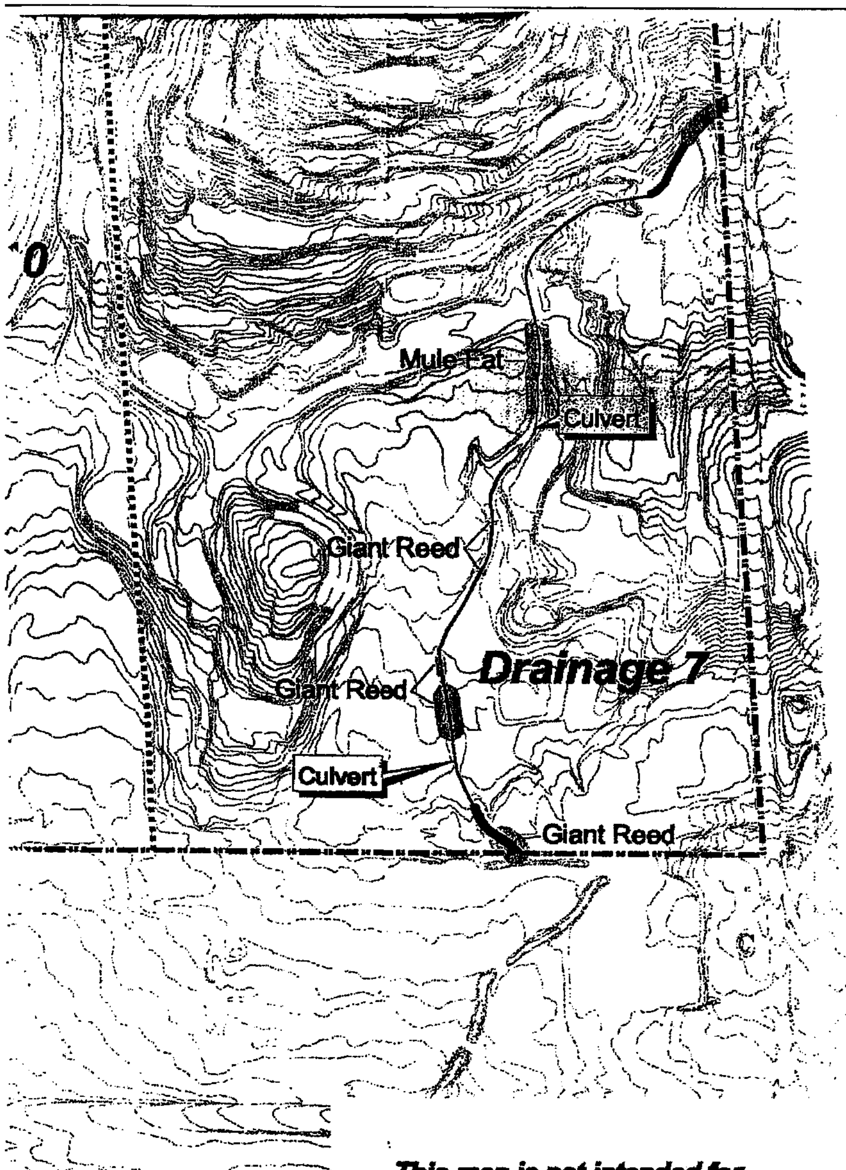
Chambers Group's Wetlands Specialists conducted the Corps and CDFG delineations on the Tonner Hills site. A total of 6.05 acres on the site fall under the jurisdiction of the Corps, including 3.11 acres that meet the Corps criteria for wetlands. A total of 16.93 acres on the site fall under CDFG jurisdiction. Figure 1-3 shows the location of waters of the United States and wetlands under the jurisdiction of the Corps and Figure 1-4 shows the location of areas under jurisdiction of the CDFG. Table 1-1 summarizes the acreage of drainages and waters of the United States on the property,



This map is not intended for site-specific purposes.

Chambers Group Inc.
Produced by:
Leslie Backus

July, 2001



This map is not intended for site-specific purposes.

Chambers Group Inc.
Produced by:
Leslie Backus

July, 2001

Table 1-1
Waters of the United States and
CDFG Jurisdiction at Tonner Hills (Acres)

	Corps Jurisdiction			CDFG Jurisdiction		
Drainage	**Jurisdictional Wetlands (Acres)**	**Other Jurisdictional Waters (Acres)**	**Total Waters of the U.S. (Acres)**	**Riparian Habitat**	**Unvegetated Channel**	**Total CDFG Jurisdiction (Acres)**
Drainage 1 (Tonner Creek)	2.85	0	2.85	7.07	0	7.07
Drainage 2	0	0.55	0.55	0	0.55	0.55
Drainage 3	0	1.31	1.31	6.52	1.31	7.83
Drainage 4	0	0.17	0.17	0	0.17	0.17
Drainage 5	0	0.29	0.29	0	0	0
Drainage 6	0.16	0	0.16	0.16	0	0.16
Drainage 7	0.10	0.32	0.42	0.42	0.34	0.70
Drainage 8	0	0.19	0.19	0.15	0.19	0.34
Drainage 9	0	0.07	0.07	0	0.07	0.07
Drainage 10	0	0.04	0.04	0	0.04	0.04
Total	**3.11**	**2.94**	**6.05**	**14.32**	**2.40**	**16.93**

1.5 SUMMARY OF IMPACTS TO WETLANDS AND WATERS OF THE UNITED STATES

The development will permanently impact 0.80 acres of federally delineated waters. However, no areas of federally defined wetlands will be affected by the proposed project. The following impact analysis refers only to CDFG jurisdiction streambed and riparian habitat because the acres of CDFG jurisdiction on the site exceed and include that under Corps jurisdiction. Therefore. mitigation for impacts to CDFG jurisdiction streambed and riparian habitat will more than adequately compensate for impacts to those areas under the joint jurisdiction of the Corps and CDFG.

The amount of CDFG jurisdictional impacted by the project is 2.05 acres of streambed and riparian habitat. Approximately 0.51 acres of impacts occur in unvegetated, ephemeral drainages. An ephemeral drainage is defined as one that carries water only during storm events. An additional 1.54 acres of riparian vegetation will be impacted, including 0.17 acres of giant reed (*Arundo donax*), an aggressive noxious weed, located in Drainage 7.

Table 1-2 summarizes the effects of the proposed project to CDFG jurisdiction and Table 1-3 summarizes the effects of the proposed project to Corps jurisdictional drainages.

Table 1-2
Impacts of Project on CDFG Jurisdiction
Within the Tonner Hills Property (Acres)

Drainage	Total CDFG Jurisdiction (Acres) on Site	Impacts to Riparian Habitat	Impacts to Unvegetated Channel	Total Impacts
Drainage 1 (Tonner Creek)	7.07	0	0	0
Drainage 2	0.55	0	0	0
Drainage 3	7.83	1.08	0	1.08
Drainage 4	0.17	0	0.09	0.09
Drainage 5	0	0	0	0
Drainage 6	0.16	0	0	0
Drainage 7	0.70	0.31[1]	0.19	0.50
Drainage 8	0.34	0.15	0.19	0.34
Drainage 9	0.07	0	0	0
Drainage 10	0.04	0	0.04	0.04
Total	**16.93**	**1.54**	**0.51**	**2.05**

[1] Includes 0.17 acres of *Arundo donax*

Table 1-3
Impacts of Project on Corps Jurisdiction
Within the Tonner Hills Property (Acres)

Drainage	Total Corps Jurisdiction (Acres) on Site	Impacts to Jurisdictional Wetlands (Acres)	Impacts to Other Jurisdictional Waters (Acres)	Total Impacts to Waters of the U.S. (Acres)
Drainage 1 (Tonner Creek)	2.85	0	0	0
Drainage 2	0.55	0	0	0
Drainage 3	1.31	0	0	0
Drainage 4	0.17	0	0.09	0.09
Drainage 5	0.29	0	0.29	0.29
Drainage 6	0.16	0	0	0
Drainage 7	0.42	0	0.19	0.19
Drainage 8	0.19	0	0.19	0.19
Drainage 9	0.07	0	0	0
Drainage 10	0.04	0	0.04	0.04
Total	**6.05**	**0**	**0.80**	**0.80**

1.6 RESPONSIBLE PARTIES

Shea Homes will be responsible for ongoing monitoring of the original mitigation plan as implemented by Nuevo. The contact person is:

Mr. Steve Armanino
Community Director
Shea Homes
603 S. Valencia Avenue
Brea, California 92821
(714) 985-4356 voice
(714) 577-6239 fax

Glenn Lukos Associates has modified and updated the original mitigation prepared by Chambers Group. The contact person is:

Ms. Ingrid Chlup
Regulatory Specialist
29 Orchard
Lake Forest, CA 92630-8300
(949) 837-0404 xt 35
(949) 837-5834 fax

The contact person for Chambers Group is:

Ms. Mari Schroeder
Program Manager
Chambers Group, Inc.
17671 Cowan Avenue, Suite 100
Irvine, California 92614
(949) 261-5414 tel
(949) 261-8950 fax
Restoration Specialist

The Restoration Specialist shall be a qualified Biologist/Restoration Ecologist who is familiar with the biology and ecology of southern California plant communities and shall have experience in horticultural practices commonly used for habitat restoration and revegetation. The specialist's name, address, telephone number, and email address (if available) shall be provided to all permitting agencies. The Restoration Specialist will be aided by approved biological monitor(s), revegetation contractors, and maintenance contractors. The Restoration Specialist or an approved biological monitor shall be a present at all preconstruction and pregrading meeting. In addition, the monitor shall be onsite during all construction activities involving removal of vegetation resulting from project implementation to ensure compliance with resource-related mitigation measures and conditions of approval contained in the permits.

SECTION 2.0 - DESCRIPTION AND GOALS OF THE MITIGATION PROGRAM

Section 2.0 provides a brief description of the natural resources that currently exist at the Tonner Hills site and the changes that have been ongoing and/or will occur due to the riparian habitat creation and enhancement efforts described in the HMMP as well as the coastal sage scrub habitat creation and enhancement efforts described in the Final Coastal Sage Scrub Mitigation and Monitoring Plan (Mitigation Plan) (Chambers Group 2003).

2.1 INTRODUCTION

Mitigation may take various forms, including avoiding and minimizing impacts as well as offsetting unavoidable impacts such as creating or enhancing in-kind replacement habitats. The HMMP for the Tonner Hills site provides for the enhancement of 5.5 acres of disturbed walnut woodland onsite.

2.2 PRESERVED HABITATS AND RESOURCES

Drainages and Riparian Woodlands

Riparian woodland and riparian scrub vegetation represent highly productive communities for both plants and wildlife, offering diverse habitat values because of the multiple vegetation layers. Because of the linear nature of most riparian systems, they typically provide suitable habitat for animals migrating between large open space areas and are essential for maintaining viable wildlife populations among fragmented habitat blocks. The southern arroyo willow scrub located along Tonner Creek near the north boundary of the site is an example of such a linear system. The Tonner Hills project was designed to preserve approximately 12.2 acres of southern arroyo willow woodland along Tonner Creek.

The project was also designed to avoid impacts to 5.5 acres of habitat (primarily disturbed walnut woodlands) associated with the drainage in Cable Canyon. The enhancement plan for this area includes removal of nonnative species and replacement planting with native species.

Coastal Sage Scrub

Approximately 126.5 acres of existing coastal sage and southern cactus scrub will be preserved onsite as part of the proposed development plan. The preserved areas include 4.3 acres of southern cactus scrub and approximately 30.7 acres of disturbed coastal sage scrub. Enhancement of the disturbed acres of the preserved coastal sage scrub community is provided in the Mitigation Plan.

Coast Live Oak and Walnut Woodlands

The proposed project preserves 72.9 acres of existing coast live oak and California walnut woodlands on the site, including 17.6 acres of California walnut woodland with a coastal sage scrub understory. Approximately 28.9 acres of the preserved woodlands are disturbed. Enhancement of 5.5 acres of disturbed walnut woodlands is included as part of this HMMP. Table 2-1 summarizes the preserved resources on the site.

Table 2-1
Vegetation Communities Preserved at the Tonner Hills Site

Vegetation Community	Total Acres Existing	Total Acres Impacted	Total Acres Preserved
SCRUB AND GRASSLAND HABITATS			
Mixed Coastal Sage Scrub (CSS)	54.7	32.7	22.0
Artemisia dominated (Sagebrush Scrub)	47.0	9.2	37.8
Sagebrush-Coyote Brush Scrub	7.0	3.8	3.2
Mixed CSS-Coyote Brush Scrub	17.4	0.0	17.4
Mixed CSS-Southern Cactus Scrub	15.3	5.8	9.5
Mixed CSS - Mule Fat Scrub	2.4	2.4	0.0
Sub-total Coastal Sage Scrub	**143.8**	**53.9**	**89.9**
Disturbed Mixed CSS	43.5	24.3	19.2
Disturbed Artemisia (Sagebrush Scrub)	5.8	0.0	5.8
Disturbed Artemisia - Coyote Brush Scrub	1.0	0.0	1.0
Disturbed Mixed CSS-Southern Cactus Scrub	4.7	0.0	4.7
Sub-total Disturbed Coastal Sage Scrub	**55.0**	**24.3**	**19.2**
Southern Cactus Scrub	9.4	5.5	3.9
Coyote Brush Scrub	1.5	1.5	0.0
Coyote Brush-Mule Fat Scrub	3.4	1.8	1.6
Mule Fat Scrub	0.2	0.0	0.2
Mule Fat Scrub-Ornamental	1.8	0.0	1.8
Annual Grassland	145.0	52.8	92.2
Sub-total other Scrub and Grasslands	**161.3**	**61.6**	**99.7**
RIPARIAN AND WOODLAND HABITATS			
Coast Live Oak Woodland	3.5	0.0	3.5
California Walnut Woodland/CSS understory	26.4	5.8	20.6
California Walnut Woodland/Grassland understory	18.0	0.0	18.0
Mixed California Walnut - Coast Live Oak	5.8	0.0	1.3
Southern Arroyo Willow Woodland	12.3	0.0	12.3
Sub-total Woodlands	**66.0**	**5.8**	**60.2**
Disturbed California Walnut Woodland/CSS understory	1.4	1.4	0.0
Disturbed Mixed California Walnut- Coast Live Oak	5.9	0.0	1.3

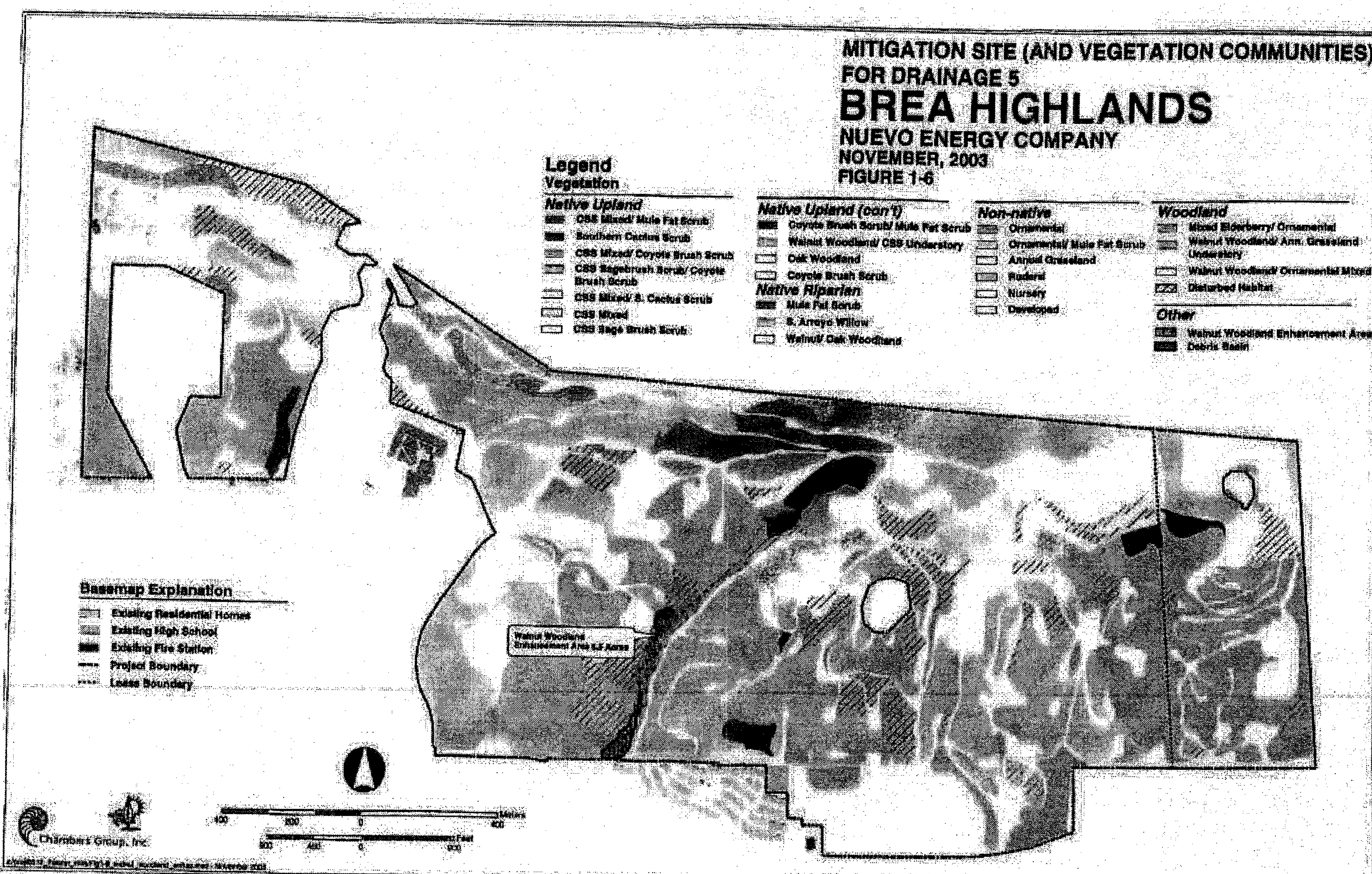
Table 2-1 (Continued)
Vegetation Communities Preserved at the Tonner Hills Site

Vegetation Community	Total Acres Existing	Total Acres Impacted	Total Acres Preserved
Disturbed California Walnut - Ornamental	31.2	8.2	23
Mixed Mexican Elderberry - Ornamental	1.3	0.0	1.3
Sub-total Disturbed Woodlands	**39.8**	**9.6**	**30.2**
ORNAMENTAL, DISTURBED, AND DEVELOPED AREAS			
Ornamental	98.6	76.4	22.2
Ruderal	21.5	17.4	4.1
Former Nursery	19.1	18.2	0.9
Developed	184.7	97.2	87.5
Sub-total Ornament, Disturbed, Developed Areas	**323.9**	**209.2**	**114.70**
TOTAL	**789.8**	**364.4**	**425.4**

2.3 TYPES OF HABITATS TO BE ENHANCED OR CREATED

A total of 5.5 acres of walnut woodland will be enhanced during project implementation. The location of this enhancement is shown in Figures 1-5 and 1-6. Enhancement entails the removal of invasive exotic species including giant reed (*Arundo donax*) and Peruvian pepper trees (*Schinus molle*) from existing walnut woodland habitat within Cable Canyon. The enhancement area will then be replanted with native species designed to create a diverse native plant community resistant to invasion by nonnative species. In addition to enhancement plantings of California walnut (*Juglans californica*) and Mexican elderberry (*Sambucus mexicana*), the species composition for the walnut woodland enhancement area includes native shrub and perennial species such as coyote brush (*Baccharis pilularis*) and purple needle grass (*Nassella pulchra*).

In addition to the enhancement of native habitat in Cable Canyon, approximately 116.6 acres of coastal sage scrub will be created during project implementation, and 19.1 acres of preserved coastal sage scrub habitat will be enhanced by removing exotic species. The specifications for the creation and enhancement of coastal sage scrub habitat on the site is addressed in the Mitigation Plan. Once revegetation and enhancement is implemented and becomes established, it will provide a site that will minimize erosion, be resistant to invasion by non-native plant species, and increase biotic interactions between micro- and macroorganisms, thus creating a closed nutrient system in which organic matter and nitrogen are cycled in a self-sustaining system. The acres of preservation, enhancement, and creation/revegetation areas are summarized in Table 2-2.


MITIGATION SITE (AND VEGETATION COMMUNITIES)
FOR DRAINAGE 5
BREA HIGHLANDS
NUEVO ENERGY COMPANY
NOVEMBER, 2003
FIGURE 1-6
Legend
Vegetation
Native Upland
CSS Mixed/ Mule Fat Scrub
Southern Cactus Scrub
CSS Mixed/ Coyote Brush Scrub
CSS Sagebrush Scrub/ Coyote Brush Scrub
CSS Mixed/ S. Cactus Scrub
CSS Mixed
CSS Sage Brush Scrub
Native Upland (con't)
Coyote Brush Scrub/ Mule Fat Scrub
Walnut Woodland/ CSS Understory
Oak Woodland
Coyote Brush Scrub
Native Riparian
Mule Fat Scrub
S. Arroyo Willow
Walnut/ Oak Woodland
Non-native
Ornamental
Ornamental/ Mule Fat Scrub
Annual Grassland
Ruderal
Nursery
Developed
Woodland
Mixed Elderberry/ Ornamental
Walnut Woodland/ Ann. Grassland Understory
Walnut Woodland/ Ornamental Mixed
Disturbed Habitat
Other
Walnut Woodland Enhancement Area
Debris Basin
Basemap Explanation
Existing Residential Homes
Existing High School
Existing Fire Station
Project Boundary
Lease Boundary
Walnut Woodland Enhancement Area 5.5 Acres
Meters
Feet
Chambers Group, Inc.

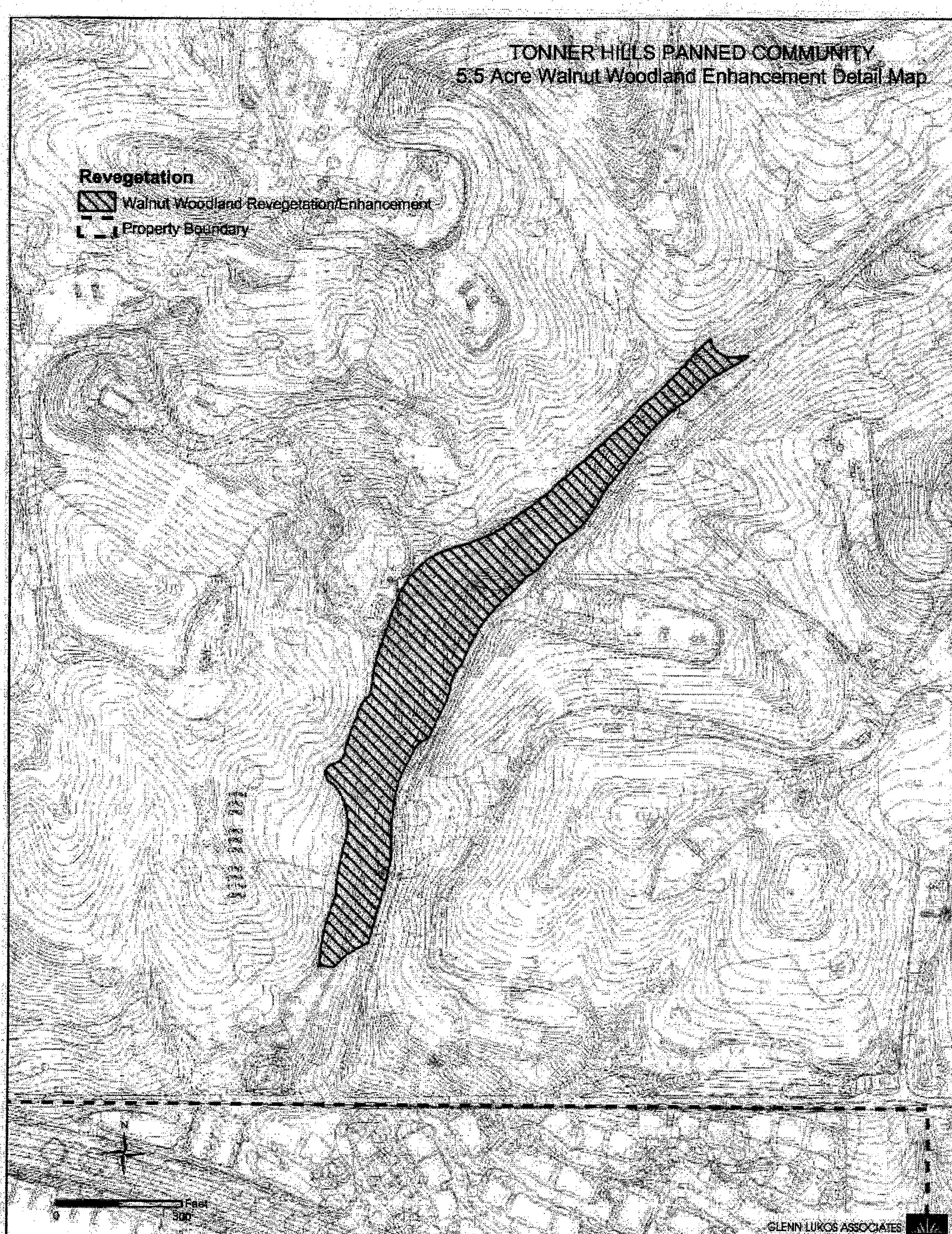

TONNER HILLS PANNED COMMUNITY
5.5 Acre Walnut Woodland Enhancement Detail Map
Revegetation
Walnut Woodland Revegetation/Enhancement
Property Boundary
N
Feet
0
300
GLENN LUKOS ASSOCIATES

Table 2-2
Mitigation Acres for the Tonner Hills Project

Community	Total Onsite (Acres)	Impacts (Acres)	Preservation (Acres)	Enhancement (Acres)	Revegetation (Acres)	Total (Acres)
Coastal Sage Scrub/Cactus Scrub	208.2	83.7	124.5	(19.1**)	116.6	241.1
California Walnut Woodland	77.0	15.4	61.6	(5.5**)	0.0	61.6

* 24.3 acres of this total is comprised of disturbed coastal sage scrub
** The areas that will be enhanced (shown as acres in parenthesis) are included in the total for the preserved areas.

SECTION 3.0 - APPROACH, RATIONALE, AND METHODOLOGY FOR PROGRAMS

Section 3.0 provides guidelines and specifications for implementing the restoration programs.

3.1 RATIONALE FOR EXPECTING IMPLEMENTATION SUCCESS

The selection of plant materials for the revegetation sites at Tonner Hills was based on the degree of bank slopes, slope aspects, substrate materials, and the expected ecological conditions at the enhancement sites. Native species selected for the revegetation areas include those present in undisturbed riparian habitat elsewhere on the property.

Success of the Mitigation Plan is expected based on the following rationale:

- Plant materials (seeds and container plants) to be used for the enhancement site were carefully selected for their adaptability to the site conditions.
- The site is located within a system that supports the type of habitat to be created or enhanced. The existence of the native habitat supports the premise that the restored community can sustain itself and support additional native species once the exotics are removed.
- The revegetation sites will be planted with container plants at a relatively high density and seeded with a native herbaceous seed mix that would inhibit the recolonization of invasive, non-native plant species.

A strict maintenance and maintenance-monitoring plan will be implemented to ensure the success of the enhancement plantings.

3.2 RESPONSIBLE PARTIES

Ongoing monitoring and maintenance of mitigation has been transferred from Nuevo Energy to Shea Homes. The contact person is:

Mr. Steve Armanino
Community Director
Shea Homes
603 S. Valencia Avenue
Brea, California 92821
(714) 985-4356 voice
(714) 577-6239 fax

The Restoration Specialist is responsible for developing project specifications, monitoring implementation of the project, and monitoring results. This person (or team of individuals) shall be responsible for tracking and preparing all progress reports for submittal to the agencies. A qualified revegetation contractor experienced in the installation and maintenance of native restoration projects shall be responsible for actual implementation of the HMMP and shall direct all the activities associated with the HMMP. The Restoration Specialist shall coordinate closely with the revegetation contractor to ensure that the specifications of the HMMP are properly implemented.

3.3 SCHEDULE

Installation of enhancement vegetation shall occur between November 1 and March 31 to take advantage of the winter rainy season, unless irrigation is provided. If for any reason the plant materials (seeds and container plants) are undeliverable or rejected by the Restoration Specialist, planting shall be completed as soon as desirable materials are available and the planting season is appropriate.

Enhancement of the habitat in Cable Canyon will be conducted in conjunction with the Phase 2 revegetation program described in the Mitigation Plan (Chambers Group 2003). Phase I revegetation of 14 acres of coastal sage scrub in areas located west of State Highway 57 was initiated in April 2003. Implementation of Phase 2 and 3 revegetation was originally scheduled to occur during the initial phase of development construction; however, these revegetation phases were accelerated so that completion of all revegetation and enhancement programs is anticipated prior to the initiation of construction on the site. Phase 2 revegetation is scheduled to being in August 2003 with preplanting weed control in areas located east of State Highway 57. Planting in the Phase 2 revegetation area, including enhancement planting in Cable Canyon, is scheduled to begin in fall 2003. Completion of the enhancement project is anticipated in February 2004. Table 3-1 provides the schedule guidelines for enhancement activities at Cable Canyon.

Table 3-1
Schedule Guidelines for Enhancement Activities at Cable Canyon

SITE PRESERVATION (August 2003 through November 2003)
• Contract for plant an seed materials
• Contract with landscape contractor
• Contract with earthmovers, if required
• Restoration Specialist attends pre-construction meeting (s)
PRESERVATION, REMOVAL, AND ACCESS AREAS DELINEATED WITH CONSTRUCTION FENCING
• Install temporary irrigation system
• Removal of exotic species and trash within Cable Canyon
PLANTING (November 2003 through February 2004)
• Schedule plant materials delivery date and planting crew
• Layout planting scheme for landscape contractor
• Container plants installed
• Seed application
MAINTENANCE AND MONITORING
• Conduct as-built assessment
• Coordinate and install replacement plantings, if necessary monitored by Restoration Specialist
• Initiate project maintenance and maintenance monitoring program
PERFORMANCE MONITORING AND DOCUMENTATION
• Initiate Performance Monitoring Program following completion of installation
• Restoration Specialist submits Annual Report to agencies by January 1 each year following implementation

3.4 PROTECTION OF PRESERVED HABITATS AND SENSITIVE SPECIES

The following measures shall be implemented to protect the biological and aesthetic values of the natural habitats and sensitive species present within the site.

- A Conservation Easement shall be placed over a 473.2-acre "conservation area" on the Tonner Hills project site, which shall include preserved and restored native habitats. The easement for the conservation area shall be submitted to USFWS for review and approval and shall be recorded with the final tract map prior to the implementation of any vegetation removal on the site.

- A biological monitor shall be present during any removal of native vegetation on the site. The monitor shall be an experienced biologist, and shall be approved by USFWS prior to initiation of vegetation removal on the site. The monitor shall supervise grubbing and/or grading equipment operations to ensure that California gnatcatchers are not killed or

injured during vegetation removal activities. The monitor shall have the authority to halt or suspend all construction activities until appropriate corrective measures are completed to protect sensitive species. The monitor shall prepare a daily construction monitoring report outlining observed activities and indicating compliance with approved construction specifications. The daily report shall also contain recommendations concerning remedial actions needed to correct any identified deficiencies.
The monitor shall report any observed violations to USFWS and CDFG within 24 hours.

- Vegetation removal shall occur outside of the nesting season (approximately August to February 15) unless a Biological Monitor approves it. By avoiding the removal of non-native species in the breeding season, impacts to nesting bird species will be avoided, and this action will also avoid violation of the Migratory Bird Treaty Act.

- All removal of existing coastal sage scrub habitats shall occur outside of the breeding season of the gnatcatcher (February 15 through August 30). If any construction activity is necessary within 500 feet of preserved coastal sage scrub habitat during gnatcatcher breeding season, the Biological Monitor shall implement nest-monitoring surveys in the adjacent habitat to determine whether nesting activity is being substantially disrupted. If the Biological Monitor determines that gnatcatcher nesting activity is substantially disrupted, the monitor shall halt or suspend all work in the vicinity of the nest until the young have fledged, the nest has been determined to be a failure, or a minimization plan approved by the USFWS has been implemented to reduce noise to 60 dBA in occupied habitat. During this time, the Biological Monitor shall provide USFWS with weekly summaries, via facsimile transmission, of all gnatcatcher monitoring activities.

- Preserved and/or protected areas shall be identified by the Restoration Specialist and delineated with construction fencing or similar materials prior to any clearing or grading activities. Protected areas include existing woodland and coastal sage scrub adjacent to revegetation areas and individual trees and patches of native habitat to be preserved within revegetation areas.

- Vehicles shall not be allowed to operate within the dripline of any preserved trees.

- Erosion control measures, including silt fencing, shall be installed at the discretion of the Restoration Specialist to contain sediments within graded or restoration areas. Silt fencing shall be semi-permanently installed at the boundary between upland revegetation areas and existing riparian habitat until vegetation is sufficiently established in the revegetation zone to prevent erosion. Maintenance of the erosion control measures is included as part of the maintenance program.

- Maintenance and refueling of construction equipment shall be limited to areas approved by the Restoration Specialist. Storage of potentially hazardous materials, including but not limited to fuel, paint, stains, pesticide, herbicides, solvents, oils, and solvents, shall not be permitted within 50 feet of any preserved native habitat or riparian zone. During construction, disposal of such material shall occur in a controlled area that is physically separated from potential storm water runoff.

- The Restoration Specialist shall approve measures to prevent fire and leakage from vehicles during construction on the project site. Such measures shall include designated no smoking zones and parking areas. Construction equipment will be restricted to designated areas and roads approved by the Restoration Specialist. A water truck shall be maintained at the project site during all construction activities. The purpose of the water truck is to provide an emergency water source in the case of fire on the site.

3.5 GENERAL CONSTRUCTION GUIDELINES

Construction Fencing and Signage

Orange plastic snow fencing (or other similar device) shall be used to define limits of clearing and access routes at the Tonner Hills site. Where possible, fencing shall be located no closer than 15 feet from habitat to be protected.

Access

Access to the Tonner Hills site shall be from the Kramer Avenue gate. Vehicles and other equipment shall be restricted to approved routes within the site.

Spoils, Trash and Debris Removal

Spoils shall be immediately removed from each site and transported to offsite locations. Garbage and debris shall also be removed from all areas of the site and transported to an appropriate offsite disposal facility. The removal of dead or downed wood will eliminate important microhabitats for small vertebrates and invertebrates, and reduce the reintroduction of organic materials into the soil. Therefore, dead or downed wood shall be salvaged wherever possible except as required for safety reasons, flood control or fuel modification (i.e., fire prevention).

Erosion Control

Only nonvegetative erosion control measures shall be used in areas with native vegetation. Such erosion control measures may include sandbags, silt fencing, slope breakers, trenches, or dissipaters. Erosion control measures that may contain materials that would contaminate the sites (e.g., hay bales or non-rice straw mulch, etc.) shall not be allowed on the site. These measures preclude the introduction of non-native weedy species into the seed bank of areas with native vegetation.

Drainage and sedimentation control devices shall be routinely cleaned, maintained, and repaired prior to and during the rainy season. All repairs to these systems shall be immediately executed to minimize erosion problems.

3.6 OAK TREE PROTECTION PLAN

Oak trees are sensitive to environmental changes that alter the availability of water and nutrients. During construction-related activities, the most common types of damage sustained by oak trees are root injury from soil cuts, fills, compaction, and trenching, and excessive branch removal due to contact with construction equipment. The purpose of these guidelines is to ensure that construction-related impacts do not adversely affect oak trees intended for preservation.

- Areas to be protected will be identified by the Restoration Specialist and isolated with construction fencing prior to and during construction.

- Best management practices include the use of adequate erosion control measures to contain sediment within the construction site. Stockpiling of sediment or grading spoil will not be permitted within 10 feet of the dripline of any preserved oak or walnut.

- No heavy equipment will be allowed to operate within the dripline of any oak or walnut tree to be preserved.

3.7 CABLE CANYON WALNUT WOODLAND ENHANCEMENT PLAN

3.7.1 Overview

The goal of the Mitigation Plan is to create enhanced walnut woodland habitat in a preserved habitat that is currently infested with invasive, nonnative species. Approximately 5.5 acres of walnut woodland shall be enhanced in Cable Canyon. This section describes the various tasks required to prepare the areas prior to enhancement planting and to install container plants and seed materials.

3.7.2 Site Preparation

Pre-Planting Weed Control

Weed control at the revegetation sites must be addressed at least 3 months before planting activities are initiated. Effective herbaceous weed eradication requires initial stimulation of weed growth. This allows a larger crop of weeds to be eradicated and reduces the weed seed bank in the soil. Weed farming method of removal will be used in revegetation site where problem invasive weeds are established. Weed farming includes a cycle of irrigation, weed germination, and weed removal that may be repeated up to12 times or more as a means of removing the weed seed bank in existing soils. Mechanical clearing, mowing, and non-residual herbicides (Rodeo®

and/or Roundup®) may also be used to remove weed and exotic species. The weed farming methods are described below.

1. The site will be cleared of weeds by mechanical mowing.

2. In the absence of natural rainfall, the revegetation area will be irrigated two times per week for a two-week period using a temporary irrigation system installed at the site. Soils should be saturated to a depth of at least 3 inches during each irrigation.

3. Germinated weeds will be mowed and/or treated with an appropriate post-emergent herbicide at the end of the first two-week irrigation cycle.

4. The cycle of irrigation and weed removal as described in items 3 and 4 above will be repeated 3 times, including the initial cycle. The cycle will be repeated in the fall to remove late summer annuals. The Restoration Specialist will determine if further treatment is required to reduce the weed seed bank.

At the time of planting, the planting contractor and the Restoration Specialist will determine whether undesirable vegetation has become established in any of the mitigation planting areas and whether eradication is necessary. Wherever feasible, pre-planting weed control will use mechanical methods such as removal by hand or string trimmers. If effective weed control cannot be attained through mechanical means, appropriate systemic non-residual herbicides may be applied under the supervision of the Restoration Specialist. Weed species to be removed may include, but are not limited to the following species:

Common Name	**Scientific Name**
Tamarisk	*Tamarix ramossissima*
Eucalyptus	*Eucalyptus* sp.
Castor bean	*Ricinus communis*
Pepper trees	*Schinus* sp.
Mustards	*Brassica* sp.
Tree tobacco	*Nicotiana glauca*
Fennel	*Foeniculum vulgare*
Italian thistle	*Carduus pycnocephalus*
Milk thistle	*Silybum marianum*
Nonnative weedy thistles	*Cirsium* sp.
Nonnative annual grasses	
Wild oats	*Avena fatua*
Slender wild oats	*Avena barbarta*
Foxtail chess	*Bromus madritensis ssp. rubens*
Ripgut brome	*Bromus diandrus*
Soft chess	*Bromus hordeaceus*
Mediterranean barley	*Hordeum nurinum*
Italian ryegrass	*Lolium multiflorum*

Common Name	Scientific Name
Annual beard grass	*Polypogon monspeliensis*
Nonnative perennial grasses	
Pampas grass	*Cortaderia selloana*
Bermuda grass	*Cynodon dactylon*
Fountain grass	*Pennisetum setaceum*
Smilo grass	*Piptatherum miliaceum*

Exotic Tree Removal

Exotic trees will be removed from the enhancement area during preplanting weed control activities. Exotic trees on the site include Peruvian pepper and eucalyptus (*Eucalyptus* sp.). These trees are common throughout the site and are particularly abundant in Cable Canyon. Exotic tree removal will generally begin after the spring and summer nesting season for raptors (approximately August 30). If trees need to be removed during the breeding season, then a qualified biologist will verify that raptor nests and other bird nests are not present in the trees prior to removal. If nesting birds are present, removal will occur after the young have fledged.

The trees will be removed by complete removal or by cutting and treating the stump with an appropriate herbicide. Rodeo® a glyphosate herbicide approved for use in aquatic systems, must be used in areas in close proximity to riparian systems (e.g., Cable Canyon). The Restoration Specialist will determine the habitat limits within which the herbicide used will be restricted to Rodeo®. All trees will be cut to within 6 inches of the ground. Cut material will be removed from the site the day it is cut and disposed of at an offsite location. Undiluted herbicide (Round-up® or Rodeo® as directed by the Restoration Specialist) will be applied to the entire stump surface immediately after cutting. Treated plants will be inspected prior to initiating planting activities. If any treated stumps show evidence of new growth, or if any new plants are found, additional herbicide treatment will be performed. All applications of herbicide will occur outside of the bird-breeding season (March 1 through August 30).

3.7.3 Plant Materials

Container Plant Materials

Installation of container plants provides the following four important functions in revegetation:

- allows established plants that are past the vulnerable sapling stage to be introduced onsite,
- provides the means to introduce species that do not establish well from seed and are best propagated from cuttings,

- provides diversity of age structure and thus speeds natural regeneration, and
- provides an efficient method to introduce beneficial soil fungi (mycorrhizae) onsite.

Mycorrhizae can be reintroduced onsite by providing inoculated host plants. This process is often very slow (Miller 1985). Container plants that have been inoculated with mycorrhizae shall be used as the prime method for spreading these beneficial fungi. In addition to spreading the mycorrhizae onsite, inoculation of container-grown plants may increase transplant success, growth, and reproductive success.

The shrubs shall be obtained from a local supplier experienced in the propagation of native plant species. Prior to delivery, the root systems of the plants shall be inspected by the Restoration Specialist to ensure that roots are straight and well established. Plants with coiled roots (rootbound) shall not be accepted.

The following specifications shall be included in the commercial collector/supplier's growing contract for the plantings:

- All plants shall be hardened to frost/drought.
- All plant species that would normally host mycorrhizal fungi shall be inoculated.
- Plants shall not be grown with excessive fertilization.
- Plant root systems must fill the containers, but not be root-bound at time of delivery.
- Plant materials shall be properly labeled as to genus, species, subspecies, and source.
- Trees shall be tagged with metal forestry tags stating the species and size at time of delivery to facilitate tracking of growth during the monitoring phase.
- Plant materials shall be provided in quantities and sizes specified.
- Plants shall be ready for planting during specified planting period.
- No plants showing signs of serious pest infestation or disease shall be accepted.
- All plant substitutions shall require written approval from the Restoration Specialist.

- Plants shall not be subjected to breakage or desiccation during transport. Any broken or desiccated plants shall be rejected.

- Plant materials shall be inspected and approved by the Restoration Specialist prior to delivery.

- Upon delivery to the mitigation sites, plants shall be stored in a shaded location, evenly spaced, and upright; and watered as needed until planting. All materials shall be protected from adverse weather, vandalism, or other conditions that may be detrimental to the product.

Materials to be planted at the woodland enhancement site will include sapling (1-gallon) California walnuts, and other container-grown tree species found in riparian woodlands. Container plants of shrub species will be installed in conjunction with the trees to create a diverse woodland habitat. Substitutions of species or adjustments of specified quantities shall not be allowed without the express approval of the Restoration Specialist. Table 3-2 lists the container plant palette for walnut enhancement areas.

Table 3-2
Container Plant Palette for California Walnut Woodland Enhancement Areas

Scientific Name	Common Name	Size	Number of Plants per Acre	Minimum Spacing
*Juglans californica**	California walnut	Deep 1 gal	225	25'
Sambucus mexicana	Mexican elderberry	Deep 1 gal	30	40'
Baccharis pilularis	Coyote brush	1 gal	150	15'
Rhamnus californica	California coffeebery	1 gal	35	40'
Ribes aureum	golden currant	1 gal	30	Scattered groups 3-5'
Total Number of Plants				
*Exact quantities and spacing will be determined based on the number of exotic trees removed during site preparation.				

Seed Collection

Seeds collected from North Orange County shall be supplied by a qualified commercial seed collector/supplier with experience in native seed collections. Seeds shall be cleaned to a commercially acceptable grade, tested, and labeled with the species name, weight, purity, and germination rate. Seeds shall be stored in a cool, dry environment until delivery for hydroseeding.

Because availability of seed may be limited, flexibility in species selection and application rates will be necessary. Actual amounts of seed necessary for the revegetation plan will ultimately be determined by the Restoration Specialist and will be based on the purity and germination rates of the available seed. Seed shall not contain more than 0.5 percent weed seed by volume. Seed types shall be as specified in the seed palette and shall be applied at the rates indicated. Seed shall be received by the revegetation contractor in separate containers specifying kind, quality, purity, germination, and source. The revegetation contractor shall provide the Restoration Specialist with each seed bag label used in the installation. Seed suppliers shall be experienced in native plant seed propagation and collection and shall be approved by the Restoration Specialist. Table 3-3 shows the seed mix for the woodland revegetation areas.

Table 3-3
Seed Mix for the Walnut Woodland Enhancement Site

Scientific Name	Common Name	Minimum Purity/Germination	Pounds of Seed Per Acre[1]
Shrub and Perennial Species			
Artemisia californica	California sagebrush	15/50	4.00
Eriogonum fasciculatum var. fasciculatum	California buckwheat	10/65	3.00
Eriophyllum confertiflorum	golden yarrow	30/60	0.50
Lotus scoparius var. *scoparius*	deerweed	90/80	3.00
Mimulus aurantiacus	orange bush monkeyflower	5/70	0.50
Herbaceous and Grass Species			
Bromus carinatus	California brome	95/80	2.00
Dichlostemma capitatum	blue dicks	95/50	1.50
Gnaphalium californicum	California everlasting	2/50	1.00
Lupinus succulentus	arroyo lupine	98/85	0.50
Lupinus bicolor	small-leaf lupine	98/80	0.50
Phacelia minor	bluebells	95/70	0.50
Melica imperfecta	coast range melic	90/60	3.00
Nassella pulchra	purple needlegrass	70/60	4.00

[1]Final specifications for the seed mix will be developed after tests for purity and seed germination for each species.

3.7.4 Planting Methods

Container Plants

One-gallon container California walnut saplings will be planted at approximately 225 trees per acre. One-gallon container plants of Mexican elderberry, coyote brush and other shrub species will also be installed on the steep, west-facing banks of the canyon. Plantings will be distributed in a natural pattern, with some trees grouped together and others spread farther apart. No tree plantings will be closer than 15 feet on center.

The Restoration Specialist shall oversee and supervise placement of the container specimens in accordance with the planting plan. Plantings shall be distributed in a natural pattern, with some plants grouped together and others spread farther apart. No large shrub plantings shall be planted closer than 8 feet on center.

Container shrub species shall be planted before hydroseeding is applied. No pruning of plant materials shall be allowed unless specified by the Restoration Specialist. The roots of the container stock shall be protected from drying during planting. Prior to planting, the holes shall be filled with water, backfilled with native soil, and refilled with water to create a moisture reserve in the soil.

On steep slopes, all planting holes will be augured to 2 to 3 feet in diameter and 4 to 6 feet deep. A small terrace (18 to 24 inches wide) that slopes slightly into the hillside will be constructed. On level ground, all planting holes will be augured to 2 to 3 feet in diameter and 3 to 5 feet deep. Containers shall be gently cut or slid away from the rootball. Plants shall be placed in the premoistened holes with the root crown1 to 2 inches above the surrounding soil. Backfill of native soil shall be gently tamped in around the rootball.

No plantings shall be staked unless the Restoration Specialist considers staking necessary at the time of planting. Any staking shall be with a single wood post, with loose ties holding the trunk to the post. The ties shall be loose enough to allow the plant to flex without snapping or bending over excessively.

Protection of Saplings

Saplings are a tempting food source for many animals. To protect the young walnut saplings from herbivory, protective cages will be placed around the saplings at planting. The cages will be buried to a minimum depth of 4 inches below ground level. This depth helps to discourage burrowing animals that may cause damage. The cages will extend at least 12 inches above the top of the sapling to deter rodents, insects, and browsing animals.

Seeding Methods

The seed mix shall be planted between October and March using hydroseed/hydromulch methods. Hydroseeding/hydromulching shall take place after the container plants have been installed to avoid disturbing the seeds. Container plants shall be avoided or otherwise protected during hydroseeding to prevent potential damage. The hydroseed shall be applied to the steep, west-facing slopes of Cable Canyon.

Hydroseeding shall consist of a hydraulic application of a slurry mixture containing water, organic soil stabilizer, cellulose wood fiber, mycorrhizae, and seed. Hydroseed mulch shall be manufactured from 100 percent virgin wood fiber and shall not contain growth or germination inhibitors. When mixed with water, the mulch shall remain in uniform suspension and when blended with the seed and other approved additives, form homogeneous slurry. A non-phytotoxic wetting agent shall be added to the slurry mixture. A water-soluble, non-toxic green dye shall be added in sufficient quantity to clearly delineate the planted areas. The following materials shall be applied in a one-step hydroseed/hydromulch operation:

- virgin cellulose wood fiber: 1,500 pounds per acre;
- organic soil stabilizer. 160 pounds per acre on slopes;
- seed mix as shown on Table 3-3

Prior to loading the specified materials, the Restoration Specialist will conduct a visual inspection of the hydroseed equipment to ensure that the equipment is clean of contaminant seed or products. The hydroseed mix will be applied within one hour of mixing. The hydroseed equipment mixing apparatus will remain in constant motion during application of the materials until the tank is emptied.

3.7.5 Irrigation

Because the goal of revegetation is to create a self-sustaining site, no permanent irrigation system will be maintained in the native plant communities at the revegetation site. Supplemental irrigation will be necessary, however, during the establishment period.

A temporary, above-ground, drip irrigation system will be installed to provide supplemental irrigation in sufficient amounts, as conditions require, to keep the container plants healthy and growing. Water will be provided only to container plants and tree saplings during the initial installation and subsequent establishment period. Irrigation shall be accomplished in such a manner as to encourage deep root growth (i.e., periodic, deep irrigation as opposed to frequent, light irrigation). During the maintenance period, the Restoration Specialist will monitor soil moisture conditions to ensure sufficient water is delivered to the container plants. This supplemental irrigation shall be tapered back and the plants weaned over the first 2 years following planting. The native plants will adapt to site conditions after establishment and will survive on rainfall as a source of moisture. The supplemental irrigation will be discontinued when the Restoration Specialist determines the revegetation plantings are established and self-sustaining.

3.7.6 As-Built Conditions

An "As-Built Assessment" shall be conducted to document the actual project conditions on the site immediately upon completion of the installation. The Restoration Specialist shall perform this assessment and will check the site for compliance with the Mitigation Plan's technical design criteria, permit conditions, and project objectives. Data pertaining to the following factors shall be collected by the Restoration Specialist and compared with the detailed construction documents:

- site location;
- site topography;
- substrata (soil source, texture);
- dates planted;
- quantity and locations of each species plants: and
- plant health and coverage.

Any differences found between the original design and the as-built conditions shall be fully assessed and documented by the Restoration Specialist through field maps, photographs, and descriptive text. It is expected that some modifications of the original plan will be deliberate and some will be due to unforeseen site conditions that became evident during construction. Any deliberate changes in the plan shall be justified to, and accepted in writing by, the Restoration Specialist and the landscape contractor before the as-built conditions are approved. Recommendations for corrective measures shall also be made by the Restoration Specialist at the conclusion of the as-built assessment.

A report of the "As-Built Conditions" shall be submitted to the Agencies within 6 weeks of completion of site preparation and planting, describing as-built status of the mitigation project. The report shall include a map or diagram showing the mitigation area and the locations of the plantings and other installation items.

SECTION 4.0 - MAINTENANCE AND MAINTENANCE MONITORING PLAN

4.1 MAINTENANCE DURING THE MONITORING PERIOD

Maintenance of the site during the five-year monitoring period shall be the responsibility of the project applicants. The maintenance period shall begin when the installation work has been accepted as completed by the project applicants. A qualified restoration contractor experienced in the care of native plant communities shall perform maintenance. During the first-year maintenance period, sufficient personnel and equipment shall be allocated to perform landscape maintenance of all planted areas. Maintenance visits shall be conducted at a minimum of once monthly during the first year after installation is complete, and quarterly thereafter. The need for additional maintenance visits shall be determined by the Restoration Specialist depending on site conditions. The required maintenance items shall include, but are not limited to, the following items:

Erosion Control Devices

Drainage and sedimentation control devices shall be routinely cleaned, maintained, and repaired as necessary. The maintenance contractor shall also install additional erosion control devices where necessary as indicated by the Restoration Specialist. Once sufficient vegetative cover has developed to prevent erosion, the erosion control devices shall be removed at the direction of the Restoration Specialist.

Weed Control

Weeds shall be controlled in the enhancement areas for a minimum of 5 years or until native plantings are well established to prevent detrimental competition of invasive species with the mitigation plantings for water, nutrients, light, and space. Target non-native species include, but are not limited to, the species listed in Section 3.6.3. All weeds shall be removed mechanically. In cases where mechanical removal is ineffective, herbicides shall be applied utilizing the appropriate methodologies. The Restoration Specialist shall determine the appropriate herbicide and application methodology in consultation with the native vegetation landscape contractor.

Follow-up foliar application of herbicide shall be applied to any resprouting stems in revegetation enhancement areas approximately 5 to 7 weeks after the initial treatment. At a minimum, quarterly inspections and reapplication of herbicide, if necessary, shall be conducted for a period of 5 years to ensure control of the infestation in both revegetation and enhanced areas. All application of herbicide should occur outside of the bird-breeding season (March 1 through August 30).

Trash and Debris Removal

Following rain events, trash and debris may enter the site. Following initial removal of the trash during site preparation, the maintenance contractor shall remove additional trash and debris during maintenance activities. Dead or downed wood of native species shall not be removed except as required for safety reasons or for flood control purposes. Garbage, debris, and noxious weed biomass shall be removed from all areas of the sites and disposed of at an offsite location.

Irrigation

The maintenance contractor shall be responsible for irrigating the restoration plantings as directed by the Restoration Specialist throughout the installation and maintenance periods. The maintenance contractor shall be responsible for maintaining all components of the temporary irrigation system installed at the site.

Vandalism

The maintenance contractor shall note any instance of vandalism and report occurrences to the Restoration Specialist within 24 hours. Recommendations for the replacement of damaged plants and their protection shall be developed by the Restoration Specialist and reported to the project applicants.

4.2 MAINTENANCE MONITORING

Maintenance monitoring of the site shall be performed with the knowledge and oversight of the Restoration Specialist. After installation is completed, maintenance activities shall be conducted on the sites as described in Section 3. The Restoration Specialist shall be responsible for overseeing maintenance of the sites and preparing maintenance reports. The person conducting maintenance monitoring inspections shall be a professional (e.g., biologist, landscape architect, horticulturist) knowledgeable of the physical requirements of native vegetation and experienced in installation and maintenance of native habitats.

4.2.1 Schedule of Maintenance Monitoring Inspections

The Restoration Specialist shall be responsible for inspecting the mitigation sites on a regular basis and, if necessary, providing recommendations to the maintenance contractor for changes in the maintenance program. At minimum, the following schedule of maintenance inspections for all plantings areas shall be implemented:

- monthly inspections during the first year following completion of installation.
- quarterly inspections during the second year following planting, and
- semiannual inspections after the second year through the fifth year or until performance standards have been met.

After each maintenance-monitoring visit, the Restoration Specialist shall submit a report to the project applicants summarizing the conditions observed at the site. The maintenance monitoring reports shall be included as an appendix to the annual performance monitoring report submitted to the agencies.

SECTION 5.0 - PERFORMANCE MONITORING PLAN

The success criteria for the enhancement plan are described below. If at any time planting functions in these areas do not appear to be meeting the performance standards set forth in the mitigation plan, Nuevo Energy Company initially will be responsible for taking action and timely remedial actions (as determined by the Restoration Specialists) to ensure compliance with the performance standards. The monitoring obligation shall be assumed by Shea Homes in 2005.

Performance monitoring shall be conducted to document the growth rates, coverage, and other general "success" attributes of the planted and enhanced areas. Monitoring of the enhanced habitat shall be performed by the Restoration Specialist, plant ecologist, native landscape horticulturist or other professional qualified to assess the performance of the habitat establishment efforts and recommend corrective measures, if needed.

5.1 TARGET FUNCTIONS AND VALUES

The goal of the mitigation program is to progress toward the performance standards detailed below. Performance standards are based on the progress of the mitigation toward achieving targets developed from existing habitat for vegetation percent cover, tree height, frequency of distribution, and species diversity. The project applicant is responsible for performance monitoring. Performance monitoring will occur for a minimum period of 5 years or until the performance standards are achieved, whichever comes first.

Aspects of the performance standards set forth in the plan include the following:

1. Performance standards may be waived by the Corps, USFWS, or CDFG in any area if monitoring indicates that good growth and functional habitats are otherwise achieved.

2. If performance standards cannot be met because of adverse soil or other unmanageable site conditions, an alternative or auxiliary mitigation plan may be submitted to the Corps, USFWS, or CDFG for approval.

5.2 TARGET WILDLIFE SPECIES

The goal of the mitigation plan is to establish breeding and foraging habitat for resident (and migratory) bird and wildlife species. In addition to the coastal California gnatcatcher and one least Bell's vireo that were observed in Tonner Creek, the project site is presently used by various common wildlife species.

Observations of common wildlife and plant species within the created habitat in Tonner Creek and the enhanced habitat in Cable Canyon will be recorded during site visits. Use of restored habitat by the least Bell's vireo and other wildlife species will be considered progress indicators of revegetation success.

5.3 VEGETATION PERFORMANCE STANDARDS

Performance standards for the walnut tree plantings shall be as follows:

- For sapling (1-gallon) revegetation, all saplings that die will be replaced with like-sized replacement container trees at the first suitable growing season to achieve 70 percent survival of the original plantings. After 3 years and for the duration of the 5-year monitoring period, 80 percent of the plantings will survive.
- At the end of 3 years, the 1-gallon saplings will reach a height of 4 feet. At the end of 5 years, the 1-gallon saplings will reach a height of 6 feet.
- The plantings will achieve an overall cover of approximately 20 percent after the first year, 50 percent after 3 years, and 75 percent after 5 years.

Table 5-1 summarizes the walnut woodland enhancement vegetation performance standards.

Table 5-1
Performance Standards for Walnut Woodlands Enhancement Plan

Standard	1st Year	*2nd Year*	3rd Year	*4th Year*	5th Year[1]
Tree and Shrub Survival	70% survival	*75% survival*	80% survival	*80% survival*	80% survival
Tree Height Standard 1 gallon	-	-	4 feet	*5 feet*	6 feet
Percent	20%	*30%*	50%	*60%*	75% cover[3]

1 Performance standards during Year 5 must be attained without human interference (irrigation, rodent control).
2 If adequate germination is not attained to prevent erosion nor exclude weed infestations, reseeding may be necessary.
3 Percent cover of seed mix is in combination with shrub cover.

5.3.1 Native Species Richness

Maximum potential species richness is one of the goals of restoration. In addition to the wide range of species included in the plant palettes, natural recruitment of native species may contribute to the overall diversity within the revegetation areas. A minimum of 80 percent of the species planted (or a combination planted and naturally recruited native species) will be represented in the revegetation areas after three years. If species richness requirements have not been met, the Restoration Specialist will make recommendations for remedial reseeding (i.e., species to be reseeded).

5.3.2 Evidence of Natural Reproduction

It is expected that natural reproduction of a variety of seeded and planted species will be evident by the third year after planting. If the Restoration Specialist notices any areas that are deficient in the recruitment of native species, appropriate remedial actions will be taken to remedy the situation.

5.3.3 Non-Native Species

Weeds shall be controlled in the revegetation and enhancement areas five years or until plantings are well enough established to prevent detrimental competition between the nonnative, invasive species with the revegetation plantings for water, nutrients, light, and space. The percent cover measurements shall be based on native plant species only; non-native plant species shall not be counted as cover in the percent cover measurements. Revegetation and enhancement areas shall have a maximum five percent cover of invasive weed species after five years.

5.4 VEGETATION PERFORMANCE MONITORING METHODS

Monitoring will be performed by the Restoration Specialist or a qualified biologist with appropriate experience in site monitoring and transect measurements. Performance monitoring of vegetation within the mitigation areas will generally include detailed analysis of growth, cover, height and viability. Permanent photo-documentation stations shall be established to record the progress of each site over the 5-year period. Photographic records shall be kept of all mitigation areas for purposes of comparing earlier and later stages of plant establishment and growth.

Plant vigor, recruitment, and patterns of growth within created and enhanced sites will be noted and documented along with the quantitative performance data. Aggregations of individual plants or species into stands or zones can provide important information relating to (1) gradients in physical parameters within the site, or (2) interactions with neighboring species (including wildlife).

Data Collection Methodology

Quantitative vegetation data shall be collected by a physical count and inspection of all tree and shrub species installed on the site. Total vegetative cover will be estimated utilizing point-intercept methodology modified from the California Native Plant Society (Sawyer and Keeler-Wolf 1995). A minimum of three transects shall be established in the planted zones. Transect locations shall be randomly selected. The location of each transect shall be recorded using a GPS unit to find the coordinates for each end of the transect line.

Plant species touching a vertical line at 0.5 m-intervals along each 50-m transect shall be recorded as "hits" and used to estimate cover by species. Species shall be categorized by layer in the vegetation as "herb/ground," "shrub," and "tree." Data shall be recorded separately for each 0.Sm interval in order to accurately assess vegetative cover.

Health of planted trees will be assessed on an annual basis near the end of the wet season (i.e. mid-spring). All trees will be measured and assessed as to their current height, change in height, crown cover, seed production, and overall health and appearance. Seven general health categories to be used during tree monitoring are described below.

- **Live** - tree is apparently in good condition; leaves are green; no symptoms of wilting, die back, or chlorotic leaf appearance.

- **Stressed** - tree appears to be in a generally poor condition; chlorotic leaves, wilting, and leaf drop.

- **Tip Die-Back** - main stem is in good condition, but apical portions are in very poor condition; wilting and die-back symptoms.

- **Basal Sprouts** - main stem is dead, but new growth from stem base or root stock.
- **Not Found** -saplings may not be found during a particular sampling period. Saplings not found during two successive sampling periods will be counted as dead.

- **Apparently Dead** - general appearance of stem is dry and brittle; no live wood observed; no observable green foliage.

- **Dead** - normally applied to trees classified as "apparently dead" during the preceding sampling period or in cases where a previous observation indicated that the specimen was in such poor condition that survival was unlikely.

5.5 WILDLIFE MONITORING SURVEYS

The use by wildlife of the site shall constitute evidence that the revegetation site is proceeding and providing good habitat values. The annual reports shall include the records of the wildlife species observed on the site during the monitoring visits. The following are considerations relating to habitat function that shall be used in assessing wildlife usage of the site:

- evidence of use of the site for reproduction through direct observations of amphibian larvae, breeding tree frogs, presence of territorial males during breeding season, nests, litters, or young of the year;

- evidence of food chain support through direct (e.g. documented observation of heron eating gopher or frog, white-tailed kite taking vole, rabbit-browsed rushes, caterpillar-eaten herbs) and indirect (e.g. scat, owl pellets, presence of appropriate or target species within created habitat) observations.

5.6 SCHEDULE OF PERFORMANCE MONITORING

Quantitative vegetation performance monitoring and wildlife surveys shall be conducted annually beginning approximately one year following completion of installation. Quantitative vegetation sampling shall occur during the spring and shall continue through the 5th year after installation is complete or until vegetation performance standards have been met.

5.7 ANNUAL REPORTS

The Restoration Specialist shall prepare an annual report for submittal to the Agencies. Monitoring reports shall present an overview of the revegetation effort and specifically address monitoring methods, plant survival, percent cover, and number of each species replanted. These reports shall include the following:

- a list of names, titles, and companies of all persons who prepared the content of the annual report and participated in monitoring activities for that year;
- a description of the existing conditions of the site;
- the results of the reconnaissance wildlife surveys;
- an analysis of all qualitative and quantitative vegetation monitoring data;
- copies of all monitoring photographs;
- maps identifying monitoring areas, transects, planting zones, and so forth as appropriate;
- discussion and recommendations;
- a copy of the permits, and any special conditions or letters modifying the original permit conditions.

5.8 NOTIFICATION OF COMPLETION

The applicant shall notify the agencies of the completion of the 5-year monitoring period in conjunction with submittal of the fifth year annual report. The Restoration Specialist shall be present during all field visits requested by the agencies to verify permit conditions have been satisfied. Earlier notification and request for release may be submitted if the mitigation sites have met the established performance standards for the fifth year and the resource agencies agree that the project is successful.

5.9 FINAL SUCCESS CRITERIA AND CORPS CONFIRMATION

For each year in which substantial remedial measures, such as additional grading to improve hydrology, are required or for each year during year 3, 4 and 5 in which the permittee fails to achieve within 5-percent of the performance standards, one additional year of revegetation and monitoring success shall be required using the same performance criteria as listed for year 5. When the 5-year monitoring period (and any additional, required years of monitoring) is complete, and if the permittee believes all performance standards have been met, the permittee shall request written confirmation from the Corps verifying final success criteria have been met. In any case, final success criteria shall not be met until at least 2 years of post-irrigation mitigation and monitoring success have occurred. At the Corps' discretion, if the final success criteria are not met, the permittee shall prepare an analysis of the cause(s) of failure and propose remedial actions for approval.

5.10 CONTINGENCY MEASURES

In the event of a major fire or flood event or other disturbance that substantially damages the revegetation plantings, the condition of the site will be assessed as soon as the area is safe (e.g.. threat of flood has passed, etc.). Assessment of the site shall be conducted by the Restoration Specialist and shall be documented in a letter report, which shall include photographic documentation. At a minimum, exotic species abatement practices will be increased to encourage natural recovery processes. If evidence of natural recovery is not observed within three months of the disturbance, or if the recovery is deemed inadequate to meet the stated goals of the project, the project applicants shall prepare an analysis detailing the cause of the failure and shall enter into consultation with the agencies to determine an appropriate remedial action or alternative mitigation program. The project applicant shall also consult with the agencies regarding remedial action if the site does not meet the project's established performance criteria. *In addition, the permittee has provided a performance bond for the amount of $244,800 to cover costs associated with planning, implementation, and monitoring of any contingency measures needed if the mitigation fails to meet its success criteria.*

<u>Replacement Plantings and Seeding</u>

Any site with significant bare areas due to low seedling germination or establishment shall be reseeded. Prior to reseeding, soil compaction and soil chemical analyses may be required in any bare areas to identify any site-specific characteristics that may require specialized procedures or seed mixes. If indicated by the soil analyses, the Restoration Specialist shall develop specific site preparation and/or seed mixes.

Similarly, significant loss of container plant material shall require plant replacement. Replacement shall depend on the overall coverage of seedling plants and the relative frequency of the species in comparison to the performance criteria set forth in Section 5.0.
All reseeding and replanting should be conducted from October through December of each year, as necessary.

SECTION 6.0 - BUDGET ESTIMATE

The costs for the implementation, maintenance, and monitoring of the 5.5 acres walnut woodland enhancement at the Tonner Hills project are estimates and they assume a 5-year program to meet the success criteria. Those tasks that are included in the cost estimates include:

- Implementation and Implementation Monitoring,
- Project Management and Meetings,
- Maintenance Monitoring and Reporting. and
- Annual Success Monitoring and Reporting.

The approximate cost to implement and maintain the 5.5 acres Walnut Woodland enhancement project is $204,000.

SECTION 7.0 - REFERENCES

Harvey & Stanley Associates, Inc.

1983 Revegetation Manual. Prepared for Alameda County Flood Control and Water Conservation District. Hayward, CA. June 1983.

Hickman, J.C. (Editor)

1993 The Jepson Manual: Higher Plants of California. University of California Press. Berkely, CA.

Holland, R.

1986 Preliminary Descriptions of the Terrestrial Natural Communities of California. Nongame Heritage Program, State of California Department of Fish and Game.

Miller, R. M.

1985 Overview Mycorrhizae. Restoration and Management Notes 3:14-20.

Munz, Philip A.

1974 A Flora of Southern California. University of California Press, Berkeley, CA.

Skiyirs, J. and M.F. Allen

1985 Use of Mycorrhizae for Land Rehabilitation. MIRCEN Journal of Applied Microbiology and Biotechnology 2(1): 161-176.

Society for Ecological Restoration (SERCAL)

1992 Restoration/Revegetation Planning: The Basics. Proceedings for workshops held November 13, 1992, Sacramento, California. Sponsored by SERCAL, California Chapter.

United States Army Corps of Engineers

2003 Mitigation Guidelines and Monitoring Requirements. Special Public Notice, January 27, 2003.

EXHIBIT "H"

TITLE REPORT OF THE CONSERVED LAND

[See attached]

Fidelity National Title Company

PRELIMINARY REPORT

In response to the application for a policy of title insurance referenced herein, ***Fidelity National Title Company*** *hereby reports that it is prepared to issue, or cause to be issued, as of the date hereof, a Policy or Policies of Title Insurance describing the land and the estate or interest therein hereinafter set forth, insuring against loss which may be sustained by reason of any defect, lien or encumbrance not shown or referred to as an Exception herein or not excluded from coverage pursuant to the printed Schedules, Conditions and Stipulations of said Policy forms.*

The printed Exceptions and Exclusions from the coverage and Limitations on Covered Risks of said Policy or Policies are set forth in Attachment One. Limitations on Covered Risks applicable to the CLTA and ALTA Homeowner's Policies of Title Insurance which establish a Deductible Amount and a Maximum Dollar Limit of Liability for certain coverages are also set forth in Attachment One. Copies of the Policy forms should be read. They are available from the office which issued this report.

This report (and any supplements or amendments hereto) is issued solely for the purpose of facilitating the issuance of a policy of title insurance and no liability is assumed hereby. If it is desired that liability be assumed prior to the issuance of a policy of title insurance, a Binder or Commitment should be requested.

The Policy(s) of title insurance to be issued hereunder will be policy(s) of Fidelity National Title Insurance Company, a California corporation.

Please read the exceptions shown or referred to herein and the exceptions and exclusions set forth in Attachment One of this report carefully. The exceptions and exclusions are meant to provide you with notice of matters which are not covered under the terms of the title insurance policy and should be carefully considered.

It is important to note that this preliminary report is not a written representation as to the condition of title and may not list all liens, defects and encumbrances affecting title to the land.

Fidelity National Title Company

CORPORATE SEAL

BY ______ President

ATTEST ______ Secretary

______
Countersigned

Visit Us on our Website: www.fntic.com

Fidelity National Title Company

1300 Dove Street, Suite 310 • Newport Beach, CA 92660
949 622-5000 • FAX 949 477-3640

PRELIMINARY REPORT

Amended

Title Officer: Martha Ramirez

Title No.: 06-**259901504**-A-MR
Locate No.: CAFNT0925-0925-0199-0259901504

Escrow No.: Tonner Hills Preserved Open Sp

TO: Shea Homes
603 South Valencia Avenue, Suite 200
Brea, CA 92823

ATTN: Steven Armanino
YOUR REFERENCE: Tonner Hills Preserved Open Sp

SHORT TERM RATE:

PROPERTY ADDRESS:

EFFECTIVE DATE: May 18, 2007, 07:30 A.M.

The form of Policy or Policies of title insurance contemplated by this report is:

Subdivision

1. THE ESTATE OR INTEREST IN THE LAND HEREINAFTER DESCRIBED OR REFERRED TO COVERED BY THIS REPORT IS:

   A Fee

2. TITLE TO SAID ESTATE OR INTEREST AT THE DATE HEREOF IS VESTED IN:

   Tonner Hills 680 LLC, a Delaware limited liability company

3. THE LAND REFERRED TO IN THIS REPORT IS DESCRIBED AS FOLLOWS:

   SEE EXHIBIT "A" ATTACHED HERETO AND MADE A PART HEREOF

EH\JK 12/15/2006

LEGAL DESCRIPTION

EXHIBIT "A"

THE LAND REFERRED TO HEREIN BELOW IS SITUATED IN THE COUNTY OF ORANGE, STATE OF CALIFORNIA, AND IS DESCRIBED AS FOLLOWS:

PARCEL 1: (APN 306-012-35, 36 & 38; APN 306-031-21, 22, 24, 27 & 28)

LOTS 11, 12, 13, 16, 17, 18, 19 AND 21 OF TRACT NO. 16178, AS PER MAP FILED IN BOOK 853, PAGES 1 THROUGH 15, INCLUSIVE, OF MISCELLANEOUS MAPS, RECORDS OF ORANGE COUNTY, CALIFORNIA.

EXCEPTING THEREFROM ANY AND ALL OIL RIGHTS, MINERALS, MINERAL RIGHTS, NATURAL GAS RIGHTS AND OTHER HYDROCARBONS BY WHATSOEVER NAME KNOWN, GEOTHERMAL STEAM AND ALL PRODUCTS DERIVED FROM ANY OF THE FOREGOING (HEREINAFTER COLLECTIVELY REFERRED TO AS, THE "MINERALS"); TOGETHER WITH THE PERPETUAL RIGHT, AS LIMITED THEREIN, OF DRILLING, EXPLORING AND OPERATING THEREOF AND STORING IN AND REMOVING THE SAME, EXCEPTING THEREFROM THE MINERALS LYING FROM THE SURFACE TO FIVE HUNDRED (500') BELOW THE SURFACE OF THE PROPERTY AND GRANTEE SHALL HAVE NO RIGHTS TO DRILL FOR, EXPLORE, OPERATE, STORE AND REMOVE THE MINERALS FROM SAID RESERVED INTERVAL, PROVIDED, HOWEVER, GRANTEE SHALL HAVE THE RIGHT OF SUBSURFACE ENTRY THROUGH SAID INTERVAL TO EXPLORE, OPERATE, STORE OR REMOVE THE MINERALS LYING BELOW FIVE HUNDRED FEET (500') FROM THE SURFACE OF THE PROPERTY; AS CONVEYED TO BLACKSAND PARTNERS, L.P., A TEXAS LIMITED PARTNERSHIP, BY MINERAL GRANT DEED RECORDED FEBRUARY 28, 2003 AS INSTRUMENT NO. 2003000226060 OF OFFICIAL RECORDS.

PARCEL 2:

THOSE PORTIONS OF SECTION 1, TOWNSHIP 3 SOUTH, RANGE 10 WEST AND THAT PORTION OF SECTION 7, TOWNSHIP 3 SOUTH, RANGE 9 WEST, SAN BERNARDINO MERIDIAN, AS PER MAP FILED IN BOOK 51, PAGE 7 OF RECORDS OF SURVEY,

THAT PORTION OF SAID SECTION 1 MORE PARTICULARLY DESCRIBED AS FOLLOWS: BEGINNING AT THE SOUTHWESTERLY CORNER OF SAID LOT 11;

THENCE ALONG THE SOUTHERLY BOUNDARY OF SAID LOT 11 NORTH 89°24'21" EAST 495.67 FEET TO THE SOUTHWESTERLY BOUNDARY OF A GRANT DEED TO METROPOLITAN WATER DISTRICT RECORDED FEBRUARY 10, 1967, IN BOOK 8173 AT PAGE 641 OF OFFICIAL RECORDS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE SOUTHEASTERLY ALONG SAID SOUTHWESTERLY BOUNDARY SOUTH 28°12'22" EAST 338.56 FEET TO THE NORTHERLY BOUNDARY OF TRACT NO. 12562 AS SHOWN ON A MAP FILED IN BOOK 579, PAGES 4 THROUGH 9 INCLUSIVE OF MISCELLANEOUS MAPS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE WESTERLY ALONG SAID NORTHERLY BOUNDARY SOUTH 89°24'21" WEST 659.12 FEET TO THE EASTERLY BOUNDARY OF TRACT NO. 9532 AS SHOWN ON A MAP FILED IN BOOK 454, PAGES 25 THROUGH 28 INCLUSIVE OF MISCELLANEOUS MAPS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE NORTHERLY ALONG SAID EASTERLY BOUNDARY NORTH 00°39'09" EAST 300.07 FEET TO THE POINT OF BEGINNING

ALSO TOGETHER WITH THAT PORTION OF SAID SECTION 1 MORE PARTICULARLY DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHEAST CORNER OF SAID LOT 11, SAID CORNER ALSO BEING ON THE WESTERLY BOUNDARY OF PARCEL A6471-4, AS CONVEYED BY A FINAL ORDER OF CONDEMNATION RECORDED SEPTEMBER 29, 1970, IN BOOK 9417, PAGE 364 OF OFFICIAL RECORDS, IN THE OFFICE OF THE COUNTY RECORDER OF SAID COUNTY;

THENCE SOUTHERLY ALONG SAID WESTERLY BOUNDARY SOUTH 10°52'43" WEST 306.11 FEET NORTHERLY BOUNDARY OF TRACT NO. 12563 AS SHOWN ON A MAP FILED IN BOOK 579, PAGES 10 THROUGH 15 INCLUSIVE OF MISCELLANEOUS MAPS, IN THE OFFICE OF SAID COUNTY RECORDER;

THENCE WESTERLY ALONG SAID NORTHERLY BOUNDARY SOUTH 89°24'21" WEST 890.93 FEET TO THE

EASTERLY BOUNDARY OF A GRANT DEED TO METROPOLITAN WATER DISTRICT RECORDED FEBRUARY 10, 1967, IN BOOK 8173 AT PAGE 641 OF OFFICIAL RECORDS, IN THE OFFICE OP SAID COUNTY RECORDER;

THENCE NORTHERLY ALONG SAID EASTERLY BOUNDARY THE FOLLOWING COURSES:

NORTH 23°43'24" WEST 110.38 FEET TO THE BEGINNING OF A TANGENT CURVE CONCAVE EASTERLY AND HAVING A RADIUS OF 100.00 FEET;

NORTHERLY ALONG SAID CURVE 20.51 FEET THROUGH A CENTRAL ANGLE OF 11°45'15";

NORTH 11°58'09" WEST 182.51 FEET4TO THE SOUTHWEST CORNER OF SAID LOT 12;

THENCE LEAVING SAID EASTERLY BOUNDARY ALONE THE SOUTHERLY BOUNDARY OF LOTS 12, "B" AND 11 OF SAID TRACT NO. 16178, NORTH 89°24'21" EAST 1037.25 FEET TO THE POINT OF BEGINNING.

EXCEPTING THEREFROM ANY AND ALL OIL RIGHTS, MINERALS, MINERAL RIGHTS, NATURAL GAS RIGHTS AND OTHER HYDROCARBONS BY WHATSOEVER NAME KNOWN, GEOTHERMAL STEAM AND ALL PRODUCTS DERIVED FROM ANY OF THE FOREGOING (HEREINAFTER COLLECTIVELY REFERRED TO AS, THE "MINERALS"); TOGETHER WITH THE PERPETUAL RIGHT, AS LIMITED THEREIN, OF DRILLING, EXPLORING AND OPERATING THEREOF AND STORING IN AND REMOVING THE SAME, EXCEPTING THEREFROM THE MINERALS LYING FROM THE SURFACE TO FIVE HUNDRED (500') BELOW THE SURFACE OF THE PROPERTY AND GRANTEE SHALL HAVE NO RIGHTS TO DRILL FOR, EXPLORE, OPERATE, STORE AND REMOVE THE MINERALS FROM SAID RESERVED INTERVAL, PROVIDED, HOWEVER, GRANTEE SHALL HAVE THE RIGHT OF SUBSURFACE ENTRY THROUGH SAID INTERVAL TO EXPLORE, OPERATE, STORE OR REMOVE THE MINERALS LYING BELOW FIVE HUNDRED FEET (500') FROM THE SURFACE OF THE PROPERTY; AS CONVEYED TO BLACKSAND PARTNERS, L.P., A TEXAS LIMITED PARTNERSHIP, BY MINERAL GRANT DEED RECORDED FEBRUARY 28, 2003 AS INSTRUMENT NO. 2003000226060 OF OFFICIAL RECORDS.

APN: 306-031-30, 306-012-36, 306-012-38, 306-031-24, 306-031-28;306-012-35, 306-031-22 and 306-031-21

AT THE DATE HEREOF, ITEMS TO BE CONSIDERED AND EXCEPTIONS TO COVERAGE IN ADDITION TO THE PRINTED EXCEPTIONS AND EXCLUSIONS IN SAID POLICY FORM WOULD BE AS FOLLOWS:

1. INTENTIONALLY DELETED

2. INTENTIONALLY DELETED

3. INTENTIONALLY DELETED

4. INTENTIONALLY DELETED

5. INTENTIONALLY DELETED

6. INTENTIONALLY DELETED

7. INTENTIONALLY DELETED

8. INTENTIONALLY DELETED

9. **The lien of supplemental taxes**, if any, assessed pursuant to the provisions of Chapter 3.5 (Commencing with Section 75) of the Revenue and Taxation code of the State of California.

10. **Water rights, claims or title to water**, whether or not disclosed by the public records.

11. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Pacific Coast Oil Company
Purpose:	Pipe lines
Recorded:	June 25, 1902, Book 75, Page 254, of Deeds
Affects:	Lots 13 and 16

12. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	County of Orange
Purpose:	Road and slope
Recorded:	November 8, 1928, Book 220, Page 38, of Official Records
Affects:	Lot 18

13. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Metropolitan Water District
Purpose:	Right of way
Recorded:	October 29, 1940, Book 1067, Page 308, of Official Records
Affects:	Lots 11, 15 and 18

14. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Brea Chemicals, Inc.
Purpose:	Pipe line and appurtenant equipment, for the transmission of gas
Recorded:	June 10, 1957, Book 3936, Page 310, of Official Records
Affects:	A portion of said land

15. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Brea Chemicals, Inc.
Purpose:	An electrical pole line, a water pipe line, and roadway
Recorded:	June 10, 1957, Book 3936, Page 324, of Official Records
Affects:	A portion of said land

The terms, provisions, and conditions contained in a document entitled "Quitclaim Deed", executed by and between Nuevo Energy Company, a Delaware corporation and Brea Walden, LLC, a California limited liability company, recorded October 9, 2001, as Instrument No. 20010710858 of Official Records.

16. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Metropolitan Water District of Southern California
Purpose:	Right of way
Recorded:	May 21, 1958, Book 5291, Page 400, of Official Records
Affects:	Lot 13

17. The terms, provisions and conditions contained in a document entitled "Agreement", executed by and between Pacific Lighting Gas Supply Company, a California public utility corporation and Union Oil Company of California, a corporation, recorded in Book 6515, Page 482 of Official Records.

18. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Southern California Edison Company
Purpose:	Public utilities
Recorded:	January 18, 1963, Book 6399, Page 705, of Official Records
Affects:	Lots 13, 19 and 21

19. **The fact** that the ownership of said land does not include rights of access to or from the street, highway, or freeway abutting said land, such rights having been relinquished by the document,

Recorded:	September 29, 1970, Book 9417, Page 364, of Official Records
Affects:	A portion of said land

20. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Southern California Edison Company
Purpose:	Public utilities
Recorded:	March 29, 1977, Book 12123, Page 814, of Official Records
Affects:	Lot 13

21. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Southern California Edison Company
Purpose:	Public utilities
Recorded:	February 5, 1979, Book 13024, Page 1157, of Official Records
Affects:	Lot 13

22. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	The City of Brea
Purpose:	Street, utility and slope maintenance
Recorded:	October 11, 1984, Instrument No. 84-421551, of Official Records
Affects:	Lot 13

23. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	The City of Brea
Purpose:	Public streets, highways, utilities, storm drains, sewers, cable television and incidental purposes
Recorded:	August 13, 1986, Instrument No. 86-359858, of Official Records
Affects:	Lot 13

24. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	The Stearns Rancho Company
Purpose:	Roads, railroads and ditches
Recorded:	July 10, 1987, Book 30, Page 11, of Deeds
Affects:	A portion of said land

25. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Southern California Edison Company
Purpose:	Public utilities
Recorded:	May 9, 1989, Instrument No. 89-243784, of Official Records
Affects:	Lot 21

26. An instrument entitled "Notice of Intent to Preserve Mineral Rights" recorded January 26, 1995 as Instrument/File No. 95-0034367 of Official Records.

Reference is made to said document for full particulars.

27. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Southern California Edison Company
Purpose:	Public utilities
Recorded:	January 4, 1996, Instrument No. 19960004773, of Official Records
Affects:	Lot 13

28. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	The City of Brea
Purpose:	Drainage
Recorded:	March 29, 1996, Instrument No. 19960153322, of Official Records
Affects:	Lot 13

29. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	The City of Brea
Purpose:	Road
Recorded:	March 29, 1996, Instrument No. 19960153323, of Official Records
Affects:	Lot 13

30. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	The City of Brea
Purpose:	Water pipeline
Recorded:	March 29, 1996, Instrument No. 19960153324, of Official Records
Affects:	Lot 13

31. Easements, covenants and conditions contained in the deed from Union Oil Company of California, a California corporation, for itself and as successor by merger to Collier Carbon and Chemical Corporation, a California corporation formerly known as R.T. Collier Corporation which was successor by merger to Brea Chemicals, Inc. and Unocal Company, a Delaware corporation, as grantee, recorded April 10, 1996 as Instrument/File No. 19960175928 of Official Records. Reference is made to said document for full particulars.

32. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Union Oil Company of California dba UNOCAL
Purpose:	Microwave tower
Recorded:	May 21, 1996, Instrument No. 19960254739, of Official Records
Affects:	A portion of said land

33. An instrument entitled "Agreement Between Adjacent Landowners" recorded October 9, 2001 as Instrument/File No. 20010710857 of Official Records.

Reference is made to said document for full particulars.

An instrument entitled "First Amendment to Agreement Between Adjacent Landowners" recorded March 9, 2004 as Instrument/File No. 2004000188721 of Official Records.

Reference is made to said document for full particulars.

34. An instrument entitled "Tonner Hills Development Agreement" recorded February 14, 2003 as Instrument/File No. 2003000171873 of Official Records.

Reference is made to said document for full particulars.

An instrument entitled "Assignment of Secured Fire Protection Agreement" recorded July 24, 2006 as Instrument/File No. 2006000490852 of Official Records.

Reference is made to said document for full particulars.

35. INTENTIONALLY DELETED

36. The Development notes on the Map of Tract No. 16178 which recite:

"This map does no create any building sites and does not allow for any grading or construction.

This map is subject to the provisions of the Tonner Hills Planned Community (Zone Change 01-01) and related area plan.

This map is within an area designated as a "High/Very High Fire Hazard Area", due to wildland exposure based on the State SRA Maps.

This map is within an area designated as a "Special Fire Protection Area", and must meet all requirements for development within the area or file for an exclusion with the Fire Chief".

37. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as delineated or as offered for dedication, on the map of said tract.

Purpose:	Future utility
Affects:	Lots 11, 13, 16, 18 and 19

38. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as delineated or as offered for dedication, on the map of said tract.

Purpose:	50' public right of way to be dedicated in the future
Affects:	Lot 16

39. **Covenants, conditions and restrictions** in the declaration of restrictions but omitting any covenants or restrictions, if any, including, but not limited to those based upon race, color, religion, sex, sexual orientation, familial status, marital status, disability, handicap, national origin, ancestry, or source of income, as set forth in applicable state or federal laws, except to the extent that said covenant or restriction is permitted by applicable law.

Recorded: December 29, 2003, Instrument No. 2003001523972, of Official Records

Said covenants, conditions and restrictions provide that a violation thereof shall not defeat the lien of any mortgage or deed of trust made in good faith and for value.

Modification(s) of said covenants, conditions and restrictions

Recorded: March 16, 2004, Instrument No. 2004000213938, of Official Records

40. Easements, covenants and conditions contained in the deed from Nuevo Energy Company, a Delaware corporation as grantor, to Tonner Hills 680 LLC, a Delaware limited liability company, as grantee, recorded December 29, 2003 as Instrument/File No. 2003001523974 of Official Records. Reference is made to said document for full particulars.

Affects: Lots 11 through 19, inclusive, and 21

41. An instrument entitled "Easement Agreement" recorded December 29, 2003 as Instrument/File No. 2003001523975 of Official Records.

Reference is made to said document for full particulars.

42. INTENTIONALLY DELETED

43. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Exxonmobil Oil Corporation, a New York corporation
Purpose:	Pipeline
Recorded:	August 18, 2005, Instrument No. 2005000651047, of Official Records
Affects:	Lot 13

44. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Southern California Edison Co.
Purpose:	Public utilities
Recorded:	June 7, 1988, Instrument No. 88-268095, of Official Records
Affects:	A portion of the land

45. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Mobil Oil Corporation
Purpose:	Fuel oil transportation purposes
Recorded:	March 31, 1982, Instrument No. 82-340271, of Official Records
Affects:	A portion of the land

46. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	Aera Energy, LLC
Purpose:	Utility purposes
Recorded:	January 9, 2004, Instrument No. 2004000017871, of Official Records
Affects:	A portion of the land

47. **Matters** contained in that certain document entitled "Memorandum of Agreement" dated February 10, 2006, executed by and between Tonner Hills SSP, LLC , a Delaware limited liability company and Blacksand Partners, L.P., a Texas limited partnership recorded March 27, 2006, Instrument No. 2006000196238, of Official Records.

Reference is hereby made to said document for full particulars.

48. **Easement(s)** for the purpose(s) shown below and rights incidental thereto as granted in a document.

Granted to:	The City of Brea
Purpose:	Road, emergency access and drainage purposes
Recorded:	May 11, 1987, Instrument No. 87-260803, of Official Records
Affects:	Parcel 2 As shown on the map of tract 16178

END OF ITEMS

Note 1. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-031-021
Fiscal Year:	2006 - 2007
1st Installment:	$47.10
2nd Installment:	$47.10
Amount:	$0.00
Exemption:	$0.00
Land:	$6,412.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	53000

Note 2. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-031-22
Fiscal Year:	2006 - 207
1st Installment:	$228.22
2nd Installment:	$228.22
Amount:	$0.00
Exemption:	$0.00
Land:	$41,211.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	53000

Note 3. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-031-24
Fiscal Year:	2006 - 2007
1st Installment:	$1,614.26
2nd Installment:	$1,614.26
Amount:	$0.00
Exemption:	$0.00
Land:	$307,508.00
Improvements:	$0.00

Note 4. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-031-27
Fiscal Year:	2006 - 2007
1st Installment:	$49.22
2nd Installment:	$49.22
Amount:	$0.00
Exemption:	$0.00
Land:	$6,819.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	53000

Note 5. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-031-28
Fiscal Year:	2006 - 2007
1st Installment:	$273.22
2nd Installment:	$273.22
Amount:	$0.00
Exemption:	$0.00
Land:	$49,856.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	53000

Note 6. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-012-32
Fiscal Year:	2006 - 2007
1st Installment:	$41.97
2nd Installment:	$41.97
Amount:	$0.00
Exemption:	$0.00
Land:	$3,027.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	02031

Note 7. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-012-33
Fiscal Year:	2006 - 2007
1st Installment:	$74.56
2nd Installment:	$74.56
Amount:	$0.00
Exemption:	$0.00
Land:	$5,991.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	02031

Note 8. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-012-35
Fiscal Year:	2006 - 2007
1st Installment:	$109.14
2nd Installment:	$109.14
Amount:	$0.00
Exemption:	$0.00
Land:	$18,331.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	53000

Note 9. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-012-36
Fiscal Year:	2006 - 2007
1st Installment:	$342.82
2nd Installment:	$342.82
Amount:	$0.00
Exemption:	$0.00
Land:	$63,229.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	53000

Note 10. Property taxes for the fiscal year shown below are PAID. For proration purposes the amounts are:

Tax Identification No.:	306-012-38
Fiscal Year:	2006 - 2007
1st Installment:	$29.17
2nd Installment:	$29.17
Amount:	$0.00
Exemption:	$0.00
Land:	$2,968.00
Improvements:	$0.00
Personal Property:	$0.00
Code Area:	53000

Note 11. Wiring instructions for Fidelity National title Company, Corona, CA, are as follows:

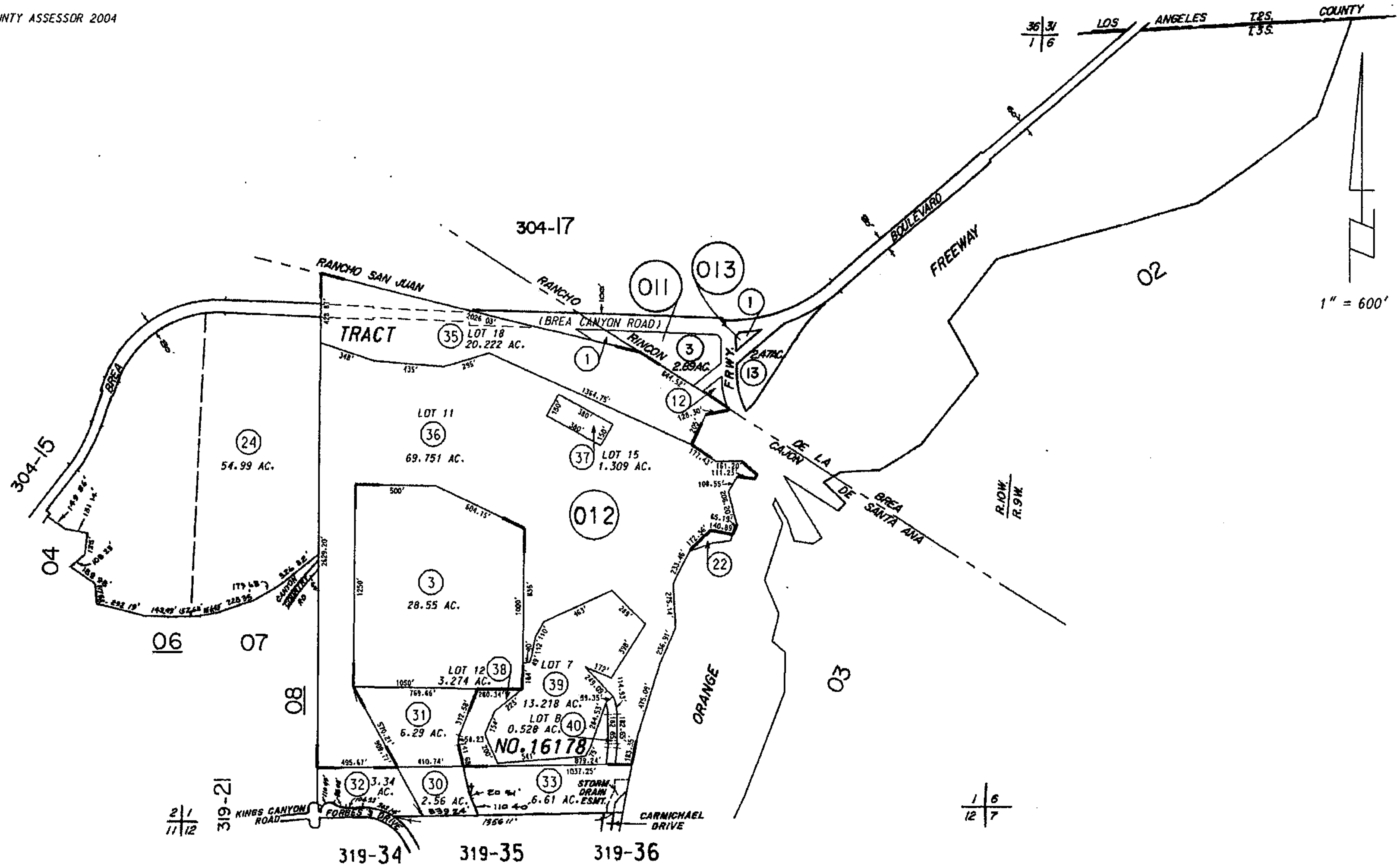
Receiving Bank:	Union Bank of California (800) 849-6466 Irvine, CA 92614
ABA Routing No.:	122000496
Credit Account Name:	Fidelity National title Company - Builder Services Payoff/Admin 1315 Corona Pointe Court, Corona, CA 92879
Credit Account No.:	9100586700
Reference No.:	06-**259901504**

These wiring instructions are for this specific transaction involving the Title Department of the Newport Beach office of Fidelity National Title Company. These instructions therefore should not be used in other transactions without first verifying the information with our accounting department. It is imperative that the wire text be exactly as indicated. Any extraneous information may cause unnecessary delays in confirming the receipt of funds.

END OF NOTES

THIS MAP WAS PREPARED FOR ORANGE
COUNTY ASSESSOR DEPT. PURPOSES ONLY.
THE ASSESSOR MAKES NO GUARANTEE AS TO
ITS ACCURACY NOR ASSUMES ANY LIABILITY
FOR OTHER USES. NOT TO BE REPRODUCED.
ALL RIGHTS RESERVED.
© COPYRIGHT ORANGE COUNTY ASSESSOR 2004

POR. SEC.6, T.3 S.R.9 W.
POR. SEC.1 & 2, T.3 S.R.10 W.



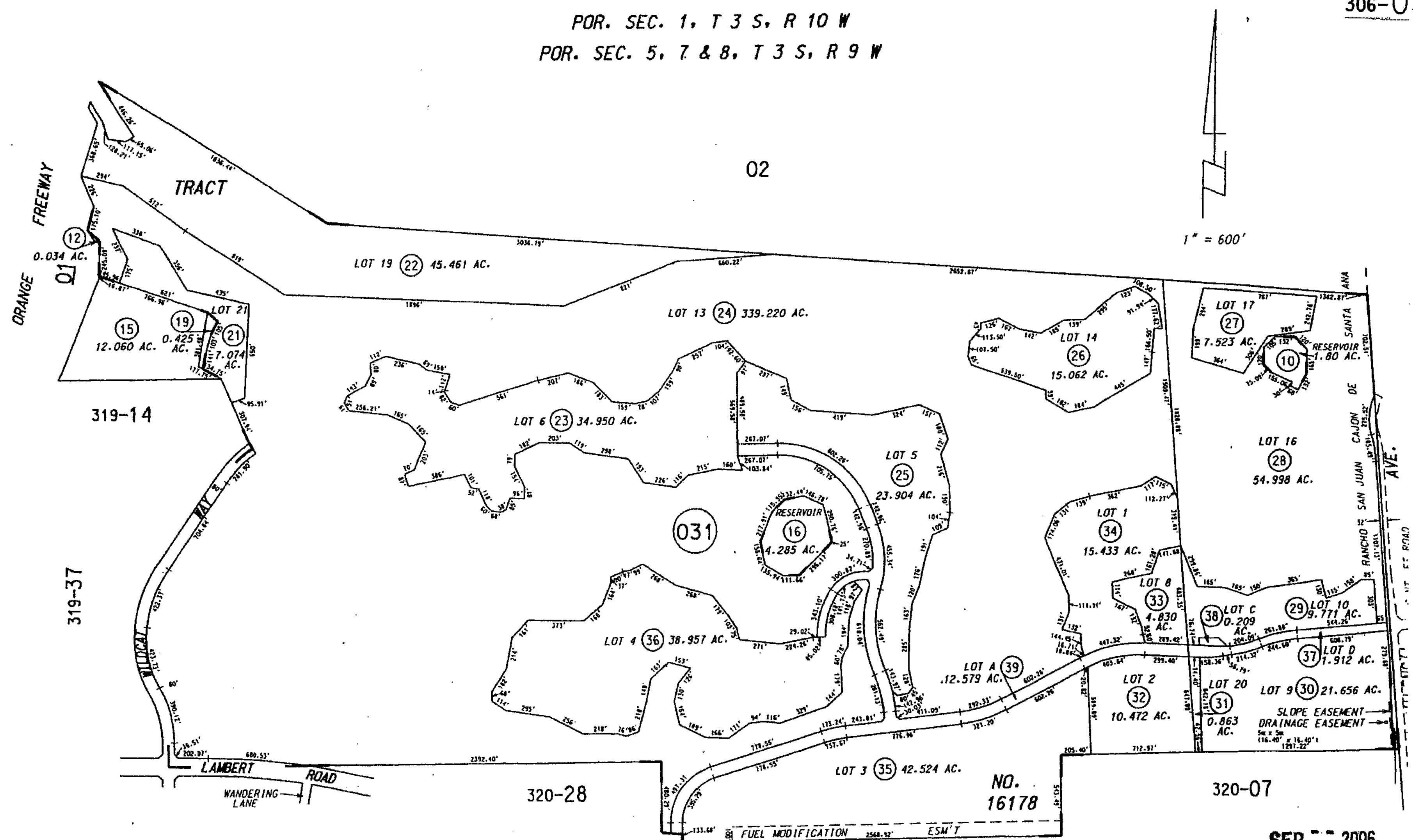
MARCH 1971

RANCHO RINCON DE LA BREA L.A. 3-79,80
RANCHO SAN JUAN CAJON DE SANTA ANA L.A. 3-97
TRACT NO. 16178 M.M. 853-01 to 15 inc.

NOTE - ASSESSOR'S BLOCK & PARCEL NUMBERS SHOWN IN CIRCLES

ASSESSOR'S MAP
BOOK 306 PAGE 01
COUNTY OF ORANGE

SEE SPECIAL PAGE 306-039 FOR SUBSURFACE FEE TITLE ASSESSMENT
POR. SEC. 1, T 3 S, R 10 W
POR. SEC. 5, 7 & 8, T 3 S, R 9 W



MARCH 1971

RANCHO SAN JUAN CAJON DE SANTA ANA L.A. 3-97
TRACT NO. 16178 M.M. 853-01 to 15 inc.

320-34

NOTE - ASSESSOR'S BLOCK & PARCEL NUMBERS SHOWN IN CIRCLES

SEP - - 2006

ASSESSOR'S MAP
BOOK 306 PAGE 03
COUNTY OF ORANGE

2/14/06

ATTACHMENT ONE

AMERICAN LAND TITLE ASSOCIATION
RESIDENTIAL TITLE INSURANCE POLICY (6-1-87) EXCLUSIONS

In addition to the Exceptions in Schedule B, you are not insured against loss, costs, attorneys' fees, and expenses resulting from:

1. Governmental police power, and the existence or violation of any law or government regulation. This includes building and zoning ordinances and also laws and regulations concerning:
   - land use
   - improvements on the land
   - land division
   - environmental protection

   This exclusion does not apply to violations or the enforcement of these matters which appear in the public records at policy date.
   This exclusion does not limit the zoning coverage described in Items 12 and 13 of Covered Title Risks.
2. The right to take the land by condemning it, unless:
   - a notice of exercising the right appears in the public records on the Policy Date
   - the taking happened prior to the Policy Date and is binding on you if you bought the land without knowledge of the taking
3. Title Risks:
   - that are created, allowed, or agreed to by you
   - that are known to you, but not to us, on the Policy Date-unless they appeared in the public records
   - that result in no loss to you
   - that first affect your title after the Policy Date – this does not limit the labor and material lien coverage in Item 8 of Covered Title Risks
4. Failure to pay value for your title.
5. Lack of a right:
   - to any land outside the area specifically described and referred to in Item 3 of Schedule A

     or
   - in streets, alleys, or waterways that touch your land

   This exclusion does not limit the access coverage in Item 5 of Covered Title Risks.

In addition to the Exclusions, you are not insured against loss, costs, attorneys' fees, and the expenses resulting from:

1. Any rights, interests, or claims of parties in possession of the land not shown by the public records.
2. Any easements or liens not shown by the public records. This does not limit the lien coverage in Item 8 of Covered Title Risks.
3. Any facts about the land which a correct survey would disclose and which are not shown by the public records. This does not limit the forced removal coverage in item 12 of Covered Title Risks.
4. Any water rights or claims or title to water in or under the land, whether or not shown by the public records.

CALIFORNIA LAND TITLE ASSOCIATION STANDARD COVERAGE POLICY – 1990
EXCLUSIONS FROM COVERAGE

The following matters are expressly excluded from the coverage of this policy and the Company will not pay loss or damage, costs, attorneys' fees or expenses which arise by reason of:

1. (a) Any law, ordinance or governmental regulation (including but not limited to building and zoning laws, ordinances, or regulations) restricting, regulating, prohibiting or relating (i) the occupancy, use, or enjoyment of the land; (ii) the character, dimensions or location of any improvement now or hereafter erected on the land; (iii) a separation in ownership or a change in the dimensions or area of the land or any parcel of which the land is or was a part; or (iv) environmental protection, or the effect of any violation of these laws, ordinances or governmental regulations, except to the extent that a notice of the enforcement thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.
   (b) Any governmental police power not excluded by (a) above, except to the extent that a notice of the exercise thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.
2. Rights of eminent domain unless notice of the exercise thereof has been recorded in the public records at Date of Policy, but not excluding from coverage any taking which has occurred prior to Date of Policy which would be binding on the rights of a purchaser for value without knowledge.
3. Defects, liens, encumbrances, adverse claims, or other matters:
   (a) whether or not recorded in the public records at Date of Policy, but created, suffered, assumed or agreed to by the insured claimant;
   (b) not known to the Company, not recorded in the public records at Date of Policy, but known to the insured claimant and not disclosed in writing to the Company by the insured claimant prior to the date the insured claimant became an insured under this policy;
   (c) resulting in no loss or damage to the insured claimant;
   (d) attaching or created subsequent to Date of Policy; or
   (e) resulting in loss or damage which would not have been sustained if the insured claimant had paid value for the insured mortgage or for the estate or interest insured by this policy.
4. Unenforceability of the lien of the insured mortgage because of the inability or failure of the insured at Date of Policy, or the inability or failure of any subsequent owner of the indebtedness, to comply with the applicable doing business laws of the state in which the land is situated.
5. Invalidity or unenforceability of the lien of the insured mortgage, or claim thereof, which arises out of the transaction evidenced by the insured mortgage and is based upon usury or any consumer credit protection or truth in lending law.
6. Any claim, which arises out of the transaction vesting in the insured the estate or interest insured by this policy or the transaction creating the interest of the insured lender, by reason of the operation of federal bankruptcy, state insolvency or similar creditors' rights laws.

SCHEDULE B, PART I
EXCEPTIONS FROM COVERAGE

This policy does not insure against loss or damage (and the Company will not pay costs, attorneys' fees or expenses) which arise by reason of:

PART I

1. Taxes or assessments which are not shown as existing liens by the records of any taxing authority that levies taxes or assessments on real property or by the public records. Proceedings by a public agency which may result in taxes or assessments, or notices of such proceedings, whether or not shown by the records of such agency or by the public records.
2. Any facts, rights, interests or claims which are not shown by the public records but which could be ascertained by an inspection of the land or which may be asserted by persons in possession thereof.
3. Easements, liens or encumbrances, or claims thereof, which are not shown by the public records.
4. Discrepancies, conflicts in boundary lines, shortage in area, encroachments, or any other facts which a correct survey would disclose, and which are not shown by the public records.
5. (a) Unpatented mining claims; (b) reservations or exceptions in patents or in Acts authorizing the issuance thereof; (c) water rights, claims or title to water, whether or not the matters excepted under (a), (b), or (c) are shown by the public records.

ATTACHMENT ONE
(CONTINUED)

AMERICAN LAND TITLE ASSOCIATION LOAN POLICY (10-17-92) WITH A.L.T.A. ENDORSEMENT-FORM 1 COVERAGE EXCLUSIONS FROM COVERAGE

The following matters are expressly excluded from the coverage of this policy and the Company will not pay loss or damage, costs, attorneys' fees or expenses which arise by reason of:

1. (a) Any law, ordinance or governmental regulation (including but not limited to building and zoning laws, ordinances, or regulations) restricting, regulating, prohibiting or relating to (i) the occupancy, use, or enjoyment of the land; (ii) the character, dimensions or location of any improvement now or hereafter erected on the land; (iii) a separation in ownership or a change in the dimensions or area of the land or any parcel of which the land is or was a part; or (iv) environmental protection, or the effect of any violation of these laws, ordinances or governmental regulations, except to the extent that a notice of the enforcement thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.
   (b) Any governmental police power not excluded by (a) above, except to the extent that a notice of the exercise thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.
2. Rights of eminent domain unless notice of the exercise thereof has been recorded in the public records at Date of Policy, but not excluding from coverage any taking which has occurred prior to Date of Policy which would be binding on the rights of a purchaser for value without knowledge.
3. Defects, liens, encumbrances, adverse claims, or other matters:
   (a) created, suffered, assumed or agreed to by the insured claimant;
   (b) not known to the Company, not recorded in the public records at Date of Policy, but known to the insured claimant and not disclosed in writing to the Company by the insured claimant prior to the date the insured claimant became an insured under this policy;
   (c) resulting in no loss or damage to the insured claimant;
   (d) attaching or created subsequent to Date of Policy (except to the extent that this policy insures the priority of the lien of the insured mortgage over any statutory lien for services, labor or material or to the extent insurance is afforded herein as to assessments for street improvements under construction or completed at Date of Policy); or
   (e) resulting in loss or damage which would not have been sustained if the insured claimant had paid value for the insured mortgage.
4. Unenforceability of the lien of the insured mortgage because of the inability or failure of the insured at Date of Policy, or the inability or failure of any subsequent owner of the indebtedness, to comply with applicable doing business laws of the state in which the land is situated.
5. Invalidity or unenforceability of the lien of the insured mortgage, or claim thereof, which arises out of the transaction evidenced by the insured mortgage and is based upon usury or any consumer credit protection or truth in lending law.
6. Any statutory lien for services, labor or materials (or the claim of priority of any statutory lien for services, labor or materials over the lien of the insured mortgage) arising from an improvement or work related to the land which is contracted for and commenced subsequent to Date of Policy and is not financed in whole or in part by proceeds of the indebtedness secured by the insured mortgage which at Date of Policy the insured has advanced or is obligated to advance.
7. Any claim, which arises out of the transaction creating the interest of the mortgagee insured by this policy, by reason of the operation of federal bankruptcy, state insolvency, or similar creditors' rights laws, that is based on:
   (i) the transaction creating the interest of the insured mortgagee being deemed a fraudulent conveyance or fraudulent transfer; or
   (ii) the subordination of the interest of the insured mortgagee as a result of the application of the doctrine of equitable subordination; or
   (iii) the transaction creating the interest of the insured mortgagee being deemed a preferential transfer except where the preferential transfer results from the failure:
      (a) to timely record the instrument of transfer; or
      (b) of such recordation to impart notice to a purchaser for value or a judgement or lien creditor.

AMERICAN LAND TITLE ASSOCIATION OWNER'S POLICY (10-17-92) EXCLUSIONS FROM COVERAGE

The following matters are expressly excluded from the coverage of this policy and the Company will not pay loss or damage, costs, attorneys' fees or expenses which arise by reason of:

1. (a) Any law, ordinance or governmental regulation (including but not limited to building and zoning laws, ordinances, or regulations) restricting, regulating, prohibiting or relating to (i) the occupancy, use, or enjoyment of the land; (ii) the character, dimensions or location of any improvement now or hereafter erected on the land; (iii) a separation in ownership or a change in the dimensions or area of the land or any parcel of which the land is or was a part; or (iv) environmental protection, or the effect of any violation of these laws, ordinances or governmental regulations, except to the extent that a notice of the enforcement thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.
   (b) Any governmental police power not excluded by (a) above, except to the extent that a notice of the exercise thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.
2. Rights of eminent domain unless notice of the exercise thereof has been recorded in the public records at Date of Policy, but not excluding from coverage any taking which has occurred prior to Date of Policy which would be binding on the rights of a purchaser for value without knowledge.
3. Defects, liens, encumbrances, adverse claims, or other matters:
   (a) created, suffered, assumed or agreed to by the insured claimant;
   (b) not known to the Company, not recorded in the public records at Date of Policy, but known to the insured claimant and not disclosed in writing to the Company by the insured claimant prior to the date the insured claimant became an insured under this policy;
   (c) resulting in no loss or damage to the insured claimant;
   (d) attaching or created subsequent to Date of Policy, or
   (e) resulting in loss or damage which would not have been sustained if the insured claimant had paid value for the estate or interest insured by this policy.
4. Any claim, which arises out of the transaction vesting in the insured the estate or interest insured by this policy, by reason of the operation of federal bankruptcy, state insolvency, or similar creditors' rights laws, that is based on:
   (i) the transaction creating the estate or interest insured by this policy being deemed a fraudulent conveyance or fraudulent transfer; or
   (ii) the transaction creating the estate or interest insured by this policy being deemed a preferential transfer except where the preferential transfer results from the failure:
      (a) to timely record the instrument of transfer; or
      (b) of such recordation to impart notice to a purchaser for value or a judgement or lien creditor.

The above ALTA policy forms, dated 10-17-92, may be issued to afford either Standard Coverage or Extended Coverage. In addition to the above Exclusions from Coverage, the Exceptions from Coverage in a Standard Coverage policy will also include the following General Exceptions:

EXCEPTIONS FROM COVERAGE

This policy does not insure against loss or damage (and the Company will not pay costs, attorneys' fees or expenses) which arise by reason of:

1. Taxes or assessments which are not shown as existing liens by the records of any taxing authority that levies taxes or assessments on real property or by the public records. Proceedings by a public agency which may result in taxes or assessments, or notices of such proceedings, whether or not shown by the records of such agency or by the public records.
2. Any facts, rights, interests or claims which are not shown by the public records but which could be ascertained by an inspection of the land or which may be asserted by persons in possession thereof.
3. Easements, liens or encumbrances, or claims thereof, which are not shown by the public records.
4. Discrepancies, conflicts in boundary lines, shortage in area, encroachments, or any other facts which a correct survey would disclose, and which are not shown by the public records.
5. (a) Unpatented mining claims; (b) reservations or exceptions in patents or in Acts authorizing the issuance thereof; (c) water rights, claims or title to water, whether or not the matters excepted under (a), (b) or (c) are shown by the public records.

ATTACHMENT ONE
(CONTINUED)

CLTA HOMEOWNER'S POLICY OF TITLE INSURANCE (10-22-03)
ALTA HOMEOWNER'S POLICY OF TITLE INSURANCE (10-22-03)
EXCLUSIONS

In addition to the Exceptions in Schedule B, You are not insured against loss, costs, attorneys' fees, and expenses resulting from:

1. Governmental police power, and the existence or violation of any law or government regulation. This includes ordinances, laws and regulations concerning:
   a. building
   b. zoning
   c. Land use
   d. improvements on Land
   e. Land division
   f. environmental protection

   This Exclusion does not apply to violations or the enforcement of these matters if notice of the violation or enforcement appears in the Public Records at the Policy Date.
   This Exclusion does not limit the coverage described in Covered Risk 14, 15, 16, 17 or 24.
2. The failure of Your existing structures, or any part of them, to be constructed in accordance with applicable building codes. This Exclusion does not apply to violations of building codes if notice of the violation appears in the Public Records at the Policy Date.
3. The right to take the Land by condemning it, unless:
   a. notice of exercising the right appears in the Public Records at the Policy Date; or
   b. the taking happened before the Policy Date and is binding on You if You bought the Land without Knowing of the taking.
4. Risks:
   a. that are created, allowed, or agreed to by You, whether or not they appear in the Public Records;
   b. that are Known to You at the Policy Date, but not to Us, unless they appear in the Public Records at the Policy Date;
   c. that result in no loss to You; or
   d. that first occur after the Policy Date – this does not limit the coverage described in Covered Risk 7, 8.d, 22, 23, 24 or 25.
5. Failure to pay value for Your Title.
6. Lack of a right:
   a. to any Land outside the area specifically described and referred to in paragraph 3 of Schedule A; and
   b. in streets, alleys, or waterways that touch the Land.

   This Exclusion does not limit the coverage described in Covered Risk 11 or 18.

LIMITATIONS ON COVERED RISKS

Your insurance for the following Covered Risks is limited on the Owner's Coverage Statement as follows:

- For Covered Risk 14, 15, 16 and 18, Your Deductible Amount and Our Maximum Dollar Limit of Liability shown in Schedule A.

The deductible amounts and maximum dollar limits shown on Schedule A are as follows:

	Your Deductible Amount	Our Maximum Dollar Limit of Liability
Covered Risk 14:	1.00% of Policy Amount or $ 2,500.00 (whichever is less)	$ 10,000.00
Covered Risk 15:	1.00% of Policy Amount or $ 5,000.00 (whichever is less)	$ 25,000.00
Covered Risk 16:	1.00% of Policy Amount or $ 5,000.00 (whichever is less)	$ 25,000.00
Covered Risk 18:	1.00% of Policy Amount or $ 2,500.00 (whichever is less)	$ 5,000.00

ALTA EXPANDED COVERAGE RESIDENTIAL LOAN POLICY (10/13/01)
EXCLUSIONS FROM COVERAGE

The following matters are expressly excluded from the coverage of this policy and the Company will not pay loss or damage, costs, attorneys fees or expenses which arise by reason of:

1. (a) Any law, ordinance or governmental regulation (including but not limited to zoning laws, ordinances, or regulations) restricting, regulating, prohibiting or relating to (i) the occupancy, use, or enjoyment of the Land; (ii) the character, dimensions or location of any improvements now or hereafter erected on the Land; (iii) a separation in ownership or a change in the dimensions or areas of the Land or any parcel of which the Land is or was a part; or (iv) environmental protection, or the effect of any violation of these laws, ordinances or governmental regulations, except to the extent that a notice of the enforcement thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the Land has been recorded in the Public Records at Date of Policy. This exclusion does not limit the coverage provided under Covered Risks 12, 13, 14, and 16 of this policy.
   (b) Any governmental police power not excluded by (a) above, except to the extent that a notice of the exercise thereof or a notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the Land has been recorded in the Public Records at Date of Policy. This exclusion does not limit the coverage provided under Covered Risks 12, 13, 14, and 16 of this policy.
2. Rights of eminent domain unless notice of the exercise thereof has been recorded in the Public Records at Date of Policy, but not excluding from coverage any taking which has occurred prior to Date of Policy which would be binding on the rights of a purchaser for value without Knowledge.
3. Defects, liens, encumbrances, adverse claims or other matters:
   (a) created, suffered, assumed or agreed to by the Insured Claimant;
   (b) not Known to the Company, not recorded in the Public Records at Date of Policy, but Known to the Insured Claimant and not disclosed in writing to the Company by the Insured Claimant prior to the date the Insured Claimant became an Insured under this policy;
   (c) resulting in no loss damage to the Insured Claimant;
   (d) attaching or created subsequent to Date of Policy (this paragraph does not limit the coverage provided under Covered Risks 8, 16, 18, 19, 20, 21, 22 ,23, 24, 25 and 26); or
   (e) resulting in loss or damage which would not have been sustained if the Insured Claimant had paid value for the Insured Mortgage.
4. Unenforceability of the lien of the Insured Mortgage because of the inability or failure of the Insured at Date of Policy, or the inability or failure of any subsequent owner of the indebtedness, to comply with applicable doing business laws of the state in which the Land is situated.
5. Invalidity or unenforceability of the lien of the Insured Mortgage, or claim thereof, which arises out of the transaction evidenced by the Insured Mortgage and is based upon usury, except as provided in Covered Risk 27, or any consumer credit protection or truth in lending law.
6. Real property taxes or assessments of any governmental authority which become a lien on the Land subsequent to Date of Policy. This exclusion does not limit the coverage provided under Covered Risks 7, 8(e) and 26.
7. Any claim of invalidity, unenforceability or lack of priority of the lien of the Insured Mortgage as to advances or modifications made after the Insured has Knowledge that the vestee shown in Schedule A is no longer the owner of the estate or interest covered by this policy. This exclusion does not limit the coverage provided in Covered Risk 8.
8. Lack of priority of the lien of the Insured Mortgage as to each and every advance made after Date of Policy, and all interest charged thereon, over liens, encumbrances and other matters affecting the title, the existence of which are Known to the Insured at:
   (a) The time of the advance; or
   (b) The time a modification is made to the terms of the Insured Mortgage which changes the rate of interest charged, if the rate of interest is greater as a result of the modification than it would have been before the modification. This exclusion does not limit the coverage provided in Covered Risk 8.
9. The failure of the residential structure, or any portion thereof to have been constructed before, on or after Date of Policy in accordance with applicable building codes. This exclusion does not apply to violations of building codes if notice of the violation appears in the Public Records at Date of Policy.

Notice

You may be entitled to receive a $20.00 discount on escrow services if you purchased, sold or refinanced residential property in California between May 19, 1995 and November 1, 2002. If you had more than one qualifying transaction, you may be entitled to multiple discounts.

If your previous transaction involved the same property that is the subject of your current transaction, you do not have to do anything; the Company will provide the discount, provided you are paying for escrow or title services in this transaction.

If your previous transaction involved property different from the property that is subject of your current transaction, you must - prior to the close of the current transaction - inform the Company of the earlier transaction, provide the address of the property involved in the previous transaction, and the date or approximate date that the escrow closed to be eligible for the discount.

Unless you inform the Company of the prior transaction on property that is not the subject of this transaction, the Company has no obligation to conduct an investigation to determine if you qualify for a discount. If you provide the Company information concerning a prior transaction, the Company is required to determine if you qualify for a discount which is subject to other terms and conditions.

Effective through November 1, 2014

Fidelity National Title Group of Companies' Privacy Statement

July 1, 2001

We recognize and respect the privacy expectations of today's consumers and the requirements of applicable federal and state privacy laws. We believe that making you aware of how we use your non-public personal information ("Personal Information"), and to whom it is disclosed, will form the basis for a relationship of trust between us and the public that we serve. This Privacy Statement provides that explanation. We reserve the right to change this Privacy Statement from time to time consistent with applicable privacy laws.

In the course of our business, we may collect Personal Information about you from the following sources:

- From applications or other forms we receive from you or your authorized representative;
- From your transactions with, or from the services being performed by, us, our affiliates, or others;
- From our internet web sites;
- From the public records maintained by governmental entities that we either obtain directly from those entities, or from our affiliates or others; and
- From consumer or other reporting agencies.

Our Policies Regarding the Protection of the Confidentiality and Security of Your Personal Information

We maintain physical, electronic and procedural safeguards to protect your Personal Information from unauthorized access or intrusion. We limit access to the Personal Information only to those employees who need such access in connection with providing products or services to you or for other legitimate business purposes.

Our Policies and Practices Regarding the Sharing of Your Personal Information

We may share your Personal Information with our affiliates, such as insurance companies, agents, and other real estate settlement service providers. We also may disclose your Personal Information:

- to agents, brokers or representatives to provide you with services you have requested;
- to third-party contractors or service providers who provide services or perform marketing or other functions on our behalf; and
- to others with whom we enter into joint marketing agreements for products or services that we believe you may find of interest.

In addition, we will disclose your Personal Information when you direct or give us permission, when we are required by law to do so, or when we suspect fraudulent or criminal activities. We also may disclose your Personal Information when otherwise permitted by applicable privacy laws such as, for example, when disclosure is needed to enforce our rights arising out of any agreement, transaction or relationship with you.

One of the important responsibilities of some of our affiliated companies is to record documents in the public domain. Such documents may contain your Personal Information.

Right to Access Your Personal Information and Ability to Correct Errors or Request Changes or Deletion

Certain states afford you the right to access your Personal Information and, under certain circumstances, to find out to whom your Personal Information has been disclosed. Also, certain states afford you the right to request correction, amendment or deletion of your Personal Information. We reserve the right, where permitted by law, to charge a reasonable fee to cover the costs incurred in responding to such requests.

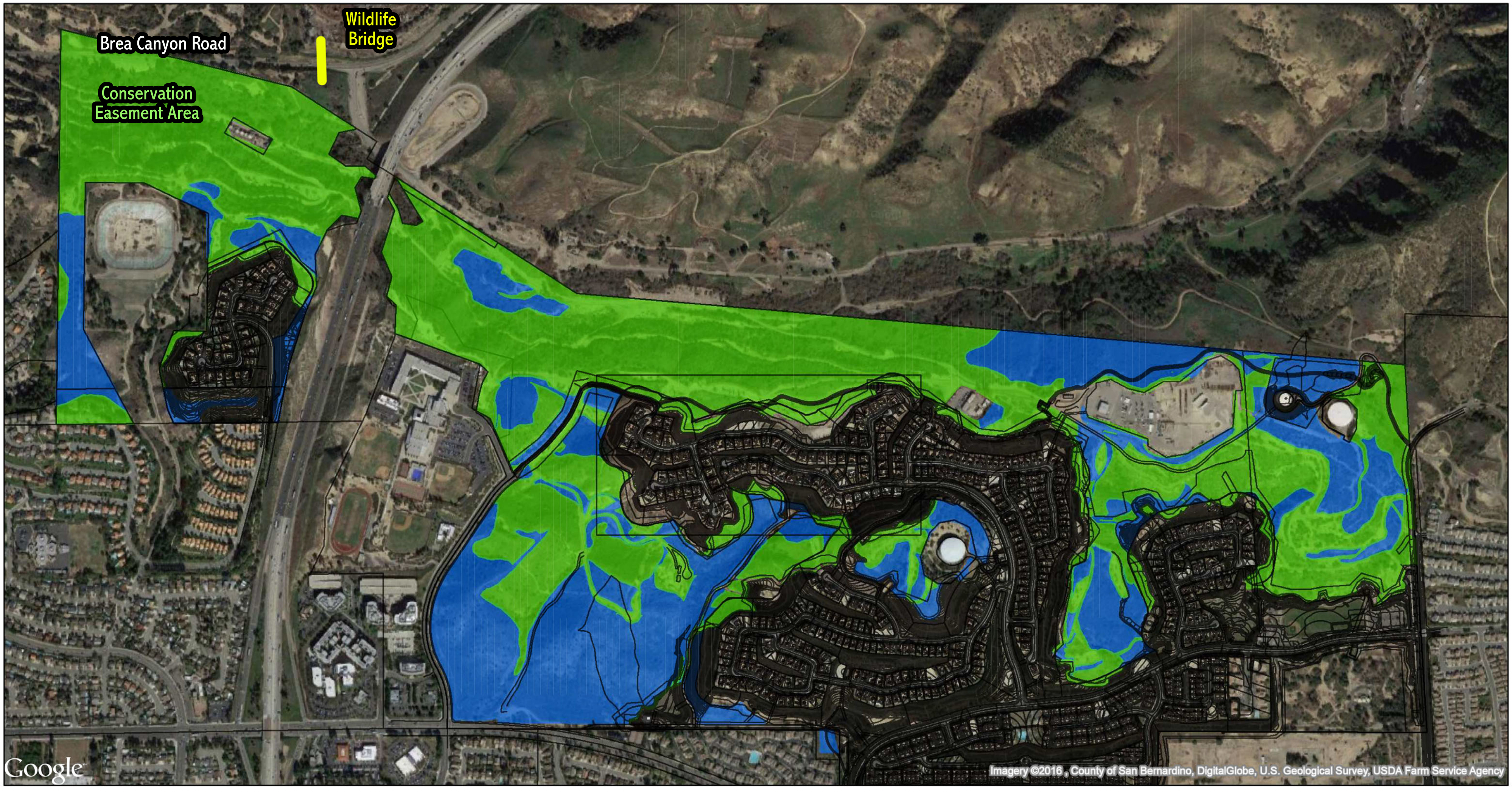
All requests must be made in writing to the following address:

Fidelity National Title Group, Inc.
Privacy Compliance Officer
601 Riverside Avenue
Jacksonville, FL 32204

Multiple Products or Services

If we provide you with more than one financial product or service, you may receive more than one privacy notice from us. We apologize for any inconvenience this may cause you.

Exhibit B



Legend

- Property Boundary
- Conserved Lands - 288.2 ac.
- Phases 1-3 Mitigation Areas = 166.93 ac.

N

0 400 800 1,600
Feet

1 inch = 800 feet

TONNER HILLS

Mitigation & Conserved Areas

GLENN LUKOS ASSOCIATES

Exhibit 2A

X:\00 - 0362 ONLY\0004-20TONN\004-20_GIS\MitigationGIS\004-20 Mitigation_Conserved Areas.mxd

Exhibit C

Rethinking How We Build So Californians Can Drive Less

Caltrans is committed to providing Californians with access to destinations while reducing the amount of motor vehicle traffic required to achieve that access. This is a departure from past practice, when adding to the supply of roadways was the default option. But over many years of observation and analysis, we have learned that adding supply has a paradoxical outcome. It generates more driving, which is both costly to personal budgets and the environment, and which often re-congests the very roadways we built or expanded.

Senate Bill (SB) 743 Implementation

Addressing induced travel was one of the motivations behind SB 743 (2013), which amended the state's long-standing, premier environmental law, the California Environmental Quality Act. Among other things, legislators and many constituents were concerned that old rules under the "level-of-service" rubric (LOS) were too focused on keeping traffic speeds up and therefore making it hard to build infill housing and other land uses in denser areas. State guidance and local regulations adopted in the wake of SB 743 have removed those burdens in many places, allowing needed development to proceed in areas that tend to generate little new traffic.

In 2020 Caltrans adopted its guidance under SB 743. The department's Transportation Analysis Framework and Transportation Analysis for CEQA provide guidance for assessing induced travel impacts from prospective projects on the State Highway System. Another document, the Transportation Impact Study Guide, provides guidance for Caltrans' comments to land-use authorities.

This guidance, which reflects a major change in the department's approach, came after extensive research and consultation with experts and stakeholders. The guidance does not answer every question about induced traffic, however, so efforts to amend or extend it are continuing. For example, in June 2021, Caltrans and the Governor's Office of Planning and Research kicked off a multi-year working group composed of 40 stakeholders to help us address unanswered questions and generally improve the departments' processes around induced travel. We also have staff around the state working with regional and local entities on the same issues. We welcome any inquires at sb743implementation@dot.ca.gov

What Is Induced Demand?

The methods by which projects may spur more driving, called "induced traffic" or "induced demand," are clearly laid out in the department's "Transportation Analysis Framework" (TAF). Induced traffic tends to result from projects that increase travel speeds, such as roadway capacity additions. Such projects allow drivers to take new or longer trips, and to move from transit or other non-auto modes to driving. In addition, greater speeds spur land uses to spread out, increasing travel distances. After a while, that extra traffic again causes congestion, but the spread-out land uses remain, so travelers must spend more time and money reaching desired destinations, with greater emissions. On the other hand, non-automotive projects – those around transit, walking, and biking – tend to reduce motor vehicle travel.

A panel of experts informed the TAF's induced travel methodology and is summarized in the Expert Panel Report (PDF).

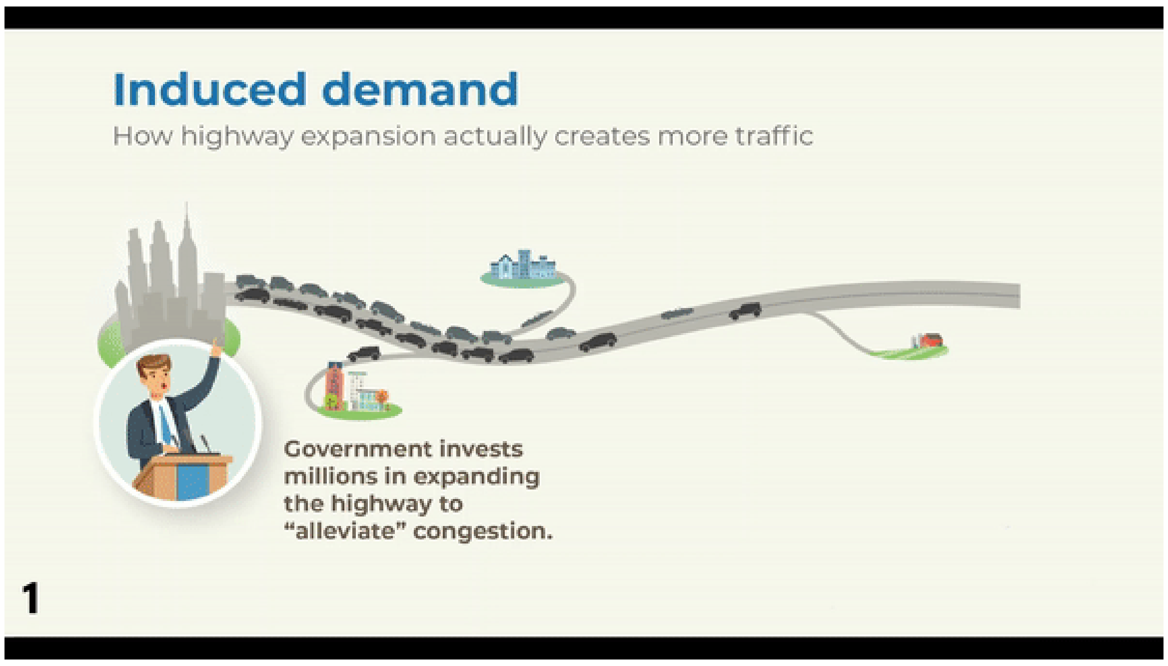
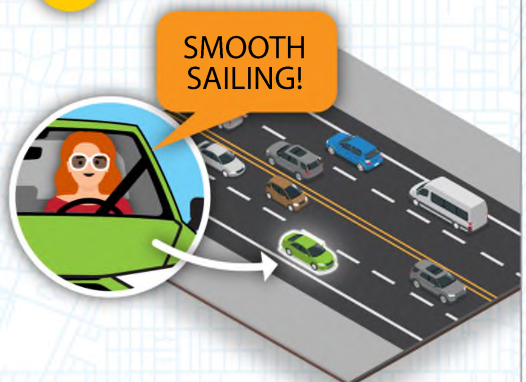


Exhibit D

BIGGER ROADS, MORE TRAFFIC

1 For years, governments tried to tackle congestion by widening our roads.

2 Adding a lane often helps at first.

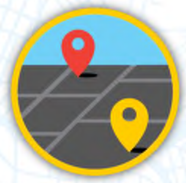


3 However, over time the wider highway creates even more traffic than before.

Why?

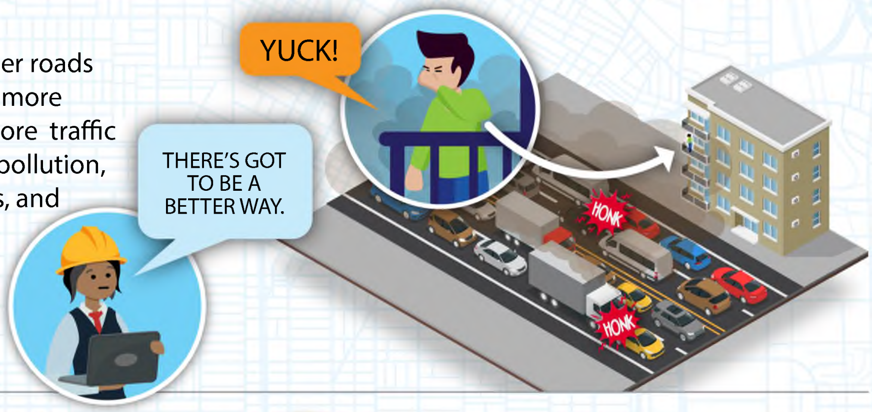
MORE & LONGER TRIPS
People may choose to drive more often than before, and to destinations farther away.

MORE DRIVERS
People who normally carpool, take transit, walk or bike decide to drive instead.



DISPERSED LAND USES
New development is built further from existing neighborhoods, forcing longer trips and reducing open space.

4 Building bigger roads often creates more traffic. And more traffic means more pollution, noise, crashes, and maintenance expense.



5 There ARE better solutions. If we make thoughtful decisions about transportation and land use, we can make it easier for people to take fewer and shorter car trips.

For more information on how Caltrans is working to reduce Californians' time behind the wheel, visit dot.ca.gov/programs/sustainability/sb-743

Exhibit E

www.vtpi.org
Info@vtpi.org
250-508-5150

Generated Traffic and Induced Travel

Implications for Transport Planning

2 November 2022

Todd Litman
Victoria Transport Policy Institute

Abstract

Traffic congestion tends to maintain equilibrium; traffic volumes increase until congestion delays discourage additional peak-period trips. If road capacity expands, peak-period trips increase until congestion again limits further traffic growth. The additional travel is called "generated traffic." Generated traffic consists of diverted traffic (trips shifted in time, route and destination), and induced vehicle travel (shifts from other modes, longer trips and new vehicle trips). Generated traffic often fills a significant portion of capacity added to congested urban road.

Generated traffic has three implications for transport planning. First, it reduces the congestion reduction benefits of road capacity expansion. Second, it increases many external costs. Third, it provides relatively small user benefits because it consists of vehicle travel that consumers are most willing to forego when their costs increase. It is important to account for these factors in analysis. This paper defines types of generated traffic, discusses generated traffic impacts, recommends ways to incorporate generated traffic into evaluation, and describes alternatives to roadway capacity expansion.

A version of this paper was published in the *ITE Journal*, Vol. 71, No. 4, Institute of Transportation Engineers (www.ite.org), April 2001, pp. 38-47.

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HOV EXIT
Memorial Drive
75
85
Chattanooga
Greenville
20
Birmingham
Augusta
1/2 MILE
Fulton St
Central Ave
Ga State Univ
EXIT
ONLY

Contents

Introduction

Traffic engineers often treat traffic as a liquid that must flow through the road system, but urban traffic often behaves more like a gas that expands to fill available space (Jacobsen 1997). Traffic congestion tends to maintain equilibrium: traffic volumes increase to the point that congestion delays discourage additional peak-period vehicle trips. Expanding congested roads attracts *latent demand*, trips from other routes, times and modes, and encourages longer and more frequent travel. This is called *generated traffic*, referring to additional peak-period vehicle traffic on a particular road. This consists in part of *induced vehicle travel*, which refers to absolute increases in vehicle miles travel (VMT) compared with what would otherwise occur (Hills 1996; Schneider 2018).

Generated traffic reflects the economic "law of demand," which states that a good's consumption generally increases as its price declines. Roadway improvements that reduce the user costs of driving (i.e., the price) encourage more vehicle travel. In the short-run generated traffic represents a shift along the demand curve; reduced congestion reduces travel time and vehicle operating costs. Over the long run it represents an outward shift in the demand curve as transport systems and land use patterns become more automobile dependent, so people must drive more to maintain a given level of accessibility to goods, services and activities (Deakin, et al. 2020).

This is not to ignore roadway expansion benefits, but generated traffic affects their nature. Accurate transport planning and project appraisal considers these three effects:

1. Generated traffic reduces the predicted congestion reduction benefits of road capacity expansion (a type of *rebound* effect).
2. Induced travel increases many costs, including user expenses, downstream congestion, crashes, parking costs, pollution, and other environmental impacts. Many of these costs are external and therefore inefficient and unfair.
3. The additional vehicle traffic provide relatively modest user benefits since it consists of marginal value vehicle-miles that consumers are most willing to forego if their costs slightly increase.

Ignoring these factors distorts planning decisions. Experts conclude, "…*the economic value of a scheme can be overestimated by the omission of even a small amount of induced traffic. We consider this matter of profound importance to the value-for-money assessment of the road programme*" (SACTRA 1994). "*…quite small absolute changes in traffic volumes have a significant impact on the benefit measures…the proportional effect on scheme Net Present Value will be greater still*" (Mackie, 1996), and "*The induced travel effects of changes in land use and trip distribution may be critical to accurate evaluation of transit and highway alternatives*" (Johnston, et al. 2001). Metz (2021) found that, expanding London's M25 motorway increased traffic volumes up to 23% two to three years after opening, but contrary to projections, failed to increase travel speeds beyond the first year, reducing expected economic benefits.

This paper describes how generated traffic can be incorporated into transport planning. It defines different types of generated traffic, discusses their impacts, and describes ways to incorporate generated traffic into transport modeling and planning, and provides information on strategies for using existing roadway capacity more efficiently.

Defining Generated Traffic and Induced Vehicle Travel

Generated traffic is the additional peak-period vehicle traffic that results from a road improvement, particularly urban roadway expansions. Congested roads cause people to defer less-urgent trips, change modes and destinations, and forego avoidable trips. Generated traffic consists of *diverted travel* (shifts in time and route) and *induced travel* (increased total motor vehicle travel). Highway expansion can stimulate sprawl (dispersed, automobile-dependent development) which further increasing per capita vehicle travel.

Below are examples of decisions that generate traffic:

- Consumers choose closer destinations when roads are congested and further destinations when traffic flows more freely. "*I want to try the new downtown restaurant but traffic is a mess now. Let's just pick up something at the local deli.*" This also affects long-term decisions. "*We're looking for a house within 40-minute commute time of downtown. With the new highway open, we'll considering anything as far as Midvalley.*"
- Travelers shift modes to avoid driving in congestion. "*The post office is only five blocks away and with congestion so bad this time of day, I may as well walk there.*"
- Longer trips may seem cost effective when congestion is light but not when congestion is heavy. "*We'd save $5 on that purchase at the Wal-Mart across town, but it's not worth fighting traffic so let's shop nearby.*"

Extensive research indicates that people tend to have fixed travel time budgets, called *Marchetti's constant* (Levinson and Kumar 1997; Litman 2021; Marchetti 1994). Regardless of conditions people devote about 75 daily minutes to personal (Ahmed and Stopher 2014). As a result, when travel speeds increase, so do their travel distances. Roadway improvements that increase traffic speeds tend to induce additional vehicle travel over the long run (Krol 2020). It is therefore inappropriate to assume that roadway improvements provide travel time savings; instead their benefits tend to result from the ability to travel to more distant destinations, for example, to accept a longer distance commute or travel to a more distant holiday destination.

Definitions

Generated Traffic: Additional peak-period vehicle trips on a particular roadway that occur when capacity is increased. This may consist of shifts in travel time, route, mode, destination and frequency.

Induced travel: An increase in total vehicle mileage due to roadway improvements that increase vehicle trip frequency and distance, but exclude travel shifted from other times and routes.

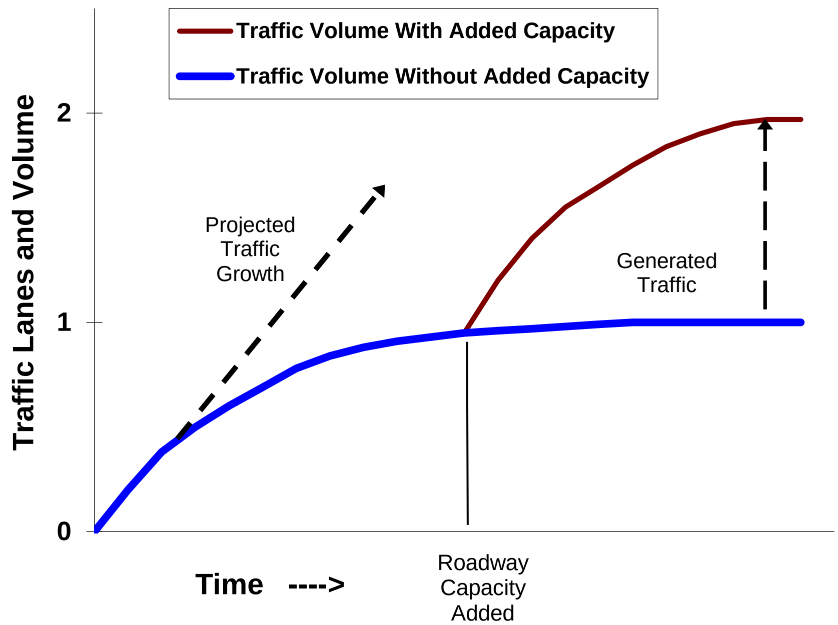
Latent demand: Additional trips that would be made if travel conditions improved (less congested, higher design speeds, lower vehicle costs or tolls).

Triple Convergence: Increased peak-period vehicle traffic volumes that result when roadway capacity increases, due to shifts from other routes, times and modes.

This is true of roadway expansions intended to reduce traffic congestion. Traffic congestion tends to maintain equilibrium: it increases to the point that delays discourage additional peak-period trips. If congested roads are expanded, motorists will make additional peak-period trips that they would otherwise forego, driving additional vehicle-miles.

Figure 1 illustrates this pattern. Traffic volumes grow until congestion develops, then the growth rate declines and achieves equilibrium, indicated by the curve becoming horizontal. A demand projection made during this growth period will indicate that more capacity is needed, ignoring the tendency of traffic volumes to eventually level off. If additional lanes are added there will be another period of traffic growth as predicted.

Figure 1 **How Road Capacity Expansion Generates Traffic**



Traffic grows when roads are uncongested, but the growth rate declines as congestion develops, reaching a self-limiting equilibrium (indicated by the curve becoming horizontal). If capacity increases, traffic grows until it reaches a new equilibrium. This additional peak-period vehicle travel is called "generated traffic." The portion that consists of absolute increases in vehicle travel (as opposed to shifts in time and route) is called "induced travel."

Generated traffic can be considered from two perspectives. Highway planners are primarily concerned with the traffic generated *on the expanded road segment*, since this affects the project's congestion reduction benefits. A broader perspective is concerned with changes in *total vehicle travel* (induced travel) that affect overall benefits and costs. Table 1 describes various types of generated traffic. In the short term, most generated traffic consists of trips diverted from other routes, times and modes, called *Triple Convergence* (Downs 1992). Over the long term an increasing portion is induced travel. In some situations, adding roadway capacity can reduce overall network efficiency, called *Braess's Paradox* (Youn, Jeong and Gastner 2008).

Highway capacity expansion can induce additional vehicle travel on adjacent roads by stimulating more dispersed, automobile-dependent development (Hansen, et al. 1993). Although these indirect impacts are difficult to quantify they are potentially large and should be considered in transport policy and planning analysis (Byun, Park and Jang 2017).

Table 1 **Types of Generated Traffic**

Type of Generated Traffic	Category	Time Frame	Travel Impacts	Cost Impacts
Shorter Route – Improved road allows drivers to use more direct route.	Diverted trip	Short term	Small reduction	Reduction
Longer Route – Improved road attracts traffic from more direct routes.	Diverted trip	Short term	Small increase	Slight increase
Time Change – Reduced peak period congestion reduces the need to defer trips to off-peak periods.	Diverted trip.	Short term	None	Slight increase
Mode Shift; Existing Travel Choices – Improved traffic flow makes driving relatively more attractive than other modes.	Induced vehicle trip	Short term	Increased driving	Moderate to large increase
Mode Shift; Changes in Travel Choice – Less demand leads to reduced rail and bus service, less suitable conditions for walking and cycling, and more automobile ownership.	Induced vehicle trip	Long term	Increased driving, reduced alternatives	Large increase, reduced equity
Destination Change; Existing Land Use – Reduced travel costs allow drivers to choose farther destinations. No change in land use patterns.	Longer trip	Short term	Increase	Moderate to large increase
Destination Change; Land Use Changes – Improved access allows land use changes, especially urban fringe development.	Longer trip	Long term	More driving and auto dependency	Moderate to large increase, equity costs
New Trip; No Land Use Changes – Improved travel time allows driving to substitute for non-travel activities.	Induced trip	Short term	Increase	Large increase
Automobile Dependency – Synergetic effects of increased automobile oriented land use and transportation system.	Induced trip	Long term	Increased driving, fewer alternatives	Large increase, reduced equity

Some types of generated traffic represent diverted trips (trips shifted from other times or routes) while others increase total vehicle travel, reduce travel choices, and affect land use patterns.

What constitutes *short-* and *long-term* impacts can vary. Some short term effects, such as mode shifts, may accumulate over several years, and some long term effects, such as changes in development patterns, can begin almost immediately after a project is announced if market conditions are suitable. Roadway expansion impacts tend to include:

- *First order.* Reduced congestion delay, increased traffic speeds.
- *Second order.* Changes in time, route, destination and mode.
- *Third order.* Land use changes. More dispersed, automobile-oriented development.
- *Fourth order*. Overall increase in automobile dependency. Degraded walking and cycling conditions (due to wider roads and increased traffic volumes), reduced public transit service (due to reduced demand and associated scale economies, sometimes called the *Downs-Thomson paradox*), and social stigma associated with alternative modes (Noland and Hanson 2013, p. 75).

Such impacts can also occur in reverse: reducing urban roadway capacity often reduces total vehicle travel (Cairns, Hass-Klau and Goodwin 1998; CNU 2011; ITDP 2012; ITF 2021) which is sometimes called *traffic evaporation* (EC 2004).

Measuring Generated Traffic and Induced Vehicle Travel

Numerous studies using various analysis methods have quantified generated traffic and induced travel impacts (Deakin, et al. 2020; WSP 2018). Their findings are summarized below:

- The National Center for Sustainable Transportation's Induced Travel Calculator (NCST 2019) estimates the incremental vehicle travel induced by adding general-purpose or high-occupancy-vehicle (HOV) lane miles to roadways. It is calibrated for California's urbanized counties, but the methodology is transferable to other geographic areas.

- Sophisticated analyses of 545 European cities indicates that urban highway expansion tends to increase vehicle traffic and so fails to solve congestion (Garcia-López, Pasidis, and Viladecans-Marsal 2020). The study indicates that each 1% increase in highway lane-kilometers typically increases total vehicle kilometers by 1.2%. The analysis found significantly less congestion (indicated by vehicle-kms relative to the log of lane-kms) in cities with road pricing and high quality rail transit. A 1% increase in lane kilometers increases congestion by 1.9% in cities without highway tolls but only 0.3% in cities with tolls. A 1% increase in railroad network length decreases congestion by 0.6% in a city without subways, 0.8% in a city with the average share of subways, and 1.3% in a city where the majority of the railroad network consists of subways.

- The report, *The Congestion Con: How More Lanes and More Money Equals More Traffic* (TfA 2020) analyzed how roadway expansions affected per capita congestion delay in the 100 largest urbanized areas in the U.S. between 1993 and 2017. During that period governments spent more than $500 billion on highway projects but congestion grew 144%, far more than population, and the regions that expanded roads the most tended to have more congestion growth than those that expanded less. The authors concluded that this resulted from generated traffic which filled the added capacity. plus the long-term effects of increased sprawl and increased per capita vehicle travel induced by the additional roadway capacity.

- Detailed analysis by Hymel (2019) found that U.S. vehicle miles traveled increase in proportion with lane-mileage, and capacity expansion congestion relief generally vanishes within five years.

- *A Statistical Model of Regional Traffic Congestion in the United States* (Marshall 2016) used real-time traffic data to analyze factors that affected congestion in 74 U.S. urban regions. It found that more arterial capacity is related to less congestion but more freeway capacity is not. It found that congestion increases with incomes indicating that economic productivity attracts population growth, which also increases congestion. The study concludes that in congested urban areas, arterial expansion may reduce congestion but freeway expansions do not.

- Graham, McCoy and Stephens (2014) quantify roadway capacity expansion effects on aggregate urban traffic volume and density in U.S. cities using a mixed model propensity score estimator which accounts for confounding unobserved characteristics. They found that a 10% increase in lane miles increases average VMT 9% beyond 'natural growth.' They conclude that even major urban highway expansions can provide little or no long-term congestion reductions.

- A review by Handy and Boarnet (2014) found that *short-run* highway expansion elasticities generally range from 0.3 to 0.6, and *long-run* effects typically range from 0.6 to just over 1.0, meaning that each 10% increase in road capacity increases traffic volumes by 3-6% within two years, and 6-10% after about five years. They found that more recent studies using more sophisticated methodologies tend to find higher elasticities. They conclude that expanding congested urban highways is unlikely to reduce long run congestion or associated GHGs.

- Duranton and Turner (2008) found that in U.S. urban regions, vehicle travel increases proportionately to highway capacity due to four effects: increased driving by current residents, an inflow of new residents, and more transport intensive production activity. They conclude that, without congestion pricing, increasing road or public transit supply is unlikely to relieve congestion, and current roadway supply exceeds optimums.

- Cervero (2003a & 2003b) used data on freeway capacity, traffic volumes, demographic and geographic factors in California between 1980 and 1994. He estimated a 0.64 long-term elasticity of VMT with respect to traffic speed, meaning that a 10% speed increases VMT 6.4%, about a quarter of which results from land use changes (e.g., additional urban fringe development). He estimated that about 80% of additional roadway capacity is filled with additional peak-period travel, about half of which (39%) can be considered the direct result of the added capacity.

- Noland (2001) and (Noland and Lem 2002) used time-series travel data for various roadway types to evaluate induced travel. They found an elasticity of vehicle travel with respect to lane miles of 0.5 in the short run, and 0.8 in the long run. This means that half of increased roadway capacity is filled with added travel within about 5 years, and that 80% of the increased roadway capacity will be filled eventually.

- Leading U.K. transportation economists concludes that the elasticity of travel volume with respect to travel time is -0.5 in the short term and -1.0 over the long term (SACTRA 1994). This means that reducing travel time on a roadway by 20% typically increases traffic volumes by 10% in the short term and 20% over the long term. The following are elasticity values for vehicle travel with respect to travel time: urban roads, short-term -0.27, long term –0.57; rural roads, short term –0.67, long term –1.33 (Goodwin 1996).

- Noland and Quddus (2006) found that increases in road space or traffic signal control systems that smooth traffic flow tend to induce additional vehicle traffic which quickly diminish any initial emission reduction benefits.

- Tennøy, Tønnesen and Gundersen (2019) found that Norwegian highway expansions provide only short-term congestion relief, and by increasing sprawled development, increase total traffic growth. They find that road authorities generally overlooked these effects.

- Cervero and Hanson (2000) found the elasticity of VMT with respect to lane-miles to be 0.56, and an elasticity of lane-miles with respect to VMT of 0.33, indicating that roadway capacity expansion results in part from anticipated traffic growth.

- A comprehensive study found that in the U.S., a 10% increase in urban road density (lane-miles per square mile) increases per capita annual VMT by 0.7% (Barr 2000).

- Yao and Morikawa (2005) analyzed the travel induced by high speed rail improvements between major Japanese cities. They calculate elasticities of induced travel (trips and VMT) with respect to fares, travel time, access time and service frequency for business and nonbusiness travel.

- Odgers (2009) found that Melbourne, Australia freeway traffic speeds did not increase as predicted following highway construction, apparently due to induced traffic. He concludes that, “major road infrastructure initiatives and the consequent economic investments have not yet delivered a net economic benefit to either Melbourne’s motorists or the Victorian community.”

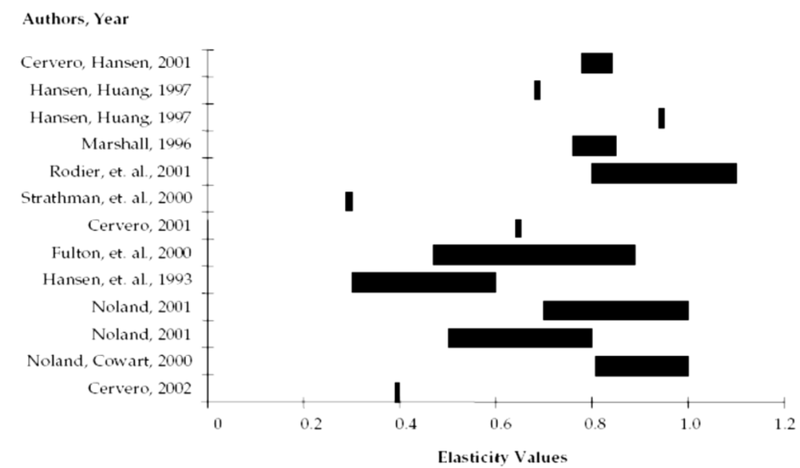
- Burt and Hoover (2006) found that each 1% increase in road lane-kilometres per driving-age person increases per capita light truck travel 0.49% and car travel 0.27%, although they report that these relationships are not statistically significant, falling just outside the 80% confidence interval for cars and the 90% confidence interval for light trucks.

- Hymel, Small and Van Dender (2010) used 1966-2004 U.S. state-level cross-sectional time series data to evaluate how income, fuel price, road supply and traffic congestion affect vehicle miles travel (VMT). They find the elasticity of VMT with respect to statewide road density is 0.019 in the short run and 0.093 in the long run (a 10% increase in total lane-miles per square mile increases state vehicle mileage by 0.19% in the short run and 0.93% in the long run); with respect to total road miles is 0.037 in the short run and 0.186 in the long run (a 10% increase in lane-miles causes state VMT to increase 0.37% in the short run and 1.86% over the long run); and vehicle use with respect to congestion is -0.045 (a 10% increase in total regional congestion reduces regional VMT 0.45% over the long run), but this increases with income, assumedly because the opportunity cost of time increases with wealth. Their analysis indicates that long-run travel elasticities are typically 3.4–9.4 times short-run elasticities.

- The *Handbook of Transportation Engineering* finds that urban highway capacity expansion often fails to significantly increase travel speeds due to latent demand (Kockelman 2010). They conclude that the long-run elasticities of VMT with respect to roadspace is generally 0.5 to 1.0 after controlling for population growth and income, with values of almost 1.0, suggesting that new roadspace is totally filled by generated traffic where congestion is relatively severe.

- A meta-analysis by Schiffer, Steinvorth and Milam (2005) reached the following conclusions:
    - *Induced travel effects exist* **–** The elasticity of VMT with respect to added lane-miles or reductions in travel time is generally greater than zero and the effects increase over time. Figure 3 summarizes their results.
    - *Short-term induced travel effects are smaller than long-term effects* **–** As measured by the increase in VMT with respect to an increase in lane-miles, short-term effects have an elasticity range from near zero to about 0.40, while long-term elasticities range from about 0.50 to 1.00. This means that a 10% increase in lane-miles can cause up to a 4% increase in VMT in the short term and a 10% increase in the long term.
    - *Induced travel effects generally decrease with the size of the unit of study* **–** Larger effects are measured for single facilities while smaller effects are measured for regions and subareas. This is mainly due to diverted trips (drivers changing routes) causing more of the change on a single facility, whereas, at the regional level, diverted trips between routes within the region are not considered induced travel unless the trips become longer as a result.
    - *Traditional four-step travel demand models do not fully address induced travel or induced growth* **–** Land use allocation methods overlook accessibility effects, trip generation often fails to account for latent trips (potential trips constrained by congestion), many models overlook time-of-day shifts, and static traffic assignment algorithms may not account for queuing impacts on route shifts; all of which underestimate generated traffic effects.

Figure 3 **VMT With Respect to Road Capacity** (Schiffer, Steinvorth and Milam 2005)



This figure summarizes long term vehicle travel elasticities with respect to roadway capacity.

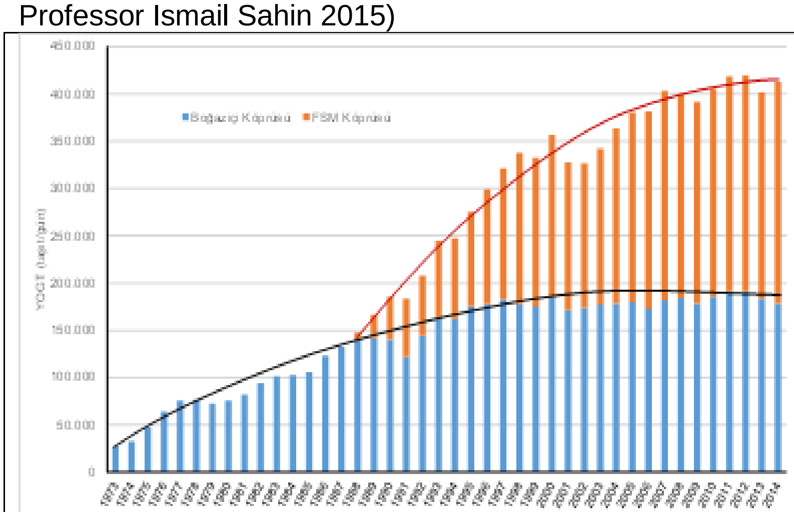
- Melo, Graham and Canavan (2012) found a positive relationship between urban highway expansion and vehicle travel in the U.S. between 1982 and 2009.

- Rahmana, Bakerb and Rahmanc (2020) found that in Dhaka, Bangladesh, urban intersection flyovers typically provide a one-minute time savings, which increased affected vehicle trip generation by 35%.

- Özuysal and Tanyel (2008) found the elasticity of travel per vehicle relative to Turkish state highway supply is 2.0 for private vehicles and 3.5 for commercial vehicles over 3-5 year periods.

- Analysis by Professor Ismail Sahin of Turkey's Yildiz Technical University shows that after new bridges were built in Istanbul, traffic volumes increased, representing induced vehicle trips, resulting in a new, higher level of congestion equilibrium.

Figure 4 **Istanbul Bridge Traffic Volumes** (Personal correspondence with Professor Ismail Sahin 2015)



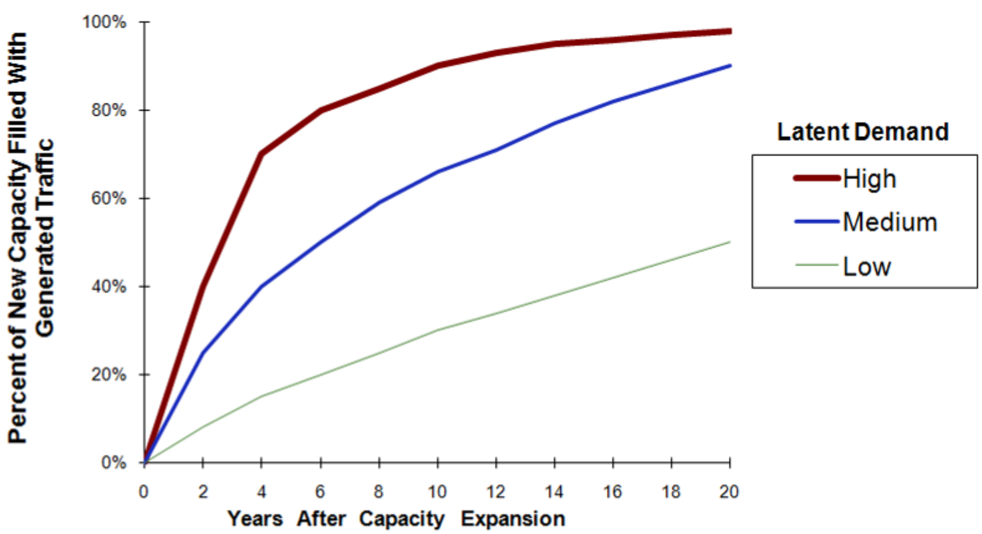
This graph shows Average Annual Daily Trips (AADTs) on Bosporus Bridge (blue bars) opened in 1973 and Fatih Sultan Mehmet (FSM) Bridge (orange bars) opened in 1988. This shows the tendency of traffic volumes to fill the new capacity and then reach equilibrium as congestion becomes self-limiting.

The amount of traffic generated by a road project varies depending on conditions. It is not capacity expansion itself that generates travel, it is the reduction in delay and therefore per-mile travel costs (Milam, et al. 2017). Expanding uncongested roads generates no traffic, although paving a dirt road or significantly raising roadway design speeds may induce more vehicle travel. In general, the more congested a road, the more traffic is generated by expansions. Increased capacity on highly congested roads often generates considerable traffic. Older studies of the elasticity of VMT growth with respect to increased roadway lane-miles performed during the early years of highway building (during the 1950s through 1970s) have little relevance for evaluating current urban highway capacity expansion. In developed countries, where most highway expansion now occurs on congested links, such projects are likely to generate considerable amounts of traffic, providing only temporary congestion reduction benefits.

Gridlock?
People sometimes warn of roadway *gridlock* without some recommended action, such as roadway expansion. Such claims are usually exaggerated because they ignore traffic congestion's tendency toward equilibrium. Gridlock is a specific condition that occurs when backups in a street network block intersections, stopping traffic flow. Gridlock can be avoided with proper intersection design and traffic law enforcement. Increasing regional highway capacity can increase this risk by adding more traffic to surface streets where gridlock occurs.

Generated traffic usually accumulates over several years. Under typical urban conditions, more than half of added capacity is filled within five years of project completion by additional vehicle trips that would not otherwise occur, with continued but slower growth in later years (Goodwin 1998). Figure 5 shows typical generated traffic growth based on various studies. Techniques for modeling these impacts are described in the next section.

Figure 5 **Elasticity of Traffic Volume With Respect to Road Capacity**



This illustrates traffic growth on a road after its capacity increases. About half of added capacity is typically filled with new traffic within a decade of construction. (Based on cited studies)

Modeling Generated Traffic and Induced Travel

Traffic congestion tends to maintain equilibrium: it increases to the point that delays cause some travellers to shift time, mode, route or destination. To predict generated traffic transport models must incorporate "feedback" reflecting how congestion affects travel behavior including long-term changes in transport and land use patterns. Because these relationships are non-linear, small amounts of generated traffic can significantly affect roadway project cost efficiency.

All current traffic models can predict route and mode shifts, and some can predict changes in trip frequency, scheduling and destination, but few incorporate feedback on long-term effects such as the tendency of highway expansions to increase automobile-dependent urban fringe development where households own more vehicles and drive more annual miles than they would if located in more central, multimodal areas (Milam, et al. 2017; Næss, Nicolaisen and Strand 2012). As a result, current models overestimate highway expansion costs and underestimate long-term induced vehicle travel, and associated costs, including downstream traffic and parking congestion, crashes and pollution emissions (Deakin, et al. 2020).

Volker, Lee, and Handy (2020) examined the evaluation methods used in five recent highway project. They found that conventional analyses frequently fail to account for induced travel effects, which exaggerated their benefits and underestimated their environmental costs. The authors used this information to develop the National Center for Sustainable Transportation's **Induced Travel Calculator**, which estimates the incremental vehicle travel induced by adding general-purpose or high-occupancy-vehicle (HOV) lane miles to roadways. The Rocky Mountain Institute used this methodology to develop the **SHIFT Calculator** which predicts induced vehicle travel and emissions from capacity expansions of large roadways for U.S. urban regions.

Ramsey (2005) found that a suburban highway expansion project's net benefits declined 50% if the project caused just 2% of the regional population to move from urban to suburban locations. Similarly, Næss, Nicolaisen and Strand (2012) found that ignoring some induced traffic effects significantly affected the estimated value of a proposed Copenhagen, Denmark highway expansion. When induced travel was considered the results show lower travel time savings and more adverse environmental impacts, resulting in significantly lower benefit-cost ratio. They conclude that, "By exaggerating the economic benefits of road capacity increase and underestimating its negative effects, omission of induced traffic can result in over-allocation of public money on road construction and correspondingly less focus on other ways of dealing with congestion and environmental problems in urban areas." Analysis of urban highway expansion impacts on total emissions by Williams-Derry (2007) indicates that construction and induced vehicle travel emission quickly exceed any emission reductions from less congestion.

A study, *Climate Emissions Analysis: Metro's Indirect Impact on Greenhouse Gas Emissions* (METRO 2022) found that the emissions reduced by public transit and active transportation improvements in Los Angeles are more than offset by planned freeway expansions, particularly over the long run.

Transportation modelers have developed techniques for incorporating full feedback (SACTRA 1994; Loudon, Parameswaran and Gardner 1997; Schiffer, Steinvorth and Milam 2005). This recognizes that expanding the capacity of congested roads increases the number and length of trips in a corridor (DeCorla-Souza and Cohen 1999). Federal clean air rules require that these techniques be used in metropolitan transportation models to evaluate the effects transport system changes have on vehicle emissions, but many metropolitan planning organizations have yet to comply, and few models used in medium and small cities have full feedback. Full feedback is necessary to accurately predict future congestion and traffic speeds, and the incremental costs and benefits of alternatives. Models that lack feedback tend to overestimate future congestion problems and overestimate capacity expansion benefits.

Models that fail to consider generated traffic were found to overvalue roadway capacity expansion benefits by 50% or more (Williams and Yamashita 1992). Another study found that the ranking of preferred projects changed significantly when feedback is incorporated into project assessment (Johnston and Ceerla 1996). Ignoring generated traffic tends to skew planning decisions toward highway projects and away from No Build and transportation demand management alternatives such as road pricing, transit improvements and commute trip reduction programs. UK Department for Transport's *Transport Analysis Guidance* (DfT 2007), includes a section on *Variable Demand Modelling* (www.dft.gov.uk/webtag/documents/expert/unit3.10.1.php) which describes methods for incorporating induced travel demand into project appraisal.

Short Cut Methods of Incorporating Induced Demand
Based on comments by Phil Goodwin, 2001.

The easiest way to incorporate induced demand into conventional traffic models is to apply an overall demand elasticity to forecasted changes in travel speed, calculated either:

- Elasticities applied to generalized costs (travel time and financial costs) using a price elasticity (about -0.3 for equilibrium, less for short term), with monetized travel time costs. The time elasticity is generally about -0.5 to -0.8 or so, though this is highly dependent on context. Where to apply it depends on the model used. With a fixed trip matrix altered only by reassignment, apply elasticities to each separate cell, or the row and column totals, or the overall control total - depending on how short the short cut has to be. Or add a separate test at the end.

or

- Direct application of a 'capacity elasticity,' i.e. percent change in vehicle miles resulting from a 1% change in highway capacity, for which lane miles is sometimes used as a proxy, the elasticity in that case usually coming out at about -0.1. This will tend to underestimate the effect if the capacity increase is concentrating on bottlenecks.

Care is needed if the basic model has cost-sensitive distribution and mode split, as this will already account for some induced traffic. Induced traffic consists of several types of travel changes that make vehicle miles "with" a scheme different from "without," including re-assignment to longer routes and increased trip generation. Although time-shifting is not induced traffic, it has similar effects on congestion reduction benefits and is often a large response. Ideally you iterate on speed and allow for the effect from retiming of journeys, and separate the various behavioural responses which make up induced traffic. These short cuts are subject to bias, but less than the bias introduced by assuming zero induced traffic.

Land Use Impacts

An important issue related to generated and induced travel is the degree to which roadway improvements affect land use patterns, and in particular, whether highway capacity expansion stimulates lower-density, urban fringe development (i.e., urban sprawl), and the costs to society that result (Deakin, et al. 2020; USEPA 2001; ICF Consulting 2005). Land use changes are one category of induced travel. Such changes take a relatively long time to occur, and are influenced by additional factors, but they are durable effects with a variety of economic, social and environmental impacts.

Urban economists have long realized that transportation can have a major impact on land use development patterns, and in many situations improved accessibility can stimulate development location and type. Different types of transportation improvements tend to cause different types of land use development patters: highway improvements tend to encourage lower-density, automobile-oriented development at the urban fringe, while transit improvements tend to encourage higher-density, multi-modal, urban redevelopment, although the exact types of impacts vary depending on specific conditions and the type of transportation improvements implemented (Rodier, Abraham, Johnston and Hunt 2001; Boarnet and Chalermpong 2002).

Some researchers claim that investing in road construction does not lead to the sprawl (Hartgen 2003), although the evidence indicates otherwise. Even in relatively slow-growth regions with modest congestion problems, highway expansions increase suburban development by 15-25%. These effects are likely to be much greater in large cities with significant congestion, where peak-period traffic congestion limits commute trip distances, and increased roadway capacity would significantly improve automobile access to urban fringe locations. This is particularly true if the alternative is to implement Smart Growth development policies and improved walking, cycling and transit transportation.

There has been considerable debate over the benefits and costs of sprawl and Smart Growth. Table 2 summarizes some benefits that tend to result from reduced sprawl.

Table 2 **Smart Growth Benefits** (Ewing and Hamidi 2014; Litman 2016)

Economic	Social	Environmental
Reduced development and public service costs. Consumer transportation cost savings. Economies of agglomeration. More efficient transportation.	Improved transportation choice, particularly for nondrivers. Improved housing choices. Community cohesion.	Greenspace and wildlife habitat preservation. Reduced air pollution. Reduce resource consumption. Reduced water pollution. Reduced “heat island” effect.

Costs of Induced Travel

Driving imposes a variety of costs, including many that are external, that is, not borne directly by users. Table 3 illustrates one estimate of the magnitude of these costs. Other studies show similar costs, with average values of 10-30¢ per vehicle-kilometer, and more under urban-peak conditions (Litman 2003).

Table 3 **Motor Vehicle Indirect and External Costs** (Delucchi 1996)

Cost Item	Examples	Vehicle-Year	Vehicle-Mile
Bundled private sector costs	Parking funded by businesses	$337-1,181	2.7-9.4 cents
Public infrastructure and services	Public roads, parking funded by local governments	$662-1,099	5.3-8.8 cents
Monetary externalities	External crash damages to vehicles, medical expenses, congestion.	$423-780	3.4-6.2 cents
Nonmonetary externalities	Environmental damages, crash pain.	$1,305-3,145	10.4-25.2 cents
Totals		*$2,727-6,205*	*22-50 cents*

This table summarizes an estimate of motor vehicle indirect and external costs. (US 1991 Dollars)

Any incremental external costs of generated traffic should be included in project evaluations, “incremental” meaning the difference between the external costs of the generated travel and the external costs of alternative activities. For diverted traffic this is the difference in external costs between the two trips. For induced travel this is the difference in external costs between the trip and any non-travel activity it replaces, which tends to be large since driving has greater external costs than most other common activities. Most generated traffic occurs under urban-peak travel conditions, when motor vehicle external costs are greatest, so incremental external costs tend to be high.

Incremental external costs depend on road system conditions and the type of generated traffic. Generated traffic often increases downstream congestion (for example, increasing capacity on a highway can add congestion on surface streets, particularly near on- and off-ramps). In some conditions adding capacity actually increases congestion by concentrating traffic on a few links in the network and by reducing travel alternatives, such as public transit (Arnott and Small 1994). Air emission and accident rates per vehicle-mile may decline if traffic flows more freely, but these benefits decline over time and are usually offset as generated traffic leads to renewed congestion and increased vehicle travel (TRB 1995; Cassady, Dutzik and Figdor 2004).

Table 4 compares how different types of generated traffic affect costs. All types reduce user travel time and vehicle costs. Diverted trips have minimal incremental costs. Longer trips have moderate incremental costs. Shifts from public transit to driving may also have moderate incremental costs, since transit service has significant externalities but also experiences economies of scale and positive land use impacts that are lost if demand declines. Induced trips have the largest incremental costs, since they increase virtually all external costs. Longer and induced vehicle trips can lead to more automobile dependent transportation and land use over the long term. These costs are difficult to quantify but are probably significant (Ewing and Hamidi 2014).

Table 4 **Cost Impacts of Roadway Capacity Expansion**

Costs Reduced	Costs Increased		
	Diverted Trips	Longer Trips	Induced Trips
• Travel Time • Vehicle Operating Costs • Per-mile crash rates (if implemented in conjunction with roadway design improvements, but these are often offset if traffic speeds increase). • Per-mile pollution emissions (if congestion declines, but these may be offset if traffic speeds increase).	• Downstream congestion	• Downstream congestion • Road facilities • Traffic services • Per-capita crash rates • Pollution emissions • Noise • Resource externalities • Land use impacts • Barrier effect	• Downstream congestion • Road facilities • Parking facilities • Traffic services • Per-capita crash rates • Pollution emissions • Noise • Resource externalities • Land use impacts • Barrier effect • Transit efficiency • Equity • Vehicle ownership costs

Increased roadway capacity tends to reduce two costs, but increases others.

The incremental external costs of road capacity expansion tend to increase over time as the total amount of generated traffic grows and an increasing portion consists of induced motor vehicle travel and trips.

Table 5 proposes default estimates of the incremental external costs of different types of generated traffic. These values can be adjusted to reflect specific conditions and analysis needs.

Table 5 **Estimated Incremental External Costs of Generated Traffic**

Type	Description	Cost Per Mile
Time and route shift	Trips shifted from off-peak to peak, or from another route.	5 cents
Transit-to-Auto mode shift, and longer trips	Trips shifted from transit to driving alone, and increased automobile trip lengths.	15 cents
Induced vehicle trip	Additional motor vehicle trip, including travel shifted from walking, cycling and ridesharing.	30 cents.

This table indicates the estimated incremental costs of different types of generated traffic.

There is considerable debate concerning the emission impacts of roadway expansion (TRB 1995). Although expanding congested roadways may sometimes reduce per-kilometer emission rates, it generally increases total emissions, particularly over the long run by increasing high traffic speeds (more than 80 kms/hr), and by inducing more vehicle travel. According to a study by the Norwegian Centre for Transport Research (TØI 2009):

> "Road construction, largely speaking, increases greenhouse gas emissions, mainly because an improved quality of the road network will increase the speed level, not the least in the interval where the marginal effect of speed on emissions is large (above 80km/hr). Emissions also rise due to increased volumes of traffic (each person traveling further and more often) and because the modal split changes in favor of the private car, at the expense of public transport and bicycling."

Table 6 summarizes roadway improvement emission impacts, including effects on emission rates per vehicle mile, increases in total vehicle mileage, and emissions from road construction and maintenance activities.

Table 6 **Roadway Expansion Greenhouse Gas Emission Impacts** (TØI 2009)

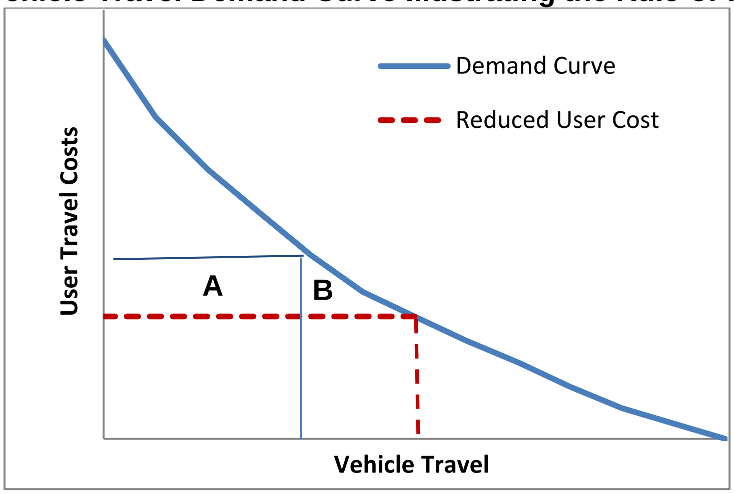
	General Estimates	Large Cities	Small Cities	Intercity Travel
Emission reductions per vehicle-kilometer due to improved and expanded roads.		Short term reductions. Stable or some increase over the long-term.	Depends on situation, ranging from no change to large increases.	Depends on situation. Emissions may decline or increase.
Increased vehicle mileage (induced vehicle travel), short term (under five years)	A 10% reduction in travel time increases traffic 3-5%	Significant emission growth	Moderate emission growth	Moderate emission growth
Increased vehicle mileage (induced travel), long term (more than five years)	A 10% reduction in travel time increases traffic 5-10%	Significant emission growth	Moderate emission growth	Moderate emission growth
Road construction and improvement activity	12 tonnes of CO_2 equivalent for 2-lane roads and 21 tonnes for 4-lane roads.	Road construction emissions are relatively modest compared with traffic emissions.		
Roadway operation and maintenance activity	33 tonnes of CO_2 equivalent for 2-lane roads and 52 tonnes for 4-lane roads.	Road operation and maintenance emissions are relatively modest compared with traffic emissions.		

This table summarizes roadway improvement emission impacts according to research by the Norwegian Centre for Transport Research.

Calculating Consumer Benefits

Generated traffic represents increased mobility, which provides consumer benefits. However, these benefits tend to be modest because generated traffic consists of marginal value trips, the trips that people are most willing to forego. To calculate these benefits economists use the *Rule of Half*, which states that the benefits of additional travel are worth half the per-trip saving to existing travelers, as illustrated in Figure 6 by the fact that B is a triangle rather than a rectangle (AASHTO 1977; Litman 2001a).

Figure 6 **Vehicle Travel Demand Curve Illustrating the Rule-of-Half**



Reduced user costs (downward shift on Y axis) increases vehicle travel (rightward shift on X axis). Rectangle A shows savings to existing trips. Triangle B shows generated travel benefits.

Explanation of the "Rule of Half"
When consumers change their travel in response to a financial incentive, the net consumer surplus averages half of their price change (called the "rule of half"). Let me illustrate.

Let's say that by purchasing a hybrid or electric car, your vehicle operating costs decline from 20₵ to 10₵ per mile, in response you increase 10,000 to 11,000 annual vehicle-miles. The added vehicle-miles have small incremental value to you, between 0¢ and 10¢. If you consider the additional mile worth less than 0¢ (i.e., it has no value), you would not take it. If you considered it worth more than 10¢ per mile, you would have driven that mile without the price reduction. Of the 1,000 miles added we can assume that the average net benefit to users (called the *consumer surplus*) is the mid-point of this range, that is, 5¢ per vehicle mile. Thus, we can calculate the value of the added miles as 5¢ times 1,000 added miles. Conversely, a 10₵ per mile price increase that reduces vehicle travel by 1,000 miles imposes a *net cost* to consumers of $50.

Some people complicate this analysis by trying to track individual changes in consumer travel time, convenience and vehicle operating costs, but that is unnecessary information. All we need to know to value the net consumer surplus is the perceived change in price, either positive or negative, and the resulting change in consumption. This incorporates all of the complex trade-offs that consumers make between money, time, convenience and the value off mobility.

Because induced travel provides relatively small user benefits, and imposes external costs such as downstream congestion, parking costs, accident risk imposed on other road users, pollution emissions, sprawl and other environmental costs, the ratio of benefits to costs, and therefore total net benefits of travel, tend to decline as more travel is induced.

Failing to account for the full impacts of generated and induced travel tends to exaggerate the benefits of highway capacity expansion and undervalue alternatives such as transit improvements and pricing reforms (Romilly 2004). Some newer project evaluation models, such as the FHWA's SMITE and STEAM sketch plan programs, incorporate generated traffic effects including the Rule of Half and some externalities (FHWA 1997; FHWA 1998; DeCorla-Souza and Cohen 1998).

The benefits of increased mobility are often capitalized into land values. For example, a highway improvement can increase urban periphery real estate prices, or a highway offramp can increase nearby commercial land values. Because this increase in land values is an economic transfer (land sellers gain at the expense of land buyers), it is inappropriate to add increased real estate values and transport benefits, such as travel time savings (which represent true resource savings). This would double count benefits.

Emission Impacts

Highway expansion advocates sometimes claim that by reducing traffic congestion, such projects will reduce air pollution emissions, but research indicates that this is generally untrue (Noland and Quddus 2006). Per-mile emission rates are generally minimized at 20-50 miles per hour, as indicated in Figures 7 and 8. As a result, reducing extreme congestion (LOS E or F), so traffic speeds rise above 30 mph may reduce emission rates, but reducing mild congestion (LOS C or D), so traffic speeds increase above 50 mph are likely to increase emission rates, and if roadway expansions induce additional vehicle travel they are likely to increase total emissions.

Figure 6 **Speed-Emission Curves** (Fontaras, et al. 2014)

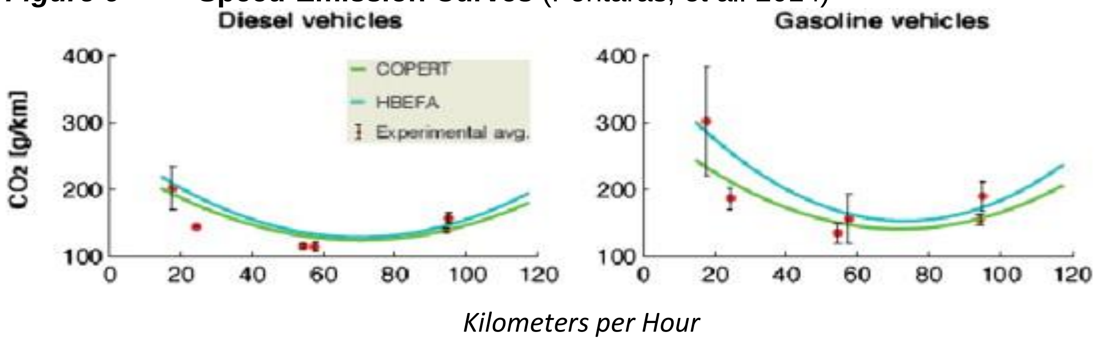
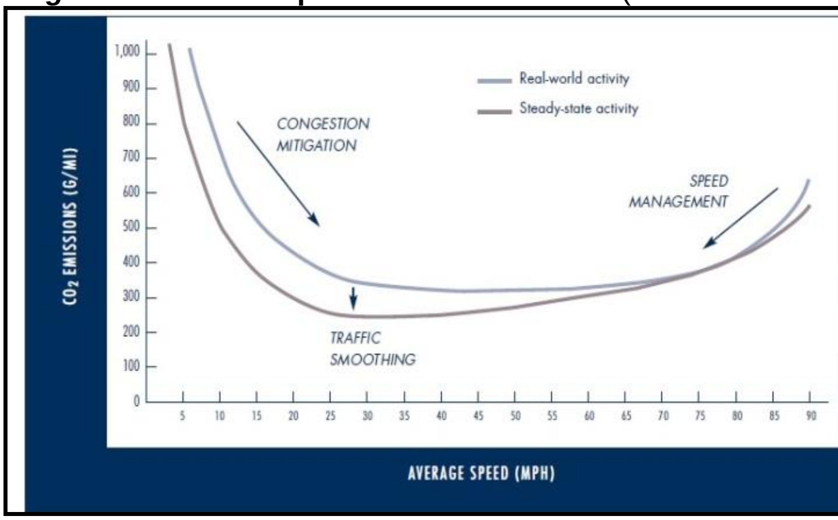


Figure 7 **U.S. Speed-Emission Curves** (Barth and Boriboonsomsin 2009)



Vehicle fuel consumption and emission rates are generally minimized at 20-50 miles per hour. As a result, reducing extreme congestion (LOS E or F), so traffic speeds rise above 30 mph may reduce emission rates, but reducing mild congestion (LOS C or D), so traffic speeds increase above 50 mph are likely to increase emission rates

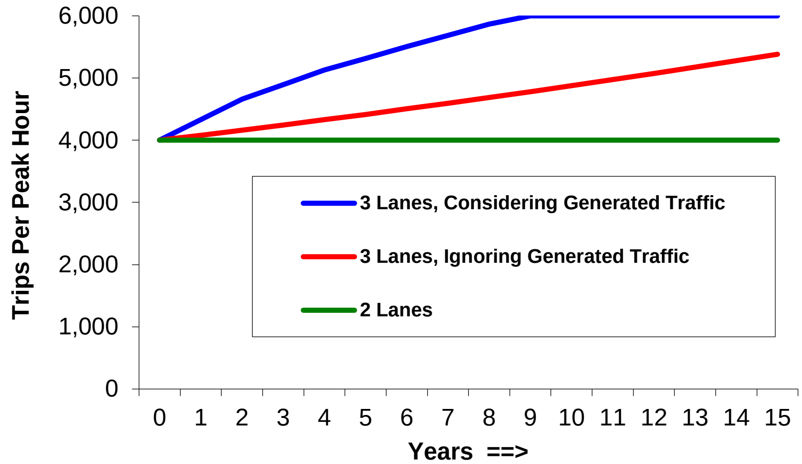
As a result, roadway expansions that reduce extreme congestion may reduce emission rates in the short run, but these impacts are generally small and more than offset over the long run by more high-speed driving and induced vehicle travel. In contrast, other congestion reduction strategies, such as high quality public transit, High Occupancy Vehicle (HOV) lanes, efficient road pricing, and commute trip reduction programs, provide much greater emission reductions (Litman 2019).

Example

A four-lane, 10-kilometer highway connects a city with nearby suburbs. The highway is congested 1,000 hours per year in each direction. Regional travel demand is predicated to grow at 2% per year. A proposal is made to expand the highway to six lanes, costing $25 million in capital expenses and adding $1 million in annual highway operating expenses.

Figure 9 illustrates predicted traffic volumes. Without the project peak-hour traffic is limited to 4,000 vehicles in each direction, the maximum capacity of the two-lane highway. If generated traffic is ignored the model predicts that traffic volumes will grow at a steady 2% per year if the project is implemented. If generated traffic is considered the model predicts faster growth, including the basic 2% growth plus additional growth due to generated traffic, until volumes levels off at 6,000 vehicles per hour, the maximum capacity of three lanes.

Figure 9 **Projected Traffic**

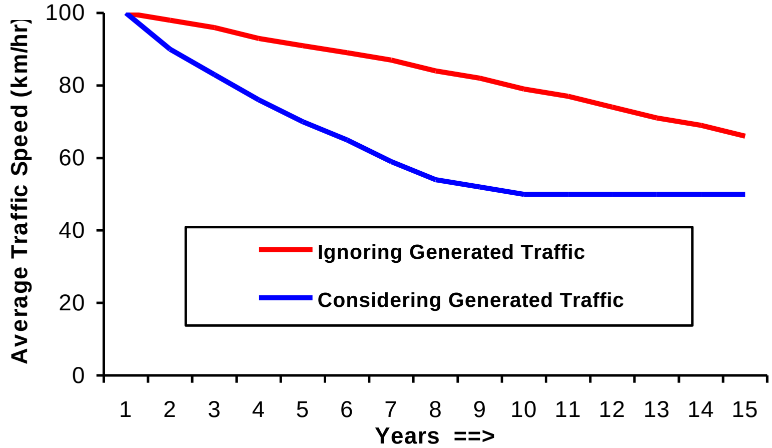


If generated traffic is ignored the model predicts that traffic volumes will grow at a steady 2% per year if the project is implemented. If generated traffic is considered the model predicts a higher initial growth rate, which eventually declines when the road once again reaches capacity and becomes congested. (Based on the "Moderate Latent Demand" curve from Figure 3)

The model divides generated traffic into diverted trips (changes in trip time, route and mode) and induced travel (increased trips and trip length), using the assumption that the first year's generated traffic represents diverted trips and later generated traffic represents induced travel. This simplification appears reasonable since diverted trips tend to occur in the short-term, while induced travel is associated with longer-term changes in consumer behavior and land use patterns.

Roadway volume to capacity ratios are used to calculate peak-period traffic speeds, which are then used to calculate travel time and vehicle operating cost savings. Congestion reduction benefits are predicted to be significantly greater if generated traffic is ignored, as illustrated in Figure 10.

Figure 10 **Projected Average Traffic Speeds**



Ignoring generated traffic exaggerates future traffic speeds and congestion reduction benefits.

Incremental external costs are assumed to average 10¢ per vehicle-km for diverted trips (shifts in time, route and mode) and 30¢ per vehicle-km for induced travel (longer and increased trips). User benefits of generated traffic are calculated using the Rule-of-Half.

Three cases where considered for sensitivity analysis. *Most Favorable* uses assumptions most favorable to the project, *Medium* uses values considered most likely, and *Least Favorable* uses values least favorable to the project. Table 7 summarizes the analysis.

Table 7 **Analysis of Three Cases**

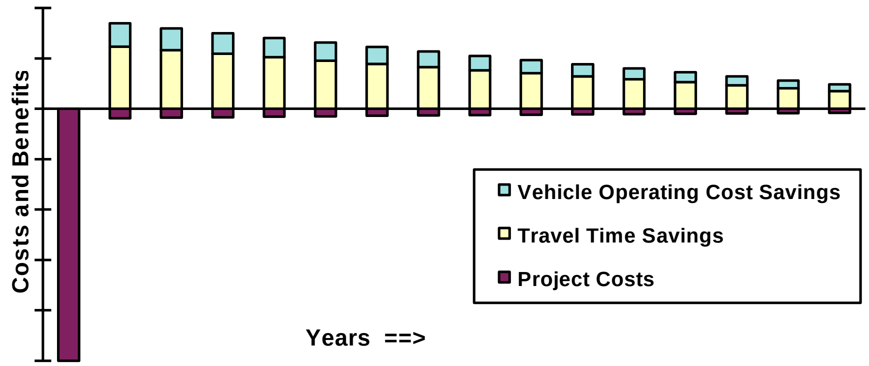
Data Input	Most Favorable	Medium	Least Favorable
Generated Traffic Growth Rate (from Figure 3)	L	M	H
Discount Rate	6%	6%	6%
Maximum Peak Vehicles Per Lane	2,200	2,000	1,800
Before Average Traffic Speed (km/hr)	40	50	60
After Average Traffic Speed (km/hr)	110	100	90
Value of Peak-Period Travel Time (per veh-hr)	$12.00	$8.00	$6.00
Vehicle Operating Costs (per km)	$0.15	$0.12	$0.10
Annual Lane Hours at Capacity Each Direction	1,200	1,000	800
Diverted Trip External Costs (per km)	$0.00	$0.10	$0.15
Induced Travel External Costs (per km)	$0.20	$0.30	$0.50
Net Present Value (millions)			
NPV Without Consideration of Generated Traffic	*$204.8*	*$45.2*	*-$9.8*
NPV With Consideration of Generated Traffic	*$124.5*	*-$32.1*	*-$95.7*
Difference	*-$80.3*	*-$77.3*	*-$85.8*
Benefit/Cost Ratio			
Without Generated Traffic	*6.90*	*2.30*	*0.72*
With Generated Traffic	*3.37*	*0.59*	*0.11*

This table summarizes the assumptions used in this analysis.

The most favorable assumptions result in a positive B/C even when generated traffic is considered. The medium assumptions result in a positive B/C if generated traffic is ignored but a negative NPV if generated traffic is considered. The least favorable assumptions result in a negative B/C even when generated traffic is ignored. In each case, considering generated traffic has significant impacts on the results.

Figure 11 illustrates project benefits and costs based on "Medium" assumptions, ignoring generated traffic. This results in a positive NPV of $45.2 million, implying that the project is economically worthwhile.

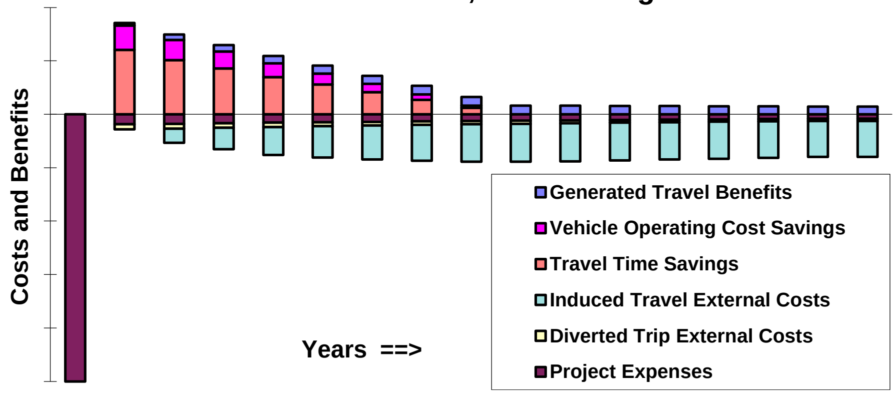
Figure 11 **Estimated Costs and Benefits, Ignoring Generated Traffic**



This figure illustrates annual benefits and costs when generated traffic is ignored, using "Medium" assumptions. Benefits are bars above the baseline, costs are bars below the baseline. Project expenses are the only cost category.

Figure 10 illustrates project evaluation when generated traffic is considered. Congestion reduction benefits decline, and additional external costs and consumer benefits are included. The NPV is –$32.1 million, indicating the project is not worthwhile.

Figure 10 **Estimated Costs and Benefits, Considering Generated Traffic**

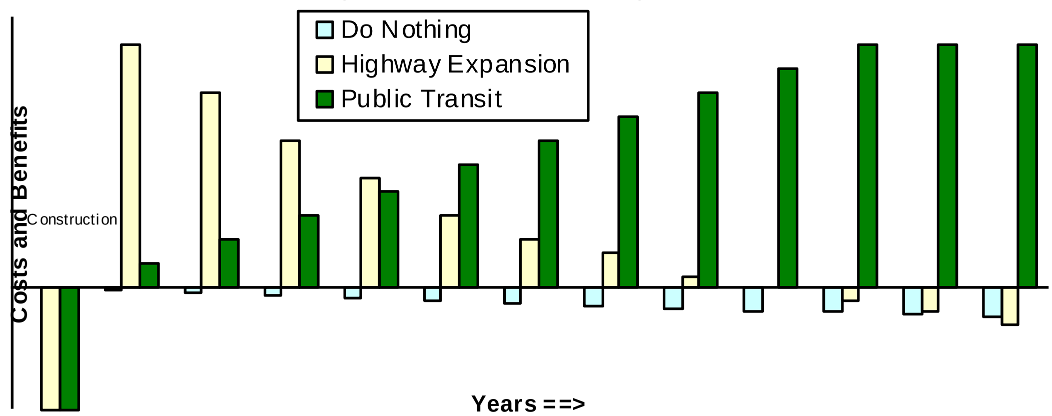


This figure illustrates benefits and costs when generated traffic is considered, using medium assumptions. Benefits are bars above the baseline, costs are bars below the baseline. It includes consumer benefits and external costs associated with generated traffic. Travel time and vehicle operating cost savings end after about 10 years, when traffic volumes per lane return to pre-project levels, resulting in no congestion reduction benefits after that time.

This analysis indicates how generated traffic can have significant impacts on project assessment. Ignoring generated traffic exaggerates the benefits of highway capacity expansion by overestimating congestion reduction benefits and ignoring incremental external costs from generated traffic. This tends to undervalue alternatives such as road pricing, TDM programs, other modes, and "do nothing" options.

For example, Figure 11 compares three possible responses to congestion on a corridor with increasing traffic demand. Do nothing causes traffic congestion costs to increase over time. Expanding general traffic lanes imposes large initial costs due to construction delays, but provides large short-term congestion reduction benefits. However, these decline over time, due to induced traffic, and the additional vehicle travel imposes additional external costs including downstream congestion, increased parking demand, accident risk and pollution emissions. Building grade-separated public transit (either a bus lane or rail line) also imposes short-run congestion delays, and the congestion reduction benefits are relatively small in the short term but increase over time as transit ridership grows, networks expand, and development becomes more transit-oriented.

Figure 11 **Road Widening Versus Transit Congestion Impacts**



A Do Nothing causes congestion costs to increase in the future. Highway expansion imposes short term construction delays, then large congestion reduction benefits, but these decline over time due to generated traffic. Grade-separated public transit provides smaller benefits in the short-term but these increase over time as public transit ridership grows.

Counter Arguments

"Widening roads to ease congestion is like trying to cure obesity by loosening your belt" Roy Kienitz, executive director of the Surface Transportation Policy Project

"Increasing highway capacity is equivalent to giving bigger shoes to growing children" Robert Dunphy of the Urban Land Institute

Some highway expansion advocates claim that generated traffic has minor implications for transport planning decisions. They argue that increased highway capacity contributes little to overall growth in vehicle travel compared with other factors such as increased population, employment and income (Heanue 1998; Burt and Hoover 2006), that although new highways generate traffic, they still provide net economic benefits (ULI 1989), and that increasing roadway capacity does reduce congestion (TRIP 1999; Bayliss 2008).

These arguments ignore critical issues, and are often based on outdated data and inaccurate analysis. Overall travel trends indicate little about the cost effectiveness of particular policies and projects. For example, studies which indicate that, in the past, increased lane-miles caused minimal growth in vehicle travel (Burt and Hoover 2006), provide little guidance for future planning, since, in the past, much of the added highway lane-miles occurred on uncongested rural highways while most future highway expansion occurs on congested urban highways. Strategies that encourage more efficient use of existing capacity, such as commute trip reduction programs and road pricing, may provide greater social benefits, particularly considering all costs (Goodwin 1997).

Highway expansion advocates generally ignore or severely understate generated traffic and induced travel impacts. For example, Cox and Pisarski (2004) use a model that accounts for diverted traffic (trips shifted in time or route) but ignores shifts in mode, destination and trip frequency. Hartgen and Fields (2006) assume that generated traffic would fill just 15% of added roadway capacity, based on generated traffic rates during the 1960s and 1970s, which is unrealistically low when extremely congested roads are expanded. They ignore the incremental costs that result from induced vehicle travel, such as increased downstream traffic congestion, road and parking costs, accidents and pollution emissions. They claim that roadway capacity expansion reduces fuel consumption, pollution emissions and accidents, because they measure impacts per vehicle-mile and ignore increased vehicle miles. As a result they significantly exaggerate roadway expansion benefits and understate total costs.

Debates over generated traffic and its implications often reflect ideological perspectives concerning whether automobile travel (and therefore road capacity expansion) is "good" or "bad". To an economist, such arguments are silly. Some automobile travel provides large net benefits (high user value, poor alternatives, low external costs), and some provides negative net benefits (low user value, good alternatives, and large external costs). The efficient solution to congestion is to use pricing or other incentives to test consumers' willingness to pay for road space and capacity expansion.

If consumers only demand roadway improvements when they are shielded from the true costs, such projects are likely to be economically inefficient. Only if users are willing to pay the full incremental costs their vehicle use imposes can society be sure that increased road capacity and the additional vehicle travel that results provides net benefits. Travel demand predictions based on underpriced roads overestimate the economically optimal level of roadway investments and capacity expansion. Increasing capacity in such cases is more equivalent to loosening a belt than giving a growing child larger shoes (see quotes above), since the additional vehicle travel is a luxury and economically inefficient.

Some highway advocates suggest there are equity reasons to subsidize roadway capacity expansion, to allow lower-income households access to more desirable locations, but most benefits from increased roadway capacity are captured by middle- and upper-income households (Deakin, et al. 2020). Improving travel choices for non-drivers tends to have greater equity benefits than subsidizing additional highway capacity since physically and economically disadvantaged people often rely on alternative modes.

Although highway projects are often justified for the sake of economic development, highway capacity expansion now provides little net economic benefit (Boarnet 1997). An expert review concluded, "The available evidence does not support arguments that new transport investment in general has a major impact on economic growth in a country with an already well-developed infrastructure" (SACTRA 1997). Melo, Graham and Canavan (2012) found a positive relationship between U.S. urban highway expansion and economic output between 1982 and 2009, but no reduction in long-term congestion. They conclude that other types of transportation system improvements could provide greater economic development benefits.

Alternative Transport Improvement Strategies

Generated traffic significantly reduces roadway capacity expansion benefits, making other congestion reduction solutions relatively more cost effective and beneficial. The article, *Spreading the Gospel of Induced Demand* (Klein, et al. 2022) argues that the general public misunderstands induced travel impacts and so tends to overestimate highway expansion benefits and underestimate the benefits of alternative congestion solutions.

Considering generated traffic tends to increase the estimated value of improvements to alternative modes (particularly grade-separated ridesharing and public transit services), transportation systems management, efficient road pricing, and transportation demand management strategies that result in more efficient use of existing roadway capacity. Although these strategies may not necessarily eliminate traffic congestion individually, an integrated package can significantly reduce congestion delays compared with what would otherwise occur, usually with less costs and greater total benefits than highway capacity expansion. Below are examples (VTPI 2001):

- Congestion pricing can provide travelers with an incentive to reduce their peak period trips and use space-efficient modes such as public transit, ridesharing, bicycling and walking.
- Commute trip reduction programs can provide a framework for encouraging commuters to drive less and rely more on travel alternatives.
- Land use management can increase access by bringing closer common destinations.
- Pedestrian and cycle improvements can increase mobility and access, and support other modes such as public transit (since transit users also depend on walking and cycling).
- Public transit service that offers door-to-door travel times and user costs that are competitive with driving can attract travelers from a parallel highway, limiting the magnitude of traffic congestion on that corridor.

Legal Issues

Environmental groups successfully sued the Illinois transportation agencies for failing to consider land use impacts and generated traffic in the Environmental Impact Statement (EIS) for I-355, a proposed highway extension outside the city of Chicago (Sierra Club 1997). The federal court concluded that the EIS was based on the "implausible" assumption that population in the rural areas would grow by the same amount with and without the tollroad, even though project was promoted as a way to stimulate growth. The court concluded that this circular reasoning afflicted the document's core findings. The judge required the agencies to prepare studies identifying the amount of development the tollroad would cause, and compare this with alternatives. The Court's order states:

> Plaintiffs' argument is persuasive. Highways create demand for travel and expansion by their very existence…Environmental laws are not arbitrary hoops through which government agencies must jump. The environmental regulations at issue in this case are designed to ensure that the public and government agencies are well informed about the environmental consequences of proposed actions. The environmental impact statements in this case fail in several significant respects to serve this purpose. (ELCP)

In 2008 the California Attorney General recognized that regional transportation plans must consider induced travel impacts when evaluating the climate change impacts of individual projects to meet California Environmental Quality Act (CEQA) requirements (Brown 2008). CEQA requires that "[e]ach public agency shall mitigate or avoid the significant effects on the environment of projects that it carries out or approves whenever it is feasible to do so." The state Attorney General recognizes that transportation planning decisions, such as highway expansion projects, can have significant emission impacts due to induced vehicle travel.

Some new laws and regulations, such as California Senate Bill 743 (S.B. 743), prohibit the use of vehicle level of service (LOS) and similar measures as the sole basis for evaluating transportation improvement options; instead, policies and project are evaluated based on their ability to reduce vehicle miles traveled (VMT). This will require consideration of induced travel effects in analysis of roadway projects (Milam, et al. 2017).

In 2020, the California Department of Transportation established specific requirements for evaluating and mitigating the induced travel impacts of roadway expansion projects (Sundquist 2020), based on an extensive expert review (Caltrans 2020a). This analysis is based on lane-miles-to-induced-VMT elasticities, as specified in the *Transportation Analysis Framework: Induced Travel Analysis* report (Caltrans 2020b), and estimated by the National Center for Sustainable Transportation's *Induced Travel Calculator* (NCST 2019).

Conclusions

Urban traffic congestion tends to maintain equilibrium. Congestion reaches a point at which it discourages additional peak-period trips. Increasing road capacity allows more vehicle travel to occur. In the short term this consists primarily of generated traffic: vehicle travel diverted from other times, modes, routes and destinations. Over the long run an increasing portion consists of induced vehicle travel, resulting in a total increase in regional VMT. This has several implications for transport planning:

- Ignoring generated traffic underestimates the magnitude of future traffic congestion problems, overestimates the congestion reduction benefits of increasing roadway capacity, and underestimates the benefits of alternative solutions to transportation problems.
- Induced travel increases many external costs. Over the long term it helps create more automobile dependent transportation systems and land use patterns.
- The mobility benefits of generated traffic are relatively small since they consist of marginal value trips. Much of the benefits are often capitalized into land values.

Ignoring generated traffic results in self-fulfilling *predict and provide* planning: Planners extrapolate traffic growth rates to predict that congestion will reach *gridlock* unless capacity expands. Adding capacity generates traffic, which leads to renewed congestion with higher traffic volumes, and more automobile oriented transport and land use patterns. This cycle continues until road capacity expansion costs become unacceptable.

The amount of traffic generated depends on specific conditions. Expanding highly congested roads with considerable latent demand tends to generate significant amounts of traffic, providing only temporary congestion reductions.

Generated traffic does not mean that roadway expansion provides no benefits and should never be implemented. However, ignoring generated traffic results in inaccurate forecasts of impacts and benefits. Road projects considered cost effective by conventional analysis may actually provide little long-term benefit to motorists and make society overall worse off due to induced travel external costs. Other strategies may be better overall. Another implication is that highway capacity expansion projects should incorporate strategies to avoid increasing external costs, such as more stringent vehicle emission regulations to avoid increasing pollution and land use regulations to limit sprawl.

Framing the Congestion Question

If you ask people, *"Do you think that traffic congestion is a serious problem?"* they frequently answer yes. If you ask, *"Would you rather solve congestion problems by improving roads or by using alternatives such as congestion tolls and other TDM strategies?"* a smaller majority would probably choose the road improvement option. This is how transport choices are generally framed.

But if you present the choices more realistically by asking, *"Would you rather spend a lot of money to increase road capacity to achieve moderate and temporary congestion reductions and bear higher future costs from increased motor vehicle traffic, or implement other types of transportation improvements?"* the preference for road building is likely to decline.

References and Information Resources

ADB (2010), *Reducing Carbon Emissions from Transport Projects*, Asian Development Bank (www.adb.org); at www.adb.org/evaluation/reports/ekb-carbon-emissions-transport.asp.

Asif Ahmed and Peter Stopher (2014), "Seventy Minutes Plus or Minus 10 — A Review of Travel Time Budget Studies," *Transport Reviews*, Vo. 34:5, pp. 607-625 (DOI: 10.1080/01441647.2014.946460).

Richard Arnott and Kenneth Small (1994), "The Economics of Traffic Congestion," *American Scientist*, Vol. 82, Sept./ Oct. 1994, pp. 446-455.

Lawrence C. Barr (2000), "Testing for the Significance of Induced Highway Travel Demand in Metropolitan Areas," *Transportation Research Record 1706*, Transportation Research Board (www.trb.org); at http://trb.metapress.com/content/lq766w66540p7432/fulltext.pdf.

Matthew Barth and Kanok Boriboonsomsin (2009), "Traffic Congestion and Greenhouse Gases," *Access 35*, (www.accessmagazine.org); at https://bit.ly/3nwZIjb.

David Bayliss (2008), *Misconceptions and Exaggerations about Roads and Road Building in Great Britain*, Royal Automobile Club Foundation (www.racfoundation.org/index.php?option=com_content&task=view&id=597&Itemid=35)

Marlon Boarnet (1997), *Direct and Indirect Economic Effects of Transportation Infrastructure*, UCTC (www.uctc.net).

Marlon Boarnet and Saksith Tan Chalermpong (2002), *New Highways, Induced Travel and Urban Growth Patterns: A "Before and After" Test*, Paper 559, University of California Transportation Center (www.uctc.net).

Robert Burchell, et al. (1998), *Costs of Sprawl – Revisited*, TCRP Report 39, Transportation Research Board (www.trb.org).

Michael Burt and Greg Hoover (2006), *Build It and Will They Drive? Modelling Light-Duty Vehicle Travel Demand*, Conference Board of Canada (www.conferenceboard.ca); at https://bit.ly/39IxQqZ.

Edward G. Brown (2008), *Comments on the Notice of Preparation for Draft Environmental Impact Report for the Transportation 2035 Plan*, California Attorney General (http://ag.ca.gov); at http://ag.ca.gov/globalwarming/pdf/comments_MTC_RT_Plan.pdf.

Jihye Byun, Sungjin Park and Kitae Jang (2017), "Rebound Effect or Induced Demand? Analyzing the Compound Dual Effects on VMT in the U.S.," *Sustainability*, (www.mdpi.com/2071-1050/9/2/219/pdf).

Sally Cairns, C. Hass-Klau and Phil Goodwin (1998), *Traffic Impacts of Highway Capacity Reductions: Assessment of the Evidence*, London Transport Planning; at https://bit.ly/3ME2aS3.

Caltrans (2020), *Transportation Analysis Framework: Induced Travel Analysis*, California Department of Transportation (https://dot.ca.gov); at https://bit.ly/3aCYo7M.

Alison Cassady, Tony Dutzik and Emily Figdor (2004), *More Highways, More Pollution: Road-Building and Air Pollution in American's Cities*, U.S. PIRG Education Fund (www.uspirg.org).

Robert Cervero (2002), "Induced Travel Demand: Research Design, Empirical Evidence, and Normative Policies," *Journal of Planning Literature*, Vol. 17, No. 1, pp. 4-19

Robert Cervero (2003a), "Are Induced Travel Studies Inducing Bad Investments?," *ACCESS*, Number 22, University of California Transportation Center (www.uctc.net), Spring, 22-27.

Robert Cervero (2003b), "Road Expansion, Urban Growth, and Induced Travel: A Path Analysis," *Journal of the American Planning Association*, Vol. 69, No. 2 (www.planning.org), pp. 145-163.

Robert Cervero and Mark Hansen (2000), *Road Supply-Demand Relationships: Sorting Out Casual Linkages*, Institute of Transportation Studies, University of California (www.uctc.net).

CNU (2012), *Highways to Boulevards Program*, Congress for New Urbanism (www.cnu.org/highways).

Wendell Cox and Alan Pisarski (2004), *Blueprint 2030: Affordable Mobility And Access For All*, Georgians for Better Mobility (http://ciprg.com/ul/gbt/atl-report-20040621.pdf).

J. M. Dargay and P. B. Goodwin (1995), "Evaluation of Consumer Surplus with Dynamic Demand Changes." *Journal of Transport Economics and Policy*, Vol. XXIX, No. 2, pp. 179-93.

Elizabeth Deakin, et al. (2020), *Calculating and Forecasting Induced Vehicle Miles of Travel Resulting from Highway Projects: Findings and Recommendations from an Expert Panel*, California Department of Transportation (https://dot.ca.gov); at https://bit.ly/3nwaf10.

Patrick DeCorla-Souza (2000), "Estimating Highway Mobility Benefits," *ITE Journal* (www.ite.org), February 2000, pp. 38-43. Also, Patrick DeCorla-Souza, "Evaluating the Trade-Offs Between Mobility and Air Quality," *ITE Journal*, February 2000, pp. 65-70.

Patrick DeCorla-Souza and Harry Cohen (1998), *Accounting for Induced Travel in Evaluation of Urban Highway Expansion*, FHWA (www.fhwa.dot.gov/steam/doc.htm).

Patrick DeCorla Souza and Harry Cohen (1999), "Estimating Induced Travel For Evaluation of Metropolitan Highway Expansion," *Transportation*, Vol. 26, pp. 249-261.

Mark Delucchi (1996), "Total Cost of Motor-Vehicle Use," *Access* (http://violet.berkeley.edu/~uctc), No. 8, Spring 1996, pp. 7-13.

DfT (2007), *Transport Analysis Guidance*, UK Department For Transport (www.webtag.org.uk). The *Variable Demand Modelling* (www.dft.gov.uk/webtag/documents/expert/unit3.10.1.php) section describes methods for incorporating induced travel demand into project appraisal.

Anthony Downs (1992), *Stuck in Traffic*, Brookings Institution (www.brookings.edu); at www.brookings.edu/book/stuck-in-traffic.

Gilles Duranton and Matthew A. Turner (2011), "The Fundamental Law of Highway Congestion: Evidence from the US," *American Economic Review* (www.aeaweb.org); at www.nber.org/papers/w15376 and https://bit.ly/35H0jJk.

Mary Ebeling (2014), *Re-Thinking the Urban Freeway*, State Smart Transportation Initiative (https://ssti.us) and Mayors Innovation Project; at https://bit.ly/3mLriZG.

EC (2004), *Reclaiming City Streets for People: Chaos or Quality Of Life?* European Commission (www.ec.europa.eu); at http://ec.europa.eu/environment/pubs/pdf/streets_people.pdf.

Reid Ewing and Shima Hamidi (2014), *Measuring Urban Sprawl and Validating Sprawl Measures*, Metropolitan Research Center at the University of Utah for the National Cancer Institute, the Brookings Institution and Smart Growth America (www.smartgrowthamerica.org); at https://bit.ly/2I6StdG.

FHWA (1997), *Spreadsheet Model for Induced Travel Estimation* (SMITE), Federal Highway Administration (www.fhwa.dot.gov/steam/smite.htm).

FHWA (1998), *Surface Transportation Efficiency Analysis Model* (STEAM), Federal Highway Administration (www.fhwa.dot.gov/steam).

FHWA (1999), *Social Costs of Alternative Land Development Scenarios*, Federal Highway Administration (www.fhwa.dot.gov/scalds/scalds.html).

FHWA (2002), *Highway Economic Requirements System: Technical Report*, FHWA, USDOT (https://trid.trb.org/view/725673); at https://rosap.ntl.bts.gov/view/dot/58541.

FHWA (2004), *Induced Travel: Frequently Asked Questions*, Federal Highway Administration (www.fhwa.dot.gov/planning/itfaq.htm).

Georgios Fontaras, et al. (2014), "Development and Review of Euro 5 Passenger Car Emission Factors Based on Experimental Results over Various Driving Cycles," *Science of the Total Environment*, Vo. 468–469, Pages 1034-1042 (https://doi.org/10.1016/j.scitotenv.2013.09.043).

Miquel-Àngel Garcia-López, Ilias Pasidis, and Elisabet Viladecans-Marsal (2020), *Congestion in Highways when Tolls and Railroads Matter: Evidence from European Cities*, Universitat Autonoma of Barcelona (https://ecap.uab.cat/RePEc/doc/wpdea2011.pdf), Ideas (https://ideas.repec.org); at https://ideas.repec.org/p/uab/wprdea/wpdea2011.html.

Phil Goodwin (1996), "Empirical Evidence on Induced Traffic," *Transportation*, Vo. 23, No. 1, pp. 35-54 (https://doi.org/10.1007/BF00166218).

Phil Goodwin (1997), *Solving Congestion*, Inaugural lecture for the Professorship of Transport Policy, University College London; at http://discovery.ucl.ac.uk/1244/1/2004_22.pdf.

Phil B. Goodwin (1998), "The End of Equilibrium," in *Theoretical Foundations of Travel Choice Modelling*. edited by T. Garling et al., Elsevier, ISBN 0080430627.

Phil Goodwin (2002), "Disappearing Traffic? The Story So Far," Proceedings of the Institution of Civil Engineers; *Municipal Engineer*, Vo. 151, Issue 1 (www.municipalengineer.com) March 2002, pp. 13-22; at www.onestreet.org/images/stories/Disappearing_traffic.pdf.

Phil Goodwin and Robert B. Noland (2003), "Building New Roads Really Does Create Extra Traffic: A Response to Prakash et al.," *Applied Economics* (www.tandf.co.uk/journals).

Roger Gorham (2009), *Demystifying Induced Travel Demand*, Sustainable Transportation Technical Document, Sustainable Urban Transportation Project (www.sutp.org) and GTZ (www.gtz.de); at http://tinyurl.com/l5q4ktp.

Dan J. Graham, Emma J. McCoy and David A. Stephens (2014), "Quantifying Causal Effects of Road Network Capacity Expansions on Traffic Volume and Density via a Mixed Model Propensity Score Estimator," *Journal of the American Statistical Association*, Vol. 109, pp. 1440-1449, (http://dx.doi.org/10.1080/01621459.2014.956871); earlier version at https://bit.ly/2CtzfBw.

Susan Handy and Marlon G. Boarnet (2014), *Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions; Technical Background Document*, California Air Resources Board (www.arb.ca.gov); at https://bit.ly/2O4exJA.

Susan Handy (2015), *Increasing Highway Capacity Unlikely to Relieve Traffic Congestion*, National Center for Sustainable Transportation (http://ncst.ucdavis.edu); at https://bit.ly/1QlDn4z.

Mark Hansen, et al. (1993), *Air Quality Impacts of Urban Highway Capacity Expansion: Traffic Generation and Land Use Changes*, Institute of Transport Studies (www.uctc.net); at https://escholarship.org/uc/item/6zz3k76c.

Mark Hansen (1995), "Do New Highways Generate Traffic?" *Access* No. 7 (www.uctc.net), Fall, pp.16-22; at www.accessmagazine.org/fall-1995/do-new-highways-generate-traffic.

Mark Hansen and Yuanlin Huang (1997), "Road Supply and Traffic in California Urban Areas," *Transportation Research A*, Vol. 31, No. 3, pp. 205-218; at http://bit.ly/2A0Gi1C.

David T. Hartgen (2003), *The Impact of Highways and Other Major Road Improvements on Urban Growth in Ohio*, The Buckeye Institute (www.buckeyeinstitute.org).

David T. Hartgen and M. Gregory Fields (2006), *Building Roads to Reduce Traffic Congestion in America's Cities: How Much and at What Cost?* Reason Foundation (www.reason.org).

Greig Harvey and Elizabeth Deakin (1993), *A Manual of Regional Transportation Modeling Practice for Air Quality*, National Association of Regional Councils (www.narc.org).

Kevin Heanue (1998), *Highway Capacity Expansion and Induced Travel; Evidence and Implications*, Circular 481, TRB (www.trb.org); at https://bit.ly/3IEgF77.

Peter Hills (1996), "What is Induced Traffic?" *Transportation*, Vol. 23, No. 1, pp. 5-16.

Kent M. Hymel, Kenneth A. Small and Kurt Van Dender (2010), "Induced Demand and Rebound Effects in Road Transport," *Transportation Research B* (www.elsevier.com/locate/trb), Vol. 44/10, Dec., pp. 1220-1241; at www.socsci.uci.edu/~ksmall/Rebound_congestion_27.pdf.

Kent Hymel (2019), "If You Build it, They Will Drive: Measuring Induced Demand for Vehicle Travel in Urban Areas," *Transport Policy*, Vo. 76, pp. 57-66 (doi.org/10.1016/j.tranpol.2018.12.006).

ICF Consulting (2005), *Handbook on Integrating Land Use Considerations into Transportation Projects to Address Induced Growth*, AASHTO; at https://onlinepubs.trb.org/onlinepubs/archive/notesdocs/25-25(3)_fr.pdf.

Induced Travel Calculator (https://blinktag.com/induced-travel-calculator), by the University of California Davis National Center for Sustainable Transportation, estimates the additional annual vehicle miles of travel (VMT) induced by state highway expansions.

ITDP (2012), *Death and Life of Urban Highways*, Institute for Transportation and Development Policy (www.itdp.org); at www.itdp.org/2012/03/13/the-life-and-death-of-urban-highways.

ITF (2021), *Reversing Car Dependency*, International Transport Forum (www.itf-oecd.org); at www.itf-oecd.org/sites/default/files/docs/reversing-car-dependency.pdf.

Peter Jacobsen (1997), "Liquid vs. Gas Models for Traffic," *Los Angeles Times*, Letters to Editor, 14 May 1997; at www.latimes.com/archives/la-xpm-1997-05-14-me-58478-story.html.

Annika K. Jägerbrand, et al. (2014), *Rebound Effects of Energy Efficiency Measures in the Transport Sector in Sweden*, The Swedish Energy Agency (www.vti.se); at https://bit.ly/3zgzfQ0.

Robert Johnston and Raju Ceerla (1996), "The Effects of New High-Occupancy Vehicle Lanes on Travel and Emissions," *Transportation Research*, Vol. 30A, No. 1, pp. 35-50.

Robert A. Johnston, et al. (2001), *Applying an Integrated Model to the Evaluation of Travel Demand Management Policies in the Sacramento Region*, Mineta Transportation Institute (www.transweb.sjsu.edu); at http://transweb.sjsu.edu/publications/01-03.pdf.

Nicholas J. Klein, et al. (2022), "Spreading the Gospel of Induced Demand," *Transfer Magazine*, Issue 9 (https://transfersmagazine.org); at https://bit.ly/3arJWFj.

Kara Kockelman (2011), "Traffic Congestion," Chapter 22, *Transportation Engineering Handbook*, McGraw Hill (www.mhprofessional.com); pre-print at https://bit.ly/3PyX3Er.

Robert Krol (2020), *Can We Build Our Way Out of Urban Traffic Congestion?*, Center for Growth and Opportunity at Utah State University (www.thecgo.org); at https://bit.ly/2ZvbDUv.

Douglass Lee, Lisa Klein and Gregorio Camus (1999), "Induced Traffic and Induced Demand," *Transportation Research Record 1659*, TRB (www.trb.org), pp. 68-75 (doi.org/10.3141/1659-09).

David Levinson and Ajay Kumar (1995), "Activity, Travel, and the Allocation of Time," *APA Journal*, Vol. 61, No. 4, pp. 458-470 (https://doi.org/10.1080/01944369508975657). .

Todd Litman (2001a), *What's It Worth? Life Cycle and Benefit/Cost Analysis for Evaluating Economic Value*, Presented at Internet Symposium on Benefit-Cost Analysis, Transportation Association of Canada (www.tac-atc.ca); at www.vtpi.org/worth.pdf.

Todd Litman (2001), "Generated Traffic: Implications for Transport Planning," *ITE Journal*, Vo. 71/4, Institute of Transportation Engineers (www.ite.org), pp. 38-47; at www.vtpi.org/gentraf.pdf.

Todd Litman (2003), *Transportation Cost Analysis: Techniques, Estimates and Implications*, Victoria Transport Policy Institute (www.vtpi.org/tca).

Todd Litman (2009), *Transportation Elasticities*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/elasticities.pdf.

Todd Litman (2012), "Changing North American Vehicle-Travel Price Sensitivities: Implications for Transport and Energy Policy" *Transport Policy* (http://dx.doi.org/10.1016/j.tranpol.2012.06.010); at www.vtpi.org/VMT_Elasticities.pdf.

Todd Litman (2013), *Transport Elasticities: Impacts on Travel Behaviour: Understanding Transport Demand To Support Sustainable Travel Behavior*, Technical Document #11, Sustainable Urban Transport Project (www.sutp.org) and GIZ (www.giz.de); at https://sutp.org/publications/transport-elasticities-impacts-on-travel-behaviour.

Todd Litman (2014), *Congestion Evaluation Best Practices*, International Transportation Economic Development Conference, Dallas, Texas; at www.vtpi.org/ITED_congestion.pdf.

Todd Litman (2014b), *Congestion Costing Critique: Critical Evaluation of the 'Urban Mobility Report,'* VTPI (www.vtpi.org); at www.vtpi.org/UMR_critique.pdf.

Todd Litman (2016), *Transportation Land Use Impacts*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/landuse.pdf.

Todd Litman (2019), *Smart Congestion Relief: Comprehensive Analysis of Traffic Congestion Costs and Congestion Reduction Benefits,* Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/cong_relief.pdf.

Todd Litman (2021), *Not So Fast: Better Speed Valuation for Transportation Planning*, Victoria Transport Policy Institute (www.vtpi.org); at https://vtpi.org/nsf.pdf.

William R. Loudon, Janaki Parameswaran and Brian Gardner (1997), "Incorporating Feedback in Travel Forecasting: Methods, Pitfalls and Common Concerns," *Transportation Research Record 1607*, TRB (www.trb.org), pp. 185-195; at http://trb.metapress.com/content/120399.

Peter Mackie (1996), "Induced Traffic and Economic Appraisal," *Transportation*, Vol. 23 (https://doi.org/10.1007/BF00166222).

Cesare Marchetti (1994), "Anthropological Invariants in Travel Behaviour, *Technological Forecasting and Social Change*," p. 75-88; at https://bit.ly/2sYBJjR. Also see Jesse H. Ausubel and Cesare Marchetti (2001), "Evolution of Transport," *Industrial Physicist*; at https://bit.ly/3v1IgZz.

Norman Marshall (2016), *A Statistical Model of Regional Traffic Congestion in the United States*, TRB Annual Meeting (https://trid.trb.org/view/1392295); at https://bit.ly/3GNI2L1.

METRO (2022), *Climate Emissions Analysis: Metro's Indirect Impact on Greenhouse Gas Emissions*, Los Angeles Region METRO (www.metro.net); at https://bit.ly/3B5QGDo.

David Metz (2021), "Economic Benefits of Road Widening: Discrepancy Between Outturn and Forecast," *Transportation Research Part A*, Vo. 147, pp. 312-319 (https://doi.org/10.1016/j.tra.2021.03.023).

Ronald T. Milam, et al. (2017), "Closing the Induced Vehicle Travel Gap Between Research and Practice," *Transportation Research Record 2653* (https://doi.org/10.3141/2653-02).

Martin Mogridge (1997), "The Self-Defeating Nature of Urban Road Capacity Policy; A Review of Theories, Disputes and Available Evidence," *Transport Policy*, Vo. 4, No. 1, pp. 5-23; at https://bit.ly/39F3Try. Also see *Lewis-Mogridge Position*, Wikipedia (http://en.wikipedia.org/wiki/Lewis-Mogridge_Position).

Patricia C. Melo, Daniel J. Graham and Shane Canavan (2012), "Effects of Road Investments on Economic Output and Induced Travel Demand," *Transportation Research Record 2297*, Transportation Research Board (www.trb.org), pp. 163-171; at http://tinyurl.com/mwdvfsl.

Petter Næss, Morten Skou Nicolaisen and Arvid Strand (2012), "Traffic Forecasts Ignoring Induced Demand: a Shaky Fundament for Cost-Benefit Analyses," *European Journal of Transport and Infrastructure Research*, Vol. 12 (3), pp. 291-301; at https://bit.ly/2OR84SC.

NCST (2019), *Induced Travel Calculator*, National Center for Sustainable Transportation (https://ncst.ucdavis.edu); at https://blinktag.com/induced-travel-calculator.

Peter Newman and Jeff Kenworthy (1998), *Sustainability and Cities; Overcoming Automobile Dependency*, Island Press (www.islandpress.org).

Robert Noland (2001), "Relationships Between Highway Capacity and Induced Vehicle Travel," *Transportation Research A*, Vol. 35, No. 1, January 2001, pp. 47-72.

Robert B. Noland and Lewison L. Lem (2002), "A Review of the Evidence for Induced Travel and Changes in Transportation and Environmental Policy in the US and the UK," *Transportation Research D*, Vol. 7, No. 1 (www.elsevier.com/locate/trd), pp. 1-26.

Robert Noland and Mohammed A. Quddus (2006), "Flow Improvements and Vehicle Emissions: Effects of Trip Generation and Emission Control Technology," *Transportation Research D*, Vo. 11 (www.elsevier.com/locate/trd), pp. 1-14; at https://bit.ly/3kueGX5.

Robert B. Noland and Christopher S. Hanson (2013), "How Does Induced Travel Affect Sustainable Transport Policy," *Transportation Beyond Oil: Policy Choices for a Multimodal Future*, (John Renne and Billy Fields, eds), *Island Press* (www.islandpress.com), pp. 70-85.

John Odgers (2009), *Have All The Travel Time Savings On Melbourne' Road Network Been Achieved?*, A GAMUT Discussion Paper, School of Management, RMIT University; at www.abp.unimelb.edu.au/gamut/pdf/have-all-the-time-savings-been-achieved.pdf.

M. Özuysal and S. Tanyel (2008), "Induced Travel Demand in Developing Countries: Study of State Highways in Turkey," *Journal of Urban Planning and Development*, Vo. 134, No 2, pp. 78-87; abstract at http://ascelibrary.org/upo/resource/1/jupddm/v134/i2/p78_s1.

Mohammad Lutfur Rahmana, Douglas Bakerb and M. Shafiq-Ur Rahmanc (2020), "Modelling Induced Travel Demand in a Developing Country: Evidence from Dhaka, Bangladesh," *Transportation Research Procedia 48*, pp. 3439–3456 (10.1016/j.trpro.2020.08.108); at www.sciencedirect.com/science/article/pii/S235214652030524X.

Stuart Ramsey (2005), "Of Mice and Elephants," *ITE Journal*, Vol. 75, No. 9 (www.ite.org), pp. 38-41; at https://bit.ly/2MuCKfX.

Caroline Rodier, et al. (2001), *Anatomy of Induced Travel; Using an Integrated Land Use and Transportation Model in the Sacramento Region*, Transportation Research Board Annual Meeting (www.trb.org).

Peter Romilly (2004), "Welfare Evaluation With a Road Capacity Constraint," *Transportation Research A*, Vol. 38/4 (DOI: 10.1016/j.tra.2003.12.001), pp. 287-303; at https://bit.ly/3lwiNmW.

SACTRA (1994), *Trunk Roads and the Generation of Traffic*, Standing Advisory Committee on Trunk Road Assessment, UKDoT, HMSO (London; www.roads.detr.gov.uk/roadnetwork).

SACTRA (1997), *Transport Investment, Transport Intensity and Economic Growth: Interim Report*, Standing Committee on Trunk Road Assessment, Dept. of Environment, Transport and Regions (www.roads.detr.gov.uk/roadnetwork/heta/sactra98.htm).

Robert G. Schiffer, M. Walter Steinvorth and Ronald T. Milam (2005), *Comparative Evaluations on the Elasticity of Travel Demand*, TRB Paper 05-0313 (www.trb.org); at https://bit.ly/3Q1LZzU.

Benjamin Schneider (2018), *Induced Demand*, CityLab University (www.bloomberg.com/citylab); at https://bloom.bg/2VDYfwd.

SHIFT Calculator (https://shift.rmi.org). The *State Highway Induced Frequency of Travel* (SHIFT), developed by the Rocky Mountain Institute, estimates long-run (i.e., after 5 to 10 years) induced vehicle travel and emissions impacts from highway expansions in U.S. urban regions. It is based on methodologies developed for California's Transportation Analysis Framework.

Sierra Club (1997)*, Ill. Chapter v U.S. Dept. of Transp*. (962 F supp. 1037, ND Ill 1997).

STPP (1998), *Do New Roads Cause Congestion?*, Surface Transportation Policy Project (www.transact.org); at www.transact.org/congestion/analysis.htm.

Eric Sundquist (2020), *California Highway Projects Face Review for Induced Travel*, State Smart Transportation Initiative (www.ssti.us); at https://bit.ly/2VW5pev.

TfA (2020), *The Congestion Con: How More Lanes and More Money Equals More Traffic*, Transportation for America (http://t4america.org); at http://t4america.org/wp-content/uploads/2020/03/Congestion-Report-2020-FINAL.pdf.

Aud Tennøy, Anders Tønnesen and Frants Gundersen (2019), "Effects of Urban Road Capacity Expansion – Experiences from Two Norwegian Cases," *Transportation Research Part D: Transport and Environment*, Vol. 69, pp. 90-106 (https://doi.org/10.1016/j.trd.2019.01.024).

TØI (2009), *Does Road Improvement Decrease Greenhouse Gas Emissions?* Norwegian Centre for Transport Research (www.toi.no); summary at https://bit.ly/3HhHM6x.

Transportation, Vol. 23, No. 1, February 1996. Special issue devoted to induced travel.

TRB (1995), *Expanding Metropolitan Highways: Implications for Air Quality and Energy Use, Committee for Study of Impacts of Highway Capacity Improvements on Air Quality and Energy Consumption*, Transportation Research Board, Special Report #345 (www.trb.org).

TRIP (1999), *The Best Solutions to Traffic Congestion: Dispelling the Myths about the Impact of Expanding Roads*, The Road Information Program (www.tripnet.org).

TRISP (2005), "Treatment of Induced Traffic," *Economic Evaluation Notes*, UK Department for International Development and the World Bank (www.worldbank.org); at http://go.worldbank.org/ME49C4XOH0.

UKERC (2007), *'Rebound Effects' Threaten Success of UK Climate Policy*, UK Energy Research Centre (www.ukerc.ac.uk); at www.ukerc.ac.uk/support/tiki-index.php?page=0710ReboundEffects.

UKERC (2009), *What Policies Are Effective At Reducing Carbon Emissions From Surface Passenger Transport?* UK Energy Research Centre; at www.ukerc.ac.uk/Downloads/PDF/T/TPA_transport_final.pdf.

ULI (1989), *Myths and Facts about Transportation and Growth*, Urban Land Ins. (www.uli.org).

USEPA (2001), *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation and Environmental Qua*lity, US Environmental Protection Agency (www.epa.gov/smartgrowth/pdf/built.pdf).

Han van der Loop (2014), *The Latent Demand in Road Traffic*, KiM Netherlands Institute for Transport Policy Analysis (http://kimnet.nl); at https://bit.ly/2Y3icON.

William S. Vickrey (1969), "Congestion Theory and Transport Investment," *American Economic Review*, Vol. 59/2, May, pp. 251-260; at https://bit.ly/2S0pkrB.

Jamey M. B. Volker, Amy E. Lee and Susan Handy (2020), "Induced Vehicle Travel in the Environmental Review Process," *Transportation Research Record* (doi.org/10.1177/0361198120923365). Also see, Jamey, Volker and Handy (2021), *The Induced Travel Calculator and its Applications*, University of California Institute of Transportation Studies (http://dx.doi.org/10.7922/G22F7KQH).

Huw C. W. L. Williams and Yaeko Yamashita (1992), "Travel Demand Forecasts and the Evaluation of Highway Schemes Under Congested Conditions," *Journal of Transport Economics and Policy*, Vol. 26, No. 3, pp. 261-282 (www.jstor.org/stable/20052987).

Clark Williams-Derry (2007), *Increases in Greenhouse-Gas Emissions from Highway-Widening Projects*, Sightline Institute (www.sightline.org); at https://bit.ly/3pJ3haw.

WSP (2018), *Latest Evidence on Induced Travel Demand: An Evidence Review*, UK Department for Transport (www.gov.uk); at https://bit.ly/3eeCm0r.

Enjian Yao and Takayuki Morikawa (2005), "A Study of An Integrated Intercity Travel Demand Model," *Transportation Research A*, Vol. 39, No. 4 (www.elsevier.com/locate/tra), May, pp 367-381.

Hyejin Youn, Hawoong Jeong and Michael T. Gastner (2008), "The Price of Anarchy in Transportation Networks: Efficiency and Optimality Control," *Journal of Physical Letters*; at http://arxiv.org/PS_cache/arxiv/pdf/0712/0712.1598v4.pdf and https://bit.ly/3vRUZOJ.

www.vtpi.org/gentraf.pdf

Exhibit F

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van der Ree, R., J. A. G. Jaeger, E. A. van der Grift, and A. P. Clevenger. 2011. Effects of roads and traffic on wildlife populations and landscape function: road ecology is moving towards larger scales. *Ecology and Society* **16**(1): 48. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art48/

Guest Editorial, part of a Special Feature on Effects of Roads and Traffic on Wildlife Populations and Landscape Function

Effects of Roads and Traffic on Wildlife Populations and Landscape Function: Road Ecology is Moving toward Larger Scales

Rodney van der Ree [1], *Jochen A. G. Jaeger* [2], *Edgar A. van der Grift* [3], *and Anthony P. Clevenger* [4]

ABSTRACT. Road ecology has developed into a significant branch of ecology with steady growth in the number of refereed journal articles, books, conferences, symposia, and "best practice" guidelines being produced each year. The main objective of this special issue of *Ecology and Society* is to highlight the need for studies that document the population, community, and ecosystem-level effects of roads and traffic by publishing studies that document these effects. It became apparent when compiling this special issue that there is a paucity of studies that explicitly examined higher order effects of roads and traffic. No papers on landscape function or ecosystem-level effects were submitted, despite being highlighted as a priority for publication. The 17 papers in this issue, from Australia, Canada, the Netherlands, and USA, all deal to some extent with either population or community-level effects of roads and traffic. Nevertheless, many higher order effects remain unquantified, and must become the focus of future studies because the complexity and interactions among the effects of roads and traffic are large and potentially unexpected. An analysis of these complex interrelations requires systematic research, and it is necessary to further establish collaborative links between ecologists and transportation agencies. Many road agencies have "environmental sustainability" as one of their goals and the only way to achieve such goals is for them to support and foster long-term and credible scientific research. The current situation, with numerous small-scale projects being undertaken independently of each other, cannot provide the information required to quantify and mitigate the negative effects of roads and traffic on higher levels. The future of road ecology research will be best enhanced when multiple road projects in different states or countries are combined and studied as part of integrated, well-replicated research projects.

Key Words: *animal movement; animal-vehicle collisions; barrier effect; ecological threshold; gene flow; habitat fragmentation; mitigation; population viability analysis; road ecology; road-effect zone; traffic mortality; traffic noise; traffic volume; transportation planning*

INTRODUCTION

Humans are responsible for the current unprecedented rate of biodiversity loss across the globe with climate change, pollution, and the loss, fragmentation, and degradation of habitat being the major drivers of extinction (Vitousek et al. 1997). Roads and other linear infrastructure are a major cause of habitat loss, fragmentation, and degradation and are ubiquitous in most landscapes around the world. Worldwide, there are already an estimated 750 million vehicles travelling on approximately 50 million km of public road (T. Langton, *personal communication*), and the road network and traffic volumes are still increasing, particularly in eastern Europe, China, India, and Latin America.

Linear infrastructure is important for society because it provides connectivity for people. However, linear infrastructure also exerts significant negative effects on adjacent habitats, wildlife populations, communities, and ecosystems. Research about the ecological effects of roads and traffic on the natural environment began in 1925 when Dayton Stoner documented the 225 traffic-killed vertebrates from 29 species that he observed during a 632 mile trip in Iowa, USA (Stoner 1925).

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The term “road ecology” was first used in German (“Straßenökologie”) in 1981 (Ellenberg et al.), and was later translated into English by Forman et al. (2003) for their book *Road Ecology: Science and Solutions*. Since the mid 1990s, there has been a rapid increase in the number of studies, publications, and symposia, particularly from Europe, North America, and Australia. These include major national and international reports and best practice guidelines (Iuell et al. 2003, Trocmé et al. 2003, National Research Council 2005, Clevenger and Huijser 2009), regular dedicated conferences such as the biennial International Conference on Ecology and Transportation (ICOET), Infra-Eco Network of Europe (IENE), and symposia and special issues of peer-reviewed journals, e.g., *Biological Conservation* (Mader 1990), *Conservation Biology* (Hourdequin 2000), *GAIA* (Jaeger et al. 2005), and *Naturschutz and Landschaftsplanung* (Roedenbeck and Jaeger 2006).

The overall aim of road ecology research is to quantify the ecological effects of roads, with the ultimate aim of avoiding, minimizing, and compensating for their negative impacts on individuals, populations, communities, and ecosystems. This research has demonstrated the numerous and diverse effects of roads and traffic on plants and animals, with most studies focusing at the level of the individual animal. These effects include the loss and fragmentation of habitat, increased rates of wildlife mortality because of collision with vehicles, alterations to light, moisture and wind regimes due to the creation of edges, pollution from traffic, e.g., light, noise, and chemical, and facilitating the spread and dispersal of weeds and feral animals. Roads also affect the aesthetic and recreational quality of landscapes for humans (Di Giulio and Holderegger 2009). Consequently, roads have been described as the single most destructive element in the process of habitat fragmentation (Noss 1993) and their ecological effects are considered “the sleeping giant of biological conservation” (Forman 2002:viii).

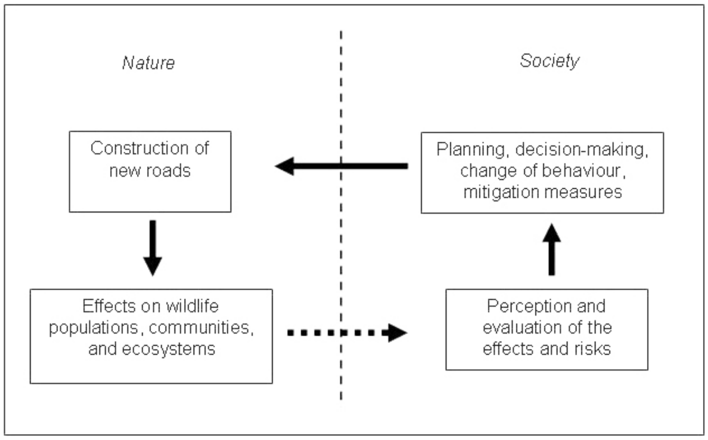
Understanding the impacts of roads and traffic at higher levels is necessary for a number of good reasons. Most governments have agreed that conservation of biodiversity is important and therefore road agencies must endeavor to ensure that they are contributing to achieving this goal. Counting the number of dead animals on the side of the road or measuring the size of the ecological road-effect zone will not, by itself, inform whether roads and vehicles are endangering the existence of populations or species. The important parameter must be the long-term viability of adjacent populations, and this requires data on the sizes of the populations, vital rates, and level of connectivity among subpopulations. Similarly, a critical question when evaluating mitigation works is the extent to which populations have become more viable, and whether they are now sufficiently viable, not simply how many animals pass through an underpass (van der Ree et al. 2007). The extent to which the results from the numerous local studies can be extrapolated to larger spatial and temporal scales is unknown. Therefore, an important next step is to evaluate how the density and configuration of entire road networks affect the functional relationships within and among ecosystems at the landscape scale. Answers to this question will inform cumulative environmental assessments and transportation planning (Roedenbeck et al. 2007). Roads also affect humans in a range of ways but little research on this topic has been completed (Di Giulio and Holderegger 2009).

Reducing the negative effects of roads and traffic will only be possible if more dialogue is achieved between the scientific community and the planners and political decision makers (Fig. 1). The majority of people in the world live in cities and increasingly, their encounters with wildlife involve animals that have died after collision with vehicles. Novel approaches to engage the public, and hence, governments, are required. A recent example was an award-winning exhibition in the Whyte Museum in Banff, Alberta, Canada in 2006 of images of wildlife using the now famous overpasses and underpasses in Banff National Park. A second example was a creative arts competition as part of the IENE 2010 conference for Hungarian school children to portray the conflict, and solutions, between roads and wildlife (Fig. 2).

ABOUT THIS ISSUE: THE EFFECTS OF ROADS AND TRAFFIC ON POPULATIONS, COMMUNITIES, AND ECOSYSTEMS

The two main objectives of this special issue of *Ecology and Society* were to (1) highlight the need for studies that document the population, community, and ecosystem-level effects of roads and traffic, and (2) publish studies that document

Fig. 1. Society's ability to address the negative effects of road networks on wildlife populations and ecosystems depends on the perception of the ecological effects and risks. As the perception of the effects by society has been severely limited (as indicated by the dotted line), alternative approaches may be required that would be based on more indirect indicators of ecological risk and on the precautionary principle.



these effects. The special issue consists of 17 papers from four countries, i.e., Australia, Canada, the Netherlands, and U.S.A., that all deal to some extent with either population or community-level effects of roads and traffic. It became apparent when compiling the special issue that there is a paucity of road ecology studies that explicitly examined higher order effects of roads. No papers on landscape function or ecosystem-level effects were submitted, despite being highlighted as a priority for publication.

The special issue begins with a synthesis paper (Fahrig and Rytwinski 2009) and ends with an insight paper (Simmons et al. 2010). The synthesis is an appropriate first paper because it assesses the widely held assertion that "there are very few studies that assess the population-level effects of roads and traffic." The assertion was found to be partly true and partly false; the authors located 79 studies that provide data on population-level effects (abundance and density) but found that in most cases, the population-level effect was 'hidden' in many of the papers reviewed. Nevertheless, Fahrig and Rytwinski (2009) found that overwhelmingly, roads and traffic had a negative effect on animal abundance, with negative effects outnumbering positive effects by a factor of five. The final paper in the special issue reviews some of the genetic methods used in road ecology and provides an insight into how conservation genetics can be better utilized in future studies. Simmons et al. (2010) argue that conservation genetics is a rapidly evolving field and that many of the widely perceived limitations to the use of genetics are either misconceptions or no longer apply. They conclude with strong recommendations that genetic approaches be combined with field studies to increase the inferential strength of whichever study design is adopted (sensu Roedenbeck et al. 2007).

The road-effect zone is the distance from the edge of the road over which significant ecological effects can be detected (Forman and Alexander 1998). Eigenbrod et al. (2009) quantified threshold effects of a motorway on anuran populations in Canada, and Bissonette and Rosa (2009) investigated the effects of a motorway on the composition and abundance of a small-mammal community in the deserts of Utah, USA. Eigenbrod et al. (2009) were the first to quantify the road-effect zone on the species richness and relative abundance of anurans, and found strong negative effects for four of seven species, extending 250 – 1000 m from the road edge. They conclude that although most anurans are likely to have reduced abundances near motorways, the extent and cause of this relationship will vary among species (Eigenbrod et al. 2009). In contrast, Bissonette and Rosa (2009) found that roadside vegetation in desert environments often provides

Fig. 2. Runner up of the "On Dangerous Roads" Competition organized by Varangy Akciócsoport Egyesület for the 2010 Infra-Eco Network of Europe Conference showing an overpass used by wildlife. An ongoing project in the Netherlands is studying the effectiveness of an overpass for amphibians, in combination with fences along the road. This overpass is equipped with a cascading series of small ponds fed with water pumped into the highest pond in the center of the overpass.

suitable habitat for small mammals. Only 2 of 13 species of small mammals were never captured near roads, and the remaining 11 species' numbers were either similar or more abundant near the road than further away.

Vegetation adjacent to roads often provides habitat (e.g., Bissonette and Rosa 2009), and in some landscapes, even the majority of habitat (van der Ree and Bennett 2003). Wildlife that use this habitat will experience traffic noise and may be affected by it. Anthropogenic noise has the potential to severely disrupt the communication of species by acoustic interference or masking. Three studies in this special issue investigate this effect on frogs and birds. Parris and Schneider (2008) found that the Grey Shrike-thrush (*Colluricincla harmonica*) sang at a higher frequency in areas with traffic noise than the Grey Fantail (*Rhipidura fuliginosa*) and that the probability of detecting either species declined substantially with increasing traffic noise and traffic volume. The effects of traffic noise on frogs were assessed by Parris et al. (2009) in an urban landscape in southeast Australia and by Hoskin and Goosem (2010) in tropical rainforest in northeastern Australia. One species of urban frog in and around Melbourne called at a higher pitch in traffic noise, while the second species studied may also call at a higher pitch, but more data is required to be sure (Parris et al. 2009). *Litoria rheocola* in tropical rainforest also called at a higher pitch when closer to the road, as well as calling at a higher rate when near roads (Hoskin and Goosem 2010). The abundance of some species of rainforest frogs was also lower near roads.

A significant proportion of the road ecology literature is focused on evaluating the use and effectiveness of mitigation measures that aim to restore connectivity for wildlife or reduce rates of animal-vehicle collisions. A review presented at the ICOET conference in 2007 concluded that most studies in the scientific and grey literature had focused almost exclusively on documenting rates of use of wildlife passages, and that few had explicitly evaluated the effectiveness of mitigation measures at enhancing population viability (van der Ree et al. 2007). In this special issue, five papers have addressed the topic of mitigation of road effects on wildlife in differing perspectives. Thorne et al. (2009) highlight the importance of landscape-scale planning to better integrate the needs of wildlife into regional transportation plans. Using two examples from California, USA, they show how road projects can benefit financially and ecologically when road agencies and conservation groups collaborate early in the planning stages. Approximately 1 – 2 million mammal-vehicle collisions occur annually in North America, causing in excess of 200 human fatalities and over one billion U.S. dollars in property damage each year (references in Huijser et al. 2009). Huijser et al. (2009) reviewed the effectiveness and cost of 13 measures considered effective at reducing collisions with large ungulates and found that for many sections of road, the effectiveness, measured as money saved, exceeds the costs to install the mitigation. The results of their cost-benefit model suggests that there must be many locations in North America where the mitigation measures are cost-effective, and thereby would save society money and improve road safety for humans and wildlife if implemented more often. At a smaller spatial scale, Grosman et al. (2009) combined real data on the movement of moose (*Alces alces*) with agent-based computer simulations to investigate if the removal of salt pools or their relocation from adjacent to the highway to 100 – 1500 m away from the road would result in fewer moose-vehicle collisions. Their model predicted that the removal of salt pools from near the edge of the highway would result in an almost 50% reduction in moose-vehicle collisions (Grosman et al. 2009).

The viability of populations adjacent to wildlife crossing structures is one of the fundamental measures of success of mitigation (van der Ree et al. 2007). Two papers in this special issue explicitly investigated the increase in the viability of a population of wildlife after mitigation (Taylor and Goldingay 2009, van der Ree et al. 2009). Taylor and Goldingay (2009) used population modeling to assess the viability of the Greater Glider (*Petauroides volans*) in Brisbane, a rapidly urbanizing area of Australia. They concluded that even a relatively low rate of dispersal across the road was sufficient to substantially reduce the risk of extinction of the smaller subpopulation isolated by the road. Similarly, van der Ree et al. (2009) used population viability modeling to assess the effectiveness of under-road tunnels installed in 1985 to restore connectivity for the critically endangered Mountain Pygmy-possum (*Burramys parvus*; Mansergh and Scotts 1989). They found that the tunnels reduced, but did not completely eliminate the negative effect of the road, with the density of the population affected by the road still 15% lower than a comparable undivided population nearby (van der Ree et al. 2009).

The majority of studies that assess the use of wildlife crossing structures have utilized two primary methods to detect and record wildlife passage, namely remotely triggered cameras, and/or the detection of tracks in a suitable substrate (van der Ree et al. 2007). Clevenger and Sawaya (2010) have used the suggestions of Simmons et al. (2010) and tested the feasibility of a noninvasive genetic sampling approach to identify the species as well as the sex, individual, and relatedness of different individuals using the crossing structure. The technique, if successful, would be applied at a larger scale to determine the level of genetic fragmentation and natural and anthropogenic factors influencing gene flow. They tested their approach on Black Bears (*Ursus americanus*) and Grizzly Bears (*U. arctos*) at two underpasses in Banff National Park. Hair was collected from 90% of crossing events (determined from cameras), and 70% of hair samples had sufficient DNA for extraction, resulting in the identification of five individual bears at each underpass, and highlighting the potential of this method for population-level analysis of the efficacy of wildlife crossing structures (Clevenger and Sawaya 2010).

There is still a paucity of data on the behavior and movement of animals near roads. Bouchard et al. (2009) evaluated the behavioral response of the Northern Leopard Frog (*Rana pipiens*), a species known to be negatively affected by roads and traffic. They studied the movement of frogs during their spring migration and also undertook short distance translocations of migrating frogs and found frogs near roads with more traffic took longer to move and tended to deviate more from straight-line movements when released near roads (Bouchard et al. 2009). The combination of the Northern Leopard Frog’s apparent inability to avoid roads and their slow rate of movement make them highly vulnerable to road mortality. The second study in this special issue on the movement behavior of wildlife near roads was for the Squirrel Glider (*Petaurus norfolcensis*) in southeast Australia (van der Ree et al. 2010). The authors found that the size of the gap in the canopy was the primary determinant of the rate of crossing in their study, with similar rates of crossing across the dual-roadway with tall trees in the median and across single-lane roads. In this study, traffic volume, i.e., approximately 5000 vehicles per day per roadway of which about 25% occurs at night when the gliders are active, did not appear to greatly influence crossing rates.

The traffic volume on minor roads is expected to continue to increase in areas with high human population densities because existing motorways are nearing capacity and the minor roads are expected to accommodate the excess flows (references in van Langevelde and Jaarsma 2009). Traffic calming is a regional planning approach to concentrate these flows onto a few roads, and ensure low-volume and low-speed roads are maintained. The conclusions of population viability modeling suggest that the results are species specific and depend upon the size of the traffic-calmed area as well as the area and quality of habitat (van Langevelde and Jaarsma 2009).

ROAD ECOLOGY: THE ROAD AHEAD

The research presented in this special feature shows that road ecology is moving toward larger scales. However, it also became evident while compiling this special issue that many higher order, e.g., population, community, ecosystem, or landscape-level, effects remain unquantified. These higher order effects must become the focus of future studies because the complexity and interactions among the effects of roads and traffic are large and potentially unexpected. An analysis of these complex interrelations requires systematic research. Therefore, a promising avenue to further develop the field of road ecology is to establish collaborative links with road and transportation agencies. Experience shows that the level of engagement with each local, state, or national road agency depends largely on the presence of interested people, rather than an institutionalized approach to environmental matters. However, institutional mandates are important as they are often a precondition for interested people to spend their efforts during work hours on these issues. Many road agencies have “environmental sustainability” as one of their goals and the only way to achieve such goals is for them to support and foster long-term and credible scientific research. Every road project is essentially an experiment and when combined with other road projects, they become replicated. The challenge we face as researchers is to (1) use good scientific approaches to design studies that are scientifically robust and maximize the individual value of each road project within a larger experimental scope; (2) ensure our research is applied and has tangible value for road agencies and for ecological outcomes; (3) address the higher order effects of roads, traffic, and mitigation measures.

This special feature demonstrates that the emerging field of road ecology is confronted with many important unanswered questions. Research needs to address large spatial and temporal scales that are not compatible within most postgraduate programs, i.e., single MSc or PhD theses, or short-term research contracts. The synergistic effects of roads and other factors that operate simultaneously, e.g., agricultural intensification and increased urbanization, have rarely been investigated. However, empirical studies are limited by the delayed response of wildlife to many environmental changes, i.e., there is an extinction debt such that wildlife populations will continue to decline for many years, in the order of decades, before they will reach a new equilibrium (Tilman et al. 1994, Findlay and Bourdages 2000). This lack of knowledge is often used as a justification to build more roads by arguing that not enough is known and more research is needed before road construction may slow down. This constitutes a “fragmentation spiral” (Jaeger 2002), because research has been unable to catch up with the ecological effects of the rapid increase in road densities. This situation is contrary to the precautionary principle and flies in the face of the principles of sustainability. The use of computer models may help overcome these limitations. For example, simulation models have demonstrated that there are thresholds in the effects of road density on the viability of wildlife populations above which populations are prone to extinction (Jaeger and Holderegger 2005, Frair et al. 2008). In addition, a research approach is required that will address the remaining uncertainties that to a large degree are irreducible, e.g., through building on the precautionary principle (e.g., Jaeger 2002). This would open up promising new lines of action for landscape management. For example, the German Federal Environment Agency recently suggested that region-specific limits to control landscape fragmentation should be introduced (Penn-Bressel 2005).

With this issue, we hope to contribute to the field of road ecology and to highlight both its appealing theoretical insights and its high practical relevance. Most importantly, we hope that this special issue will inspire further research in road ecology at the scale of populations, communities, and ecosystems. We are looking forward to these exciting research studies to come.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol16/iss1/art48/responses/

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LITERATURE CITED

Bissonette, J. A., and S. A. Rosa. 2009. Road zone effects in small-mammal communities. *Ecology and Society* 14(1): 27. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art27/.

Bouchard, J., A. T. Ford, F. Eigenbrod, and L. Fahrig. 2009. Behavioral response of northern leopard frogs (*Rana pipens*) to roads and traffic: implications for population persistence. *Ecology and Society* 14(2): 23. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art23/.

Clevenger, A. P., and M. P. Huijser. 2009. *Handbook for design and evaluation of wildlife crossing structures in North America.* Department of Transportation, Federal Highway Administration, Washington, D.C., USA.

Clevenger, A. P., and M. A. Sawaya. 2010. Piloting a non-invasive genetic sampling method for evaluating population-level benefits of wildlife crossing structures. *Ecology and Society* 15(1): 7. [online] URL: http://www.ecologyandsociety.org/vol15/iss1/art7/.

Di Giulio, M., and R. Holderegger. 2009. Effects of habitat and landscape fragmentation on humans and biodiversity in densely populated landscapes. *Journal Of Environmental Management* 90:2959-2968.

Eigenbrod, F., S. J. Hecnar, and L. Fahrig. 2009. Quantifying the road-effect zone: threshold effects of a motorway on anuran populations in Ontario, Canada. *Ecology and Society* 14(1): 24. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art24/.

Ellenberg, H., K. Müller, and T. Stottele. 1981. Straßen-Ökologie: Auswirkungen von Autobahnen und Straßen auf Ökosysteme deutscher Landschaften. *Ökologie und Straße. Bonn, Germany: Broschürenreihe der deutschen Straßenliga*, Ausgabe 3:19-122.

Fahrig, L., and T. Rytwinski. 2009. Effects of roads on animal abundance: an empirical review and synthesis. *Ecology and Society* 14(1): 21. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art21/.

Findlay, C. S., and J. Bourdages. 2000. Response time of wetland biodiversity to road construction on adjacent lands. *Conservation Biology* 14:86-94.

Forman, R. T. T. 2002. Foreword. Pages vii - x *in* K. J. Gutzwiller, editor. *Applying landscape ecology in biological conservation.* Springer, New York, New York, USA.

Forman, R. T. T., and L. E. Alexander. 1998. Roads and their major ecological effects. *Annual Review of Ecology and Systematics* 29:207-231.

Forman, R. T. T., D. Sperling, J. A. Bissonette, A. P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, and T. C. Winter. 2003. *Road Ecology. Science and Solutions.* Island Press, Washington, D.C., USA.

Frair, J. L., E. H. Merrill, H. L. Beyer, and J. M. Morales. 2008. Thresholds in landscape connectivity and mortality risks in response to growing road networks. *Journal Of Applied Ecology* 45:1504-1513.

Grosman, P. D., J. A. G. Jaeger, P. M. Biron, C. Dussault, and J.-P. Ouellet. 2009. Reducing moose-vehicle collisions through salt pool removal and displacement: an agent-based modelling approach.

Ecology and Society 14(2): 17. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art17/.

Hoskin, C. J., and M. W. Goosem. 2010. Road impacts on abundance, call traits, and body size of rainforest frogs in northeast Australia. *Ecology and Society* 15(3): 15. [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art15/.

Huijser, M. P., J. W. Duffield, A. P. Clevenger, R. J. Ament, and P. T. McGowen. 2009. Cost-benefit analyses of mitigation measures aimed at reducing collisions with large ungulates in the United States and Canada: a decision support tool. *Ecology and Society* 14(2): 15. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art15/.

Hourdequin, M., editor. 2000. The ecological effects of roads. Special issue of *Conservation Biology* 14(1):16-94.

Iuell, B., G. J. Bekker, R. Cuperus, J. Dufek, G. Fry, C. Hicks, V. Hlavác, V. Keller, B. Rosell, T. Sangwine, N. Tørsløv, and B. l. M. Wandall. 2003. *COST 341 - Wildlife and traffic: a European handbook for identifying conflicts and designing solutions.* KNNV Publishers, Brussels, Belgium.

Jaeger, J. A. G. 2002. *Landschaftszerschneidung. Eine transdisziplinäre Studie gemäß dem Konzept der Umweltgefährdung.* [Translation: Landscape fragmentation. A transdisciplinary study according to the concept of environmental threat.] Verlag Eugen Ulmer, Stuttgart, Germany.

Jaeger, J. A. G., S. Grau, and W. Haber, editors. 2005. Landscape fragmentation due to transportation infrastructure and urban development: from recognition of the problem to implementation of measures. Special issue of *GAIA* 14(2):98-185.

Jaeger, J. A. G., and R. Holderegger. 2005. *Schwellenwerte der Landschaftszerschneidung.* [Translation: Thresholds of landscape fragmentation.] *GAIA* 14:113-118.

Mader, H.-J., editor. 1990. Survival and dispersal of animals in cultivated landscapes. Special issue of *Biological Conservation* 54(3):167-290.

Mansergh, I. M., and D. J. Scotts. 1989. Habitat continuity and social organisation of the mountain pygmy-possum restored by tunnel. *Journal of Wildlife Management* 53:701-707.

National Research Council. 2005. *Assessing and managing the ecological impacts of paved roads.* L. Gunderson, A. Clevenger, A. Cooper, V. Dale, L. Evans, G. Evink, L. Fahrig, K. Haynes, W. Kober, S. Lester, K. Redford, M. Strand, P. Wagner, and J. Yowell, committee members. National Academies Press, Washington, D.C., USA.

Noss, R. F. 1993. Wildlife corridors. Pages 43-68 *in* D. S. Smith and P. C. Hellmund, editors. *Ecology of Greenways.* University of Minneapolis Press, Minneapolis, Minnesota, USA.

Parris, K. M., and A. Schneider. 2008. Impacts of traffic noise and traffic volume on birds of roadside habitats. *Ecology and Society* 14(1): 29. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art29/.

Parris K. M., M. Velik-Lord, and J. M. A. North. 2009. Frogs call at a higher pitch in traffic noise. *Ecology and Society* 14(1): 25. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art25/.

Penn-Bressel, G. 2005. *Begrenzung der Landschaftszerschneidung bei der Planung von Verkehrswegen.* [Translation: Limiting landscape fragmentation and the planning of transportation routes.] *GAIA* 14:130-134.

Roedenbeck, I. A., L. Fahrig, C. S. Findlay, J. E. Houlahan, J. A. G. Jaeger, N. Klar, S. Kramer-Schadt, and E. A. van der Grift. 2007. The Rauischholzhausen agenda for road ecology. *Ecology and Society* 12(1): 11. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art11/ .

Roedenbeck, I. A., and J. A. G. Jaeger, editors. 2006. Road ecology research. [Articles in English and German.] Special issue of *Naturschutz und Landschaftsplanung* 38(10-11):293-356.

Simmons, J., P. Sunnucks, A. C. Taylor, and R. van der Ree. 2010. Beyond road-kill, radiotracking, recapture and F_{ST} - a review of some genetic methods to improve understanding of the influence of roads on wildlife. *Ecology and Society* 15(1): 9. [online] URL: http://www.ecologyandsociety.org/vol15/iss1/art9/.

Stoner, D. 1925. The toll of the automobile. *Science* 61:56-57.

Taylor, B. D., and R. Goldingay. 2009. Can road-crossing structures improve population viability of an urban gliding mammal? *Ecology and Society* 14(2): 13. [online] URL: www.ecologyandsociety.org/vol14/iss2/art13/.

Thorne, J. H., P. R. Huber, E. H. Girvetz, J. Quinn, and M. C. McCoy. 2009. Integration of regional mitigation assessment and conservation planning. *Ecology and Society* 14(1): 47. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art47/.

Tilman, D., R. M. May, C. L. Lehman, and M. A. Nowak. 1994. Habitat destruction and the extinction debt. *Nature* 371:65-66.

Trocmé, M., S. Cahill, J. G. de Vries, H. Farrall, L. Folkeson, G. Fry, C. Hicks, and J. Peymen. 2003. *COST 341 - Habitat fragmentation due to transportation infrastructure: the European review.* Publications Office of the European Union, Luxembourg.

van der Ree, R., and A. F. Bennett. 2003. Home range of the squirrel glider *Petaurus norfolcensis* in a network of linear habitats. *Journal of Zoology (London)* 259:327-336.

van der Ree, R., S. Cesarini, P. Sunnucks, J. L. Moore, and A. C. Taylor. 2010. Large gaps in canopy reduce road crossing by a gliding mammal *Ecology and Society* 15(4): 35. [online] URL: http://www.ecologyandsociety.org/vol15/iss4/art35/.

van der Ree, R., D. Heinze, M. McCarthy, and I. Mansergh. 2009. Wildlife tunnel enhances population viability. *Ecology and Society* 14(2): 7. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art7/.

van der Ree, R., E. A. van der Grift, C. Mata, and F. Suarez. 2007. Overcoming the barrier effect of roads - how effective are mitigation strategies? An international review of the effectiveness of underpasses and overpasses designed to increase the permeability of roads for wildlife. Pages 423-431 *in* C. L. Irwin, D. Nelson, and K. P. McDermott, editors. *International Conference on Ecology and Transportation.* Center for Transportation and The Environment, North Carolina State University, Raleigh, North Carolina, Little Rock, Arkansas, USA.

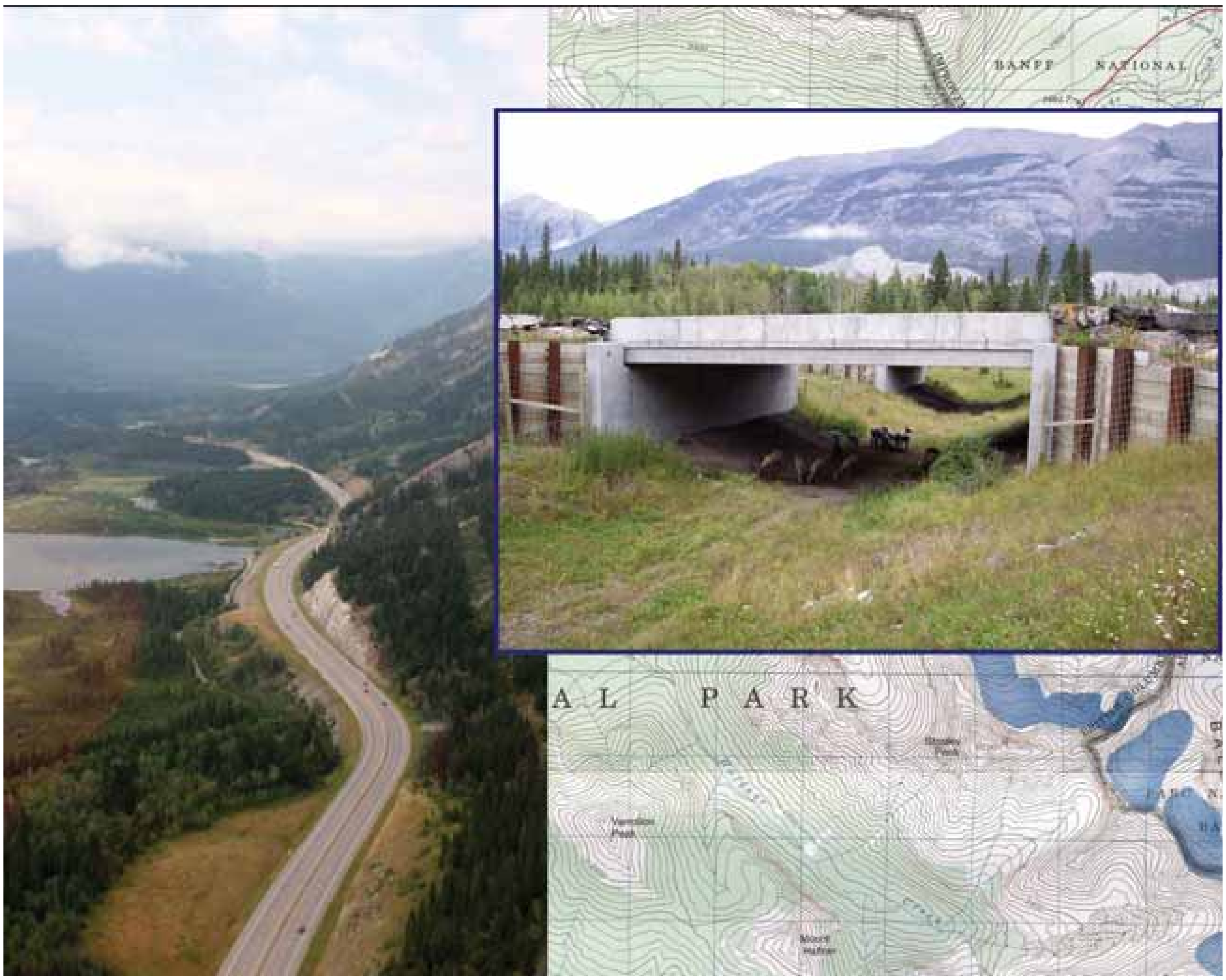
van Langevelde, F., and C. F. Jaarsma. 2009. Modeling the effect of traffic calming on local animal population persistence. *Ecology and Society* 14(2): 39. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art39/.

Vitousek, P. M., H. A. Mooney, J. Lubchenco, and J. M. Melillo. 1997. Human domination of Earth's ecosystems. *Science* 277:494-499.

Exhibit G

WILDLIFE CROSSING STRUCTURE HANDBOOK
Design and Evaluation in North America

Publication No. FHWA-CFL/TD-11-003 **March 2011**



U.S. Department of Transportation
Federal Highway Administration

Federal Lands Highway
Commitment to Excellence

Central Federal Lands Highway Division
12300 West Dakota Avenue
Lakewood, CO 80228

FOREWORD

The Federal Highway Administration (FHWA) encourages programs that protect both wildlife and roadway users when the two groups eventually interact. An ever increasing human population demands safe and efficient access to their facilities, but this often comes with the need to mitigate the compromises to the animal habitats. Safety of drivers and preservation of animals are important components that when they successfully mesh we achieve major program goals for improved safety, enhanced livability, and protection of the environment.

This FHWA report called the *Wildlife Crossing Structure Handbook* offers key background information on defining the overall wildlife-vehicle interaction problem, the needs to be addressed, and offers a multitude of tangible solutions to plan, design, construct, monitor and maintain effective critter crossings. This handbook is for all transportation, environmental, wildlife resource, and stakeholder officials who strive to preserve and reweave safe corridor passages for animals and vehicle travelers.

F. David Zanetell, P.E., Director of Project Delivery
Federal Highway Administration
Central Federal Lands Highway Division

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16. Abstract

This handbook provides numerous solutions to wildlife-vehicle interactions by offering effective and safe wildlife crossing examples. It initially describes the critter crossing problem and justifies the need to solve it. Project and program level considerations are identified for planning, placement and design of wildlife crossing structures. Key design and ecological criteria, construction and maintenance guidelines, and effective monitoring techniques are shown and described in this handbook's practical application examples called Hot Sheets.

17. Key Words	18. Distribution Statement
ANIMAL MOVEMENT BARRIERS, HABITAT CONNECTIVITY, HABITAT LOSS, ROAD ECOLOGY, WILDLIFE CROSSING, WILDLIFE MORTALITY, WILDLIFE-VEHICLE INTERACTION	No restriction. This document is available to the public from the sponsoring agency at the website http://www.cflhd.gov.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	224	

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	Millimeters	mm
ft	feet	0.305	Meters	m
yd	yards	0.914	Meters	m
mi	miles	1.61	Kilometers	km
		AREA		
in^2	square inches	645.2	Square millimeters	mm^2
ft^2	square feet	0.093	Square meters	m^2
yd^2	square yard	0.836	Square meters	m^2
ac	acres	0.405	Hectares	ha
mi^2	square miles	2.59	Square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	Milliliters	mL
gal	gallons	3.785	Liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	Grams	g
lb	pounds	0.454	Kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	Lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	Newtons	N
lbf/in^2	poundforce per square inch	6.89	Kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	Inches	in
m	meters	3.28	Feet	ft
m	meters	1.09	Yards	yd
km	kilometers	0.621	Miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	Hectares	2.47	Acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	Milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	Gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	Ounces	oz
kg	kilograms	2.202	Pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	Poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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CHAPTER 1 – INTRODUCTION

BACKGROUND

The linear nature of surface transportation systems creates a suite of concerns for transportation and natural resource management agencies as they seek to ameliorate the impacts of their projects on environmental resources, as roads divide habitats and hydrological features. To help better understand the interactions between roads and environment the discipline of road ecology has emerged in the last 10 years. Road ecology strives to understand surface transportation infrastructure and its impacts on wildlife and motorist safety, aquatic resources, habitat connectivity, and many other environmental values.

The effects of roads on wildlife populations have been the focus of many studies in the last decade and increasing concern for transportation and natural resource management agencies. Roads affect populations in numerous ways, from habitat loss and fragmentation, to barriers to animal movement, and wildlife mortality. The impact of roads on wildlife populations is a significant and growing problem worldwide. In rural and suburban areas of North America, accidents with wildlife are quickly becoming a major safety concern for motorists as shown in Figure 1.

In parts of North America today, roads are a serious obstacle to maintaining population connectivity and a threat to the long-term survival of some regionally important wildlife populations. Wildlife crossing structures are intended to increase permeability and habitat connectivity across roads and reduce wildlife–vehicle collisions. These are above-grade (wildlife overpasses) or below-grade (wildlife underpasses) structures designed to facilitate movement of animals and connections among populations. Like landscape corridors, the conservation value of wildlife crossing structures are gaining attention as applied measures to help adapt changes in species ranges and animal distributions to climate change. The effect of roads on wildlife and biodiversity in general are a primary reason why the public raises questions about the environmental impacts of roads and vehicles. Calls for implementation of solutions are increasingly heard from environmental scientists, the transportation community, and decision makers.

Over the last decade, federal, state and provincial land management and transportation agencies have become increasingly aware of the effects that roads have on wildlife. Significant advances in our understanding of these impacts have been made; however, the means to adequately mitigate these impacts have been slower in coming. There are examples where wildlife crossing structures and fencing significantly reduce the impacts of roads on wildlife populations and have increased motorist safety. Anticipated population growth and ongoing highway investments in many regions as shown in Figure 2, coupled with the resounding concern for maintaining large-scale landscape connectivity for wildlife populations has generated increasing interest in crossing structures as management tools. Yet currently there is limited knowledge and technical guidance on how best design wildlife crossing systems for the range of wildlife found throughout North America.

Figure 1. Photo. Accidents with wildlife in rural and suburban areas are becoming a major safety concern for motorist and transportation agencies (credit: John Nordgren).

JUSTIFICATION

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. Research in this area has increased over the years but has not resulted in sufficient rigorously tested practices useful to transportation agencies. As a result, many transportation agencies continue to build costly structures for wildlife connectivity with little evidence-based guidance. Technical guidelines and best management practices have not been articulated and are still much in need for many North American wildlife species and their habitats.

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. The number of methods used to determine these key locations on roads has increased in recent years. However, few attempts have been made to critically review the techniques that are currently available to transportation agencies.

Figure 2. Photo. Wildlife crossings are becoming more common in highway expansion projects in North America. An example is the Greenway Landbridge on Interstate 75 in Marion County, Florida (Credit: Google Earth).

Two recent publications help guide transportation agencies in the development of effective wildlife crossing structures. “Safe Passage” (Southern Rockies Ecosystem Project 2007) provides a simplified approach to planning the location and design of wildlife crossings. A comprehensive National Cooperative Highway Research Project 25-27 report provides decision support for issues related to the planning and general design of wildlife crossings. Both reports, however, lack technical guidelines for the design of wildlife crossings and fencing for species and species groups in North America.

Performance evaluations are not a regular part of transportation projects with wildlife crossing structures. Most monitoring efforts have been largely short-term or sporadic. Monitoring typically is aimed at single species; consequently, such programs may not recognize the requirements of other non-target species and populations in the area. Further, monitoring is rarely conducted long enough to meet the adaptation periods (or learning curves) wildlife need to begin using crossings on a regular basis. Guidance is still needed on the increasing number of techniques available for monitoring wildlife crossings, designing sound monitoring programs, and evaluating performance for adaptively managing future transportation projects.

IMPORTANT DATES IN ROAD ECOLOGY HISTORY

1955—First wildlife crossing built in United States: Black bear underpass, Florida
1974—First wildlife crossing built in Europe: Badger tunnel, The Netherlands
1975—First wildlife overpass built in United States: Interstate 15, Utah
1982—First wildlife crossing built in Canada: Trans-Canada Highway wildlife underpass, Banff National Park
1982—First wildlife overpass built in Europe: Le Hardt, France
1990—First wildlife overpass built in Canada: Coquihalla Highway, British Columbia
1991—ISTEA: Intermodal Surface Transportation Efficiency Act of 1991
1996—"Transportation and Wildlife: Reducing Wildlife Mortality and Improving Wildlife Passageways Across Transportation Corridors." First international meeting on wildlife and transportation in Orlando, Florida (30 April to 2 May 1996)
1997—National Academies publication "Toward a sustainable future: addressing the long-term effects of motor vehicle transportation on climate and ecology," National Academy Press, Washington, D.C.
1998—TEA-21: Transportation Efficiency Act of the 21st Century
1998—First International Conference on Wildlife Ecology and Transportation (ICOWET) at Fort Meyers, Florida (10–12 February 1998)
2001—ICOWET becomes ICOET (International Conference on Ecology and Transportation), Keystone, Colorado
2001—Federal Highway Administration (FHWA) European Scan Tour, "Wildlife habitat connectivity across European highways"
2002—National Cooperative Highway Research Program (NCHRP) Synthesis paper published, "Interaction between roadways and wildlife ecology: a synthesis of highway practice"
2003—"Road Ecology: Science and solutions" published by Island Press. First major publication that outlines, describes and synthesizes available knowledge of the ecological effects of roads and emerging field of road ecology
2005—SAFETEA-LU passed (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users)
2005—National Academies publication "Assessing and Managing the Ecological Impacts of Paved Roads," National Academy Press, Washington, D.C.
2005 – First Transportation Research Board Task Force on Animal–Vehicle Collisions (ANB20(2))
2006—First Transportation Research Board (TRB) Standing Committee (ADC30) on Ecology and Transportation
2007—Society for Conservation Biology (SCB) has session at the ICOET meeting in Little Rock, Arkansas
2008—Western Governors' Association policy resolution to protect wildlife migration corridors and crucial wildlife habitat in the West
2008—FHWA report to U.S. Congress on mitigation measures aimed at reducing wildlife–vehicle collisions
2008—FHWA manual provides technical guidance on the design and implementation of mitigation measures that are considered best practice to reduce wildlife-vehicle collisions
2010—ARC International Wildlife Crossing Infrastructure Design Competition. First design crossing competition. Launched in 2010, and winners announced at the 2011 Transportation Research Board meeting, Washington, DC.

OBJECTIVES

This handbook provides technical guidelines for the planning, design and evaluation of wildlife crossing structures and their associated measures (fencing, gates) that facilitate the safe movement of wildlife across roads and increase motorist safety. It has been prepared for transportation, natural resource and land management agencies responsible for planning, designing and implementing measures for mitigating the impacts of roads on wildlife populations. Stakeholder and other groups involved in mitigation planning will also find this handbook useful in their discussions with agencies.

This handbook describes how to increase the effectiveness of established designs and recommends ways to design for particular species and species groups in different landscapes. The guidelines can be used for wildlife crossings on new or existing highways, highway expansions (e.g., two-lane to four-lane) and bridge reconstruction projects. The response of particular wildlife species to these measures may vary across North America. Therefore, the design guidelines are intended to be generalized and a starting point for the future development of more regionalized, landscape-specific guidelines based on an adaptive management process.

This handbook is the product of an extensive collection and synthesis of current literature, knowledge, and science-based data with regard to the current practices in wildlife crossing mitigation. This handbook provides a sound scientific basis for effective planning, policy and implementation of mitigation aimed at reducing habitat fragmentation and mortality effects of roads on wildlife populations. Recommended designs once implemented and their performance evaluated through monitoring will serve to advance our understanding of the utility of different wildlife crossing designs across North America.

ORGANIZATION

This handbook is organized to provide assistance to transportation and natural resource management practitioners charged with the planning, design and performance evaluations wildlife crossing mitigation. This handbook was designed so that chapters could be consulted independently, depending on the information or technical guidance needs, or all chapters in a practical sequence of project development.

Chapter 2 – Intersections provides background information on the ecological function of roads and examines the main impacts roads have on wildlife populations. These primary functions are important for understanding the landscape and biological context of mitigating road effects on wildlife.

Chapter 3 - Planning and Placement describes in a stepwise approach the different methods to plan the location of highway mitigation for wildlife movement with wildlife crossings at different spatial scales (project-level or systems/landscape-level) of resolution. Planning resources used to help identify appropriate locations for wildlife crossings are listed and describe how they can be used at the two different scales of application.

Chapter 4 - Design is the core of this handbook material. This chapter addresses the question of how to space wildlife crossings followed by context-sensitive and species-specific considerations in selecting 11 types of wildlife crossing design, based on habitat quality and topography. The 11 wildlife crossing types consist of over-grade and below-grade crossing structures ranging from landscape bridges to amphibian-reptile tunnels. The specific details of each wildlife crossing type are compiled in "Hot Sheets" at the back of this handbook shown in Appendix C. The latter part of the chapter provides guidelines for planning the dimensions of the 11 types of wildlife crossings, in addition to the suitability of each wildlife crossing type for six species groups and 20 species of North American wildlife.

Chapter 5 - Monitoring outlines the basics of monitoring wildlife crossing structures, including a stepwise approach to testing whether management objectives have been met, how to determine performance targets, what monitoring methods are available, and how to design rigorous studies evaluating performance of built mitigation. The chapter concludes discussing the benefits of monitoring for adaptive management and their direct application to future transportation planning.

Suggested Reading—Rather than provide footnotes or literature citations throughout the document, key literature is cited at the end of each chapter for further reading.

Appendix A consists of a glossary of commonly used terms throughout this handbook.

Appendix B lists all the common and scientific names of wildlife covered in this handbook.

Appendix C lists Hot Sheets 1 -14 for the different wildlife crossings showing their fencing and gate details.

Appendix D provides a framework for designing monitoring studies.

Appendix E lists the current monitoring techniques available.

Appendix F and G list relevant handbooks and professional journals with information on wildlife crossing design, planning and performance.

SUGGESTED READING

Davenport, J., Davenport, J.L. (eds). 2006. *The ecology of transportation: managing mobility for the environment.* Springer, London, UK.

Evink, G., 2002. *Interaction between roadways and wildlife ecology: a synthesis of highway practice*. National Cooperative Highway Research Program Synthesis 305. Transportation Research Board, Washington, D.C.

Forman, R. T. T., Sperling, D., Bissonette, J., Clevenger, A., Cutshall, C., Dale, V., Fahrig, L., France, R., Goldman, C., Heanue, K., Jones, J., Swanson, F., Turrentine, T. and Winter, T. 2003. *Road ecology: Science and solutions*. Island Press, Washington, D.C.

Heller, N. E., E. S. Zavaleta. 2009. Biodiversity management in the face of climate change: A review of 22 years of recommendations. *Biological Conservation* 142:14-32.

Huijser, M.P., P. McGowen, J. Fuller, A. Hardy, A. Kociolek, A.P. Clevenger, D. Smith and R. Ament. 2008. *Wildlife-vehicle collision reduction study*. Report to Congress. U.S. Department of Transportation, Federal Highway Administration, Washington D.C., USA. Available from the internet: http://www.tfhrc.gov/safety/pubs/08034/index.htm

Huijser, M.P., P. McGowen, A. P. Clevenger, and R. Ament. 2008. *Best practices manual: Wildlife-vehicle collision reduction study*. Report to U.S. Congress. Federal Highway Administration, McLean, Virginia, USA. Available from the internet: http://www.fhwa.dot.gov/environment/hconnect/wvc/index.htm

National Research Council (NRC). 1997. *Towards a sustainable future: Addressing the long-term effects of motor vehicle transportation on climate and ecology*. The National Academies Press, Washington, DC.

National Research Council (NRC). 2005. *Assessing and managing the ecological impacts of paved roads.* The National Academies Press, Washington, DC.

Transportation Research Board. 2002. *Surface transportation environmental research: a long-term strategy.* Special report 268, National Academy Press, Washington, D.C.

Transportation Research Board, 2002. *Environmental research needs in transportation*. Conference proceedings 28. National Academy Press, Washington, D.C.

Trocme, M. (ed.). 2003. *Habitat fragmentation due to transportation infrastructure: The European review*. European Commission, Directorate General for Research, COST Action 341. Publication EUR 20721. Luxembourg.

Vos, C. C., P. Berry, P. Opdam, H. Baveco, B. Nijhof, J. O’Hanley, C. Bell, H. Kuipers. 2008. Adapting landscapes to climate change: Examples of climate-proof ecosystem networks and priority adaptation zones. *Journal of Applied Ecology* 45:1722-1731.

Western Governors’ Association. 2008. *Wildlife corridors initiative report*. Western Governors’ Association, Denver, CO.

CHAPTER 2 – WILDLIFE POPULATIONS AND ROAD CORRIDOR INTERSECTIONS

INTRODUCTION

The massive 4-million-mile (6.2 million-km) system of public roads in the United States is used by more than 200 million vehicles every year. This engineering marvel, largely a product of the post-war economy, permeates and links nearly every urban and rural area in the country as illustrated in Figure 3. Together these paved roads constitute approximately one percent of the land area in the United States, roughly the size of Maine. Richard Forman (Harvard University) took this one percent figure one step further by placing roads in the environmental context in which they occur. Since the environmental impacts of roads extend well beyond their paved edge, he estimated that roads affect roughly 20 percent of the land area of the United States.

Figure 3. Photo. The highway system in the United States is used by more than 200 million vehicles and covers more than 6.2 million km (Credit: Tony Clevenger).

The North American economy and population are expected to grow considerably in the next 25 years. In the United States today, traffic and roads are strongly implicated in many of the major environmental problems: air and water pollution, heavy energy use, fragmented farmland and habitat, wildlife and biodiversity losses, and disruption of ecological communities. In turn, these problems can adversely affect human and ecosystem health and the nation's overall quality of life.

It comes as little surprise that the ecological effects of roads are gaining more attention among transportation agencies, land managers, local decision makers and the general public. Today road networks continue to expand and there are increasing public and political concerns regarding transport, ecology, quality of life, and local communities.
Understanding how roads affect their surrounding environment and wildlife populations will be important for planning and designing practical applications to properly mitigate their impacts.

THE NEW WEST

In much of the North American West, road networks are extensive and the volume of traffic on rural roads has sharply increased, as wild lands are progressively being developed and suburbanized. This new frontier phenomena results in vast changes in land use patterns and the alteration of natural habitats, leading to increased motorist–wildlife conflicts. In the East, the footprint of road systems is relatively stable compared to the growing New West phenomena. Nevertheless, traffic volumes in the East continue to rise on existing roads; suburban areas are expanding amidst a general trend of increasing deer populations.

THE ECOLOGY OF ROAD CORRIDORS

Historically, roads followed natural landscape contours and ran parallel and adjacent to rivers and streams. But post-war transportation planning and road building diverged from the sinuous, landscape form of roads and became more angular and rectilinear in order to provide efficient travel between population centers and key points of interest. As a result, today many roads and highways cut across landscapes, intersect ecosystems and impact local habitats. In doing so, terrestrial and aquatic flows such as wildlife movements and distributions, subsurface and surface hydrology and wind erosion may be blocked or altered. Roads have five different ecological functions that affect wildlife. Roads function as habitats, sources, sinks, barriers, and conduits. Depending on the road, its location and the number of vehicles traveling on it, some of these functions may have important ecological significance.

- As *habitats*, road corridors may harbor entire populations of plants and animals and may be of conservation importance. If they contain some of the last remaining native or semi-native habitats for a species they may be critically important.
- Road corridors may be *sources*, if wildlife populations thrive in these linear habitats compared to adjacent habitats.
- Road corridors where wildlife populations consistently experience high levels of mortality compared to populations in adjacent habitats are considered *sink populations*.
- When roads disrupt wildlife movements connecting habitats and populations, then road corridors are a *barrier*, blocking or selectively filtering important population movements and interchange of individuals and genes.
- The *conduit* or *corridor function* of road corridors occurs when wildlife move parallel along roads in corridor habitat, linking populations found in otherwise isolated patch habitats.

IMPACTS OF ROADS ON WILDLIFE POPULATIONS

Many studies have documented how roads affect wildlife populations and their ability to persist locally or even at a larger landscape scale. Some of the mechanisms for these impacts range from habitat loss and fragmentation to disrupting animal movement and road-related mortality. Mortality and habitat fragmentation are considered to be the greatest threat by far to maintaining wildlife populations. The many ways that roads alter wildlife habitats and the distribution of wildlife populations are described below.

Change In Habitat

Habitat Loss

Road construction and expansion result in loss of wildlife habitat by transforming natural habitats to pavement, dirt tracks, and cleared roadsides or right-of-ways. Some wildlife are more vulnerable to habitat loss than others. Wildlife that have large area needs, are found in relatively low densities, and have low reproductive rates tend to be the most sensitive to road-induced habitat loss. Wide-ranging carnivores are particularly vulnerable to road impacts for those reasons, and thresholds of road density for some carnivore species are known to limit their distributions. Similar patterns of road densities and population persistence have been documented for some amphibian populations in North America and Europe.

Road construction can increase the amount of edge habitat in a landscape conceptually shown in Figure 4. Because roads tend to be shaped long and thin, a disproportionately large amount of forest edge is created. This may benefit some edge-dwelling species, but can be detrimental to forest interior species as it may decrease in the amount of available habitat.

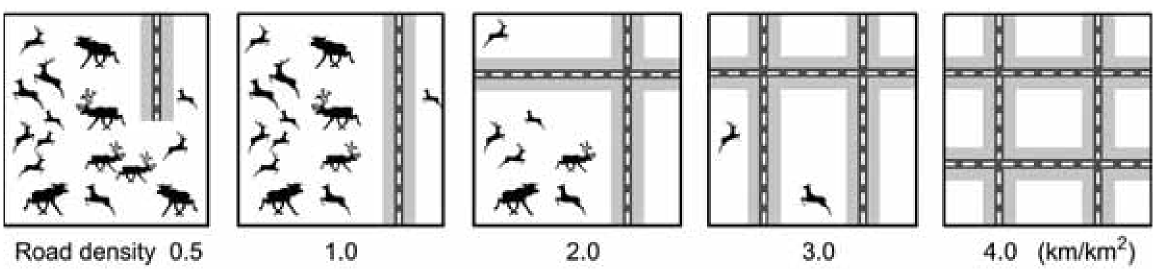

Figure 4. Schematic. Increasing road density fragments habitat into smaller patches and creates a disproportionate amount of edge habitat (from Iuell 2005).

Metapopulation theory suggests that the more mobile species are, the better they are able to manage with habitat loss. Yet mortality of individuals in the areas between the important core habitat patches (i.e., matrix habitat) usually does not figure into metapopulation theory as illustrated in Figure 5. Studies have shown that when mortality is high in the matrix habitat, highly mobile species are actually more vulnerable to habitat loss. Road corridors are one example of many possible matrix habitats in fragmented landscapes.

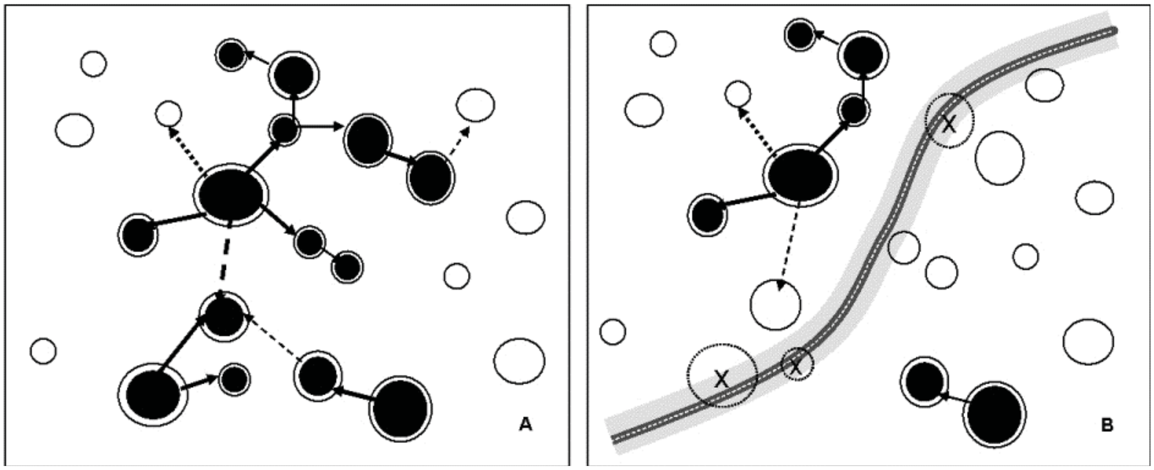

Figure 5. Schematic. Barrier effects on populations. (A) A metapopulation consists of a network of local subpopulations that may vary in size and local dynamics but are linked to each other through dispersal. (B) Road construction causes a disturbance and loss of local populations within the network. In addition, infrastructure imposes a barrier to dispersal that can prevent recolonisation and isolate local subpopulations from the rest of the metapopulation. If important source populations are cut off from the remaining sink populations, the entire metapopulation may be at risk of extinction (from Iuell 2005).

Diminished Habitat Quality

Disturbance from roads can affect wildlife behaviorally and numerically. Behavioral responses of wildlife typically consist of two types:

1. An avoidance response (zone of road avoidance) associated with regular or constant traffic disturbance, and
2. Avoidance due to irregular, less predictable isolated disturbances.

The numerical effect of roads on wildlife may be a decrease in population abundance or density of breeding individuals in habitats adjacent to roads. Should these distributions be strong enough to limit movements across roads, populations can become genetically isolated and the ability to persist over the long term becomes more precarious as graphed in Figure 6.

Improved Habitat Quality

Some wildlife (e.g., snakes) may be attracted to road corridors or the physical surface of roads for a variety of reasons as also shown in Figure 7, but most often the attraction is a result of conditions related to adjacent habitat (nesting, living space) or food found in the right-of-way.

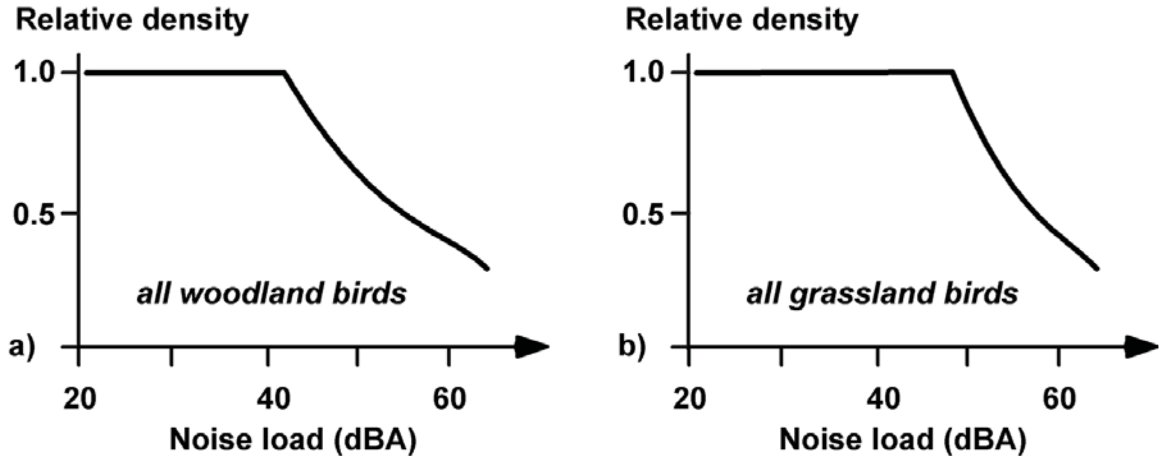

Figure 6. Graph. Results of studies on the impact of traffic noise on breeding bird populations in The Netherlands. When the noise load exceeds a threshold of between 40 and 50 dBA, bird densities were found to drop significantly. The sensitivity to noise and the threshold is different between species and between forested and open habitats (from Reijnen, Veenbaas and Foppen 1995).

Figure 7. Photo. Mountain goats attracted to roadside vegetation along Highway 93 South in Kootenay National Park, British Columbia, Canada (Credit: Tony Clevenger).

Road construction can create high quality habitat where food resources are more abundant compared to adjacent areas. When roads are fenced to keep wildlife out, lush forage along medians and right-of-ways is created and attracts herbivores, from Microtine Rodents to Deer and Elk. Locally abundant small mammal populations living in these fenced areas become targets for avian and terrestrial predators such as Owls, Hawks, Coyotes and Foxes.

When predators forage in the fenced road corridor close to traffic, collisions with vehicles are inevitable, thus making roadside carrion available and attracting aerial and terrestrial scavengers if not promptly removed by highway maintenance crews.

Change In Wildlife Distribution

Barrier Effects

Landscape connectivity is the degree to which the landscape facilitates animal movement and other ecological flows. High levels of landscape connectivity occur when the area between core habitats in the landscape comprise relatively benign types of habitats without barriers, thus allowing wildlife to move freely through them in meeting their biological needs.

Landscape connectivity is important for two reasons:

1. Many animals regularly move through the landscape to different habitats to meet their daily, seasonal and basic biological needs.
2. Connectivity allows areas to be recolonized, for dispersal, for maintaining regional metapopulations and minimizing risks of inbreeding within populations.

Reduced landscape connectivity and limited movements due to roads may result in higher wildlife mortality, lower reproduction rates, ultimately smaller populations and overall lower population viability. These harmful effects have underscored the need to maintain and restore essential movements of wildlife across roads to maintain within population movements and genetic interchange. This is particularly important on roads with high traffic volumes that can be complete barriers to movement.

The fragmentation effect of roads begins as animals become reluctant to move across roads to access mates or preferred habitats for food and cover. The degree of aversion to roads may vary by age group and gender. The reasons why roads are avoided can generally be attributed to features associated with the road, e.g., traffic volume, road width or major habitat alterations caused by the road.

High-volume and high-speed roads tend to be the greatest barriers and most effective in disrupting animal movements and population interchange. However, some studies have shown that secondary highways and unpaved roads can also impede animal movements.

Corridor Function

Roads can limit movement for some wildlife, but they can also facilitate dispersal and range extensions of others, native and non-native. Depending on the species and the surrounding landscape, the right-of-way can be important habitat and possibly the only remaining functional habitat for some species in highly developed landscapes as shown in Figure 8. Right-of-ways may also serve as travel corridors between patches of important wildlife habitat.

Figure 8. Photo. Right-of-ways can vary considerably between different landscapes and parts of North America. Left: A two-lane highway in Jasper National Park. Dense vegetation of plants, shrubs and trees along roads provide potential nesting sites for birds and screen the road and its traffic from the surrounding landscape. Right: Interstate-65 in Kentucky consisting of a wide right-of-way with little native vegetation. (Credits: Tony Clevenger).

Mortality

The total number of motor vehicle accidents with large wildlife each year has been estimated at one to two million in the United States and at 45,000 in Canada. These numbers have increased even more in the last decade. In the United States alone, these collisions were estimated to cause 211 human fatalities, 29,000 human injuries and over US$1 billion in property damage annually.

National trends were studied through reviewing several sources of crash data from the United States. From 1990 to 2004, the number of all reported motor vehicle crashes has been relatively steady at slightly above six million per year. By comparison, the number of reported wildlife–vehicle collisions over the same period has grown from less than 200,000 per year to a high of approximately 300,000 per year, a 50 percent increase. Looking at the data another way, wildlife–vehicle collisions now represent approximately 5 percent (or 1 in 20) of all reported motor vehicle collisions. The increase in wildlife-related accidents appears to be associated with an increase in "vehicle miles traveled" and increases in deer population size in most parts of the United States.

Traffic has been shown to be the leading mortality source for some wide-ranging mammals, e.g., Florida Panther, regional Bear and Bighorn Sheep populations. Roads were also shown to be the primary cause of wildlife population declines and habitat fragmentation among many amphibian populations.

ROAD-RELATED MORTALITY VS. BARRIER EFFECTS

Road-related mortality and reduced wildlife movements have the biggest effect on keeping wildlife populations viable over the long term. However, the degree to which these factors depress or threaten populations depends on the level of traffic volume. A conceptual model shown in Figure 9 describes the effect traffic volume has on (1) animal avoidance of roads, (2) the likelihood of them getting killed while trying to cross, and (3) successful crossing attempts.

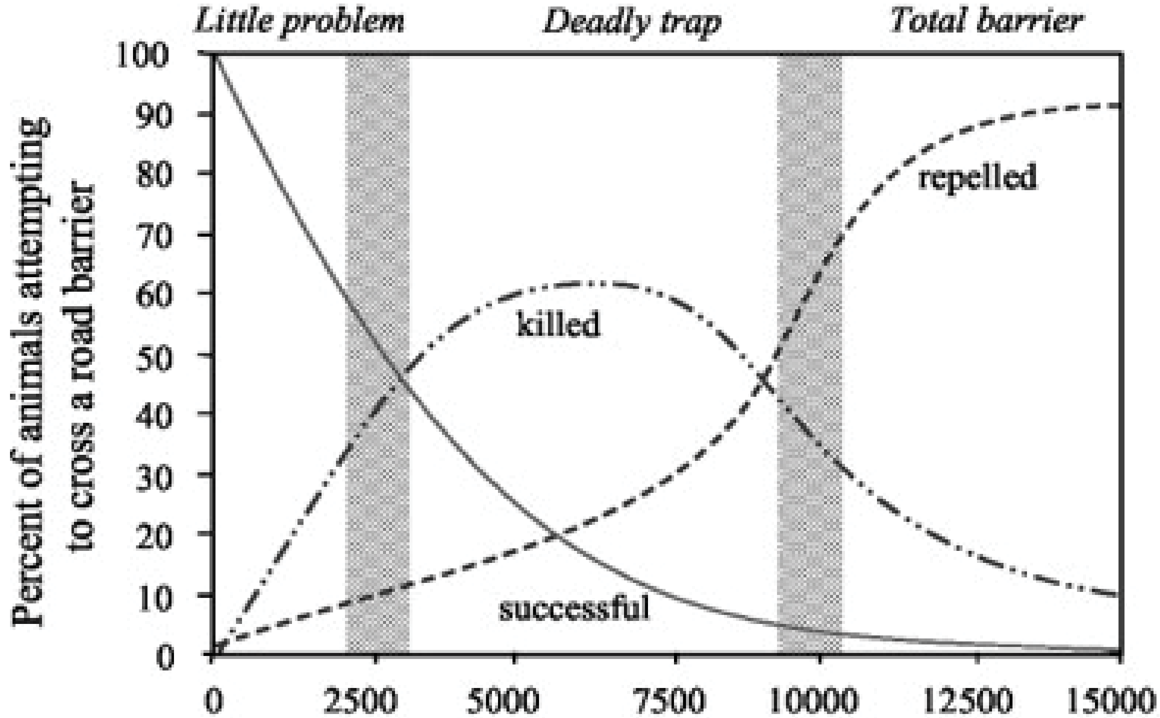

Figure 9. Graph. Conceptual model on the effect of traffic volume on the percentage of animals that successfully cross a road, are repelled by traffic noise and vehicle movement, or get killed as they attempt to cross. The conceptual model indicates that most collisions occur on intermediate roads (from Seiler 2003).

At low traffic volumes (<2500 annual average daily traffic volume (AADT)) the proportion of traffic-related mortalities is generally low, as is the number of animals that may be repelled by the road and traffic disturbance, thus having little or no impact on the population.

As traffic volumes increase to moderate levels (2500–10,000 AADT) mortalities are expected to be high, the number of animals repelled by roads will likely increase, and the proportion of successful crossings should start to decrease dramatically.

At high traffic volumes (>10,000 AADT), only a small proportion of attempted road crossings are expected to be successful. A large proportion of the animals approaching the road are likely repelled due to disturbance and heavy traffic volume, thus traffic-related mortality rarely occurs at all.

The model is particularly useful for understanding how wildlife mortality and cross-highway movements change with varying levels of traffic volume. Low rates of road-related mortality on a busy highway might be interpreted as evidence that impacts are negligible to wildlife, but in actuality the impacts may be that species have become locally extinct or that traffic disturbance effectively keeps them far from the highway surface. The thresholds and shape of the distribution in the model may be species-specific.

A THRESHOLD FOR TRAFFIC VOLUME AND ROAD EFFECTS?

There has been some thought towards exactly what is the threshold of traffic volume above which roads become a deadly trap, as the model[1] describes, and when there is an urgent need for management intervention. It is unclear whether 2000–3000 vehicles per day is a threshold for transportation agencies to be concerned about. How abundant species are, their behavior and their biological needs will strongly affect what the threshold levels are for different wildlife. Nevertheless, the model provides a basis for further examination of two-lane or low-volume road impacts on mortality and fragmentation of wildlife populations.

[1]Andreas Seiler, unpublished data.

Road-related mortality and barrier effects do not impact wildlife populations equally. The effects of road-related mortality on local populations may be seen in one or two generations, while loss of connectivity may take several generations to manifest.

Performance assessments of mitigation measures designed to reduce the impacts of road-related mortality and barrier effects should consider the combined performance of the measures in reducing those two impacts, rather than just one or the other.

Reducing road-related mortality and loss of individuals from populations generally has the greatest positive impact in maintaining populations locally. This is particularly true for medium- and large-sized mammals such as Bears, Cats, Wolves, given their tendency to occur in low densities, their slow rates of reproduction and long generation times.

The design and implementation of functional wildlife crossing structures should promote adequate interchange within the populations affected by roads, allow access to important resources, and ultimately enhance the viability of wildlife populations. However, scientifically understanding how much movement within the population is necessary, and what constitutes a barrier to connectivity, are difficult questions, especially for rare, elusive species such as Wolverine, Grizzly Bear or Lynx as captured in Figure 10. Future research using new methods such as non-invasive genetic sampling of hair or scats, satellite technology using global positioning system (GPS) transmitters, and spatially explicit population viability models may help answer some of these elusive management questions regarding roads, habitat fragmentation and population connectivity.

Figure 10. Photo. Lynx photographed using a wildlife overpass, as part of crossing structure monitoring along the Trans-Canada Highway in Banff National Park, Alberta. Long-term monitoring of the wildlife crossings in Banff has enabled the documentation of the crossings used by locally rare carnivores such as Lynx, and Wolverine (Credit: Tony Clevenger/WTI/Parks Canada).

SUGGESTED READING

Bennett, A. F. 1999. *Linkages in the landscape: the role of corridors and connectivity in wildlife conservation*. IUCN, Gland, Switzerland and Cambridge, U.K.

Brown, D. G., K. M. Johnson, T. R. Loveland, D. M. Theobald. 2005. Rural land-use trends in the conterminous United States, 1950–2000. *Ecological Applications* 15:1851–63.

Conover, M. R., W.C. Pitt, K. K. Kessler, T. J. DuBow, W. A. Sanborn. 1995. Review of human injuries, illnesses and economic losses caused by wildlife in the U.S. *Wildlife Society Bulletin* 23:407–414.

Crooks, K.R. and Sanjayan, M. 2006. *Connectivity conservation*. Cambridge University Press, Cambridge, UK.

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. *Conservation Biology* 14, 31-35.

Forman, R. T. T., Sperling, D., Bissonette, J., Clevenger, A., Cutshall, C., Dale, V., Fahrig, L., France, R., Goldman, C., Heanue, K., Jones, J., Swanson, F., Turrentine, T. and Winter, T. 2003. *Road ecology: Science and solutions*. Island Press, Washington, D.C.

Gibbs, J. P. 1998. Amphibian movements in response to forest edges, roads, and streambeds in southern New England. *Journal of Wildlife Management* 62:584-9.

Gibbs, J. P. and G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. *Conservation Biology* 16: 1647-1652.

Hansen, A. J., Rasker, R., Maxwell, B., Rotella, J. J., Johnson, J. D., Parmenter, A. W., Langner, U., Cohen, W. B., Lawrence, R. L., Kraska, M. P. V. 2002. Ecological Causes and Consequences of Demographic Change in the New West. *BioScience* 52:151–162.

Hanski, I. 1999. *Metapopulation ecology*. Oxford University Press, Oxford, U.K.

Hels, T. and E. Buchwald. 2001. The effect of road kills on amphibian populations. *Biological Conservation* 99:331–340.

Hilty, J., W. Lidicker, and A. Merenlender. 2006. *Corridor ecology: the science and practice of linking landscapes for biodiversity conservation*. Island Press, Washington, D.C.

Huijser, M. P. and A. P. Clevenger. 2006. Habitat and corridor function of rights-of-ways. Pages 233-254. In : *The ecology of transportation: managing mobility for the environment*. J. Davenport & J. L. Davenport (eds). Springer, London, UK.

Huijser, M. P., P. McGowen, J. Fuller, A. Hardy, A. Kociolek, A.P. Clevenger, D. Smith and R. Ament. 2007. *Wildlife–vehicle collision reduction study*. Report to congress. U.S. Department of Transportation, Federal Highway Administration, Washington D.C.

Jaeger, J. A. G. and L. Fahrig. 2004. Effects of road fencing on population persistence. *Conservation Biology* 18:1651–1657.

Long, R. A., P. MacKay, W. J. Zielinski, and J. C. Ray, editors. 2008. *Noninvasive survey methods for carnivores.* Island Press, Washington D.C., USA.

McRae, B. H., P. Beier, L. E. DeWald, L. Y. Huynh and P. Keim. 2005. Habitat barriers limit gene flow and illuminate historical events in a wide-ranging carnivore, the American puma. *Molecular Ecology* 14:1965–1977.

Mumme, R. L., S. J. Schoech, G. E. Woolfenden, and J. W. Fitzpatrick. 2000. Life and death in the fast lane: demographic consequences of road mortality in the Florida scrub-jay. *Conservation Biology* 14:501–12.

Reijnen, R., Foppen, R. and Meeuwsen, H. 1996. The effects of car traffic on the density of breeding birds in Dutch agricultural grasslands. *Biological Conservation* 75:255–260.

U.S. Department of Transportation. 2008. *National transportation statistics*. Bureau of Transportation Statistics, Research and Innovation Technology Administration, Washington, D.C.

CHAPTER 3 – IMPACT IDENTIFICATION, REMEDIATION, PLANNING AND PLACEMENT

INTRODUCTION

When planning, designing and evaluating wildlife crossings, it is important to remember that every mitigation plan will be different, and it is not always possible to extrapolate results or expectations across political boundaries or landscapes. Each mitigation scheme has its own set of wildlife components, population connectivity concerns, transportation objectives, and land management priorities. The requirements for mitigation and plans prepared may be vastly different between adjacent watersheds, municipalities, states/provinces and countries.

These political, management and landscape-related issues should guide the planning process and will play an important role when designing effective mitigation for wildlife populations.

The most common management questions that arise in the planning stage are:

1. Where should wildlife crossing structures go?
2. What should they look like?
3. How will they perform?

In this chapter we will address the first question. The second question will be covered in Chapter 4 and question three will be explored in Chapter 5.

STARTING OUT

Rule of Thumb: Avoid, Mitigate or Compensate

Mitigation is only one of the planning alternatives transportation agencies have to reduce or eliminate impacts of road construction and expansion projects. Transportation projects can (1) have road alignments that *avoid* critical wildlife habitat, (2) *mitigate* affected wildlife populations and habitats, or (3) *compensate* for the loss of wildlife habitat as Figure 11 shows.

Before initiating project planning for wildlife habitat connectivity, the first step in *avoiding* impacts from road construction on wildlife populations and their habitats is to make alignment adjustments to prevent conflicts. The majority of major road construction projects today are expansions or reconstructions, so there may be few opportunities to avoid critical habitats with existing alignments. Some road expansion projects may encroach upon wetland habitats, but chances are based on proximity alone, the existing road has impacted them to some extent.

Road construction or expansion projects may be unable to avoid habitats completely, but road alignments can be planned to minimize impacts to wildlife. Having roadways traverse suboptimal habitat for wildlife can help reduce adverse effects, e.g., alignments on north-facing slopes. Roads that bisect optimal habitat generally have more adverse effects on wildlife compared to those in peripheral, suboptimal habitat illustrated in Figure 12.

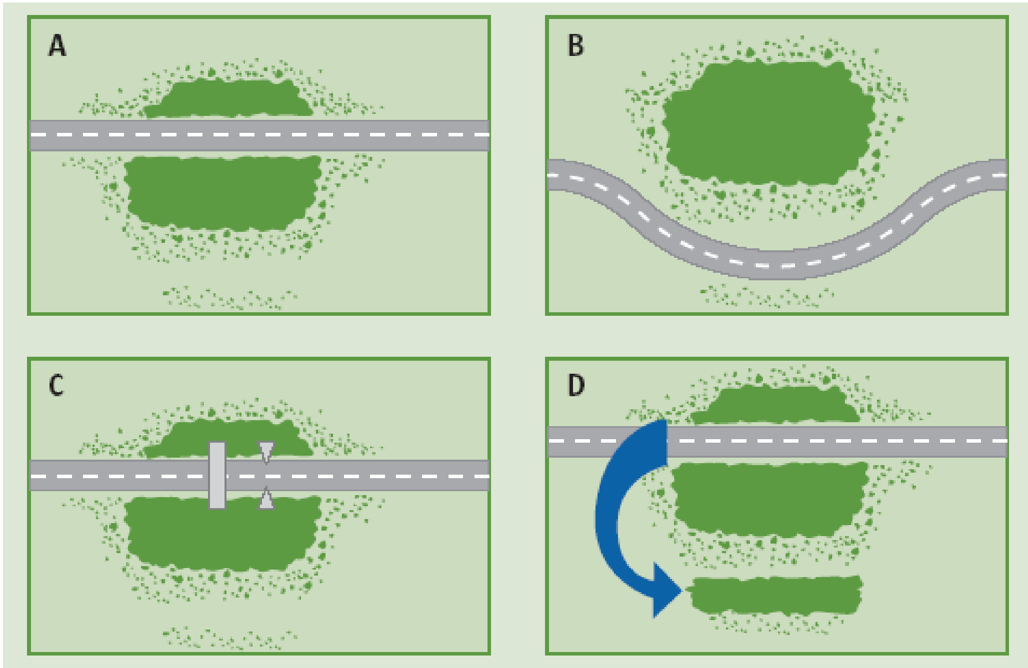

Figure 11. Schematic. Representation of road construction and habitat (A) fragmentation (B) avoidance (C) mitigation by use of under/overpasses, and (D) compensation by creation of replacement habitat nearby (from Iuell et al. 2005).

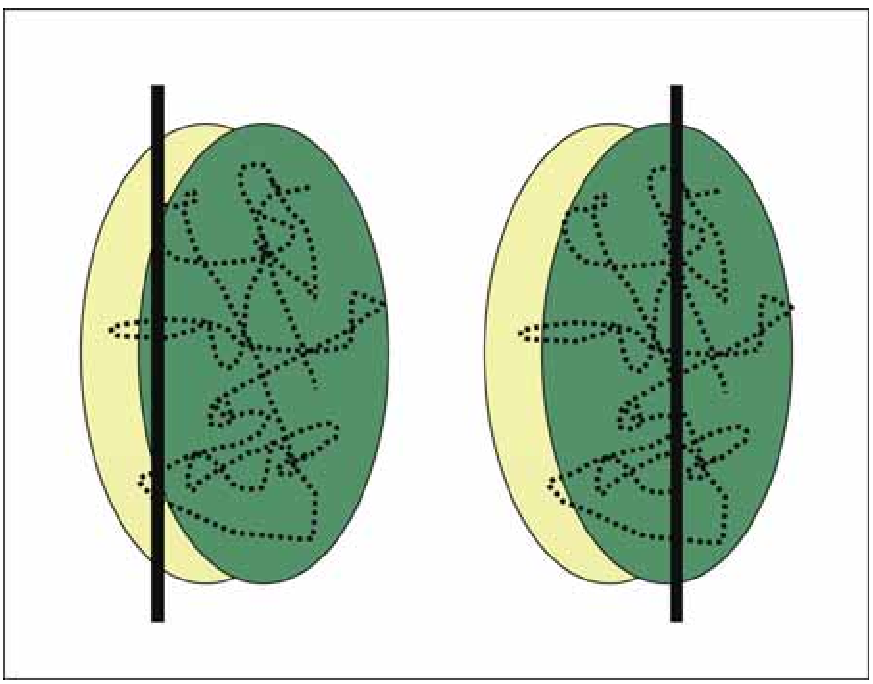

Figure 12. Schematic. Location of alignment of highways with respect to habitat quality may have differential impacts on wildlife movements (dotted line). The impact of a highway alignment located on the periphery in sub-optimal habitat (yellow) would be expected to impact wildlife movements less than if the disturbance equally bisected optimal habitat (green).

If the impacts cannot be avoided, then *mitigation* is an alternative. In North America this is the most common approach when roads impact wildlife habitat. Today there are many examples of mitigation techniques and strategies implemented for wildlife in nearly every North American landscape.

Finally, if projects are unable to avoid or mitigate their impacts then the third option consists of *compensation* measures. The compensation principle holds that for road construction or expansion there is no net loss of habitat, natural processes or biodiversity. This principle is commonly applied in transportation projects throughout North America through the National Environmental Protection Act (NEPA) in the United States and the Canadian Environmental Assessment Act (CEA).

SCALED HABITAT CONNECTIVITY PLANNING

Project-level and systems-level approaches are two different scales of habitat connectivity planning and means of incorporating measures to reduce the effects of roads on wildlife populations. Project-based approaches are most common with transportation agencies, although systems-level approaches that encompass entire states and provinces have become more common in the last few years.

Project-Level Approaches

Mitigating roads for wildlife conservation is most economical during road expansion or upgrade projects. Thus, funding for road mitigation measures such as wildlife crossing structures is most likely to originate from specific transportation projects that address multiple transportation management concerns, one of which may reduce vehicle collisions with wildlife and provide safe passage across busy roadways.

This *project-level approach* is concerned with proximate objectives—i.e., those within the transportation corridor and occasionally lands adjacent to it as mapped in Figure 13. A project-level focus may not necessarily consider how the wildlife crossing structures fit into the larger landscape and regional wildlife corridor network. Wildlife crossings should not lead to ecological "dead-ends" or "cul-de-sacs," where wildlife have nowhere to go, but must link to a larger regional landscape and habitat complex that allows them to disperse, move freely, and meet their daily and life requisites. This requires not only large spatial-scale considerations but should also incorporate future (or projected) land-use change into the planning process.

Systems-Level or Landscape-Level Approaches

Wildlife crossings may also emerge from a systems-level analysis of transportation management concerns and priorities over a much larger area than transportation corridor projects. Rather than seeking to place a specific crossing structure (± 1 mile), the systems perspective identifies which stretches of highway should require mitigation (± 10–100 miles) and how intensive the mitigation should be. Key wildlife crossing areas may also be identified from a regional landscape assessment of wildlife connectivity needs around a state-/province-wide road system or regional transportation corridor.

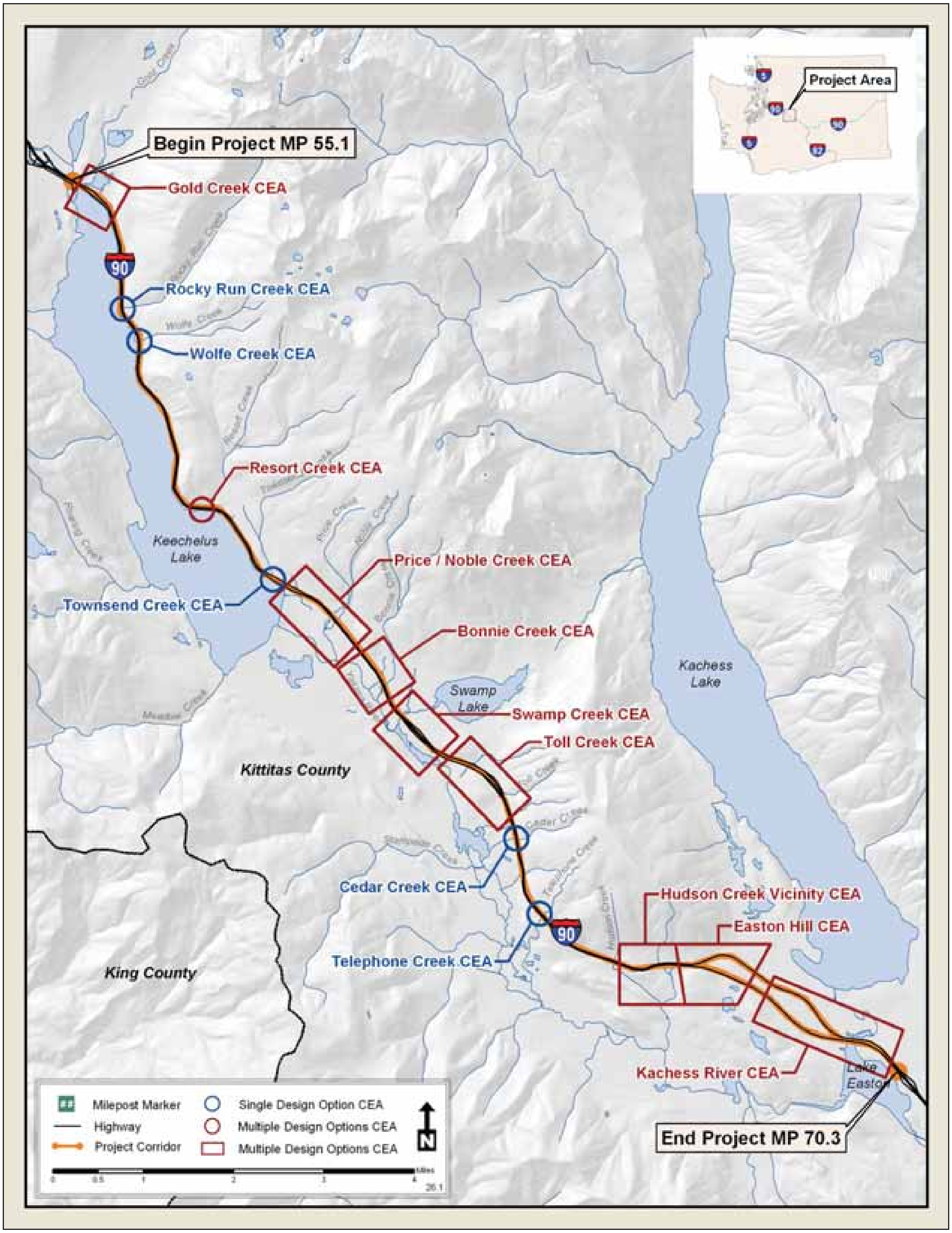

Figure 13. Map. A project-scale analysis of connectivity emphasis areas (CEA) for the Interstate 90 Snoqualmie Pass East project area, Washington State. These are locations where wildlife crossing mitigations are proposed to be installed (Source: Washington State Department of Transportation).

This landscape-focused approach can be viewed as the inverse of the project-level, or corridor-focused approach. With the right information it is possible to identify key habitat linkages or zones of important connectivity for wildlife that are bisected by transportation corridors as the Figure 14 map shows. Linkages and potential wildlife crossing locations can be prioritized based on future transportation investments, scheduling, ecological criteria and changing climate regimes. This helps to strategically plan mitigation schemes at a regional or ecosystem level.

This landscape-level approach, which is institutionalized in most of Europe, is gaining appeal with North American transportation agencies. In the United States, the overlay of two state agency maps—Statewide Transportation Improvement Program (STIP) plans with comprehensive Wildlife Conservation Plans from natural resources agencies—facilitates the integration and coordination of spatially explicit transportation and wildlife habitat conservation plans at the state level. A recent policy by the Western Governors' Association to "protect wildlife migration corridors and crucial wildlife habitat in the West" sets a management directive to coordinate habitat protection and land use management for wildlife across jurisdictional boundaries. Of particular note was the section of the report produced by the Transportation Infrastructure Working Group, which makes detailed recommendations on ways to integrate future transportation planning with wildlife habitat conservation at the systems level.

Climate change has been inducing range shifts for many species during the last century. The potential impacts of climate change, coupled with an increasingly fragmented North American landscape less permeable for wildlife dispersal, will require conservation planning that enables wildlife to move and adapt to changing climatic conditions. Incorporating climate change scenarios in systems-level planning of transportation infrastructure makes good sense given the importance of crossing structures in allowing species affected by climate change and habitat fragmentation to expand their range into new climatic space.

There are substantial benefits from the systems-level analysis. By establishing a formal, broad-scaled planning process, it is possible to readily address stakeholder concerns, prioritize agency objectives, and incorporate landscape patterns and processes and climate change into the planning and construction process. It also helps ensure that project-level efforts contemplate the larger ecological network in the surrounding region. This results in more streamlined projects that save transportation agencies money over the long term.

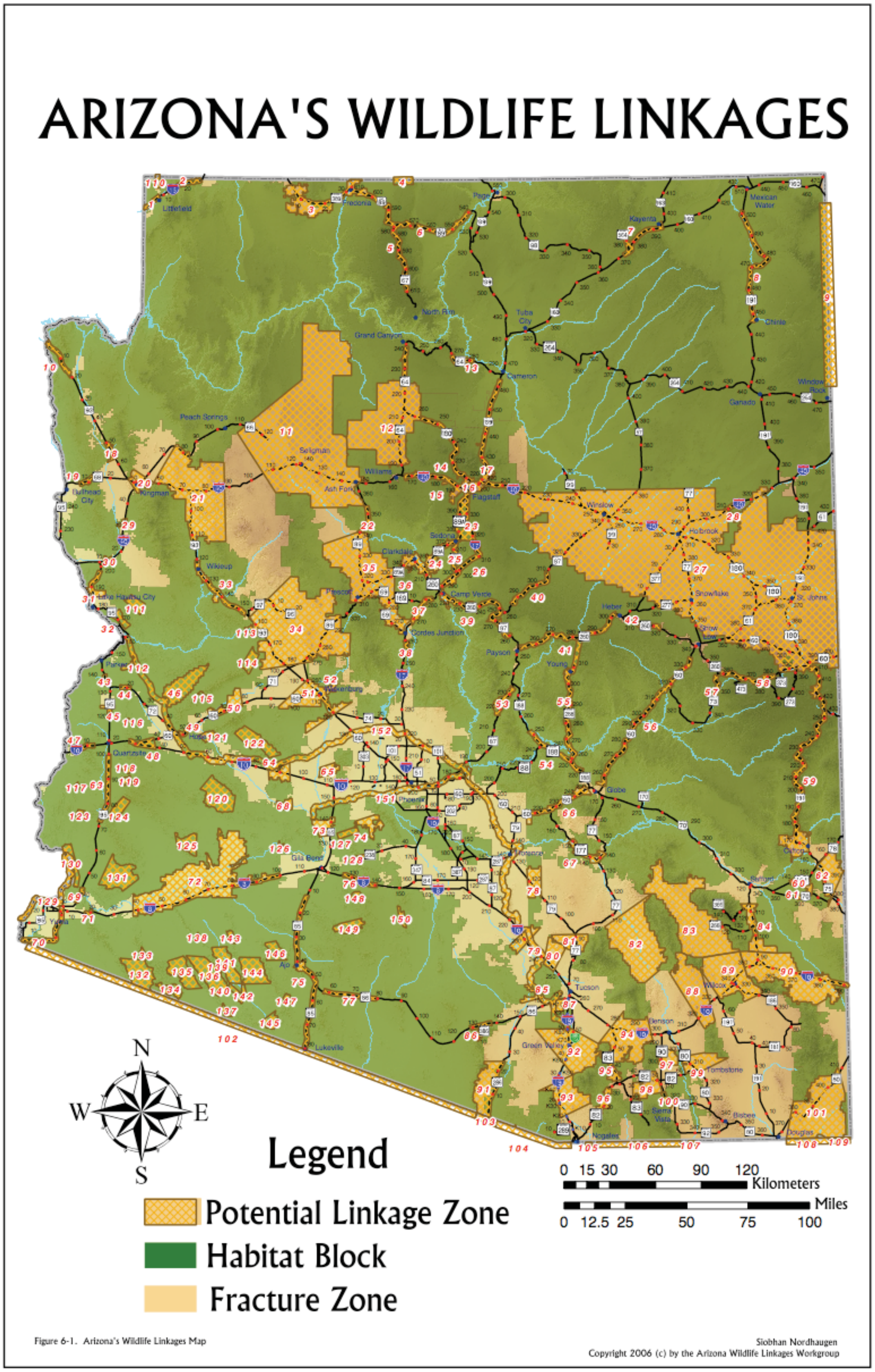

Figure 14. Map. Statewide mapping of highways and fracture zones, blocks of wildlife habitat and connectivity linkage zones for Arizona (Source: Arizona Wildlife Linkages Work Group).

ECO-LOGICAL

Infrastructure consists of the basic facilities—such as transportation and communications systems, utilities, and public institutions—needed for the functioning of a community or society. Sometimes the development of these facilities can negatively impact habitat and ecosystems. Techniques have been developed to better avoid, minimize, and mitigate these impacts, as well as the impacts of past infrastructure projects. However, the avoidance, minimization, and mitigation efforts used may not always provide the greatest environmental benefit, or may do very little to promote ecosystem sustainability. The most important sites for long-term ecological benefits may be "off-site" or outside the project area. This concern, along with a 1995 Memorandum of Understanding to foster the ecosystem approach and the Enlibra Principles, mobilized an interagency Steering Team to collaborate over a three-year period to write *Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects* (Brown 2006).

Eco-Logical encourages Federal, State, tribal, and local partners involved in infrastructure planning, design, review, and construction to use flexibility in regulatory processes. Specifically, *Eco-Logical* puts forth the conceptual groundwork for integrating plans across agency boundaries, and endorses ecosystem-based mitigation—an innovative approach of mitigating infrastructure impacts that cannot be avoided.

Eco-Logical is a guide to making infrastructure more sensitive to wildlife and ecosystems through greater interagency cooperative conservation. It describes ways for streamlining the processes that advance approvals for infrastructure projects—in compliance with applicable laws—while maintaining safety, environmental health, and effective public involvement. As a way to accomplish this, the guide outlines an approach for the comprehensive management of land, water, and biotic and abiotic resources that equitably promotes conservation and sustainable use. Key components of the approach include integrated planning, the exploration of a variety of mitigation options, and performance measurement.

PLANNING RESOURCES

Deciding where to locate wildlife crossing structures requires adequate tools and resources to identify the most suitable sites for crossing structures at the project and systems level. Listed below are resources that can help define the important wildlife linkages across roads and identify key areas for mitigation.

Maps and Data

Many resources are available today that facilitate the identification of wildlife habitat linkages and movement corridors. Many electronic resources are geographic information system (GIS)-based, readily available from government or non-governmental agencies, and can be downloaded from Internet sites, e.g., state/provincial or national Geospatial Data clearinghouses. Some basic map and data resources for planning wildlife connectivity and crossing mitigation include:

- Aerial photos
- Land cover-vegetation maps
- Topographic maps
- Landownership maps
- Wildlife habitat maps

- Wildlife movement model data
- Wildlife ecology field data
- Wildlife road-kill data
- Road network data

Table 1 describes each resource and how it can be used for project-level and systems-level planning of wildlife habitat connectivity and highway mitigation. Use of these resources in combination with road network and traffic data is an ideal place to start identifying the intersections of high probability habitat linkages and roads. Combining multiple resources will provide greater accuracy in identifying habitat linkages and finalizing site selection for wildlife crossing structures. Most of the resources listed in Table 1 work best at the more localized, project level, however some can be used or adapted for larger, systems-level assessments.

Table 1. Data layers and maps for planning wildlife connectivity and crossing mitigation.

Map/Data Type	Project-level	Landscape-level
Aerial photos	Photos can be used to help identify vegetation types and human developments. Photos come in many scales and image formats (ortho-photos, color infrared, black and white). Some images are high resolution (to 5 m). Readily available from local and state/provincial government agencies.	Typically not practical to use for large landscape-scale assessments of linkage zones. Landsat TM satellite imagery or other remotely sensed imagery are good substitutes for working at a state/provincial scale. Satellite imagery should be available at most local and state/provincial government agencies.
Land cover-vegetation maps	These maps help identify general vegetation types such as deciduous vs coniferous forests, shrublands, grassland/marshes, rock and ice. Land cover maps are more general and include physical (built areas) and biological information. Readily available from local and state/provincial government agencies and their websites.	Maps are available for large-scale habitat and corridor network planning. The scale is much larger and resolution lower, nonetheless important resource to use in large scale planning endeavors. Readily available from local and state/provincial government agencies and their websites.
Topographic map	Information on slopes, ridgelines, valley bottoms, drainages and other main topographic features are valuable for identifying wildlife habitat corridors. Roads, power lines and other human developments are usually found on these maps. Readily available from local and state/provincial government agencies.	Like land cover-vegetation maps above, topo maps are available for state/provincial-wide mapping exercises, however resolution is lower. Readily available from local and state/provincial government agencies.

Landownership map	Coordinating management of lands adjacent to roads is key to successful mitigation. Maps that identify adjacent land use management such as public/crown lands, designated reserves, municipal and private lands are needed for planning corridors and crossings. Readily available from local and state/provincial government agencies.	Also available for large scale planning endeavors. Generalized vegetation and land-use types are provided. Readily available from local and state/provincial government agencies.
Wildlife habitat map	Generally developed from combination of biophysical maps (vegetation maps being one) and models of habitat suitability for certain wildlife species or groups. They identify key habitat types for the species for which they are prepared. Some are very accurate and derived from site-specific studies, while others are less accurate relying on extrapolated information. Readily available from local and state/provincial government agencies and NGOs.	Some states have prepared (or are in preparation) statewide habitat connectivity maps (e.g., FL, WA, CA). In the U.S., state natural resource agencies have prepared "comprehensive wildlife conservation plans" that identify statewide, key habitats for wildlife conservation. These should be readily available from most, if not all, state natural resource agencies today.
Wildlife movement model	Similar to wildlife habitat maps but more specific to where wildlife are most likely to move through the landscape. These are based on either expert opinion or empirical studies that integrate species ecology and landscape suitability. Generally available from wildlife agencies conducting the modeling research.	Generally not available for large-scale exercises unless designed specifically for that purpose. Least-cost path and circuit theory modeling may be promising methods at this scale.
Wildlife ecology field data	Supplemental data in form of telemetry points or population surveys can help guide the location selection for connectivity and crossing structures. Generally available from wildlife agencies conducting research in the project area.	Not generally available for state/provincial-wide work, however, local data can be extrapolated to larger landscapes to aid in habitat corridor planning.

Road-kill data	Many state/provincial transportation agencies collect location-specific data on wildlife species killed on their roads, either through carcass collections or collision reports. These data are primarily collected for large mammals and rarely for small or medium-sized fauna. These data can be used to identify road-kill hotspots, but do not provide information on where wildlife are successfully crossing the roadway.	Data are readily available from state/provincial transportation agencies, usually collected by districts and then stored in a state/provincial-wide database. These data can be used to identify most critical sections of state/provincial highway for accidents with large mammals (primarily elk and deer).
Road network	Municipal and state/provincial governments have digital information on all road types in their jurisdiction.	Road data from state/provincial to national scale can be obtained from the U.S. Census Bureau geospatial database or GeoConnections in Canada.

GIS LAYERS

GIS analysis is widely used in transportation and natural resources management today. Analyses can be done in multiple spatial scales ranging from project to landscapes and regions. Many of the map and data resources listed above are available in digital format and can be overlaid and analyzed in ArcView/GIS® or ArcMap®. Basic GIS layers useful for identifying habitat linkages and siting wildlife crossings at the systems-level include:

- Digital elevation model (DEM; characterizes topography, preferably $\leq$30m resolution)
- Water or hydrology (includes all lakes, ponds, rivers, streams)
- Vegetation or ecological land classification system (general habitat types)
- Wildlife habitat suitability (species-specific habitat map)
- Built areas (areas of human development and activity)
- Roads (network of all paved and unpaved roads)

How To Site Wildlife Crossings

Generally habitat linkage assessments at the systems-level are not suitable for identifying specific locations for wildlife crossings due differences in design considerations, e.g. broad-scale movement patterns of large carnivores versus local topographic and engineering concerns. However, a linkage assessment can help prioritize and identify where wildlife–road conflict areas occur over a large area. Once identified, this is a good starting point for initiating discussions with transportation and regulatory agencies about mitigation plans in the short and long term.

Determining the specific placement or siting of wildlife crossings is generally done at the project-level, or after a thorough field survey as part of a larger systems-level assessment. Regardless of the method, considerations of wildlife crossing placement begin by determining the wildlife species or groups of concern as discussed later in Chapter 4. Once the focal species or group is identified, many of the resources listed above can be used to identify the best locations for wildlife crossing mitigation. Methods to identify those locations are briefly described below. *It is critical to make a field visit and be on the ground at the potential location for any wildlife crossings regardless of the tools or techniques used.*

Below we describe several different approaches used by transportation agencies to location wildlife crossing structures.

FIELD DATA

Physical Data

Road-Kill Data

Intuitively road-kill data would be best suited for determining where wildlife crossings should be placed. However, research suggests that the locations where wildlife are struck by vehicles may have little in common with where they safely cross roads. Many factors associated with roads and adjacent habitats can be the causes of wildlife–vehicle collisions and these factors may not influence where wildlife safely cross roads. Use of road-kill data alone provides a very limited scope of wildlife movement areas and should be combined with habitat linkage mapping or movement models (see below). If reducing road-kill and increasing habitat connectivity is a project objective, then identifying the location of safe wildlife crossings will be an important consideration in planning crossing structures.

Radio And Satellite Telemetry

Telemetry has been commonly used to describe successful road crossing locations usually through intensive monitoring of wildlife movements. More accurate crossing data are now being obtained using global positioning system (GPS) monitoring devices and satellite-based telemetry captured in Figure 15. Satellite methods allow for more frequent and more accurate relocation data while the animal is collared when compared to radio-based methods.

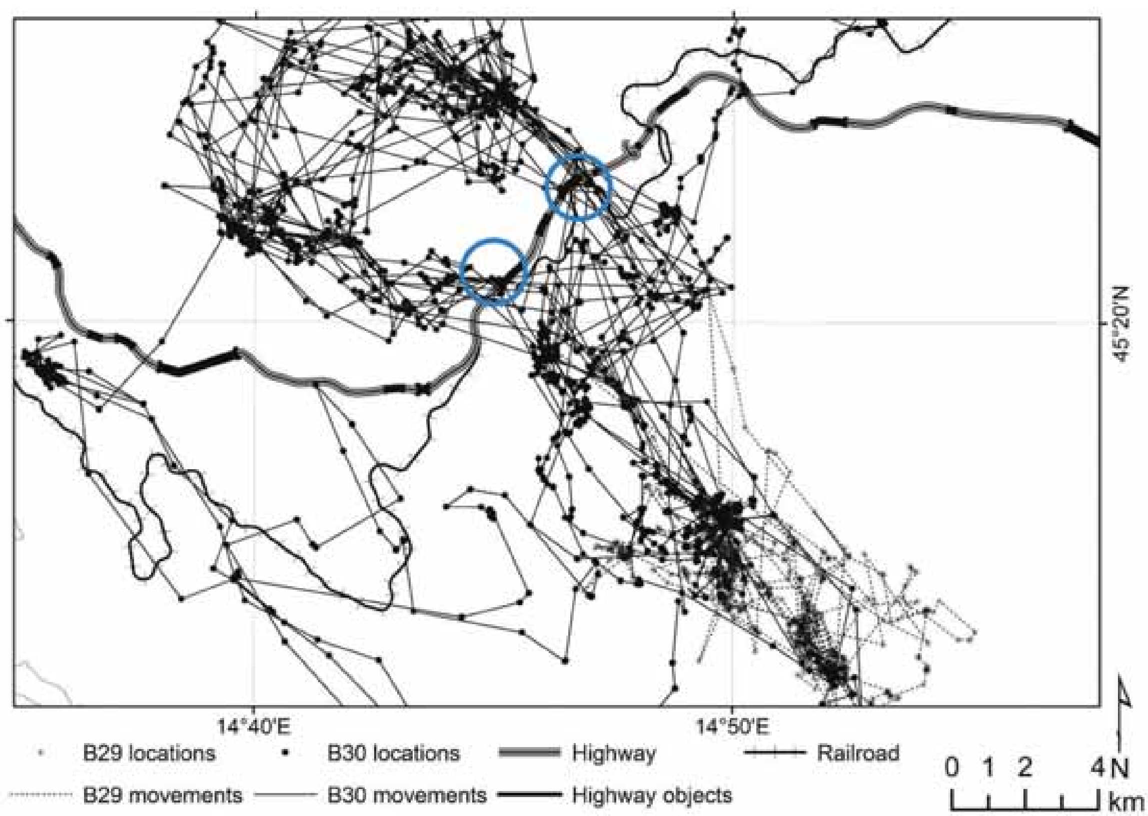

Figure 15. Map. Global position system (GPS) movement data from a male brown bear crossing a major four-lane highway and wildlife crossings (blue circle) in Croatia (Source: D. Huber, Zagreb University).

Capture-Mark-Recapture

By live-trapping and marking individuals and monitoring their movements via translocation or natural movements across roads, the distribution and population density of wildlife can be identified. This approach is most common among smaller fauna, but is becoming less popular as more non-invasive survey methods are being developed.

Road Surveys

In areas that receive regular snowfall, transects adjacent and parallel to the road or road surveys carried out while driving slowly along the road edge are two commonly used techniques to identify animal crossing locations.

Track Beds

Beds of sand or other tracking medium laid out along sections of roadway to intercept animal movements across roads as shown in Figure 16 have been used to estimate the number of animal crossings before road expansion and constructing wildlife crossings. These data can be used to determine the duration of monitoring required to detect a proportional change in crossing rates after construction.

(A) (B)

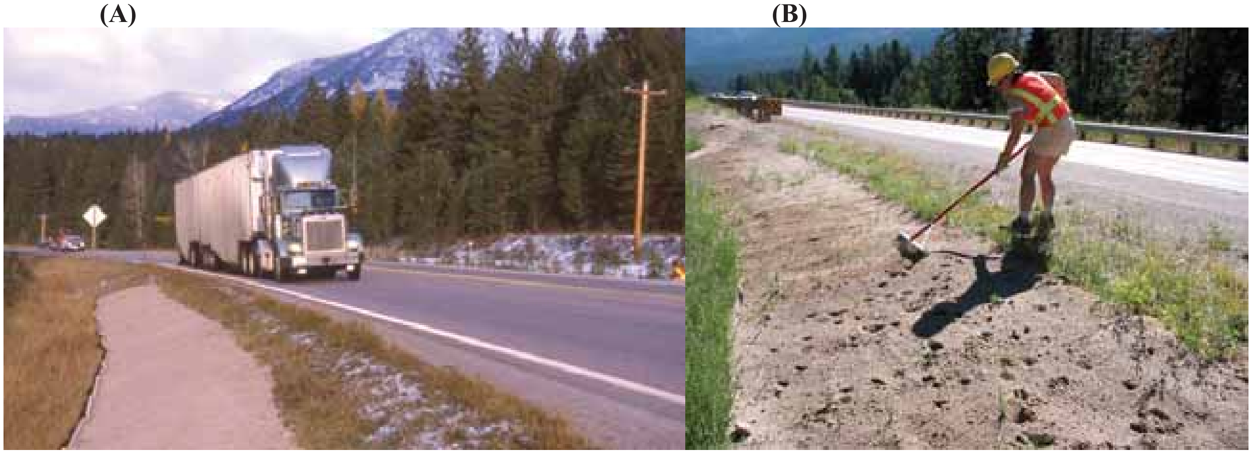

Figure 16. Photo. (A) Use of track beds is one method for obtaining information on wildlife movement across roads and key crossing locations prior to installation of wildlife crossing structures. (B) Raking of track beds along US 93 in Montana to collect pre-mitigation information on wildlife movements in the highway corridor (Credits: M. Huijser).

Camera Detection

Camera systems along roads have their own inherent operating problems and have not proven to be a reliable method of obtaining information on where animals actually cross roads. These problems are related to a camera's limited range of detection. However, camera data can be used to provide information on wildlife distribution and relative abundance by using camera "traps." Camera sampling stations can be placed in the study area (road corridor) using a grid or stratified sampling approach that will provide the best results per unit of effort. Animal distributions can be modeled using presence-only data from cameras. Determining relative abundance is more problematic, as it is difficult to identify individual animals detected by cameras.

Genetic Sampling

Similar to camera traps, non-invasive genetic sampling of hair for DNA analysis may be practical if used in a high-density grid pattern and/or focusing efforts at a smaller scale of resolution (e.g., medium-sized mammals). A genetic sampling grid used for obtaining hair samples from bears in Banff National Park, Alberta, is shown in Figure 17. Genetic sampling may only be able to provide general information on the potential location of wildlife crossing structures. Unlike data from camera systems, genetic sampling and DNA analysis can provide minimum estimates of local population size and identify individuals, their gender and genetic relatedness.

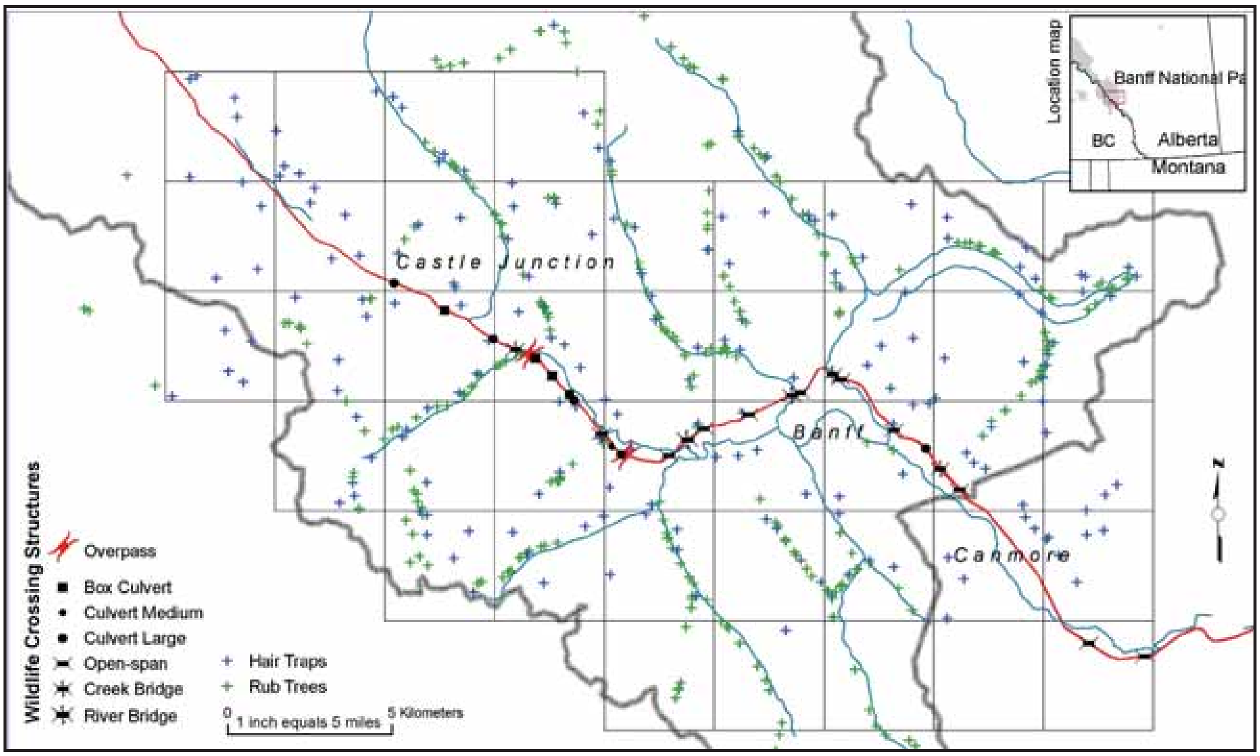

Figure 17. Map. DNA sampling grid in Banff National Park. Hair snag sites and rub tree sites were used to collect population genetic data on individuals in the population and from bears using the wildlife crossings on the Trans-Canada Highway (Source: WTI/Parks Canada).

GIS-Based Movement Model

Landscape-scale GIS-based models have been used to identify key habitat linkages, evaluate habitat fragmentation resulting from human activities, and discover areas where highways are permeable to wildlife movement. Models that simulate movements of wildlife tend to use "resource selection functions" that map habitat quality. The models have rules for simulated movements based on habitat quality and how animals are able to travel through the landscape. The data used to generate a GIS-generated "habitat surface" for these models is based on some type of information on animal distribution, usually obtained by radiotelemetry locations, but can also be derived from other methods to survey animal populations, such as genetic sampling, sooted track plates, acoustic surveys or scat-detection dogs. Regardless of how the simulated movement or habitat linkage models are developed, the model's ability to predict crossing locations needs to be tested with empirical field data, e.g., road-kill locations, telemetry location data, field observations, transects and survey data, etc.

WHAT IS A RESOURCE SELECTION FUNCTION?

Resource selection functions (RSFs) estimate the relative amount of time an individual animal spends using a resource (e.g., habitat type) as a function of the proportional availability of that resource. The units being selected by animals (e.g., habitat types) are conceived as resources, and predictor variables associated with these resource units may be "resource" variables or covariates of the resources—e.g., elevation, human disturbance. RSF models are similar to methods that have been developed for mapping distributions of animals using species-environment patterns. A RSF model can be considered a form of habitat suitability index (HSI; U.S. Fish and Wildlife Service 1981), but with statistical rigor. RSF models are always estimated directly from data. A RSF usually is estimated from observations of (1) presence/absence (used vs. unused), or (2) presence/available (used vs. available) resource units (Boyce et al. 2002). When linked to a geographic information system (GIS), RSF models can be powerful tools in natural resource management, with applications for cumulative effects assessment, land management planning, and population viability analysis.

No Data

Often transportation and natural resource agencies lack easily accessible field data for planning the location of wildlife crossing structures. Usually decisions regarding design and location need to be made in a few months leaving no time for preconstruction studies. When this is the case, there are several options to consider.

Expert-Based Habitat Model

Expert information can be used to develop simple, predictive, habitat linkage models in a relatively short period of time. Expert information may consist of models based on the opinion of experts or qualitative models based on the best available information obtained from the literature. Several methods have been used to quantitatively analyze expert opinion data, but the analytical hierarchy process (AHP) is popular among environmental biologists. Expert opinion has been successfully used to identify key habitat linkages across roads and site wildlife crossings. The advantages are: (1) it is quick and easy to carry out; (2) legitimacy can be quite high if a consensus-model is employed by participants; (3) the method can be statistically sound and biologically robust for identifying and prioritizing critical habitat linkages; and (4) GIS software to assist in linkage identification is readily available. Software for the AHP is freely available on the Internet, and was designed by AHP authority Thomas L. Saaty. Major limitations of expert-based modeling are that it works best when having a narrow taxonomic focus, and like all models they are best when validated with field data. There are also important considerations for determining who is invited as an expert and how transparent the process is when it comes to finding broader support for the findings of the model. Like all models, it must be validated with field data, like those shown above.

Rapid Assessment

A rapid assessment process has been used that involves gathering experts from the area of concern. This process differs from the expert-based habitat model in that there is no quantitative analysis of expert opinion or modeling. Through consensus participants delineate where they believe key corridors are located on a given section of highway. The advantages are similar to the above model, however they can have a broad taxonomic focus. The main shortcomings are (1) criteria are rarely used for the selection of potential linkage areas, and (2) a lack of decision rules or weighting of factors considered makes it difficult to identify and prioritize the most critical linkages in a biologically robust way. As such, large sections of highway may be deemed "critical" when actually a smaller subset and the most ecologically important linkages are not teased out and identified. Also, rapid assessment results are rarely validated with field data.

Local Knowledge

Historically, local knowledge has been important for wildlife biologists conducting research or managing habitats for wildlife. Long-term residents can provide valuable information about where and how wildlife moves across the land. In landscapes where crossing locations are limited, local knowledge can help guide the planning of wildlife crossings. Local participation in project planning is not only good public relations but also provides stakeholders with input and participation in the project. Local knowledge and public participation have been formalized through citizen-scientist programs. These programs encourage active participation by the local community in wildlife movement and road mortality data collection.

Compatibility Of Adjacent Land Use

The most important part of site selection for wildlife crossing structures is the compatibility of adjacent land use in the present and future. Wildlife crossings will only be as effective as the management strategies developed around them that incorporate all the key landscape elements (humans, terrain, natural resources, transportation). Wildlife crossings are in essence small, narrow, site-specific habitat corridors. Thus, for these measures to fulfill their function as habitat connectors, mitigation strategies must be contemplated at two scales. Site-level or local-scale impacts from development or human disturbance adjacent to crossing structures may impede wildlife use. Similarly, alteration of landscape elements at a broader regional-scale could impede or obstruct movements towards the crossing structures and prevent animals from using them, thus rendering them ineffective. The larger scale concerns must be recognized if the local-scale measures are to be effective.

Coordination between land management and transportation agencies, and in some cases municipal planning organizations, can reconcile the connectivity concerns at both scales. If a transportation agency designs and builds appropriate wildlife crossings, but the land management agency fails to manage adjacent lands, the transportation agency funds will be wasted and the measures likely ineffective. Similarly, if adjacent lands are managed to ensure regional-scale connectivity across a highway, but the transportation agency fails to provide appropriate wildlife crossing structures, then efforts of the land management agency will be of limited value.

In developing recommendations for mitigating with wildlife crossings, it is important to remember the temporal and spatial context of ecosystems. Mitigating highways for wildlife is a long-term process that will last for many decades and affect individuals and populations alike. Thus, highway mitigation strategies developed around land-use planning should not terminate with the construction process. They need to be proactive at both local and regional scales to ensure that crossing structures remain functional over time.

Like bridge structures, the lifespan of wildlife crossing structures is 75–80 years, so mitigation needs to be thought of as long term. The planning of wildlife crossing mitigation requires forecasting, visualization and understanding how to proactively integrate wildlife conservation concerns around a growing infrastructure and a changing landscape.

Long-term planning needs to take into consideration not only change in land use but also range shifts due to climate change. Crossing structures are practical measures that transportation agencies can integrate into state or regional planning exercises to help adapt changes in species ranges and animal distributions to climate change. The potential impacts of climate change, coupled with an increasingly fragmented North American landscape less permeable for wildlife dispersal, will require conservation planning that enables wildlife to move and adapt to changing climatic conditions. Incorporating climate change scenarios in systems-level planning of transportation infrastructure makes good sense given the importance of crossing structures in allowing species affected by climate change and habitat fragmentation to expand their range into new climatic space.

SUGGESTED READING

Beier, P., K.L. Penrod, C. Luke, W.D. Spencer and C. Cabanero. 2006. South Coast missing linkages: restoring connectivity to wildlands in the largest metropolitan area in the USA. Pages 555-586, in K Crooks and M. Sanjayan (eds.), *Connectivity conservation.* Cambridge University Press, Cambridge, UK.

Beier P, D.R. Majka and W.D. Spencer WD. 2008. Forks in the road: Choices in procedures for designing wildland linkages. *Conservation Biology* 22:836-851.

Bissonette, J.A. 2007. *Evaluation of the use and effectiveness of wildlife crossings*. National Cooperative Highway Research Program (NCHRP) 25-27 final report. Transportation Research Board, Washington DC.

Boyce, M.S., P.R. Vernier, S.E. Nielsen, and F.K.A. Schmiegelow. 2002. Evaluating resource selection functions. *Ecological Modelling* 157:281-300.

Chetkiewicz, C-L.B., Cassady St. Clair, C. and Boyce, M.S. 2006. Corridors for conservation: integrating pattern and process. *Annual Review of Ecology and Systematics* 37:317-342.

Clevenger, A.P., J. Wierzchowski, B. Chruszcz, and K. Gunson. 2002. GIS-generated expert based models for identifying wildlife habitat linkages and mitigation passage planning. *Conservation Biology* 16:503-514.

Clevenger, A.P., Chruszcz, B., Gunson, K., and Wierzchowski, J. 2002. *Roads and wildlife in the Canadian Rocky Mountain Parks - Movements, mortality and mitigation.* Final Report (October 2002). Report prepared for Parks Canada, Banff, Alta.

Cuperus, R., K.J. Canters, A. Udo de Haes, and D.S. Friedman. 1999. Guidelines for ecological compensation associated with highways. *Biological Conservation* 90:41-51.

Forman, R.T.T., Sperling, D., Bissonette, J., Clevenger, A., Cutshall, C., Dale, V., Fahrig, L., France, R., Goldman, C., Heanue, K., Jones, J., Swanson, F., Turrentine, T. and Winter, T. 2003. *Road ecology: Science and solutions*. Island Press, Washington, D.C.

Kintsch, J. 2006. Linking Colorado's landscapes. Pages 138-142 in *Proceedings of the 2005 International Conference on Ecology and Transportation*, edited by C. Leroy Irwin, Paul Garrett, and K.P. McDermott. Raleigh, NC: Center for Transportation and the Environment, North Carolina State University.

Lee, T., M.S. Quinn, D. Duke. 2006. Citizen, science, highways, and wildlife: Using a web-based GIS to engage citizens in collecting wildlife information. *Ecology and Society* 11(1): 11 URL:http://www.ecologyandsociety.org/vol11/iss1/art11/

Long, R. A., P. MacKay, W. J. Zielinski, and J. C. Ray, editors. 2008. *Noninvasive survey methods for carnivores.* Island Press, Washington D.C., USA.

National Research Council (NRC). 2005. *Assessing and Managing the Ecological Impacts of Paved Roads.* The National Academies Press, Washington, DC.

Saaty, T. L. 1990. How to make a decision—the Analytic Hierarchy Process. *European Journal of Operational Research*. 8:9-26.

Singleton, P.H., W.L. Gaines, and J.F. Lehmkuhl. 2002. *Landscape permeability for large carnivores in Washington: a geographic information system weighted-distance and least-cost corridor assessment.* USDA Forest Service research paper, PNW-RP-549.

Smith, D. 1999. Identification and prioritization of ecological interface zones on state highways in Florida. Pages 209-230 in G.L. Evink, P. Garrett, and D. Zeigler, editors. *Proceedings of the Third International Conference on Wildlife Ecology and Transportation*. FL-ER-73-99. Florida Department of Transportation, Tallahassee, Florida. 330 pp.

SREP. *Safe passages*. 2007. Southern Rockies Ecosystem Project, Denver, CO.

Transportation Research Board, 2004. *Environmental spatial information for transportation: a peer exchange on partnerships*. Conference proceedings on the web 1. National Academy Press, Washington, D.C.

US Fish and Wildlife Service. 1981. *Standards for the development of suitability index models.* Ecology Service Manual 103, US Fish and Wildlife Service, Division of Ecological Sciences, Washington DC, USA.

Van Manen, F.T., Jones, M.D., Kindall, J.L., Thompson, L. and Scheick, B.K. 2001. Determining the potential mitigation effects of wildlife passageways on black bears. *Proceeding of the International Conference on Ecology and Transportation* 2001:435-446.

Western Governors' Association. 2008. *Wildlife corridors initiative report*. Western Governors' Association, Denver, CO.

White, T. 2007. *Linking conservation and transportation: Using the state wildlife action plans to protect wildlife from road impacts*. Defenders of Wildlife, Washington, DC.

CHAPTER 4 – DESIGNS, TOOLBOXES, GUIDELINES, AND PRACTICAL APPLICATIONS

INTRODUCTION

Just as important as the correct location of wildlife crossings is to have them properly designed to meet the performance objectives. Questions arise as to the size of the crossing and how species-specific behaviors should be incorporated into the crossing structure design. These concerns are offset by the logistics of the project, which include costs of the structure, available material and expertise, and physical limitations of the site, e.g., soil, terrain, hydrology. Stakeholders involved in the crossing structure design process can then find themselves searching through published and grey literature regarding the design, performance and cost of the project. As project managers attempt to incorporate the designs and lessons from other experiences, several general questions arise:

- What do wildlife crossings look like?
- Where were they built?
- For what species were they designed?
- For what types of roads and highways were they built?
- In what environmental settings were they built (national park/forest, wildland–urban interface, urban, rural agricultural, etc.)?
- Were they successful?

The general questions are followed by many specific questions:

- What documentation is there regarding specific design and construction cost?
- What are the practicalities of each design?
    - Were they over-designed? (They were successful but could have been built more cheaply.)
    - Were they under-designed? (Wildlife used them less than expected and they performed poorly.)

This chapter provides examples of what tools and practical applications are available today for designing wildlife crossings in transportation projects. It is not meant to be a complete list of technical designs or methods used, but describe the most common wildlife crossing structure design types that are currently in use.

FUNCTION OF WILDLIFE CROSSINGS AND ASSOCIATED MEASURES

Wildlife crossing mitigation has two main objectives: 1) to connect habitats and wildlife populations and 2) reduce mortality of wildlife on roads as the Figure 18 chart shows.

Objective
Facilitate connections between habitats and wildlife populations

Wildlife Overpasses

- Landscape bridge (Sheet 1)
- Wildlife overpass (Sheet 2)
- Multi-use overpass (Sheet 3)
- Canopy crossing (Sheet 4)

Wildlife Underpasses

- Viaduct or flyover (Sheet 5)
- Large mammal underpass (Sheet 6)
- Multi-use underpass (Sheet 7)
- Underpass with Waterflow (Sheet 8)
- Small to medium-sized mammal underpass (Sheet 9)
- Modified culvert (Sheet 10)
- Herpetile tunnel (Sheet 11)

Objective
Improve motorist safety and reduce wildlife-vehicle collisions[1]

Specific measures

- Fencing–Large mammals (Sheet 12)
- Fencing–Small and medium vertebrates (Sheet 13)
- Gates and escape ramps (Sheet 14)
- Signage
- Animal–vehicle detection systems
- Speed reduction
- Lighting
- Reflectors

Habitat adaptation

- Managing habitat and right-of-ways
- Intercept feeding

Infrastructure adaptation

- Adapting road infrastructure (curbs, drainage grates, Jersey barriers) for wildlife movement
- Increasing width of road median

[1]See Huijser et al. (2008).

Figure 18. Chart. Types of measures used to reduce the impacts of roads on wildlife (adapted from Iuell 2005).

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Objective 1: Facilitate connections between habitats and wildlife populations

To achieve this goal, wildlife crossing structures are designed to allow movement of wildlife above or below road, either exclusively for wildlife use, mixed wildlife–human use, or as part of other infrastructure, e.g., creeks, canals. Wildlife crossing structures come in a variety of shapes and sizes, depending on their specific objective, and can be divided into 11 different design types (see Appendix C, Hot Sheets 1-11).

- Four wildlife crossings are above-grade (over-the-road); seven are designed for below-grade (under-the-road) wildlife movement
- Two of the 11 crossings are designed for both wildlife and human use (multi-use); nine are exclusively for wildlife use
- Unique wildlife crossings include:
  - Canopy crossings for arboreal wildlife
  - Underpasses that accommodate movement of water and wildlife
  - Adapted walkways at canal and creek bridges, and
  - Below-grade tunnels designed for movement of amphibians and reptiles

Objective 2: Improve motorist safety and reduce wildlife–vehicle collisions

Traffic-related mortality of wildlife can significantly impact some wildlife populations; particularly those that are found in low densities, slow reproducing, and need to travel over large areas. Common and abundant species like Deer, Elk and Moose can present serious problems for motorist safety. Many mitigation measures have been designed over the years to reduce collisions with wildlife; but few actually perform well or have been rigorously tested. Mitigation measures can be categorized as three types:

1) Specific mitigation measures designed to improve motorist safety and reduce collisions with wildlife
2) Mitigation measures that require habitat alterations near roads, and
3) Mitigation measures that require modifications to the road infrastructure

Objectives 1 and 2 should work together and can be integrated to provide for safe movements of wildlife across road corridors, by reducing motor vehicle accidents with wildlife. Wildlife crossings generally require one or more types of specific measures designed to improve motorist safety and reduce wildlife–vehicle collisions, e.g., fencing, escape gates and ramps (see Appendix C, Hot Sheets 12-14). Other techniques used to increase motorist safety and reduce collisions with wildlife, such as specific measures (signage and animal detection system) and the adaptation of habitats and road infrastructure, are not within the scope of this work. Detailed descriptions and guidelines for using these types of mitigation measures for wildlife can be found in Huijser et al. (2007a,b) and Iuell (2005).

SPACING OF WILDLIFE CROSSINGS

Landscape connectivity is the degree to which the landscape facilitates wildlife movement and other ecological flows. However, no two landscapes are the same. Terrain, habitat type, levels of human activity and climate are some factors that influence wildlife movements and ecological flows. Therefore the spacing of wildlife crossings on a given section of roadway will depend largely on the variability of landscape, terrain, population densities, the juxtaposition of critical wildlife habitat that intersects the roadway and the connectivity requirements for different species. In landscapes that are highly fragmented with little natural habitat bisected by roadways shown in Figure 19, generally fewer wildlife crossings will be required compared to relatively intact, less fragmented landscapes as Figure 20 shows.

Figure 19. Photo. Benavente, Spain. Highly fragmented landscape (high contrast; adapted from Google Earth).

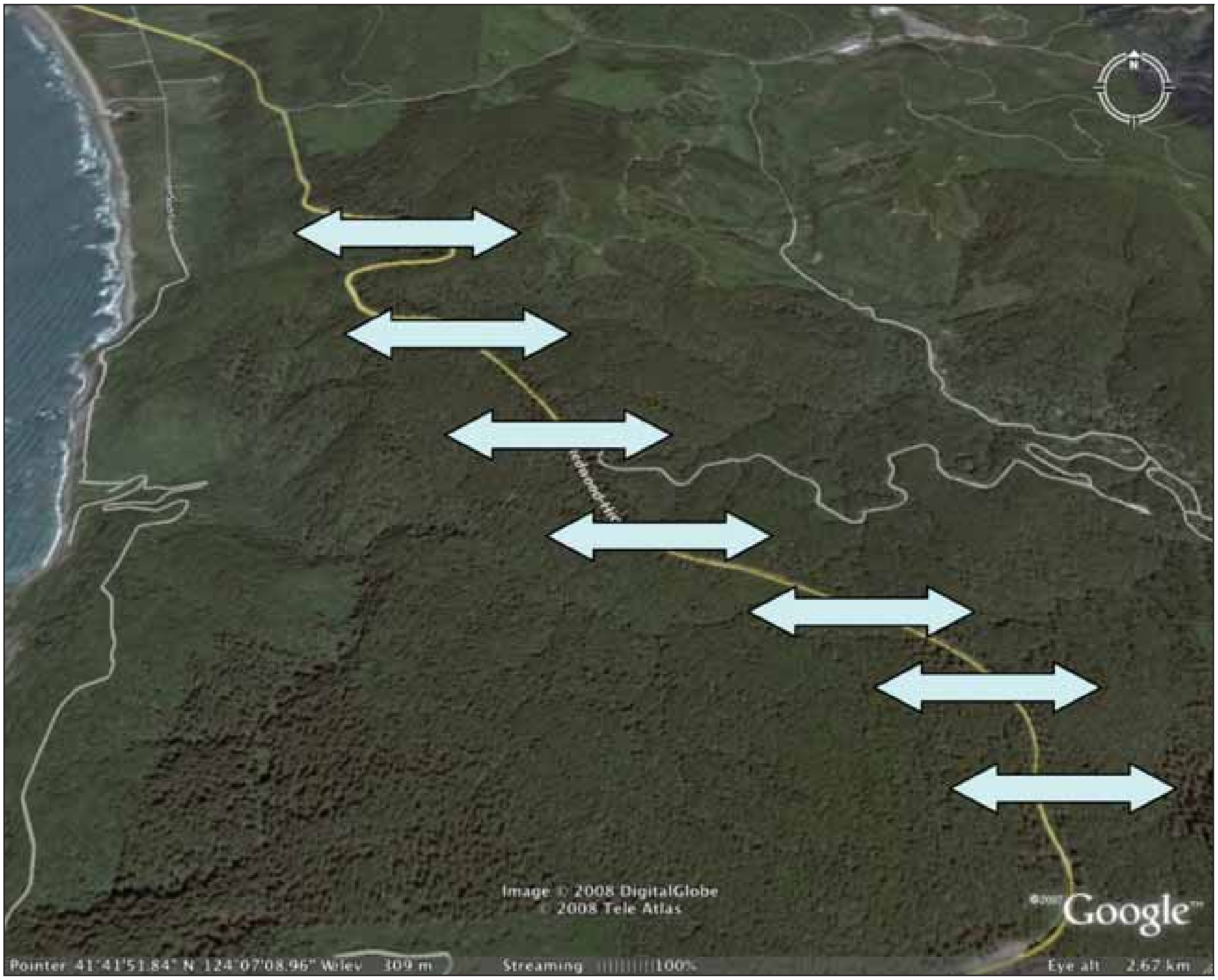


Figure 20. Photo. Hwy 101, Redwood highway, California. Low contrast landscape with low level of habitat fragmentation (adapted from Google Earth).

Wildlife crossings are permanent structures embedded within a dynamic landscape. With the lifespan of wildlife crossing structures around 70–80 years, the location and design of the crossings need to accommodate the changing dynamics of habitat and climatic conditions and their wildlife populations over time. How can we reconcile the dynamic environmental processes of nature with static physical structures on roadways? Environmental change is inevitable and will occur during the lifespan of the crossing structures. Some basic principles that management needs to consider:

- *Topographic features:* Wildlife crossings should be placed where movement corridors for the focal species are associated with dominant topographic features (riparian areas, ridgelines, etc). Sections of roadway can be ignored where terrain (steep slopes) and land cover (built areas) are unsuitable for wildlife and their movement.

- *Multiple species:* Crossings should be designed and managed to accommodate multiple species and variable home range sizes. A range of wildlife crossing types and sizes should be provided at frequent intervals along with necessary microhabitat elements that enhance movement, e.g., root crowns for cover. Unlike the physical structure of wildlife crossings, microhabitat elements are movable and can be modified over time as conditions and species distributions change.

- *Adjacent land management:* How well a wildlife crossing structure performs is partly dependent upon the land management that surrounds them. Transportation and land management agencies need to coordinate in the short and long term to ensure that tracts of suitable habitat adjacent to the crossings facilitate movement to designated wildlife crossings.

- *Larger corridor network:* Wildlife crossings must connect to, and form an integral part of, a larger regional corridor network. They should not lead to "ecological dead-ends." The integrity and persistence of the larger corridor network is not the responsibility of the transportation agency, but that of neighboring land management agencies and municipalities.

These basic principles will help guide the determination of how many wildlife crossings may be necessary and how to locate them in order to get the greatest long-term conservation value. There is no simple formula to determine the recommended distance between wildlife crossings, as mentioned earlier each site is different. Planning will largely be landscape- and species-specific.

The spacing interval of some wildlife crossing projects designed for large mammals are found in Table 2. Listed are several large-scale mitigation projects in North America (existing and planned). The spacing interval varies from one wildlife crossing per 0.9 mi (1.5 km) to one crossing per 3.8 miles (6.0 km). The projects listed indicate that wildlife crossings are variably spaced but on average about 1.2 mi (1.9 km) apart.

Table 2. Average spacing interval per mile between wildlife crossings designed for large mammals at existing and planned transportation projects.

Number of crossings	Road length (km)	**Average Spacing/mile** (km)	Location (Reference)
17	17 (27)	**1 / 1.0** (1 / 1.6)	SR 260, Arizona USA (Dodd et al. 2007)
24	27 (45)	**1 / 1.2** (1 /1.9)	Trans-Canada Highway,[a] Banff, Alberta Canada (Clevenger et al. 2002)
8	7.5 (12)	**1 / 0.9** (1 / 1.5)	Trans-Canada Highway,[b] Banff, Alberta Canada (Parks Canada, unpubl. data)
32	32 (51)	**1 /1.0** (1 / 1.6)	Interstate 75, Florida USA (Foster and Humphries 1995)
42	56 (90)	**1 / 1.3**[c] (1 / 2.14)	US 93, Montana USA (Marshik et al. 2001)
16	15 (24)	**1 / 0.9** (1 / 1.5)	Interstate 90, Washington USA (Wagner 2005)
4	15 (24)	**1 / 3.8** (1 / 6.0)	US 93 Arizona USA (McKinney and Smith 2007)
82	45 (72)	**1 / 0.5**[c] (1 / 0.9)	A-52, Zamora Spain (Mata et al. 2005)

[a] Phase 1, 2 and 3A reconstruction.
[b] Phase 3B reconstruction.
[c] Includes crossings for small and large mammals.

GUIDELINES FOR THE SELECTION OF WILDLIFE CROSSINGS

Earlier, the 11 different wildlife crossing design types were introduced. Their intended use and function are each described below.

Wildlife Crossing Design Types (Appendix C, Hot Sheets 1-11)

Overpass Design

1. *Landscape bridge*—Designed exclusively for wildlife use. Due to their large size they are used by the greatest diversity of wildlife and can be adapted for amphibian and reptile passage.
2. *Wildlife overpass*—Smaller than landscape bridges, these overpass structures are designed exclusively to meet needs of a wide range of wildlife from small to large.
3. *Multi-use overpass*—Generally the smallest of the wildlife overpasses. Designed for mixed wildlife–human use. This wildlife crossing type is best adapted in human disturbed environments and will benefit generalist type species adapted to regular amounts of human activity and disturbance.
4. *Canopy crossing*—Designed exclusively for semi-arboreal and arboreal species that commonly use canopy cover for travel. Meets the needs of species not built for terrestrial travel and generally have difficulties crossing open, non-forested areas.

Underpass Design

5. *Viaduct or flyover*—The largest of underpass structures for wildlife use, but usually not built exclusively for wildlife movement. The large span and vertical clearance of viaducts allow for use by a wide range of wildlife. Structures can be adapted for amphibian and reptiles, semi-aquatic and semi-arboreal species.
6. *Large mammal underpass*—Not as large as most viaducts, but the largest of underpass structures designed specifically for wildlife use. Designed for large mammals but small- and medium-sized mammals use readily as well.
7. *Multi-use underpass*—Design similar to large mammal underpass, however management objective is co-use between wildlife and humans. Design is generally smaller than a large mammal underpass because of type of wildlife using the structures along with human use. These structures may not be adequate for all wildlife, but usually results in use by generalist species common in human-dominated environments (e.g., urban or peri-urban habitats). Large structures may be constructed to accommodate the need for more physical space for humans and habitat generalist species.
8. *Underpass with waterflow*—An underpass structure designed to accommodate the needs of moving water and wildlife. These underpass structures are frequently used by some large mammal species, but their use depends largely on how it is adapted for their specific crossing needs. Small- and medium-sized mammals generally utilize these structures, particularly if riparian habitat or cover is retained within the underpass.
9. *Small- to medium-sized mammal underpass*—One of the smaller wildlife crossing structures. Primarily designed for small- and medium-sized mammals, but species use will depend largely on how it may be adapted for their specific crossing needs.
10. *Modified culvert*—Crossing that is adaptively designed for use by small- and medium-sized wildlife associated with riparian habitats or irrigation canals. Adapted dry platforms or walkways can vary in design and typically constructed on the lateral interior walls of the culvert and above the high-water mark.
11. *Amphibian and reptile tunnels*—Crossing designed specifically for passage by amphibians and reptiles, although other small- and medium-sized vertebrates may use as well. Many different amphibian and reptile designs have been used to meet the specific requirements of each species or taxonomic group.

Determining the type of wildlife crossing structure most suitable for a given location will depend on several criteria. Selection begins by identifying a general wildlife crossing type that conforms to the wildlife habitat connectivity potential for the target species and topography of the site chosen. Figures 21, 22 and 23 can be used to guide the selection of wildlife crossing type based on the two main criteria—quality of wildlife habitat and topographical constraints.

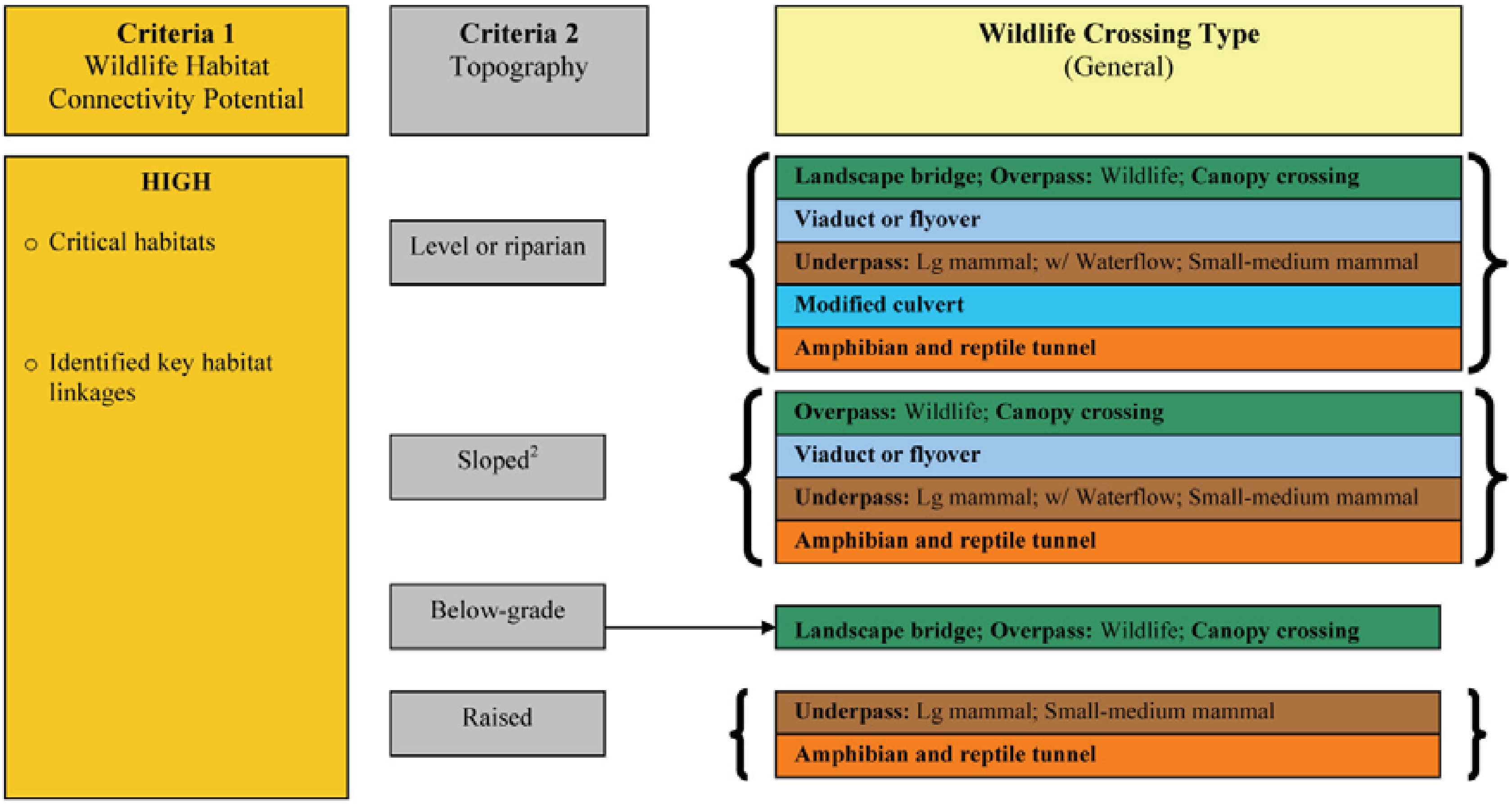


Figure 21. Chart. Criteria for selecting general wildlife crossing type where roads bisect habitats of high conservation value.

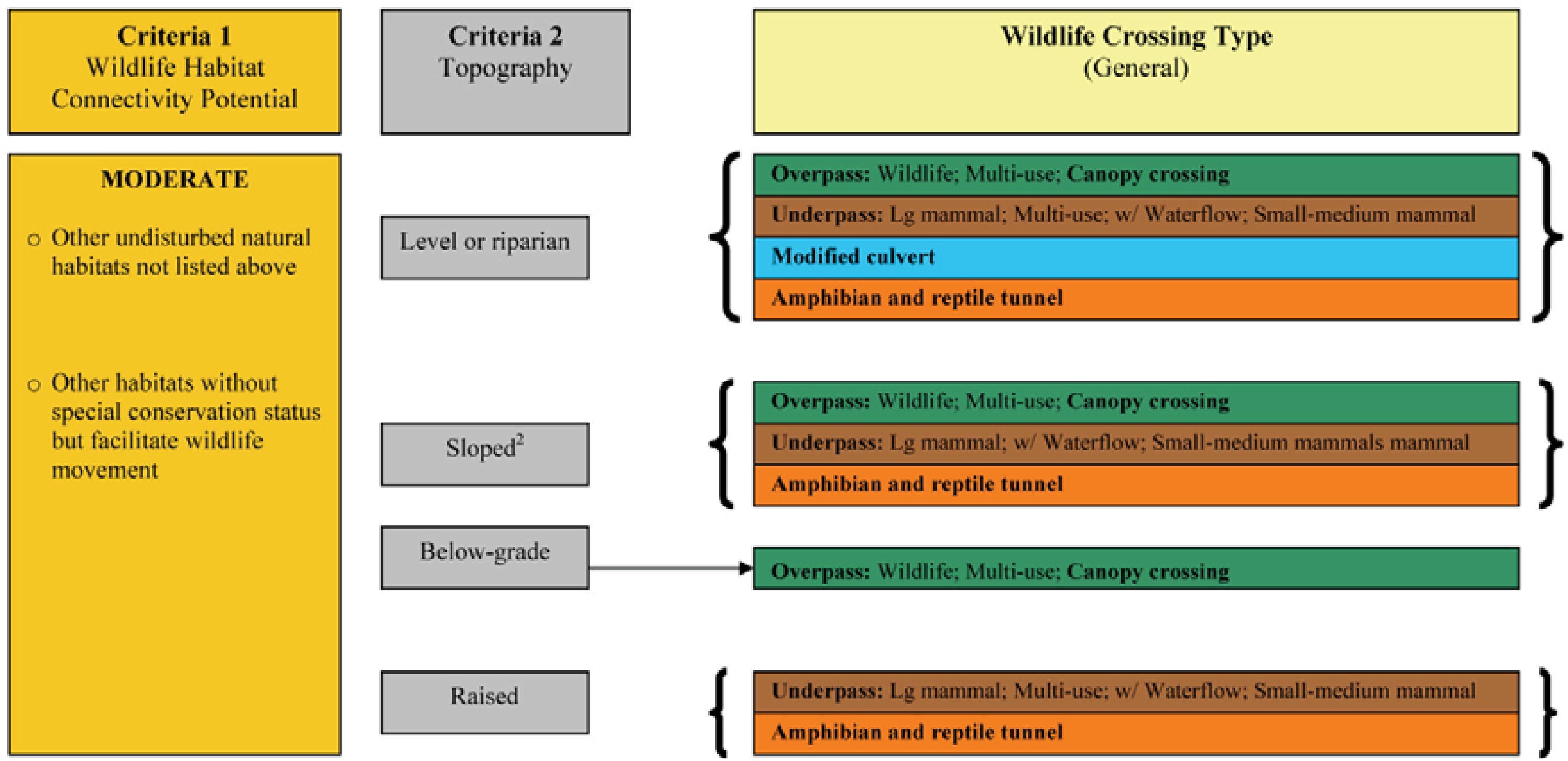


Figure 22. Chart. Criteria for selecting general wildlife crossing type where roads bisect habitats of moderate conservation value.

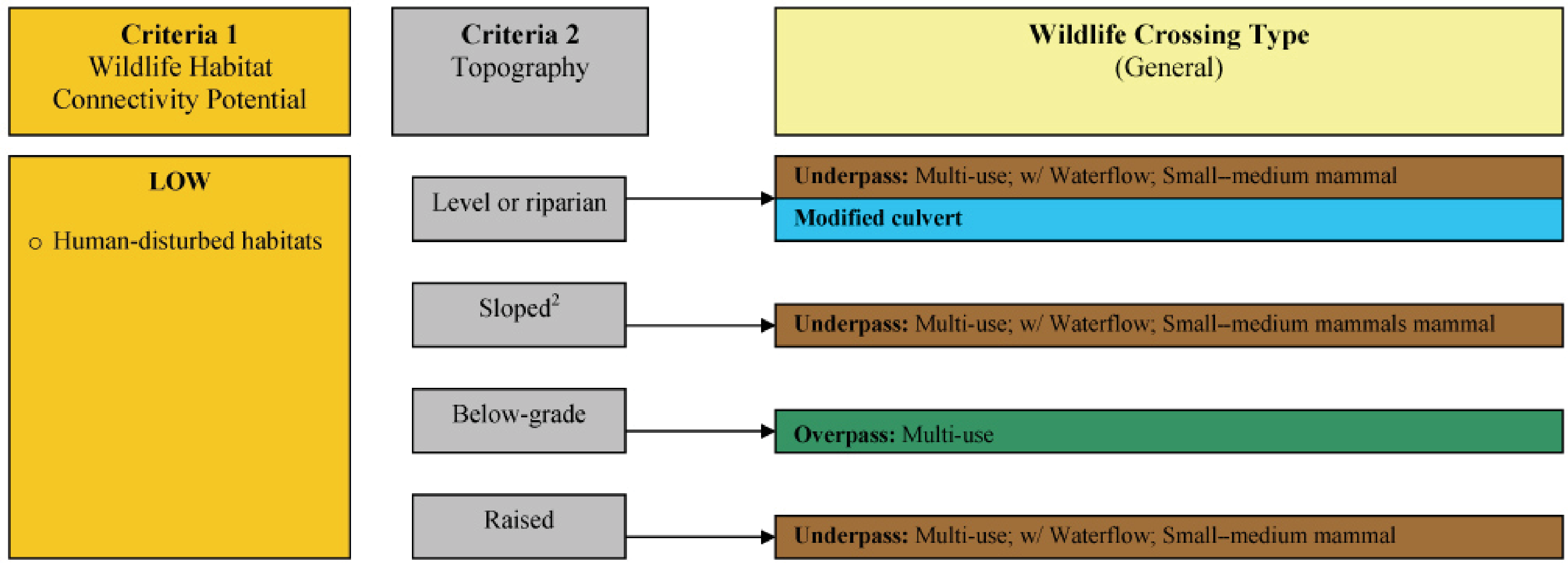


Figure 23. Chart. Criteria for selecting general wildlife crossing type where roads bisect habitats of low conservation value.

•

Wildlife Habitat Connectivity Potential

Wildlife habitat connectivity potential can be grouped into three categories:

- *High potential*—Sites that occupy high quality or critical habitats for wildlife and/or are identified as key habitat linkages to facilitate movement of wildlife at a local or regional scale.

  Associated wildlife crossing types: These are prime areas for wildlife habitat connectivity. Mixed-used (multi-use with humans) wildlife crossings should not be used.

- *Moderate potential*—Relatively intact or undisturbed habitats, but not considered critical wildlife habitat, such as: (a) habitats that lack special conservation value or designation but are suitable for moving wildlife, and (b) habitats that may not be suitable at present but future restoration is planned.

  Associated wildlife crossing types: In these areas mixed-use wildlife crossings become an option, but landscape bridges and viaducts or flyovers should not be built.

- Low potential—Habitats with human disturbance or regular human activity.

  Associated wildlife crossing types: These areas are low potential for wildlife habitat connectivity; overpass structures designed specifically for wildlife are not recommended. However, underpasses adapted for wildlife use (wildlife underpasses with waterflow, modified culverts) and mixed-use and specialized smaller crossing types (small- to medium-sized mammal underpass; amphibian and reptile tunnels) are suggested options.

Topography

Topography strongly influences what type of wildlife crossing can be built at each location. The proximity to water (lakes, ponds, rivers, streams) is another factor, as is the water table at the location, but these factors will not be discussed here. Four general topographies have been identified where wildlife crossings may be constructed on roadways as sketched in Figure 24.

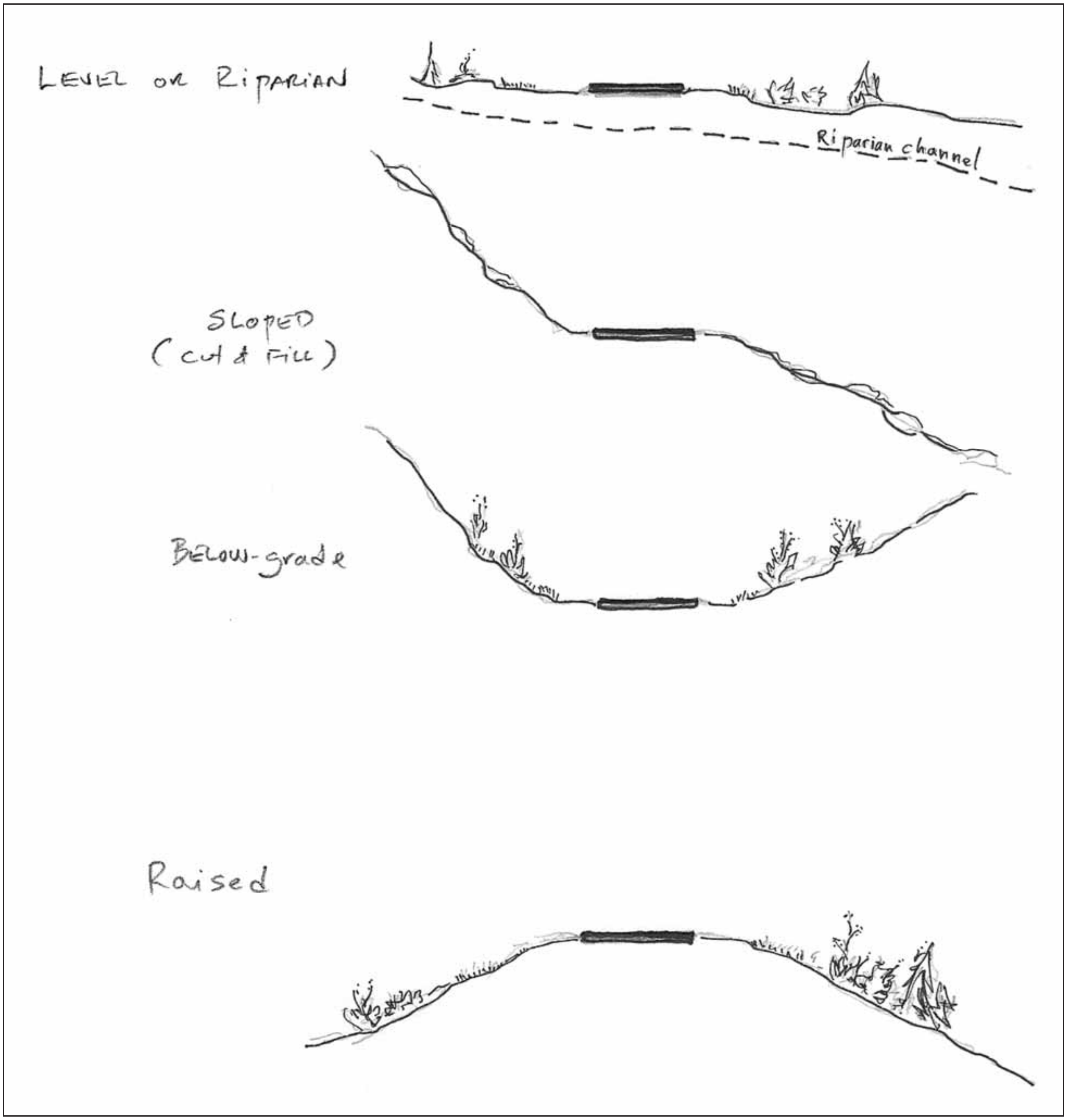


Figure 24. Schematic. Four general types of topography where wildlife crossings maybe constructed on roadways (Credit: Tony Clevenger).

- *Level or riparian*—Sections of road and rights-of-way that traverse level terrain or cross over riparian habitats and drainages.

  Associated wildlife crossing types: Most wildlife crossing types can be constructed in these areas. Some may require raising the road grade to obtain elevation necessary at the crossing site for underpass or lower the road below grade and excavate to allow the overpass design to fit into the local terrain.

- *Sloped*—Road sections on cut-and-fill slopes.

  Associated wildlife crossing types: Road sections on sloped terrain (cut-and-fill) make it difficult to construct overpass designs and canals–adapted design.

- *Below-grade*—Roads that are in cut sections and well below grade level.

  Associated wildlife crossing types: These areas are best suited for overpass structures (landscape connectors, overpasses, canopy crossings) given the ease of construction having embankments and natural support on one or both sides of the highway.

- *Raised*—Road sections built on fill and are elevated compared to adjacent terrain including rights-of-way.

  Associated wildlife crossing types: Raised sections of road are ideal for all underpass structures. Today, small tunnel-boring machines can perforate roadbeds of two-lane roads making underpasses for small- and medium-sized mammals and amphibian and reptile tunnels an option.

WILDLIFE SPECIES GROUPS AND CROSSING STRUCTURE CLASSIFICATION

Planning and designing wildlife crossings will often be focused on a certain species of conservation interest (e.g., threatened or endangered species), a specific species group (e.g., amphibians) or abundant species that pose a threat to motorist safety (e.g., Deer, Elk).

In this handbook we refer to North American wildlife and species groups when discussing the appropriate wildlife crossing designs. The eight groups mentioned below are general in composition. However, recommendations will be provided, if it is available, for species-specific design requirements (Appendix C, Hot Sheets 1-11). Their ecological requirements and how roads affect them are described along with some sample wildlife species for each group.

1. Large mammals (*ungulates* [Deer, Elk, Moose, Pronghorn], *carnivores* [Bears, Wolves]) – Species with large area requirements and potential migratory behavior; large enough to be a motorist safety concern; traffic-related mortality may cause substantial impacts to local populations; susceptible to habitat fragmentation by roads.

2. High mobility medium-sized mammals (*Bobcat, Fisher, Coyote, Fox*) – Species that range widely; fragmentation effects of roads may impact local populations.

3. Low mobility medium-sized mammals (*Raccoon, Skunk, Hare, Groundhog*) – Species with smaller area requirements; common road-related mortality; relatively abundant populations.

4. Semi-arboreal mammals (*Marten, Red Squirrel, Flying Squirrel*) – Species that are dependent on forested habitats for movement and meeting life requisites; common road-related mortality.

5. Semi-aquatic mammals (*River Otter, Mink, Muskrat*) – Species that are associated with riparian habitats for movement and life requisites; common road-related mortality.

6. Small mammals (*Ground Squirrels, Voles, Mice*) – Species that are common road-related mortality; relatively abundant populations.

7. Amphibians (*Frogs, Toads, Salamanders, Turtles*) – Species with special habitat requirement; relatively abundant populations at the local scale; populations are highly susceptible to road mortality.

8. Reptiles (*Snakes,Llizards*) – Species with special habitat requirement; road environment tends to attract individuals; relatively abundant populations.

DESIGN AND DIMENSIONS

General Design Specifications For Wildlife Species

- As a rule, wildlife crossings should be designed so they allow for movement of the greatest diversity of wildlife species or taxa possible. The diversity of taxa will strongly depend on location and adjacent land use and conservation status. Wildlife species groups and taxa can be associated with different structure types based on general design and dimensions as shown in Tables 3 and 4. Length, width and height of crossings are shown in Figures 25 and 26.

Table 3. General guidelines for minimum and recommended dimensions of wildlife overpass designs.

Type	Usage	Species & Groups	Dimensions Minimum	Dimensions Recommended
Landscape bridge	Wildlife only	All wildlife species Amphibians (if adapted)	**W: 230 ft** (70 m)	**W: >330 ft** (>100 m)
Wildlife overpass	Wildlife only	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Reptiles Amphibians (if adapted)	**W: 130–165 ft** (40–50 m)	**W: 165–230 ft** (50–70 m)
Multi-use overpass	Mixed use: Wildlife & Human activities	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Amphibians (if adapted) Reptiles	**W: 32 ft** (10 m)	**W: 50–130 ft** (15–40 m)
Canopy crossing	Wildlife only	Semi-arboreal mammals	—	—

Table 4. General guidelines for minimum and recommended dimensions of wildlife underpass designs.

Type	Usage	Species groups	Dimensions: Minimum	Dimensions: Recommended
Viaduct or flyover	Multi-purpose	All wildlife species	*There are no minimum dimensions. Structures are generally larger than the largest wildlife underpass structures*	*There are no recommended dimensions. Structures are generally larger than the largest wildlife underpass structures*
Large mammal underpass	Wildlife only	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Semi-arboreal & semi-aquatic mammals (adapted) Small mammals Amphibians (adapted) Reptiles	**W: 23 ft** (7 m) **Ht: 13 ft** (4 m)	**W: >32 ft** (>10 m) **Ht: >13 ft** (>4 m)
Multi-use underpass	Mixed use: Wildlife & Human activities	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Semi-arboreal & semi-aquatic mammals (adapted) Small mammals Amphibians (adapted) Reptiles	**W: 16.5 ft** (5 m) **Ht: 8.2 ft** (2.5 m)	**W: >23 ft** (>7 m) **Ht: >11.5 ft** (>3.5 m)

Underpass with waterflow	Wildlife and drainage	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Semi-arboreal mammals (adapted) Semi-aquatic mammals Small mammals & amphibians Semi-arboreal mammals & reptiles (adapted)	**W*: 6.5 ft path** (2 m) **Ht: 10 ft** (3 m) **Width will be dependent on width of hydrologic channel in crossing*	**W*: >10 ft path** (>3 m) **Ht: >13 ft** (>4 m) **Width will be dependent on width of hydrologic channel in crossing*
Small to medium-sized mammal underpass	Wildlife and seasonal drainage	High-mobility medium-sized mammals (adapted) Low mobility medium-sized mammals Semi-aquatic mammals (adapted) Small mammals Amphibians (adapted) Reptiles	**Same as recommended dimensions** *Size selection is based on the target species needs or connectivity objective at the site.*	**W: 1-4 ft** (0.3–1.2 m) **Ht: 1-4 ft** (0.3–1.2 m) OR **1 – 4 ft diameter** (0.3–1.2 m)
Modified culvert	Wildlife and drainage	High-mobility medium-sized mammals (adapted) Low mobility medium-sized mammals Semi-aquatic mammals Small mammals Reptiles (adapted) Amphibians	**W: 1.5 ft** (0.5 m) **Clearance: >3 ft** (>1 m)	**W: >3 ft** (>1 m) **Clearance: >4 ft** (>1.5 m)
Amphibian and reptile tunnel	Wildlife only	Amphibians Low mobility medium-sized mammals (adapted) Semi-aquatic (adapted) Small mammals & reptiles (adapted)	*Dimensions vary depending on target species or taxa or local conditions. Tunnels range from 1–3 ft (0.35–1 m) in diameter*	*Dimensions vary depending on target species or taxa or local conditions. Tunnels range from 1–3 ft (0.35–1 m) in diameter*

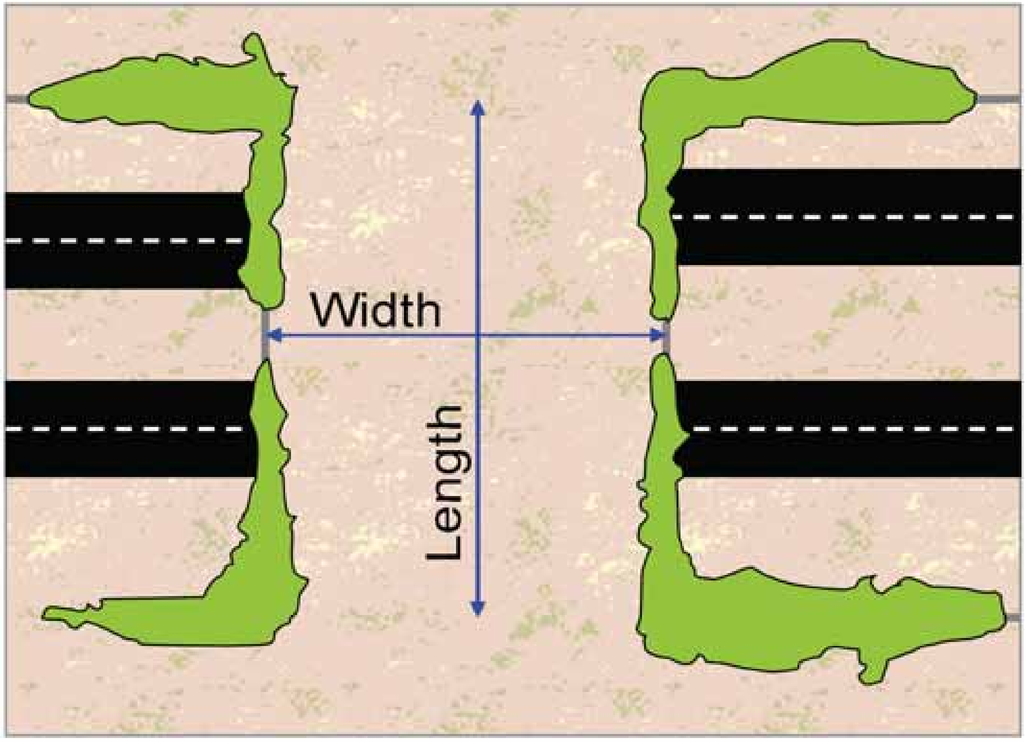


Figure 25. Schematic. Length and width measurements of wildlife overpass (Credit: Tony Clevenger).

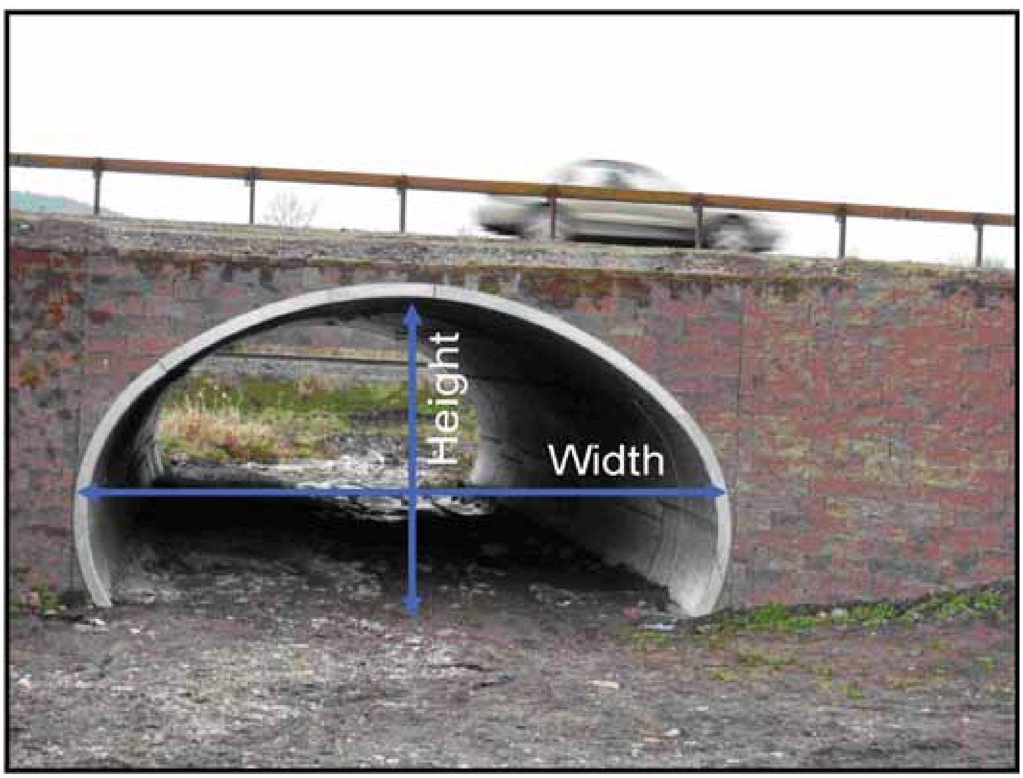


Figure 26. Photo. Width and height measurements of wildlife underpass structure (Credit: Marcel Huijser/WTI).

- Divided vs. undivided highways: Divided highways contain a central median and consist of two separate physical structures; one for each direction of traffic. Undivided highways have traffic lanes bundled and consist of one physical crossing structure. Although crossing structures on undivided highways have less daytime light than those with a central median, the open median generally has higher traffic noise levels. Crossing structures on undivided highways are shorter in length compared to structures on divided highways and have lower noise levels. We recommend that a shorter structure, with less daytime light and lower noise levels will be more effective than crossing structures designed on divided highways. This recommendation is based primarily on structure length and traffic noise levels. The amount of light an underpass receives is not an important factor on which to base crossing structure design when a large part of wildlife movement typically occurs during nighttime hours.

- Normally, wildlife crossings are not be greater than 230–260 ft (70–80 m) in length except in special situations such as spanning ≥6-lane highways or spanning highways in addition to other types of infrastructure, for example, frontage roads and railway line as Figure 27 shows.

Figure 27. Photo. Most wildlife overpasses or landscape bridges are less than 70-80 m long; however, the one shown above near Hilversum, The Netherlands, is 800 m long and spans two roads and a railroad. (Credit: Goois Natuurreservaat, The Netherlands/Photo: W. Metz).

- The recommended and minimum dimensions for each of the 11 wildlife crossing types are provided below. The measurements are for crossing structures designed for 4-lane highways. The guidelines should be followed if the crossings are at minimum to allow for the simplest and most basic connectivity requirement of crossings structures, i.e., the exchange of individuals within populations. Crossings designed for exchange of individuals may not allow for normal demographic processes, thus allowing passage use by few individuals and biased towards male movement. Both genders need to mix freely across the highway for wildlife crossings to perform effectively, and monitoring should be able to document that.

- Follow-up monitoring is discussed in the following chapter, but should determine whether the basic functions of wildlife crossings are being met and provide demographic information on the number of individuals using the crossing structure and their gender. Whether the crossings are functional for local populations affected by a highway will depend largely on how well the structure is planned and designed to integrate species' biological needs with the larger landscape and ecological context in which it is placed.

Specific Design of Wildlife Crossings and Adjacent Habitat

The dimensions shown earlier in Tables 3 and 4 are meant to serve as a general guideline when planning and designing for species groups or taxa. However, oftentimes project objectives are species-specific and design must be customized to their needs.

Our monitoring and research of crossing structures in North American during the last 10 years has yielded valuable information on design needs of a variety of wildlife species. Research results were published in scientific journals and internal agency reports. In Table 5 we synthesized the research results to determine the suitability of the 11 crossing structure types for the most common wildlife species or taxonomic groups in North America. We list 26 wildlife species or taxa and we categorize the suitability of each of the 11 crossing design types for each species as follows:

- Recommended/Optimum solution
- Possible – if adapted to local conditions
- Not recommended
- Unknown – more data are required
- Not applicable

Table 5. Suitability of wildlife crossing design types from Appendix C, Hot Sheets 1-11 for distinct wildlife species and taxa.

	Landscape bridge (Sheet 1)	Wildlife overpass (Sheet 2)	Multi-use overpass (Sheet 3)	Canopy crossing (Sheet 4)	Viaduct or flyover (Sheet 5)	Large mammal underpass (Sheet 6)	Multi-use underpass (Sheet 7)	Underpass with waterflow (Sheet 8)	Small- to medium-sized mammal underpass (Sheet 9)	Modified culvert design (Sheet 10)	Amphibian and reptile tunnel (Sheet 11)
Ungulates											
Moose	●	●	⊗	—	●	⊙	⊗	⊙	⊗	⊗	—
Elk	●	●	●	—	●	●	●	●	⊗	⊗	—
Deer sp.	●	●	●	—	●	●	●	●	⊗	⊗	—
Pronghorn	●	●	⊗	—	●	?	⊗	⊙	⊗	⊗	—
Bighorn sheep	●	●	⊗	—	●	⊙	⊗	⊙	⊗	⊗	—
Mountain goat	●	●	⊗	—	●	⊙	⊗	⊙	⊗	⊗	—
Carnivores											
Black bear	●	●	⊗	—	●	●	⊗	●	⊗	⊗	—
Grizzly bear	●	●	⊗	—	●	⊙	⊗	⊙	⊗	⊗	—
Wolf	●	●	⊗	—	●	⊙	⊗	⊙	⊗	⊗	—
Coyote	●	●	●	—	●	●	●	●	●	⊙	—
Fox1 (*V vulpes, Urocyon*)	●	●	●	—	●	●	●	●	●	⊙	—
Fox2 (*V macrotis, V velox*)	●	●	●	—	●	⊙	⊙	⊙	⊙	⊙	—
Cougar	●	●	⊗	—	●	●	⊗	●	⊗	⊗	—
Bobcat	●	●	●	—	●	●	●	●	⊗	⊙	—
Lynx	●	●	⊗	—	●	?	⊗	?	⊗	⊗	—
Wolverine	●	●	⊗	—	●	?	⊗	?	⊗	⊗	—

Fisher	●	●	●	●	●	⦿	●	⦿	●	●	—
Marten	●	●	●	●	●	⦿	●	⦿	●	●	—
Weasel	●	●	●	—	●	⦿	●	⦿	●	●	—
Badger	●	●	●	—	●	⦿	●	⦿	●	⊗	—
Low mobility medium	●	●	●	—	●	●	●	●	●	●	⦿
Semi-arboreal mammals	⦿	⦿	⦿	●	⦿	⦿	⦿	⦿	⊗	⊗	⊗
Semi-aquatic mammals	⦿	⦿	⦿	—	⦿	⦿	⦿	●	⦿	●	⦿
Small mammals	●	●	●	⦿	●	●	●	●	●	●	⦿
Amphibians	⦿	⦿	⦿	—	⦿	⦿	⦿	⦿	⦿	●	●
Reptiles	●	●	●	—	●	●	●	⦿	●	●	⦿

● Recommended/Optimum solution; ⦿ Possible if adapted to local conditions; ⊗ Not recommended; ? Unknown, more data are required;
— Not applicable

OPENNESS?

$$\frac{\textit{Height} \times \textit{Width}}{\textit{Length}}$$

The measure of *openness* was used early on to describe and measure the stimulus of a given underpass to approaching Deer, by calculating the above formula. The thought was that, in theory, an underpass could be so long and confining that it could preclude Deer use[1] and that Deer prefer underpasses with a clear view of the horizon. Since then, openness has been used on many occasions in planning the design of wildlife underpasses and researching their effectiveness. Openness has gained popularity, likely due to its ease and assumed validity based on a simple metric or "magic number." Engineers, planners and biologists alike tend to aim for the magical openness measure and expect performance without much critical thought of other factors (structural and environmental) that might influence performance. However the relationship between openness and underpass performance may be species-specific and time dependent.

An *openness index* combines underpass width, height, and length. Problems have been identified with its use such as inconsistent use of metric vs. Imperial units, as well as a changing understanding of how openness is measured—as an index, a ratio, or simply a state or concept. Further, underpasses are not always rectilinear, but can be arched, circular or elliptical. There is no guidance regarding how different shaped underpass designs may affect the openness index. As mentioned, the index may be metric or in Imperial measure and can be confused. Some suggested "minimum" openness indices have ranged from 0.6 (metric) for Mule Deer and 0.75 (metric) for Roe Deer and 1.5 (metric) for Red Deer (Elk). Like other roadway geometric design components, designing for the "minimum" is not recommended or appropriate in most cases. However, despite the appeal and popularity of openness indices, there has never been a critical evaluation of the measure for designing wildlife underpasses. There is no recognized guidance on use other than the absolute values that have been bounced around in the grey and published literature.

The validity of using openness as a proven and reliable measure in planning and designing wildlife underpasses is questionable. Openness has been found to be highly correlated to underpass length. Similarly the three main underpass structural measures (length, width, height) exhibit multicollinearity—i.e., they tend to be redundant and highly correlated with one another. We DO NOT recommend the use of the openness index in planning and designing wildlife crossings due to the reasons stated above. We DO recommend the use of underpass measures (length, width, height) in conjunction with other structural (divided vs. undivided highway configurations) and environmental (habitat quality, target species, etc.) factors when designing wildlife crossing structures.

[1] Reed, D. F., A. L. Ward. 1985. Efficacy of methods advocated to reduce deer–vehicle accidents: research and rationale in the USA. Pages 285–293 in *Routes et faune sauvage*. Service d'Etudes Techniques de Routes et Autoroutes, Bagneaux, France.

Detailed design information for the 26 species and 11 crossing structure types are found in Appendix C, Hot Sheets 1-11.

Hot Sheets 1-11 – Wildlife Crossing Prescriptions (Appendix C)

The Hot Sheets are a guide for the general design, basic building prescriptions, landscaping, possible design variations, and maintenance of each of the 11 crossing structure types. Being a logical endpoint for this chapter, by starting broadly and progressively narrowing the taxonomic focus, the Hot Sheets provide the most detailed design guidelines for the 26 wildlife species and taxa in North America.

Hot Sheets 12-14 – Fencing and Gate Guidelines (Appendix C)

Fencing is a key part of a mitigation plan involving wildlife crossings. Hot Sheets 12-14 provide details on fence configurations, construction specifics, design alternatives and maintenance.

Fences and wildlife crossings have been around many years, however, relatively little is known about effective fence designs and other innovative solutions to keep wildlife away from roads and traffic.

Small- and medium-sized mammals can pass through most fence types for large mammals. Different fencing types and designs are needed to keep these smaller animals from reaching roads (Hot Sheet 13).

When wildlife become trapped inside fenced areas measures need to be in place to allow them to safely exit the right-of-way. Steel swing gates, hinged metal doors or earthen ramps or jump-outs are some commonly used methods (Hot Sheet 14).

SUGGESTED READING

Bissonette, J.A. 2007. *Evaluation of the use and effectiveness of wildlife crossings*. National Cooperative Highway Research Program (NCHRP) 25-27 final report. Transportation Research Board, Washington DC.

Clevenger, A.P. & Waltho, N. 2000 Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. *Conservation Biology*, 14, 47-56.

Clevenger, A.P. & N. Waltho. 2005. Performance indices to identify attributes of highway crossing structures facilitating movement of large mammals. *Biological Conservation* 121:453-464.

Dodd, C.K., W.J. Barichivich, and L.L. Smith. 2004. Effectiveness of a barrier wall and culverts in reducing wildlife mortality on a heavily traveled highway in Florida. *Biological Conservation* 118, 619-631.

Dodd, N., J. Gagnon, S. Boe, A. Manzo and R. Schweinsburg. 2007. *Evaluation of measures to minimize wildlife–vehicle collisions and maintain permeability across highways: Arizona Route 260*. Final report prepared for Arizona Department of Transportation, Phoenix, Arizona.

Forman, R.T.T., Sperling, D., Bissonette, J., Clevenger, A., Cutshall, C., Dale, V., Fahrig, L., France, R., Goldman, C., Heanue, K., Jones, J., Swanson, F., Turrentine, T. & Winter, T. 2003. *Road ecology: Science and solutions*. Island Press, Washington, D.C.

Huijser, M.P., P. McGowen, J. Fuller, A. Hardy, A. Kociolek, A.P. Clevenger, D. Smith and R. Ament. 2007. *Wildlife–vehicle collision reduction study*. Report to US Congress. U.S. Department of Transportation, Federal Highway Administration, Washington D.C.

Iuell, B. (ed.). 2005. *Wildlife and traffic: A European handbook for identifying conflicts and designing solutions.* KNNV Publishers, Utrecht, The Netherlands.

Langton, T.E.S. (Ed.). 1989. *Amphibians and roads*. ACO Polymer Products Ltd., Bedfordshire, England. 199 pages.

Lebarrères, D., T. Lodé, and J. Merilä. 2003. What type of amphibian tunnel could reduce road kills? *Oryx* 38, 220-223.

MacKenzie, D.I., J.D. Nichols, J.A. Royale, K.H. Pollock, L.L. Bailey, J.E. Hines. 2006. *Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence*. Academic Press, New York, NY.

Ministerio de Medio Ambiente. 2006. *Prescripciones técnicas para el diseño de pasos de fauna y vallados perimetrales. Documentos para la reducción de la fragmentación de hábitats causada por infraestructura de transporte*. Parques Nacionales. Ministerio de Medio Ambiente. Madrid, Spain. 112pp.

CHAPTER 5 – MONITORING TECHNIQUES, DATA INTERPRETATION, AND EVALUATIONS

CONSERVATION VALUE OF WILDLIFE CROSSINGS

Some basic rules about monitoring the function of wildlife crossings and assessing their conservation value were provided in Forman et al. (2003). The criteria used to measure their function or conservation value, however, will depend on the intended purpose of the wildlife crossings, the taxa of interest and the biological level of organization most relevant to monitoring and research goals.

Monitoring needs to be an integral part of a highway mitigation project, even long after the measures have been in place. Mitigation is costly, generally requiring a large investment of public funds. Post-construction evaluations are not only necessary but also a judicious use of public infrastructure funds and can help agencies save money in future projects (see Adaptive Management below).

Monitoring and research can range from a simple, single-species population within the highway corridor to more complex ecological processes and functions within regional landscapes of conservation importance.

Wildlife crossing structures are, in essence, site-specific movement corridors strategically placed over highways that bisect important wildlife habitat as Figure 28 shows. Like wildlife corridors, crossing structures should allow for the following five biological functions:

1. Reduced mortality and increased movement (genetic interchange) within populations;

2. Meeting biological requirements such as finding food, cover and mates;

3. Dispersal from maternal or natal ranges and recolonization after long absences;

4. Redistribution of populations in response to environmental changes and natural disturbances (e.g., fire, drought); movement or migration during stressful years of low reproduction or survival; and

5. Long term maintenance of metapopulations, community stability, and ecosystem processes.

These functions encompass three levels of biological organization—genes, species/population, community/ecosystem—which form the basis for developing natural resource management and conservation plans.

From these five functions it is possible to set performance objectives, determine best methods to monitor, develop study designs, and resolve the management questions associated with the project objectives.

Figure 28. Photo. Crossing structures are site-specific movement corridors that link wildlife habitat separated by pavement and high-speed vehicles (Credit: Jeff Stetz).

Note that these functions increase both in complexity and in the cost and time required to properly monitor whether they are being facilitated as shown in Table 6. Not all ecological functions may be of management concern for transportation agencies, particularly those at the more complex end of the scale; however, they will be of concern for land and natural resource management agencies.

Simple and low-cost techniques using remote cameras can be used to detect animals using wildlife crossing structures, i.e., level 1 - *genes*. However, information about numbers of distinct individuals, their gender and genetic relationships cannot be reliably obtained using remote cameras.

A non-invasive genetic sampling method was used to assess population-level benefits (level 2 – *species/populations*, Table 6) of 20 wildlife crossings on the Trans-Canada Highway in Banff National Park, Alberta (see Appendix E, Figures 78 and 79; Clevenger and Sawaya 2009).

LEVELS OF BIOLOGICAL ORGANIZATION AND ROAD IMPACTS

A recent U.S. National Academies report on assessing and managing the impacts of roads recommended using the three levels of biological organization as a framework to design future research to assess the ecological effects of paved roads (NRC 2005).

Table 6. Levels of conservation value for wildlife crossing systems as measured by ecosystem function achieved, level of biological organization targeted, type of connectivity potential, and cost and duration of research required to evaluate status.

Level	Ecosystem Function (simple to complex)	Level of Biological Organization[a]	Level of Connectivity[b]	Cost and Duration of Research[c]
1a	Movement within populations and genetic interchange	Genetic	Genetic	Low cost – Short term
1b	Reduced mortality due to roads	Genetic & Species/population	Genetic & Species/population	Low cost – Short term
2	Ensure that the biological requirements of finding food, cover and mates	Species/population	Demographic	Moderate-to-High cost – Long term
3	Dispersal from maternal ranges and recolonization after long absences	Species/population	Functional	Moderate-to-High cost – Long term
4	Populations to move in response to environmental changes and natural disasters;	Ecosystem/community	Functional	High cost – Long term
5	Long term maintenance of metapopulations, community stability, and ecosystem processes	Ecosystem/community	Functional	High cost – Long term

[a] See Noss 1990, Redford and Richter 1999.
[b] Genetic: Predominantly adult male movement across road barriers; Demographic: Genetic connectivity with confirmed adult female movement across road barriers; Functional: Genetic and demographic connectivity with confirmed dispersal of young females that survive and reproduce.
[c] Based on studies of large mammals. Cost and duration will largely be dependent upon area requirements, population densities, and demographics.

AN APPROACH FOR MONITORING IMPACTS

Roads and traffic affect wildlife at multiple levels of biological organization: therefore different management questions require different types of research and mitigation measures. Certain questions can be "big" or general and may require answers from multiple scales and perspectives. However, big picture research is not necessarily general in nature. General principles have to be well founded, and they are often based on thorough studies of the life histories of wildlife species.

This hierarchical approach covers the entire biological spectrum from genes on up to higher levels of communities and ecosystems. It is well suited to answering most transportation and natural resource agency management needs of reducing road impacts on wildlife populations. It can provide guidelines and decision support regarding the monitoring and evaluation of wildlife crossings.

Another value of the hierarchy approach is the recognition that effects of roads and traffic can reverberate through other levels, often in unpredictable ways, as secondary and cumulative effects. Specific indicators can be identified at multiple levels of organization to monitor and assess the performance of mitigation designed to reduce road-related mortality, and restore movements and interchange within populations.

MONITORING AND ASSESSMENT GUIDELINES

The guidelines below are designed for monitoring plans evaluating the conservation value and efficacy of wildlife crossings. This framework can be used to formulate management questions, select methodologies, and design studies to measure performance of wildlife crossings in mitigating road impacts.

1. *Establish goals and objectives.* What are the mitigation goals? Generally the goals are to reduce wildlife–vehicle collisions and/or reduce barrier effects to movement and maintain genetic interchange.
2. *Establish baseline conditions.* Determine the extent, distribution and intensity of road and traffic impacts to wildlife in the area of concern. The impacts may consist of mortality, habitat fragmentation (reduced movements) or some combination thereof. In most cases, the conditions occurring pre-mitigation will comprise the baseline or control.
3. *Identify specific management questions to be answered by monitoring.* These questions will be formulated from the goals and objectives identified in Step 1 and conditions identified in Step 2. Some questions might include:
   - Is road-related mortality increasing or decreasing as a result of the mitigation measures?
   - Is animal movement across the road increasing or decreasing?
   - Are animals able to disperse and are populations able to carry out migratory movements?

Before starting a monitoring program, specific benchmarks and thresholds should be agreed upon that trigger management actions. For example, >50% reduction in road-kill would be acceptable, but <50% reduction would trigger additional management actions to improve mitigation performance. Normally a power analysis is also performed to determine if these reductions can actually be detected (see below).

4. *Select indicators.* Identify indicators at the appropriate level(s) of biological organization (i.e., genes, species/population, and community/ecosystem) that correspond to the specific goals and objectives identified in Step 1 and the questions developed in Step 3. For example:
   - Gene flow and genetic structure may indicate whether exchange of genes (i.e., breeding or movement of individuals) occurs across the highway;
   - Population distribution, abundance and within-population movement data, as well as demographic processes such as dispersal, fecundity, survivorship, and mortality rates, may permit the assessment of species or population-level connectivity; and
   - Herbivory and predation rates may indicate whether exchange across highways contributes to more stable ecosystem processes and community dynamics.
5. *Identify control and treatment areas.* If pre-mitigation data are available, then indicator response in adjacent "control" areas may be compared with treatment areas—i.e., road sections with wildlife crossings. It will be important to control for differences in habitat type and population abundance between treatment and control areas. Therefore controls and treatments should comprise similar habitats, and some means of obtaining population abundance indices to control for confounding effects should be used.
6. *Design and implement a monitoring plan.* Apply principles of experimental design to select sites for monitoring the identified goals and objectives from Step 1 and questions in Step 3. Although treatments and controls should ideally be replicated, this may not always be possible.
7. *Validate relationships between indicators and benchmarks.* Research carried out over the short and long term will be needed to determine whether the selected indicators are meeting the management goals and objectives.

SETTING MONITORING AND PERFORMANCE TARGETS

Developing Performance Targets – Who Defines Them?

Few studies have rigorously monitored and researched the performance of highway mitigation measures using study designs with high inferential strength. For some agencies, monitoring has not been a priority, much less research—if circumstantial evidence suggested that animals appeared to use wildlife crossings, then they were deemed effective.

One of the difficulties in developing performance targets is agreeing on what defines a "reduction" in wildlife–vehicle collisions and an "increase" in landscape connectivity or animal movements across a highway. Transportation agencies tend to have relatively relaxed targets or expectations for how well crossing structures perform. In contrast, resource and land management agencies generally require more science-based evidence that wildlife crossings or other measures result in positive changes to wildlife movements and regional population connectivity.

Reliably Detecting Change in Target Parameters

A decrease in road-related mortality and an increase in the frequency of highway crossings by focal species may generally be considered performance targets for mitigation efforts. Broad definitions such as these can be used to measure the effectiveness of mitigation measures and whether targets are being met.

However, properly designed monitoring programs with research-specific study designs and predefined performance targets will have the greatest ability to evaluate whether mitigation efforts are meeting their targets (Appendix D).

Developing Consensus-Based Performance Targets

The lead agency and other stakeholders need to know how their mitigation investment dollars are being spent and how the technology can be transferred to future projects. Taxpayers will also want to know whether the measures are effective.

Targets designed to evaluate whether the amount of observed change is acceptable should be determined *a priori* by the transportation agency responsible for the project with the concerns of the natural resource management agency and other project stakeholders in mind.
The agreed-upon targets need to be scientifically defensible. Without specific targets and a means to track performance, transportation and resource management agencies can come under scrutiny for not having objectively defined targets or performance standards.

Because landscape conditions and population dynamics vary over time, short- and long-term monitoring and performance targets should be assessed periodically and readjusted accordingly.

FOCAL SPECIES

All species from a project area cannot be monitored. The selection of focal species should result in monitoring data that will be most relevant to either the greatest number of species in the area, or to those species that are the most sensitive to the process being monitored, e.g., ability to cross highways. Table 7 provides some criteria to help guide the selection of focal species.

Selected focal species are indicators of changes—positive or negative—that result from efforts to mitigate road impacts in the project corridor.

The selected survey methods should permit the collection of data from a large number of species—e.g., most medium and large mammals. Rigorous evaluation of these data will, however, be limited to those species that generate sufficient amounts of data for statistical analyses and inference. In these cases, focal species will not be identified until pre-mitigation population surveys have begun or pilot data is collected in the project area.

Another consideration is how monitoring focal species can translate into direct management benefits and support from outside the project as shown in Table 7. Some wildlife species may resonate with the public and information about them may help generate support for the project. While this is a secondary criterion, it is important to consider in the selection process.

Table 7. Guide to selecting focal species based on monitoring criteria and ecosystem context.

1. Monitoring	
Primary Criteria	
Ecological Attributes	Which focal species will serve as the best indicators of change and maintenance of ecological processes?
Sample Size Requirements	Which focal species will provide large enough datasets to permit sufficiently accurate and precise analyses for the monitoring needs?
Secondary Criteria	
Benefits to Management	Will the information acquired from monitoring the selected focal species provide benefits to (a) local management (e.g., DOT, land management agency) and/or (b) management elsewhere, such that it will have broader research application (e.g., significant contribution to knowledge base and science of road ecology)?
Public Profile and Support	Is at least a subset of the selected focal species high-profile and charismatic such that they resonate with the general public and help to gain public and private support for the project (e.g., cougar, wolverine)?
2. Ecosystem Context	
Taxonomic Diversity	Do the selected focal species represent a diversity of taxonomic groups?
Levels of Biological Organization (see Noss 1990)	Do the selected focal species provide information suitable for addressing questions aimed at the first two levels of biological organization (genes/individuals, species/populations)?

Monitoring information must be of value at the project level, as managers are interested in project-specific applications. However, some results will have management benefits beyond the project area boundaries and have national or international significance in advancing knowledge of wildlife crossing mitigation. Attempts should be made to choose focal species and management questions that have impacts at the project and national or international scale.

After identifying suitable focal species, a second consideration relates to how well the focal species fit within an ecosystem context. For each of the management questions it will be important to maximize the taxonomic diversity represented in the suite of focal species, e.g., amphibians, reptiles, small to large mammals. Road effects on wildlife populations are scale-specific, and such an approach will, therefore, help to ensure that some of the more important scale-related issues (spatial and temporal) of the investigation are adequately addressed.

MONITORING TECHNIQUES

There are a variety of wildlife survey methods available today. These methods range from the relatively simple (reporting of wildlife–vehicle collisions by transportation agency personnel) to the complex (capture and global positioning system [GPS] collaring of individual animals). Whatever the monitoring objective and focal species, the selection of appropriate survey methods is critically important as Table 8 shows.

In some cases multiple methods exist for a given objective–species combination and researchers will have the luxury of balancing cost with specific data requirements and available funding or personnel.

For some methods, most costs occur at the onset of monitoring efforts (e.g., purchase of remote cameras), whereas for others the costs are largely distributed throughout the monitoring period (e.g., snow tracking).

Appendix E describes many methods that can be used to meet a number of basic monitoring objectives. Decisions as to the best methods must be made based on the particular objective, focal species, season, cost, and location.

Table 8. Summary of available monitoring methods, the appropriate time to employ them (pre- or post-construction), potential target species, and cost estimates for conducting wildlife monitoring. See Appendix E for detailed description of each monitoring method (From Clevenger et al. 2008).

Monitoring purpose	Available monitoring methods	Timing	Target species	Check frequency	Area of use	Estimated cost	Cost loading
Assess wildlife–vehicle collision rate							
	Carcass removal by maintenance crews and natural resource agency staff	Pre; post	Elk, deer, black bear and other large species when possible	As occurs	Median/right-of-way	Low	Continuous
	Wildlife–vehicle collision reports by highway patrol	Pre; post	Elk, deer, black bear and other large species when possible	As occurs	Median/right-of-way	Low	Continuous
	Systematic driving surveys	Pre; post	Medium to large mammals	1–7 days	Median/right-of-way	High	Continuous

Assess use/effectiveness of wildlife crossing structures (existing and proposed)							
	Remote still cameras or video	Pre; post	Medium to large mammals	Weekly	Wildlife crossings/Culverts	Medium	Front-loaded
	Track beds	Pre; post	Medium to large mammals	1–3 days	Wildlife crossings/Dry culverts	Medium	Continuous
	Unenclosed track plates	Pre; post	Medium to large mammals	1–3 days	Wildlife crossings/Dry culverts	Medium	Continuous
	Enclosed track plates	Pre; post	Smaller mammals	1–3 days	Small dry culverts	Medium	Continuous
	Hair collection devices with DNA methods	Pre; post	Select medium to large mammals	3–5 days	Wildlife crossings/Culverts	Medium to high*	Continuous and end-loaded
	Trap, tag, and recapture/ resight	Pre; post	Amphibians, reptiles, small mammals	Select times	Ponds and water bodies within or adjacent to highway	Low	Continuous
	GPS collaring	Pre; post	medium to large mammals	Select times	Within animal home range	High	Front-loaded

Assess rate of at-grade highway crossings by wildlife							
	Remote still cameras or video (deployed randomly)	Pre**	Medium to large mammals	Weekly	Right-of-way	Medium to high	Front-loaded
	Remote still cameras or video (deployed at targeted locations)	Pre**	Medium to large mammals	Weekly	Right-of-way	Medium to high	Front-loaded
	Track beds (deployed randomly)	Pre**	Medium to large mammals	1–3 days	Right-of-way	Medium to high	Continous
	Track beds (deployed at targeted locations)	Pre**	Medium to large mammals	1–3 days	Right-of-way	Medium to high	Continous
	Snow track transects	Pre**	Medium to large mammals active in winter	3–5 times per winter***	Right-of-way	Medium	Continous
	GPS collaring	Pre; post	medium to large mammals	Select times	Within animal home range	High	Front-loaded

Monitor wildlife use of locations throughout and adjacent to the project area							
	Remote still cameras or video at scent stations	Pre; post	Medium to large mammals	Weekly	Within 1 mile of highway	Medium	Front-loaded
	Track plots or track plates at scent stations	Pre; post	Small to large mammals	1–3 days	Within 1 mile of highway	Medium	Continous
	Hair collection devices with DNA methods	Pre; post	Small group of targeted species	3 days	Within 1 mile of highway	Low to high*	Continuous and end-loaded
	Snow tracking	Pre; post	Medium and large mammals active in winter	3–5 times/winter	Within 1 mile of highway	Medium	Continous
	Scat detection dogs with DNA methods	Pre; post	3-4 targeted mammals	1 full season	Within 1 mile of highway	Medium to high*	Front-loaded
	Trap, tag, and recapture/ resight	Pre; post	Amphibians, reptiles, small mammals	Select times	Ponds and water bodies within or adjacent to highway	Low	Continuous
	GPS collaring	Pre; post	medium to large mammals	Select times	Within animal home range	High	Front-loaded

Evaluate effectiveness of wildlife fencing							
	Highway maintenance crews report animals inside fencing	Post	Medium to large mammals	As occurs	Median/right-of-way	Medium	Continuous
	Highway patrol report animals inside fencing	Post	Medium to large mammals	As occurs	Median/right-of-way	Medium	Continuous
	Systematic checks of fence integrity	Post	Medium to large mammals	Monthly	Fenceline	Medium	Continuous
	GPS collaring	Pre; post	medium to large mammals	Select times	Within animal home range	High	Front-loaded
Evaluate effectiveness of jump-outs							
	Remote still cameras or video	Post	Medium to large mammals	Weekly	Jump-outs	Medium	Front-loaded
	Track beds on top of jump-outs	Post	Medium to large mammals	1–3 days	Jump-outs	Medium	Continuous

* Cost depends largely on objectives—species-specific identification via DNA methods costs less than individual identification. Both can be cost effective when compared with more labor-intensive methods.
** Although these methods can be used to monitor post-construction, it is assumed that wildlife fencing will so dramatically reduce at-grade highway crossing attempts as to make monitoring unnecessary and extremely cost-ineffective.
*** Will depend on statistical power considerations, number and timing of snow events, and time constraints.

CAMERA VS. TRACK-PAD MONITORING

A recent paper compared the overall efficiency of wildlife monitoring activity using track pads and motion-sensitive cameras, based on the estimated number of detections by each method (Ford et al. 2009). Mammals coyote-sized and larger were used in the analysis. Cameras outperformed track pads by most performance metrics. The only instances where track pads were preferred were at sites where security (e.g., high risk of theft or vandalism) was a concern. One of the most important factors limiting the use of track pads is the frequency of field visits required. Monitoring based on track pads needs to keep the checking intervals short enough to minimize trampling of tracks and loss of data. Increasing the frequency of visits to each site becomes more costly for the project.

ADAPTATION PERIODS

Monitoring of wildlife crossing structures has shown that an adaptation period and learning curve does exist. The few studies that have obtained more than two years of monitoring data showed that animals require an adaptation period that varies in length between ungulates and carnivores. Most monitoring efforts do not sample for sufficient duration to adequately assess how wildlife utilize crossing structures because they don't give them enough time to adapt to the structures and the changes made to the surrounding habitat where they reside. Small sampling windows, typical of one- or two-year monitoring programs, are too brief, can provide spurious results and do not adequately sample the range of variability in a species' wildlife crossing structure use patterns in landscapes with complex wildlife–human interactions.

STUDY DESIGNS TO MEASURE PERFORMANCE

Inferential Strength

Inferential strength in the context of mitigation monitoring is the ability to accurately evaluate whether mitigation efforts have achieved their desired effect. Maximizing inferential strength depends both on the ability to minimize confounding effects and to maximize statistical power.

Monitoring designs with low inferential strength lead to situations where researchers either detect an effect that is not actually there (a Type I error) or fail to detect an effect that is actually present (a Type II error). Minimizing the likelihood of making either type of error is of critical importance to transportation managers and researchers if they are to reliably demonstrate that mitigation measures are effective.

Roedenbeck et al. (2007) addressed this subject by identifying relevant research questions in road ecology today, recommending experimental designs that maximize inferential strength, and giving examples of such experiments for each of five research questions.

Types of Study Design and Resulting Inferential Strength

There are several types of study designs for evaluating how well mitigation measures perform.

BACI Design

One design consists of measuring and comparing impacted areas (I) with non-impacted areas or control sites (C) and assessing how some variable of interest behaves before (B) and after (A) a management intervention such as highway construction or mitigation. In this "BACI" design, if the difference between the control and impact (often referred to as "treatment") site is greater after intervention than before, then there is strong evidence that intervention has had a causal effect.

To increase inferential strength BACI designs should sample at more than one paired treatment + control site. Locating suitable control sites unaffected by roads can be a challenge, particularly when studying impacts on wide-ranging large mammals.

BA Design

Of lower inferential strength than BACI is the before and after impact (BA) design. This requires sampling one site and evaluating how some environmental variable behaves before and after the impact. The impact could also be some form of management intervention, such as the implementation of mitigation measures. The BA design at one site can demonstrate that the environmental variable changed over time, but it cannot exclude the possibility that change was caused by some reason other than the observed impact.

CI Design

A third approach compares impacted (I) sites with control (C) sites (those that are non-impacted) using a CI design. Data are only collected or made available for the period after intervention or mitigation. The inference is that if the control and impact sites differ in some environmental variable of concern, this difference is, at least in part, due to the intervention. This inference is valid only if control and impact sites would be identical in the absence of intervention.

The study design options described run from high to low inferential strength: BACI, BA, and CI. The key monitoring and research questions identified earlier are found in Appendix D. The table provides a suggested framework for designing studies to evaluate whether the general objectives of highway mitigation are being met.

ADAPTIVE MANAGEMENT

Adaptive management consists of deriving benefits from measured observations from monitoring to inform decision-making with regard to planning and design of subsequent phases of a project. An example of adaptive management would be changing the design of wildlife crossing structures on subsequent phases of highway reconstruction after obtaining empirical data from the use of structures from earlier phases.

- Microhabitat elements within wildlife crossings may require changes if monitoring shows they do not facilitate movement of smaller wildlife.

- Monitoring of fencing may identify deficiencies that lead to revised design or materials used for construction in future phases.

- Pre-construction data on local species occurrence and wildlife movements may lead to changes in the locations and types of wildlife crossing structures (e.g., from small-sized to medium-sized culverts) should monitoring reveal previously undocumented unique populations or important habitat linkages.

Whatever the case may be, monitoring ultimately provides management with sound data for mitigation planning, helps to streamline project planning and saves on project costs.

Regular communication and close coordination between research and management is necessary for adaptive management to be effective. This will allow for timely changes to project design plans that reflect the most current results from monitoring activities.

SUGGESTED READING

Beissinger, S.R., D.R. McCullough. 2002. *Population viability analysis*. University of Chicago Press, Chicago, Illinois, USA.

Beier, P. and R. Noss. 1998. Do habitat corridors provide connectivity? *Conservation Biology* 12:1241-1252.

Block, W., A. Franklin, J. Ward, J. Ganey, and G. White. 2001. Design and implementation of monitoring studies to evaluate the success of ecological restoration on wildlife. *Restoration Ecology* 9: 292-303.

Boitani, L. and T. K. Fuller. 2000. *Research techniques in animal ecology: Controversies and consequences.* Columbia University Press, New York, NY.

Chetkiewicz, C-L.B., Cassady St. Clair, C. and Boyce, M.S. 2006. Corridors for conservation: integrating pattern and process. *Annual Review of Ecology and Systematics* 37:317-342.

Clevenger, A.P., R. Long, R. Ament. 2008. *I-90 Snoqualmie Pass East wildlife monitoring plan*. Prepared for Washington State Department of Transportation, Yakima, Washington.

Clevenger, A.P., M. Sawaya. 2009. A non-invasive genetic sampling method for measuring population-level benefits of wildlife crossings for bears in Banff National Park, Alberta, Canada. *Ecology and Society 15(1): 7. [online] URL: http://www.ecologyandsociety.org/vol15/iss1/art7/*.

Crooks, K.R. and Sanjayan, M. 2006. *Connectivity conservation*. Cambridge University Press, Cambridge, UK.

Foran, D.S., K.C. Crooks, and S.C. Minta. 1997. DNA-based analysis of hair to identify species and individuals for population research and monitoring. *Wildlife Society Bulletin* 25 : 840-847.

Ford, A.T., A.P. Clevenger and A. Bennett. 2009. Comparison of non-invasive methods for monitoring wildlife crossing structures on highways. *Journal of Wildlife Management* 73:1213-1222.

Gaines, W., R. Harrod, and J. Lehmkuhl. 1999. *Monitoring biodiversity: quantification and interpretation.* General Technical Report PNW-GTR-443. Portland, OR: US Dept. Agriculture, Forest Service, Pacific Northwest Research Station. 27p.

Hardy, A. A.P. Clevenger, M. Huijser & G. Neale. 2003. An overview of methods and approaches for evaluating the effectiveness of wildlife crossing structures: Emphasizing the science in applied science. Pages 319-330, in: *Proceedings of the International Conference on Ecology and Transportation.* Irwin, C.L., Garrett, P. McDermott, K. (eds.). Center for Transportation and the Environment, North Carolina State University, Raleigh, N.C.

Hardy, A.R., Fuller, J., Huijser, M., Kociolek, A.M. and Evans, M. 2007. *Evaluation of wildlife crossing structures and fencing on US Highway 93 Evaro to Polson, phase I: preconstruction data collection and finalization of evaluation plan*. FHWA/MT-06-008/1744-1, Helena, MT. 190pp.

Lambeck, R.J. 1997. Focal species: A multi-species umbrella for nature conservation. *Conservation Biology* 11: 849-856.

Larson, M., F. Thompson, J. Millspaugh, W. Dijak and S. Shifly. 2004. Linking population viability, habitat suitability, and landscape simulation models for conservation planning. *Ecological Modelling* 180: 103-118.

Lee, K. N. 1999. Appraising adaptive management. *Conservation Ecology* 3 (2): 3. [online] URL: http://www.consecol.org/vol3/iss2/art3/

Long, R. A., P. MacKay, W. J. Zielinski, and J. C. Ray, editors. 2008. *Noninvasive survey methods for carnivores.* Island Press, Washington D.C., USA.

MacKenzie, D.I., J.D. Nichols, J.A. Royale, K.H. Pollock, L.L. Bailey, J.E. Hines. 2006. *Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence*. Academic Press, New York, NY.

Margolius, R. and N. Salafsky. 1999. *Measures of success: designing, managing and monitoring conservation and development projects*. Island Press, Washington, DC.

National Research Council (NRC). 2005. *Assessing and managing the ecological impacts of paved roads.* The National Academies Press, Washington, DC.

Noss, R.F. 1990. Indicators of monitoring biodiversity: a hierarchical approach. *Conservation Biology* 4, 355-364.

Quinn, G.P., M.J. Keough. 2002. *Experimental design and data analysis for biologists*. Cambridge University Press, New York, NY.

Redford, K.H. and B.D. Richter. 1999. Conservation of biodiversity in a world of use. *Conservation Biology* 13, 1246-1256.

Roedenbeck, I., L. Fahrig, C. Findlay, J. Houlahan, J. Jaeger, N. Klar, S. Kramer-Schadt and E. van der Grift. 2007. The Rauischholzhausen agenda for road ecology. *Ecology and Society* 12 (1): 11 [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art11/.

Underwood, A.J. 1997. *Experiments in ecology: their logical design and interpretation using analysis of variance.* Cambridge University Press, Cambridge, U.K.

Walters, C. and C.S. Holling. 1990. Large-scale management experiments and learning by doing. *Ecology* 71:2060-2068.

APPENDIX A – GLOSSARY

Words, expressions and terms used in this handbook.

Term	Meaning
Amphibian fencing	A continuous structure erected alongside infrastructure to prevent amphibians from crossing or direct them to a specific crossing point or pitfall trap.
Amphibian tunnel	An enclosed passage structure designed to allow amphibians to move from one side of a roadway to another.
Barrier effect	The combined effect of traffic mortality, physical barriers and avoidance, which together reduce the likelihood and success of wildlife crossing roadways.
Berm	An earth bank constructed to reduce light and noise impacts from traffic.
Biodiversity	The richness among living organisms including terrestrial, marine and freshwater ecosystems. It includes diversity within and between species and ecosystems as well as the processes linking ecosystems and species.
Bottleneck	Defined area (e.g., habitat corridor) which, due to the presence of roadways or other land use, has become a limiting factor to wildlife movement or migration.
Compensation measure	Measure or action taken to compensate for a residual adverse ecological effect that cannot be satisfactorily mitigated. See also “Mitigation.”
Connectivity	The state of structural landscape features being connected, enabling access between places via a continuous route of travel.
Corridor	Physical linkage or connection between habitat patches within a landscape.
Culvert	Box, pipe or channel structure that allows a watercourse or excess water (surface or subsurface) to be removed by passing below road surface.
Dispersal	Process or result of a species movement away from an existing population or away from a parent organism.

Ecoduct	Widely used term in Europe for "wildlife overpass" or "landscape bridge."
Ecological corridor	Habitat of various sizes and shapes that maintain, establish or enhance connectivity of landscapes, organisms within the landscapes, and environmental processes associated with them.
Ecological network	Regional- or landscape-scale system of ecological corridors (see above) that maintains the connection of core habitats, organisms and environmental processes necessary for conservation of species, communities and ecosystems.
Ecosystem	Complex of plant and animal and micro-organism communities and their physical environments that are dynamic and interact as a functional unit.
Ecotone	Transitional zone between two distinct habitat types.
Edge (effect)	Portion of an ecosystem near its perimeter, where influences of the surroundings prevent the development of interior environmental conditions.
Endemic species	A species confined to a particular region and thought to have originated there.
Environmental Impact Assessment (EIA)	A method and process by which information about potential environmental impacts is collected, assessed and used to inform decision-making.
Escape (refuge) area	A place that provides refuge or shelter.
Fauna	Animal species.
Filter effect	The limiting or selective filtering of movement of certain species or individuals across transportation infrastructure.
Flora	Plant or bacterial life.
Fragmentation	Splitting up or separation of a habitat, landscape or ecosystem into smaller parcels.

Generalist species	A species that is able to thrive in a wide variety of environmental conditions and can make use of a variety of different resources. See Specialist species for opposite.
Habitat	The type of site (vegetation, soils, etc) where an organism or population naturally occurs—including a mosaic of components required for the survival of a species.
Habitat elements	Specific components of natural habitats that make them whole, including habitat structure, vegetative cover and density.
Habitat fragmentation	Subdivision and reduction of the habitat area available to a given species caused directly by habitat loss (e.g., land take) or indirectly by habitat isolation (e.g., barriers preventing movement between habitat patches).
Impact	The immediate response of an organism, species, population or community to an external factor. This response may have an effect on the species that results in wider consequences at the population, species, or community level.
Indicator	Measures of simple environmental variables used to indicate some aspect of the state of the environment, such as the degree of habitat fragmentation.
Indicator species	Species indicative of change from environmental baseline conditions or success of restoration or mitigation actions. Some indicators track changes related to air pollution, environmental contaminants, habitat quality, etc.
Invertebrate	Any animal without a vertebral column or backbone.
Jersey (median) barrier	Tapered concrete barrier used in many narrow highway medians to prevent vehicle crossovers into oncoming traffic.
Keystone species	A species that plays a pivotal role in an ecosystem and upon which a large part of the community depends for survival.
Land cover	Combination of land use and vegetation cover.

Landscape	The total spatial and visual entity of human living space integrating the geological, biological and human-made environment. A heterogeneous land area composed of a cluster of interacting ecosystems that create a specific recognizable pattern.
Landscape bridge	Large wildlife overpass or ecoduct used to connect habitats over transportation infrastructure.
Landscape diversity	The variation and richness of landscapes in a region.
Landscaping	To modify the original landscape by altering the topography and/or vegetative cover—this may include earthmoving and contouring to form new landscape structures.
Linear transport infrastructure	Road, railway or navigable inland waterway.
Matrix	In landscape ecology, the background habitat or land use type separating two patches of core habitat.
Mesic habitat	Pertaining to conditions of moderate moisture or water supply.
Metapopulation	A patchily distributed network of localized subpopulations that cannot survive on their own and are subject to local extinction. Maintenance of the subpopulations depends on the movement of individuals from "source" patches through the metapopulation network.
Migration	The regular, usually seasonal, movement of all or part of an animal population to and from a given area of biological importance.
Mitigation	Action to reduce the severity of an adverse impact.
Monitoring	Combination of observation and measurement used to quantify the performance of a plan, change against a set of predetermined indicators, criteria or policy objectives.
Mosaic	The pattern of patches and corridors embedded in a matrix (referred to within a landscape context). See "Matrix."

Noise barrier	Measure installed to reduce the emission of traffic-related noise in designated sensitive areas (human-altered and natural areas) typically using walls, fence or screen.
Overpass	Structure that allows passage above transportation infrastructure or obstacle.
Population	Functional group of individuals that interbreed within a given, often arbitrarily chosen area.
Region	A geographical area (usually larger than 100 km^2) consisting of several landscapes and ecosystems that share some environmental features, e.g., topography, wildlife, plant communities, climate, etc.
Restoration	The process of returning something to an historical condition or state. Ecological restoration consists of a series of measures and actions designed to restore a degraded ecosystem, or its components, to their former state.
Right-of-way	Strip of land, often vegetated, beyond road surface and within the road corridor.
Riparian habitat	Habitat associated with or situated adjacent to a watercourse (e.g., creek, stream, river) or other body of water.
Road corridor	Linear surface used by vehicles plus any associated rights-of-way (normally vegetated). Includes the land area immediately influenced by the road and traffic in terms of auditory, visual, hydrological and chemical impacts (typically within 160–330 ft [50–100 m] of road surface edge).
Road network	The interconnected system of roads serving an area.
Root wad	Mass of roots, soil and rocks that remains intact when a tree, shrub, or stump is uprooted. See Stump wall.
Scale	In landscape ecology, the spatial and temporal dimension of patterns and processes.
Semi-aquatic species	Species that are adapted for living and traveling both in water and on land.

Semi-arboreal species	Species that are adapted for living and traveling both on land and in trees.
Site	Defined place, point or locality in a given landscape.
Slope protection	Action or measure to prevent soil erosion on slopes. May consist of seeding or planting vegetation, or structural measures (e.g., retaining walls).
Sink habitats and populations	Areas where populations of a given species have a non-sustaining birth/death ratio and are dependent on immigration from source populations.
Source habitats and populations	Areas where populations of a given species can reach a positive balance between births and deaths, and thus act as a source of emigrating individuals.
Specialist species	A species that can only thrive in a narrow range of environmental conditions and/or have a limited diet. See Generalist species for opposite.
Stepping stone	Ecologically suitable patches where an organism temporarily stops while moving along a heterogeneous path.
Stump wall	Wall of tree stumps generally placed along interior wall of wildlife underpass structure and designed to provide cover for movement of small mammals.
Surface-water drainage	System devised to remove excess water from the surface of the ground (or infrastructure).
Target species	A species that has been identified as the subject of conservation or monitoring actions.
Taxon (plural = taxa)	Category in the Linnaean classification of living organisms, i.e., species that are considered sufficiently distinct from other groups to be treated as a separate unit.
Terrestrial	Pertaining to land or earth.
Topsoil	Top layer of soil that supports vegetation.
Underpass	Structure that allows passage below transportation infrastructure or obstacle.

Vertebrate	Any animal with a vertebral column or backbone.
Viaduct	Long elevated bridge, supported on pillars, that carries infrastructure over a valley or low-lying area.
Wetlands	Land or area with high levels of soil moisture or entirely inundated with water for part of or the entire year.
Wildlife corridor	Generally a linear or elongated area of habitat that facilitates movement of individuals between core habitat patches and provides for connectivity among populations.
Wildlife fence	Fence designed and built to keep animals from accessing right-of-way habitat and road surface, or to funnel animal movement to safe crossing locations (e.g., wildlife crossing structures).
Wildlife overpass	Structure built over road designed to connect habitats and wildlife on either side. Generally layered with topsoil, planted with vegetation and bordered by wall or fence. Fencing of some design is attached to direct animals to structure.
Wildlife underpass	Structure built under road designed to connect habitat and wildlife on either side. Substrate is covered in soil and, at minimum, wing-fencing is attached to direct animals to structure.
Wing fencing	Fencing of short length (generally < 650 ft [200 m]) that extends out from wildlife crossing structure and does not connect with neighboring wildlife crossing structures.
Woody debris	Dead woody material typically consisting of logs, branches and tree stumps.
Xeric habitat	Habitat having very little moisture and characterized by dry conditions.

APPENDIX B – COMMON AND SCIENTIFIC NAMES

MAMMALS

American mink (*Mustela vison)*

Beaver *(Castor canadensis)*

Black bear *(Ursus americanus)*

Bobcat *(Lynx rufus)*

Canada lynx *(Lynx canadensis)*

Coati (*Nasua narica)*

Coyote *(Canis latrans)*

Elk *(Cervus elaphus)*

Fisher *(Martes pennanti)*

Florida panther (*Puma concolor coryi)*

Gray wolf *(Canis lupus)*

Grizzly bear *(Ursus arctos)*

Hoary marmot *(Marmota caligata)*

Key deer (*Odocoileus virginianus clavium)*

Marten *(Martes americana)*

Moose (*Alces alces)*

Mountain goat *(Oreamnos americanus)*

Mountain lion *(Puma concolor)*

Mule deer *(Odocoileus hemionus)*

Muskrat (*Ondatra zibethica)*

Northern flying squirrel *(Glaucomys sabrinus)*

Opossum (*Didelphis virginiana)*

Pika *(Ochotona princeps)*

Porcupine *(Erethizon dorsatum)*

Pronghorn (*Antilocapra americana)*

Raccoon *(Procyon lotor)*

Red fox *(Vulpes vulpes)*

Red squirrel (*Tamiasciurus hudsonicus)*

Ringtail (*Bassariscus astutus)*

River otter *(Lutra canadensis)*

Snowshoe hare *(Lepus americanus)*

Weasel *(Mustela sp.)*

White-tail deer (*Odocoileus virginianus)*

Wolverine *(Gulo gulo)*

Woodchuck/Groundhog (*Marmota monax)*

REPTILES

Desert tortoise (*Gopherus agassizii)*

AMPHIBIANS

Long-toed salamander (*Ambystoma macrodactylum)*

Mole salamanders (family *Ambystomatidae)*

Spotted salamander (*Ambystoma maculatum)*

APPENDIX C – HOT SHEETS

HOT SHEET 1: LANDSCAPE BRIDGE

GENERAL DESIGN

Landscape bridges are the largest wildlife crossing structures that span highways. They are primarily intended to meet the movement needs of a broad spectrum of wildlife from large mammals to reptiles, and even invertebrate taxa as shown in Figure 29. Small mammals, low-mobility medium-sized mammals and reptiles will utilize structures particularly if habitat elements are provided on the overpass. Types of vegetation and placement can be designed to enhance crossings by bats and birds.

Figure 29. Photo. Landscape bridge (Credit: Anonymous).

USE OF THE STRUCTURE

These structures are designed exclusively for the use of wildlife. Prohibiting human use and human-related activities adjacent to structure is highly recommended.

GENERAL GUIDELINES

- Large size enables the restoration of habitats, particularly if designed and integrated so there is habitat continuity from one side to the other.
- To facilitate use by largest number of species, structure should have vegetative composition similar to the vegetation in adjacent habitats.
- To ensure performance and function, landscape bridges should be situated in areas that are known wildlife corridors and have minimal human disturbance.
- Should be closed to public and any other human use/activities as Figure 30 shows.
- Maximize continuity of native soils adjacent to and on landscape bridge. Avoid importation of soils from outside project area.
- Reduce light and noise from vehicles by using earth berms, solid walls, dense vegetation or combination of these on the sides of the structure.

Figure 30. Photo. Closure signage (Credit: Tony Clevenger).

DIMENSIONS – GENERAL GUIDELINES

Bridge Width

Minimum: 230 ft (70 m)
Recommended: >330 ft (>100 m)

Fence/Berm Height

8 ft (2.4 m)

Soil Depth

5–8 ft (1.5–2.0 m)

TYPES OF CONSTRUCTION

Span

Bridge span (steel truss or concrete)

Arch

Pre-fabricated cast-in-place concrete arches
Corrugated steel

SUGGESTED DESIGN DETAILS

Crossing Structure

- Landscape bridges should be a heterogeneous environment, combining open areas with shrubs and trees. Species that are taxonomically close to existing vegetation adjacent to structure should be employed. Site and environmental conditions (climate) may require hardy drought-tolerant species.
- Landscape design should mimic adjacent habitats that the structure intends to connect. Trees and dense shrubs should be planted on edges of structure to provide cover and refuge for small- and medium-sized wildlife. The center section of overpass should be left open with low-lying or herbaceous vegetation. Piles of shrubs, large woody debris or rocks should be placed in stepping-stone fashion to provide refuge for small fauna.
- Soil depth should be sufficient to support 8–12 ft (2.4–3.6 m) trees. Soil must be deep enough for water retention for plant growth. Drainage should slope slightly (at 2–3 percent) from the central longitudinal axis to sides.
- Local topography can be created on surface with slight depressions and mounding of material used for fill.
- Amphibian habitat can be created in a stepping-stone fashion or isolated ponds. Pond habitat may be artificial with impermeable substrates to hold water from rainfall or landscape designed areas for high water retention.
- Earth berms, solid walls, dense vegetation or a combination of these should be installed as sound- and light-attenuating walls on the sides of the structure. The walls should extend

down to approach ramps and curve around to wildlife exclusion fence. The minimum height of walls should be 8 ft (2.4 m).

Local Habitat Management

- Adjacent lands should be acquired, zoned or managed as reserve or protected area into perpetuity.
- Trees and shrubs should be located at the edges of the approach ramps to guide wildlife to the entrance to the structure. The vegetation should integrate with the adjacent habitat.
- Landscape bridges are best situated in areas bordered by elevated terrain, enabling the approach ramps and surface of structure to be at the same level as the adjacent land/grade. If the structure is built on level ground, then approach ramps should have gentle slopes (e.g., 5:1 or less). One or both slopes may be steeper if built in mountainous areas, especially if built on a side slope rather than valley bottom.
- There is a trade-off between slope and retaining vegetative cover on approach ramps. A steep-sloped ramp will retain vegetative cover close to the overpass structure. Gentle slopes (>3:1) generally require more fill, which extends the approach ramp farther out away from the structure and will bury vegetation, including trees.
- Efforts should be made to avoid having roads of any type pass in front of or near the entrance to the landscape bridge, as it will hinder wildlife use of the structure.
- Large boulders can be used to block any vehicle passage on the landscape bridge.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way. Mechanically stabilized earth (MSE) walls, if high enough, can substitute for fencing and is not visible to motorists.

POSSIBLE VARIATIONS

- Piles of brush, rocks and isolated large boulders will be important for small fauna (small mammals, reptiles, invertebrates) immediately after construction in order to provide cover and refuge until vegetation takes shape, shown in Figure 31.
- Raised earth berms may be located in the center of the structure (as well as the sides) to allow ungulates greater visibility during use.

MAINTENANCE

- Relatively low maintenance. Walls may need to be checked and maintained regularly to ensure stability.
- During first few years it may be necessary to irrigate vegetation on the structure, particularly if there are extended periods with little rainfall. Sufficient watering (assisted or rainfall) will allow vegetation to settle and take root.
- Monitor and document any human use in area that might affect wildlife use of the structure and take action necessary to control.

Figure 31. Photo. Brush piles on wildlife overpass (Credit: Tony Clevenger).

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Ungulates

- Moose, Elk, Deer, Pronghorn, Bighorn Sheep, Mountain Goat

Carnivores

- Black Bear, Grizzly Bear, Wolf, Coyote, Fox1, Fox2, Cougar, Bobcat, Lynx, Wolverine, Fisher, Marten, Badger, Weasel

Low-mobility medium-sized mammals

Small mammals

Reptiles

Possible if adapted to local conditions

Semi-arboreal mammals

- Tend to prefer arboreal habitats with structure that provides cover and protection during travel. Providing cover and escape or refuge areas such as piles of brush, stones or large woody debris should help movement across structure.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species may be reluctant to use a landscape bridge unless located in or near their preferred habitats. The construction of amphibian habitat, as Figure 32 shows, may facilitate crossings by species associated with those habitat types.
-

Amphibians

- Not likely to use structure unless located in migratory route or during dispersal. Amphibian habitat can be created with series of ponds in a stepping-stone pattern connecting wetland habitats separated by highway.

Not recommended or applicable

None

Unknown – more data are required

None

Figure 32. Photo. Constructed amphibian habitat on edge of wildlife overpass (Credit: Tony *Clevenger).*

HOT SHEET 2: WILDLIFE OVERPASS

GENERAL DESIGN

Next to a landscape bridge, a wildlife overpass is the largest crossing structure to span highways similar to that shown in Figure 33. It is primarily intended to move large mammals. Small mammals, low-mobility medium-sized mammals and reptiles will utilize these structures if habitat elements are provided on the overpass. Semi-arboreal, semi-aquatic and amphibian species may use the structures if they are adapted for their needs. Types of vegetation and their placement can be designed to encourage crossings by bats and birds.

Figure 33. Photo. Recently completed but unlandscaped wildlife overpass (Credit: Tony Clevenger)

USE OF THE STRUCTURE

Wildlife overpasses are intended for the exclusive use of wildlife. Prohibiting human use and human-related activities adjacent to the structure is highly recommended.

GENERAL GUIDELINES

- Same general design as landscape bridge but not as wide.
- Being narrower in width than landscape bridge, the ability to restore habitats will be limited.
- To ensure performance and function, wildlife overpasses should be situated in areas with high landscape permeability, are known wildlife travel corridors and have minimal human disturbance.
- Maximize continuity of native soils adjacent to and on wildlife overpass. Avoid importation of soils from outside project area.
- Should be closed to public and any other human use/activities as Figure 30 showed.

- Reduce light and noise from vehicles by using earth berms, solid walls, dense vegetation or a combination of these placed on the sides (lateral edges) of the structure as illustrated in Figure 34.

Figure 34. Photo. Berm on wildlife overpass (Credit: Tony Clevenger).

DIMENSIONS – GENERAL GUIDELINES

Overpass Width

Minimum: 130–165 ft (40–50 m)
Recommended: 165–230 ft (50–70 m)

Fence/Berm Height

8 ft (2.4 m)

Soil Depth

5–8 ft (1.5–2.4 m)

TYPES OF CONSTRUCTION

Span

Bridge span (steel truss or concrete)

Arch
Pre-fabricated cast-in-place concrete arches
Corrugated steel

Design will be similar to a landscape bridge. Parabolic arch design overpass creates better opportunities for wildlife to locate approach ramps; however, costs are higher than rectangular or straight-edged constructions as sketch in Figure 35.

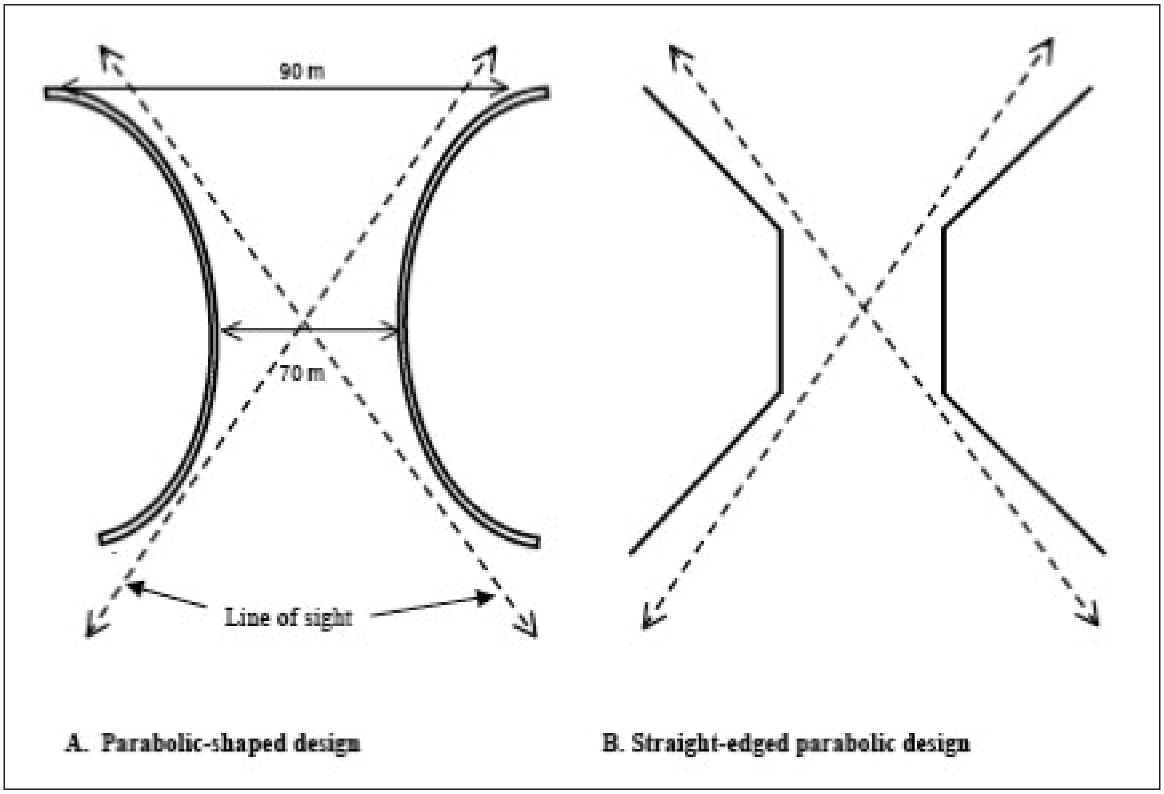


Figure 35. Schematic. (A) Parabolic-shaped design overpass (B) Straight-edged design.

SUGGESTED DESIGN DETAILS

Crossing structure

- Wildlife overpass should be vegetated with native trees, shrubs and grasses. Species that match or are taxonomically close to existing vegetation adjacent to structure should be employed. Site and environmental conditions (including climate) may require hardy, drought-tolerant species. Composition of trees, shrubs and grasses will vary depending on target species needs.
- Suggested design consists of planting shrubs on edges of overpass providing cover and refuge for small- and medium-sized wildlife. The center section of overpass should be left open with low-lying or herbaceous vegetation. Place piles of shrubs, woody debris (logs) or rock piles in stepping-stone fashion to provide microhabitat and refuge for small, cover-associated fauna as Figure 30 showed. In arid areas, more piles of woody debris and rocks should be used to provide cover for small and medium-sized fauna.

- Soil depth should be sufficient to support 8–12 ft (2.4–3.6 m) trees. Structure should generally be vegetated with grasses and shrubs of varying height. Soil must be deep enough for water retention for plant growth. Structure must have adequate drainage.
- Local topography can be created on surface with slight depressions and mounding of material used for fill.
- Amphibian habitat can be created in a stepping-stone fashion or isolated ponds. Pond habitat may be artificial with impermeable substrates to hold water from rainfall or landscape designed areas for high water retention.
- Earth berms, solid walls, dense vegetation or a combination of these should be installed as sound- and light-attenuating walls on the sides of the structure shown earlier in Figure 34. The walls should extend down to approach ramps and curve around to wildlife exclusion fence. The minimum height of walls should be 8 ft (2.4 m).
-

Local habitat management

- Trees and shrubs should be located at the edges of approach ramps to guide wildlife to the structure entrance. The vegetation should integrate with the adjacent habitat. Adjacent lands should be acquired, zoned or managed as reserve or protected area into perpetuity.
- Wildlife overpasses are best situated in areas bordered by elevated terrain, enabling the approach ramps and surface of structure to be at the same level as the adjacent land. If the structure is built on level ground, then approach ramps should have gentle slopes (e.g., 5:1). One or both slopes may be steeper if built in mountainous areas.
- There is a trade-off between slope and retaining vegetative cover on approach ramps. A steep-sloped ramp will retain vegetative cover close to the overpass structure. Gentle slopes (3:1 or 4:1) generally require more fill, which extends the approach ramp farther out away from the structure and will bury vegetation, including trees.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way. Mechanically stabilized earth (MSE) walls, if high enough, can substitute for fencing and is not visible to motorists.
- Efforts should be made to avoid having roads of any type pass in front of or near the entrance to the wildlife overpass, as it will hinder wildlife use of the structure.
- Large boulders can be used to block any vehicle passage on the overpass.
- Existing or planned human development in adjacent area must be at a sufficient distance to not affect long-term performance of underpass. Long-range planning must ensure that adjacent lands will not be developed and the wildlife corridor network is functional.

POSSIBLE VARIATIONS

- Vegetation for screening and fence
- Berms on approach ramps
- Berm in middle of overpass

MAINTENANCE

- Relatively low maintenance. Walls and any fences may need to be checked and repaired if necessary.
- During first few years it may be necessary to irrigate vegetation on the structure, particularly if there are extended periods with little rainfall. Sufficient watering (assisted or rainfall) will allow vegetation to settle and take root.
- Monitor and document any human use in the area that might affect wildlife use of the structure and take action necessary to control.

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Ungulates
- Moose, Elk, Deer, Pronghorn, Bighorn Sheep, Mountain Goat

Carnivores
- Black Bear, Grizzly Bear, Wolf, Coyote, Fox1, Fox2, Cougar, Bobcat, Lynx, Wolverine, Fisher, Marten, Badger, Weasel

Low-mobility medium-sized mammals

Small mammals

Reptiles

Possible if adapted to local conditions

Semi-arboreal mammals
- Tend to prefer arboreal habitats with structure that provides cover and protection during travel. Providing cover and escape or refuge areas such as piles of brush, stones or large woody debris should help movement across structure.

Semi-aquatic mammals
- Mink, River Otter, Muskrats and other riparian-associated species may be reluctant to use wildlife overpass unless located in or near their preferred habitats. The construction of amphibian habitat may facilitate crossings by species associated with those habitat types.

Amphibians
- Not likely to use structure unless located in migratory route or during dispersal. Amphibian habitat can be created with series of ponds in a stepping-stone pattern connecting wetland habitats separated by highway.

Not recommended or applicable

None

Unknown – more data are required

None

HOT SHEET 3: MULTI-USE OVERPASS

GENERAL DESIGN

Design of the structure is similar to a wildlife overpass, however the management objective is to allow co-use between wildlife and humans. Design is generally narrower than a wildlife overpass because of mixed use. It may be adequate for movement of some large mammals. Small- and medium-sized mammals will utilize these structures, particularly generalist species common in human-dominated environments. Structures may be adapted for semi-arboreal species. Semi-aquatic and amphibian species may use them if they are located within their preferred habitats.

USE OF THE STRUCTURE

The multi-use overpass is intended for mixed wildlife and human use (recreational, agricultural, etc.).

GENERAL GUIDELINES

- Not as wide as wildlife overpass, but mixes needs of wildlife and human use.
- Human use (e.g., paths, riding trails) should be confined to one side, leaving greater space for wildlife use. Vegetation can be used to shield human use from wildlife as noted in Figure 36.
- May be located in prime wildlife habitat, but are generally near human use areas.
- Bridges can be adapted easily for wildlife use if they have low traffic (e.g., rural, agricultural-related) and human disturbance.
- Modifications consist of designating a section(s) of bridge as a pathway, one on each side, installing a soil substrate and, if possible, vegetation.
- Maximize continuity of native soils adjacent to and on multi-use overpass. Avoid importation of soils from outside the project area.
- Reduce light and noise from vehicles by using earth berms, walls, vegetation or a combination of these.
- Soil depth: not as deep as for wildlife overpass, as less need for deep-rooted trees/shrubs, generally vegetated with grasses and low-lying shrubs.

Figure 36. Photo. Human use lane and vegetated strip on multi-use overpass (Credit: Marcel Huijser).

DIMENSIONS – GENERAL GUIDELINES

Width:

Minimum: 32ft (10 m)
Recommended: 50–82 ft (15–25 m)

Fence/berm height:

8 ft (2.4 m)

Soil depth:

1.6–3.2 ft (0.5–1.0 m)

TYPES OF CONSTRUCTION

Span

Bridge span (steel truss or concrete)

Arch

Pre-fabricated cast-in-place concrete arches
Corrugated steel

SUGGESTED DESIGN DETAILS

Crossing structure

- If the structure has a one-lane road, the lane may be paved or gravel, but sides vegetated with grasses or shrubs. The same is true if the lane is a trail for hiking or horseback riding.
- Borders or other separations (e.g., curbs) should not be installed at interface between human-use lane and wildlife pathway. The interface between the two should be as natural as possible and without obstacles of any kind.
- Plant species that match or are taxonomically close to existing vegetation adjacent to the structure should be employed. Site and environmental conditions (including climate) may require hardy, drought-tolerant species. Composition of trees, shrubs and grasses will vary depending on target species needs.
- In arid areas it may be difficult to keep vegetation alive unless drought-resistant species are used. Piles of woody debris and rocks should be used in these situations to provide cover for small and medium-sized mammals.
- A solid wall or fence should be constructed as a sound- and light-attenuating wall on the sides of the structure. The minimum height of walls should be 8 ft (2.5 m).
-

Local habitat management

- Trees and shrubs should be located at the edges of approach ramps to guide wildlife to the entrance to the structure. The vegetation should integrate with the adjacent habitat as best as possible.
- Multi-use overpasses are best situated in areas bordered by elevated terrain, enabling the approach ramps and surface of structure to be at the same level as the adjacent land. If the structure is built on level ground, then approach ramps should have gentle slopes (e.g., 5:1 or less). One or both slopes may be steeper if built in mountainous areas.
- Large boulders can be used to block any vehicle passage on the overpass.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way.

MAINTENANCE

- Relatively low maintenance. Walls and any fences may need to be checked and repaired if necessary.
- During the first few years it may be necessary to irrigate vegetation on the structure, particularly if there are extended periods with little rainfall. Sufficient watering (assisted or rainfall) will allow vegetation to settle and take root.

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Ungulates

- Elk, Deer,

Carnivores

- Coyote, Fox1, Fox2, Bobcat, Fisher, Marten, Badger, Weasel

Low-mobility medium-sized mammals

Small mammals

Reptiles

Possible if adapted to local conditions

Semi-arboreal mammals

- Tend to prefer arboreal habitats with structure that provides cover and protection during travel. Providing cover and escape or refuge areas such as piles of brush, stone or large woody debris should help movement across structure.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species are not likely to use a multi-use overpass unless they are located in or near their preferred habitats

Amphibians

- Not likely to use structure unless located in migratory route or during dispersal.

Not recommended or applicable

Ungulates

- Moose – Tend to prefer large, open structures with good visibility and vertical clearance in areas with little human disturbance. Recommended dimensions are likely not sufficient to ensure regular use by individuals of all gender and age classes. Regular human use would deter moose use of overpass.
- Pronghorn – Like moose they tend to prefer large, open structures in areas with little human activity.
- Bighorn Sheep, Mountain Goat – Like Moose, tend to prefer large, open structures with good visibility and minimal human activity.

Carnivores

- Black Bear, Grizzly Bear, Wolf, Cougar, Lynx, Wolverine – Not recommended for these species because of their need for large structures and/or preference for areas in close proximity to humans.

Unknown – more data are required

None

HOT SHEET 4: CANOPY CROSSING

GENERAL DESIGN

Canopy crossings are above-grade crossing structures designed to link forested habitats separated by roads. They are designed for semi-arboreal and arboreal species whose movements are strongly impacted by roads, limiting movements and potentially fragmenting habitat. Canopy crossings allow for movements between forests over many road types and widths. Structures can be designed to meet the needs of particular focal species. Relatively few canopy crossings have been constructed to date.

USE OF THE STRUCTURE

Canopy crossings are intended exclusively for the use of wildlife.

GENERAL GUIDELINES

- Specific crossing structure designed to reduce road-related mortality and increase movements between forested habitats separated by roads.
- The design and materials selected will be site- and species-dependent.
- Structure consists of anchoring thick ropes or cables to trees or permanent fixtures (signage beams, light posts, etc) allowing animals to move between tree canopies situated on opposite sides of the road.
- Over small roads (or railways) ropes or cables can be installed between trees. For multilane highways and roads with wide clearance where there is a greater distance between trees, more permanent and stable fixtures such as that in Figure 37 will be required for anchoring the crossing.
- Permanent fixtures such as signage beams may have wooden platforms or trough-like runways built into them, ropes then extend out to adjacent tree canopies as Figure 38 shows. These trough-like runways shield animals from lights of traffic while using the canopy crossing.
-

DIMENSIONS – GENERAL GUIDELINES

- Ropes at least 3 in (8 cm) diameter.
- Wooden platforms at least 1 ft (30 cm) wide.
- Two steel cables parallel to one another, separated by 8–12 in (20–30 cm) with a nylon net fabric between the cables. In areas receiving snowfall, mesh should be large enough to filter and not accumulate snow.

Figure 37. Photo. Canopy crossing installed in permanent signage fixture (Credit: Tony Clevenger).

Figure 38. Photo. Ropes extending out from canopy crossing to forest canopy (Credit: Tony Clevenger).

SUGGESTED DESIGN DETAILS

Crossing structure

- To ensure performance and function, canopy crossings should be situated in areas with high landscape permeability for target species, that are known corridors for cross-highway population connections, and that experience minimal human disturbance.
- If crossing structure consists of signage beam, $\geq$3 ropes should extend out from end of beam into nearest canopy to allow for animal access.
- For Flying Squirrels, trees in central median or landing post may be sufficient to allow travel across some highways without a canopy crossing structure.

Local habitat management

- Ensure that habitat around canopy crossing is managed for target species populations and their connectivity needs. Maintain continuity of habitat and canopy to allow target species to move throughout the area and access canopy crossing structure.

TYPES OF CONSTRUCTION

Diverse types of construction (rope, steel cable, wood platforms).

POSSIBLE VARIATIONS

- To minimize avian predation and provide greater protection for prey species using the canopy crossing an additional rope or cable can be placed above the devices used for travel.

MAINTENANCE

- Regular inspection and maintenance to avoid deterioration and wear of materials used for the canopy crossing (ropes, cables, attachments, wooden runways) and replacement of any components in poor condition.

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Semi-arboreal mammals

- Species include: Tree Squirrels, Flying Squirrels, Fishers, Martens, Raccoons, Ringtails, Coatis and Opossums.

Possible if adapted to local conditions

Small mammals

- Some species with arboreal habits may use canopy crossings.

Not recommended or applicable

Ungulates

***Carnivores* (other than those listed above)**

***Low-mobility medium-sized mammals* (other than those listed above)**

Semi-aquatic mammals

Amphibians

Reptiles

Unknown – more data are required

None

HOT SHEET 5: VIADUCT OR FLYOVER

GENERAL DESIGN

The viaduct, or flyover, is the largest of wildlife underpass structures; however, it is usually not built specifically for wildlife movement. The large span and clearance of viaducts shown in Figure 39 allow for use by a wide range of wildlife. Structures can be adapted for amphibians, semi-aquatic and semi-arboreal species. Viaducts with support pillars help keep habitats intact and nearly undisturbed. Viaducts also help restore or maintain hydrological flows and the biological diversity associated with riparian habitats. They are commonly used for crossing wetland habitats. A range of dimensions exist from long structures with low vertical clearance for wetlands to short structures with high clearance spanning deep canyons.

Figure 39. Photo. Viaduct as wildlife underpass (Credit: Ministère des Transports du Québec).

USE OF THE STRUCTURE

The viaduct is intended for wildlife, but may support occasional human use.

GENERAL GUIDELINES

- Viaducts are an alternative to constructing underpasses on cut-and-fill slopes, which tend to limit wildlife movement and reduce habitat connectivity compared to viaducts.
- Viaducts minimize the disturbance to habitats, vegetation, and riparian areas during construction. Design should be sufficiently wide enough to conserve riparian habitats and maintain local landform as in the Figure 40 example.
- Replant with local native vegetation if the area is disturbed during construction.

Figure 40. Photo. Wide span viaduct designed to conserve floodplain (Credit: Tony Clevenger).

DIMENSIONS – GENERAL GUIDELINES

Variable dimensions depending on location and terrain.

TYPES OF CONSTRUCTION

Concrete bridge span with support structures

Steel beam span

SUGGESTED DESIGN DETAILS

Crossing structure

- Areas under viaduct should be restored after construction with same vegetation in adjacent undisturbed areas leading up to the structure as shown in Figure 41. Effort should be made to reconstruct the habitat and eventually have continuous vegetation types and structure within and adjacent to the viaduct.

Figure 41. Photo. Viaduct with retention of riparian vegetation (Credit: Tony Clevenger).

- Ponds or wetland habitat may be constructed connecting isolated habitats for amphibian species.
- Stringers of brush and root wads can be used to provide cover and microhabitat for cover-dwelling species until native vegetation can be restored to area.
- Drainage is generally not a problem if spanning water courses, however, riparian habitats should be protected as best as possible during and after construction. Pillars should avoid impacting riparian habitats completely, being outside the high-water mark.

Local habitat management

- If wildlife fencing is used below viaduct to funnel animals, then fencing should tie into the support structures or be close as possible to side slopes, thus providing the widest area for wildlife passage.

- Human use and any signs of human presence (e.g., storage of materials) should be minimized around viaducts.

POSSIBLE VARIATIONS

- Road construction and operation should be avoided if at all possible underneath viaducts that are adapted for wildlife use. If roads are necessary, they should have low traffic volumes and be placed to one side of the viaduct. Trees, shrubs and other shielding devices should be used to reduce any impacts of vehicle disturbance to wildlife use of the site.
- Some viaducts spanning wetlands may have sound-attenuating walls to reduce traffic noise or disturbance to adjacent habitat. In these cases, walls should not be transparent. If they are, they should have proper markings to adequately warn birds of their presence. Poles have been used effectively on bridges to deflect terns flying over a viaduct.

MAINTENANCE

- Inspections should be made periodically to ensure that there are no obstructions to wildlife movement below the viaduct.
- While restoring native vegetation, periodic checks should be made to ensure that vegetation is properly cared for and there is adequate water or fertilizer for vegetation to grow.
- Sound-attenuating walls should be inspected and repaired as necessary.

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Ungulates
- Species will vary based on structure dimensions

Carnivores
- Species will vary based on structure dimensions
- Fisher, Marten, Badger, Weasel

Low-mobility medium-sized mammals

Small mammals

Reptiles

Possible if adapted to local conditions

Semi-arboreal mammals

- Tend to prefer arboreal habitats with structure that provides cover and protection during travel. Providing cover and escape or refuge areas such as piles of brush, stones or large woody debris should help movement under structure and between preferred habitats.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species will use if riparian habitat is present or nearby.

Amphibians

- Not likely to use structure unless located within or adjacent to their preferred habitats, in a migratory route, or during dispersal. Amphibian habitat can be created with series of ponds in a stepping-stone pattern connecting wetland habitats separated by highway Figure 42 provides an example of this pattern on a wildlife overpass.

Figure 42. Photo. "Stepping stone" ponds on wildlife overpass used to assist amphibian movement (Credit: Tony Clevenger).

Not recommended or applicable

None

Unknown – more data are required

None

HOT SHEET 6: LARGE MAMMAL UNDERPASS

GENERAL DESIGN

The large mammal underpass is not as large as most viaducts, but is the largest of underpass structures designed specifically for wildlife use. It is primarily designed for large mammals, but use by some large mammals will depend largely on how it may be adapted for their specific crossing requirements. Small- and medium-sized mammals (including carnivores) generally utilize these structures, particularly if cover is provided along walls of the underpass by using brush or root wads. These underpass structures can be readily adapted for amphibians, semi-aquatic and semi-arboreal species.

USE OF THE STRUCTURE

The large mammal underpass is designed exclusively for use by wildlife.

GENERAL GUIDELINES

- Being generally smaller than a viaduct or flyover, the ability to restore habitat underneath will be limited. Open designs that provide ample natural lighting will encourage greater development of native vegetation as shown in Figure 43.
- To ensure performance and function, large mammal underpasses should be situated in areas with high landscape permeability and that are known wildlife travel corridors and experience minimal human disturbance.
- Motor vehicle or all-terrain vehicle use should be prohibited. Eliminating public or any other human use, activity or disturbance at the underpass and adjacent area is recommended for its proper function and for maximizing wildlife use.
- Underpass should be designed to conform to local topography. Design drainage features so flooding does not occur within the underpass as Figure 44 shows. Run-off from highway near structure should not be directed toward the underpass.
- Maximize continuity of native soils adjacent to and within the underpass. Avoid importation of soils from outside the project area.

DIMENSIONS – GENERAL GUIDELINES

Width:

Minimum: 20 ft (7 m)
Recommended: >40 ft (>12 m)

Height:

Minimum: 10 ft (4 m)
Recommended: >15 ft (>4.5 m)

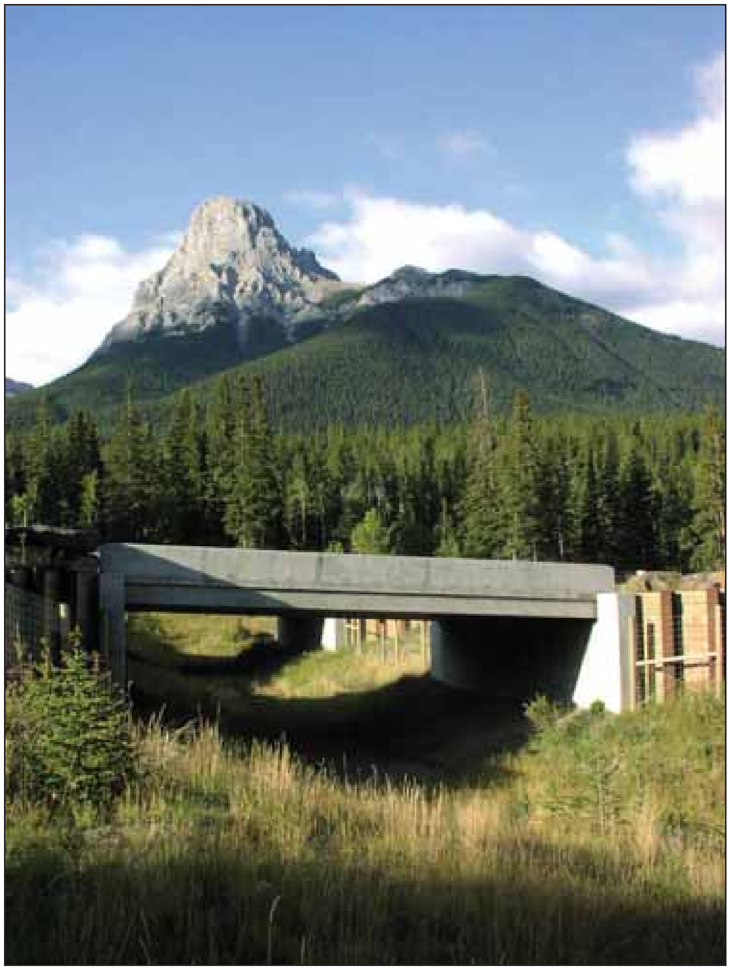


Figure 43. Photo. Open span wildlife underpass (Credit: Tony Clevenger).

TYPES OF CONSTRUCTION

Span
Concrete bridge span (open span bridge)
Steel beam span

Arch
Concrete bottomless arch
Corrugated steel bottomless (footed?) arch
Elliptical multi-plate corrugated steel culvert

Box culvert
Prefabricated concrete

Figure 44. Photo. Brush and root wads placed along underpass wall to provide cover for mammals (Credit: Nancy Newhouse).

SUGGESTED DESIGN DETAILS

Crossing structure

- Structures should be designed to meet the movement needs of the widest range of species possible that live in the area or might be expected to recolonize the area, e.g., high- and low-mobility species.
- Attempt to mirror habitat conditions found on both sides of the road and provide continuous habitat adjacent to and within the structure.
- Maximize microhabitat complexity and cover within the underpass using salvage materials (logs, root wads, rock piles, boulders, etc.) to encourage use by semi-arboreal mammals, small mammals, reptiles and species associated with rocky habitats as Figure 44 showed.
- It is preferable that the substrate of underpass is of native soils. If construction type has closed bottom (e.g., concrete box culvert), a soil substrate $\geq$ 6 in (15 cm) deep must be applied to interior.
- Revegetation is possible in areas of underpass closest to the entrance. Light conditions tend to be poor in the center of the structure.
- Design underpass to minimize the intensity of noise and light coming from the road and traffic.

Local habitat management

- Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within underpass.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way. Mechanically stabilized earth (MSE) walls, if high enough, can substitute for fencing and is not visible to motorists.
- Encourage use of underpass by either baiting or cutting trails leading to structure, if appropriate.
- Avoid building underpass in location with road running parallel and adjacent to entrance, as it will affect wildlife use.
- If traffic volume is high on the road above the underpass it is recommended that sound attenuating walls be placed above the entrance to reduce noise and light disturbance from passing vehicles.
- Underpass must be within cross-highway habitat linkage zone and connect to larger corridor network.
- Existing or planned human development in adjacent area must be at sufficient distance to not affect long-term performance of underpass. Long-range planning must ensure that adjacent lands will not be developed and the wildlife corridor network is functional.

POSSIBLE VARIATIONS

Divided road (two structures)

In-line:

Off-set:

Undivided road (one structure)

MAINTENANCE

- If wildlife underpass is not being monitored on regular basis, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the underpass that might affect wildlife use.
- Fence should be checked, maintained and repaired periodically (minimum once per year, preferably twice per year).

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Ungulates

- Elk, Deer

Carnivores

- Black bear, Coyote, Fox1, Cougar, Bobcat

Low-mobility medium-sized mammals
- For maximum use, cover and protection should be provided in form of rocks, logs, brush or root wads placed along one or both walls. Cover should be continuous within and adjacent to underpass.

Small mammals
- Same as for *low-mobility medium-sized mammals*

Reptiles
- Same as above for *low-mobility medium-sized mammals*

Possible if adapted

Ungulates
- Moose – Tend to prefer large, open structures with good visibility and vertical clearance. Recommended dimensions may not be sufficient to ensure regular use by individuals of all gender and age classes. Recommend minimum 40 ft (12 m) width and 15 ft (4.5 m) height.
- Bighorn Sheep, Mountain Goat – Like Moose, tend to prefer large, open structures with good visibility. Recommended dimensions may not be sufficient to ensure regular use by individuals of all gender and age classes. Recommend minimum 40 ft (12 m) width and 15 ft (4.5 m) height.

Carnivores
- Grizzly Bear, Wolf – Tend to prefer large, open structures with good visibility, such as landscape bridges, wildlife overpasses or viaducts. Recommended dimensions may not be sufficient to ensure regular use by individuals of all gender and age classes. Recommend minimum 40 ft (12 m) width and 15 ft (4.5 m) height.
- Fox2 – Species adapted to arid, open grassland habitats that generally experience high levels of mortality from roads and larger predators (e.g., Coyotes). Few documented cases of Swift/Kit Foxes using wildlife crossings, suggesting they avoid them and prefer to cross at grade-level. To encourage Fox use of structures they should be designed for their body size. Small- and medium-sized mammals, particularly prey species, tend to use passages of a size that allow for their movement, but may limit movement of their larger predators. Hinged iron gates can be placed on underpass entrance. A 6 in x 6 in (15 x 15 cm) mesh spacing on gates will allow foxes to pass through but not the larger predators. In larger structures (e.g., 4 ft x 4 ft (1.2 x 1.2 m) culvert), artificial dens should be installed within structures and near entrances to provide escape cover for Swift/Kit Foxes.
- Fisher, Marten – Forest-dwelling species that tend to prefer structures with ample vegetative cover or form of protection while traveling. Recommended to place brush or root wads along underpass wall (one wall is sufficient; two is preferred but will depend on width of structures) to ensure regular use by individuals of all gender and age classes. In large underpasses, culvert or pipes can be placed to provide cover.
- Badger, Weasel sp. – Species adapted to open habitats and require subterranean burrows for protection. Recommended to place brush or root wads along underpass wall (one wall is sufficient; two is preferred but will depend on width of structures) to ensure regular use

by individuals of all gender and age classes. In large underpasses, culvert or pipes can be placed to provide cover.

Semi-arboreal mammals

- Tend to prefer arboreal habitats with structure that provides cover and protection during travel. Providing cover and escape or refuge areas such as piles of brush, stone or large woody debris should help movement under structure and between preferred habitats.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species may be reluctant to use a wildlife underpass unless riparian habitat is present or nearby. The construction of amphibian habitat may facilitate crossings by species associated with those habitat types. See Figure 32 shown earlier for an example of amphibian habitat constructed on a wildlife overpass.

Amphibians

- Not likely to use structure unless located in migratory route or during dispersal. Amphibian habitat can be created with series of ponds in a stepping-stone pattern connecting wetland habitats separated by highway. See Figure 42 shown earlier for an example of this pattern on a wildlife overpass.

Not recommended or applicable

None

Unknown – more data are required

Pronghorn

- Little information available on wildlife crossing design needs of this species. Most reports indicate that good visibility is critical and overpass structures are preferred. However, recently this species has been detected using a large span underpass structure in California.

Lynx

- Similar to Pronghorn, scarce data exist on what type of crossings Lynx will use. Monitoring of wildlife crossings on the Trans-Canada Highway in Banff National Park and adjacent provincial lands have detected Canada Lynx using a range of structure types on the Trans-Canada Highway: 165 ft (50-m) wide overpass, open span bridge underpass (40 ft [12 m] wide x 13 ft [4 m] high).

Wolverine

- The only data at time of writing on Wolverine use of wildlife crossing structures comes from Banff National Park and adjacent Bow Valley Provincial Park. Wolverine have been documented using the following:

- Underpass with Waterflow – Open span bridge with creek
  Width: 37 ft (11.5 m)
  Height: 8.2 ft (2.5 m)
  Usage: 3 detections

- Large Mammal Underpass – Open span bridge
  Width: 42.5 ft (13 m)
  Height: 16.5 ft (5.0 m)
  Usage: 1 detection

- Large Mammal Underpass – Multi-plate elliptical culvert
  Width: 24 ft (7.2 m)
  Height: 3 ft (4 m)
  Usage: 1 detection

HOT SHEET 7: MULTI-USE UNDERPASS

GENERAL DESIGN

A multi-use underpass is similar in design to a large mammal underpass, however the management objective is to allow co-use between wildlife and humans. These structures can be retrofit bridges for wildlife passage or designed specifically for co-use as Figure 45 illustrates. They may be adequate for movement of some large mammals, but not all wildlife. Small- and medium-sized mammals will utilize the structures, particularly generalist species common in human-dominated environments (e.g., urban habitats). Structures may be able to be adapted for semi-arboreal species. Semi-aquatic and amphibian species may use them if they are located within their habitats.

Figure 45. Photo. Multi-use underpass in The Netherlands retrofitted for human use and wildlife passage (Credit: Marcel Huijser).

USE OF THE STRUCTURE

Multi-use underpasses are designed for mixed wildlife and human use (recreational, agricultural, etc.).

GENERAL GUIDELINES

- Being generally smaller than a viaduct or large mammal underpass, the ability to restore habitat underneath will be limited. Open designs that provide ample natural lighting will encourage greater development of native vegetation.
- May be located in prime wildlife habitat, but generally are near human use areas.

- If the structure is > 40 ft (>12 m) wide, human use (e.g., paths, riding trails) should be confined to one side, leaving greater space for wildlife use. Vegetation can be used to shield human use from wildlife.
- Frequent motor vehicle or all-terrain vehicle (ATV) use of underpass should be discouraged. High levels of disturbance from ATVs or other motorized vehicles at the underpass and adjacent area will likely disturb most wildlife in the area and negatively affect the ability of wildlife to use underpass for cross-road movements.
- Low-level vehicular traffic is acceptable through the underpass, e.g., rural or agricultural use. Keep the road unpaved and its margin vegetated providing continuity through the underpass and adjacent habitats.
- Underpass should be designed to conform to local topography. Design drainage features so flooding does not occur within the underpass. Run-off from highway near structure should not be directed toward the underpass.
- Maximize continuity of native soils adjacent to and within the underpass. Avoid importation of soils from outside the project area.

DIMENSIONS – GENERAL GUIDELINES

Width:

Minimum: 16.5 ft (5 m)
Recommended: >23 ft (>7 m)

Height:

Minimum: 8.2 ft (2.5 m)
Recommended: >11.5 ft (>3.5 m)

TYPES OF CONSTRUCTION

Concrete bottomless arch

Concrete bridge span (open span bridge)

Steel beam span

Elliptical multi-plate metal culvert

Prefabricated concrete box culvert

SUGGESTED DESIGN DETAILS

Crossing structure

- Attempt to mirror habitat conditions found on both sides of the road and provide continuous habitat adjacent to and within the structure.
- Revegetation is possible in areas of the underpass closest to entrances, as light conditions tend to be better than in the center of the structure.

- Design underpass to minimize the intensity of noise and light coming from the road and traffic.
- Maximize microhabitat complexity and cover within the underpass using salvage materials (logs, root wads, rocks, etc.) to encourage use by semi-arboreal mammals, small mammals, reptiles, and species associated with rocky habitats.
- It is preferable that the substrate of the underpass is of native soils. If the design has a closed bottom (e.g., concrete box culvert), a soil substrate $\geq$ 6 in (15 cm) deep must be applied to the underpass interior.
- If rural traffic uses the underpass, do not install curbs or elevated margins of road that separate areas of vehicular use from wildlife use. The transition between the two areas should be natural and not present obstacles.
- Depending on the width of the underpass with vehicular traffic, wildlife paths could run along both sides (of a wide underpass) or along one side (of a narrow underpass); regardless of configuration, the wildlife paths should be > 8 ft (2.4 m) wide.
-

Local habitat management

- Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within the underpass.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way.
- Discourage building underpass in location with a road running parallel and adjacent to the entrance, as it will affect wildlife use.
- If traffic volume is high on the road above the underpass it is recommended that sound-attenuating walls be placed above the entrance to reduce noise and light disturbance from passing vehicles.

POSSIBLE VARIATIONS

Divided road (2 structures)
    In-line:
    Off-set:

Undivided road (1 structure)

MAINTENANCE

- If wildlife underpass is not being monitored on a regular basis, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the underpass that might affect wildlife use.
- Fence should be checked, maintained and repaired periodically (minimum once per year, preferably twice per year).

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Ungulates

- Elk, Deer

Carnivores

- Coyote, Fox1, Bobcat, Fisher, Marten, Weasel, Badger

Low-mobility medium-sized mammals

Small mammals

Reptiles

Possible if adapted

Carnivores

- Fox2 – Species adapted to arid, open grassland habitats that generally experience high levels of mortality from roads and larger predators (e.g., Coyotes). Few documented cases of Swift/Kit Foxes using wildlife crossings, suggesting they avoid them and prefer to cross at grade-level. To encourage Fox use of structures they should be designed for their body size. Small- and medium-sized mammals, particularly prey species, tend to use passages of a size that allow for their movement but may limit movement of their larger predators. Hinged iron gates can be placed on underpass entrance. A 6 in x 6 in (15 x 15 cm) mesh spacing on gates will allow Foxes to pass through but not the larger predators. In larger structures (e.g., a 4 ft x 4 ft [1.2 x 1.2 m] culvert) artificial dens should be installed within structures and near entrances to provide escape cover for Swift/Kit Foxes.

Semi-arboreal mammals

- Tend to prefer arboreal habitats with structure that provides cover and protection during travel. Providing cover and escape or refuge areas such as piles of brush, stone or large woody debris should help movement under structure and between preferred habitats.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species may be reluctant to use a wildlife underpass unless riparian habitat is present or nearby. The construction of amphibian habitat may facilitate crossings by species associated with those habitat types.

Amphibians

- Not likely to use structure unless located in migratory route or during dispersal. Amphibian habitat can be created with series of ponds in a stepping-stone pattern connecting wetland habitats separated by highway.

Not recommended or applicable

Ungulates

- Moose, Pronghorn, Bighorn Sheep, Mountain Goat

Carnivores

- Black Bear, Grizzly Bear, Wolf, Cougar, Lynx, Wolverine

Unknown – more data are required

None

HOT SHEET 8: UNDERPASS WITH WATERFLOW

GENERAL DESIGN

Underpass structures like those in Figure 46 can be designed to accommodate dual needs of moving water and wildlife. Structures are generally located in wildlife movement corridors given their association with riparian habitats; however, some maybe only marginally important. Structures aimed at restoring proper function and connection of aquatic and terrestrial habitats should be situated in areas with high landscape permeability, are known wildlife travel corridors and have minimal human disturbance. These underpass structures are frequently used by several large mammal species, yet use by some large mammals will depend largely on how it may be adapted for their specific crossing requirements. Small- and medium-sized mammals (including carnivores) generally utilize these structures, particularly if riparian habitat is retained or cover is provided along walls of the underpass by using logs, brush or root wads. These underpass structures can be readily adapted for amphibians, semi-aquatic and semi-arboreal species.

Figure 46. Photo. Wildlife underpass designed to accommodate waterflow (Credit: Tony Clevenger).

USE OF THE STRUCTURE

Exclusively for wildlife, but may have some human use

GENERAL GUIDELINES

- Underpass structure should span the portion of the active channel migration corridor of unconfined streams needed to restore floodplain, channel and riparian functions.
- If underpass structure covers a wide span, support structures should be placed outside the active channel.
- Design underpass structure with minimal clearing widths to reduce impacts on existing vegetation.
- Even with large span structures the ability to restore habitat underneath will be limited. Open designs that provide ample natural lighting will encourage greater development of important native riparian vegetation.
- Maximize the continuity of native soils adjacent to and within the underpass. Avoid importation of soils from outside project area.
- Motor vehicle or all-terrain-vehicle use should be prohibited. Eliminating public or any other human use, activity or potential disturbance at the underpass and adjacent area is recommended for proper function and maximizing wildlife use.
- Underpass should be designed to conform to local topography. Design drainage features' so flooding does not occur within underpass. Run-off from highway near structure should not end up in underpass.

DIMENSIONS - GENERAL GUIDELINES

Dimensions will vary depending on width of active channel of waterflow (creek, stream, river). Guidelines are given below for dimensions of wildlife pathway alongside active channel and height of underpass structure.

Minimum:
Width: 6.5 ft (2 m) pathway
Height: 10 ft (3 m)

Recommended:
Width: >10 ft (>3 m) pathway
Height: >13 ft (>4 m)

TYPES OF CONSTRUCTION

Concrete bridge span (open span bridge)

Steel beam span

Concrete bottomless arch

SUGGESTED DESIGN DETAILS

Crossing structure

- Structures should be designed to meet the movement needs of widest range of species possible that live in the area or might be expected to recolonize the area, e.g., high and low mobility species.
- Attempt to mirror habitat conditions found on both sides of the road and provide continuous riparian habitat adjacent to and within the structure.
- Maximize microhabitat complexity and cover within underpass using salvage materials (logs, root wads, rock piles, etc.) to encourage use by semi-arboreal mammals, small mammals, reptiles and species associated with rocky habitats.
- Preferable that the substrate of underpass is of native soils.
- Revegetation will be possible in areas of underpass closest to the entrance, as light conditions tend to be poor in the center of the structure.
- Design underpass to minimize the intensity of noise and light coming from the road and traffic.

Local habitat management

- Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within underpass.
- Wildlife fencing is most effective and preferred method to guide wildlife to structure and prevent intrusions to the right-of-way. Mechanically stabilized earth (MSE) walls like the one in Figure 47, if high enough, can substitute for fencing and is not visible to motorists.
- Encourage use of underpass by either baiting or cutting trails leading to structure, if appropriate.
- Avoid building underpass in location with road running parallel and adjacent to entrance, as it will affect wildlife use.
- If traffic volume is high on the road above the underpass it is recommended that sound attenuating walls be placed above the entrance to reduce noise and light disturbance from passing vehicles.
- Underpass must be within cross-highway habitat linkage zone and connects to larger corridor network.
- Existing or planned human development in adjacent area must be at sufficient distance to not affect long-term performance of underpass. Long-range planning must ensure that adjacent lands will not be developed and the wildlife corridor network is functional.

POSSIBLE VARIATIONS

Divided road (2 structures)
In-line:

Undivided road (1 structure)

Figure 47. Photo. Mechanically stabilized earth (MSE) wall serving as wildlife exclusion "fence" (Credit: Tony Clevenger).

MAINTENANCE

- If wildlife underpass is not being monitored on regular basis, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the underpass that might affect wildlife use.
- Fence should be checked, maintained and repaired periodically (minimum once per year, preferably twice per year).

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Ungulates

- Elk, Deer

Carnivores

- Black Bear, Coyote, Fox1, Cougar, Bobcat

Low mobility medium-sized mammals

- Providing cover within underpass by using salvage materials (logs, root wads, rocks, etc.) will encourage use by these species.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species may be reluctant to use a wildlife underpass unless riparian habitat is present or nearby. Recommended maintaining riparian vegetation through the wildlife underpass to ensure use and regular movement by these species.

Small mammals

- Providing cover within underpass by using salvage materials (logs, root wads, rocks, etc.) will encourage use by these species.

Possible if adapted

Ungulates

- Moose – Tend to prefer large, open structures with good visibility and vertical clearance. The dimensions of some smaller underpasses may not be sufficient to ensure regular use by individuals of all sex and age classes. Recommend minimum 40 ft (12 m) width and 15 ft (4.5 m) height.
- Pronghorn, Bighorn Sheep, Mountain Goat – Like Moose, these species tend to prefer large, open structures with good visibility. Dimensions of some underpasses may not be sufficient to ensure regular use by individuals of all gender and age classes. Recommend minimum 40 ft (12 m) width and 15 ft (4.5 m) height for Bighorn Sheep and Mountain Goat; Recommended minimum 65 ft (20 m) width and 15 ft (4.5 m) height for Pronghorn.

Carnivores

- Grizzly Bear, Wolf - Tend to prefer large, open structures with good visibility, such as landscape bridges, wildlife overpasses and viaducts. Recommended dimensions may not be sufficient to ensure regular use by individuals of all gender and age classes. Recommend minimum 40 ft (12 m) width and 15 ft (4.5 m) height.

- Fox2 - Species adapted to arid, open grassland habitats that generally experience high levels of mortality from roads and larger predators (e.g., Coyotes). Few documented cases of Swift/Kit Foxes using wildlife crossings, suggesting they avoid them and prefer to cross at grade-level. To encourage Fox use of structures they should be designed for their body size, to limit predation risks associated with the crossings. It is unlikely these structures be designed specifically for Swift/Kit Fox use, thus wide and high underpasses with good visibility for prey species would be the most effective. In larger structures artificial dens should be installed within structures and near entrances to provide escape cover for Swift/Kit Foxes.

- Fisher, Marten – Forest-dwelling species that tend to prefer structures with ample riparian habitat, vegetative cover or form of protection while traveling. Recommended to place brush or root wads along underpass wall (one wall is sufficient; two is preferred, but will depend on width of structure) to ensure regular use by individuals of all gender and age classes. In large underpasses, culvert or pipes can be placed to provide cover.

- Badger, Weasel sp. – Species adapted to open habitats and require subterranean burrows for protection. Recommended to place brush, root wads along underpass wall (one wall is sufficient; two is preferred, but will depend on width of structure) to ensure regular use by individuals of all gender and age classes. In large underpasses, culvert or pipes can be placed to provide cover as Figure 48 shows.

Figure 48. Photo. Pipes placed in culverts to provide cover for small mammal movement (Credit: Tony Clevenger).

Semi-arboreal mammals

- Tend to prefer arboreal habitats with structure that provides cover and protection during travel. Providing cover and escape or refuge areas such as piles of brush, stone or large woody debris should help movement under structure and between preferred habitats.

Amphibians

- Not likely to use structure unless located in migratory route or during dispersal. Amphibian habitat can be created with series of ponds in a stepping-stone pattern connecting wetland habitat separated by highway shown previously in Figure 42 as an example for wildlife overpass. Recommended maintaining riparian vegetation, soil moisture and natural light conditions throughout the wildlife underpass to ensure use and regular movement by the species of concern.

Not recommended or applicable

None

Unknown – more data are required

Lynx

Similar to Pronghorn, scarce data exist on what type of crossings Canada Lynx will use. Monitoring of wildlife crossings on the Trans-Canada Highway in Banff National Park and adjacent provincial lands have detected Canada Lynx using a range of structure types on the Trans-Canada Highway: 165 ft (50-m) wide overpass, open span bridge underpass (40 ft [12 m] wide x 13 ft [4 m] high). For this species, recommendations are to design large structures but more importantly provide cover in form of logs, brush or root wads within the underpass. Siting the crossing within suitable Lynx habitat will be critical for successful design and use by Lynx.

Wolverine

The only data on Wolverine use of a wildlife crossing comes from Banff National Park and adjacent Bow Valley Provincial Park. Wolverine have been documented using the following:

- Underpass with Waterflow – Open span bridge with creek
  Width: 37 ft (11.5 m)
  Height: 8.2 ft (2.5 m)
  Usage: 3 detections

- Large Mammal Underpass – Open span bridge
  Width: 42.5 ft (13 m)
  Height: 16.5 ft (5.0 m)
  Usage: 1 detection

- Large Mammal Underpass – Multi-plate elliptical culvert
  Width: 24 ft (7.2 m)
  Height: 3 ft (4 m)
  Usage: 1 detection

For this species, recommendations are to design large structures but more importantly provide cover in form of logs, brush or root wads within the underpass. Similar to Canada Lynx, siting the crossing within suitable Wolverine habitat will be critical for successful design and use by this species.

HOT SHEET 9: SMALL-TO-MEDIUM-SIZED MAMMAL UNDERPASS

GENERAL DESIGN

One the smallest wildlife crossing structures. Primarily designed for small- and medium-sized mammals, but use by most species will depend largely on how it may be adapted for their specific crossing requirements and cover needs as Figure 49 shows. Small- and medium-sized mammals (including carnivores) generally utilize these structures, particularly if they provide sufficient cover and protection. These underpass structures can be of value to semi-aquatic mammals and amphibians if underpass structure is located in or near the habitat of these species.

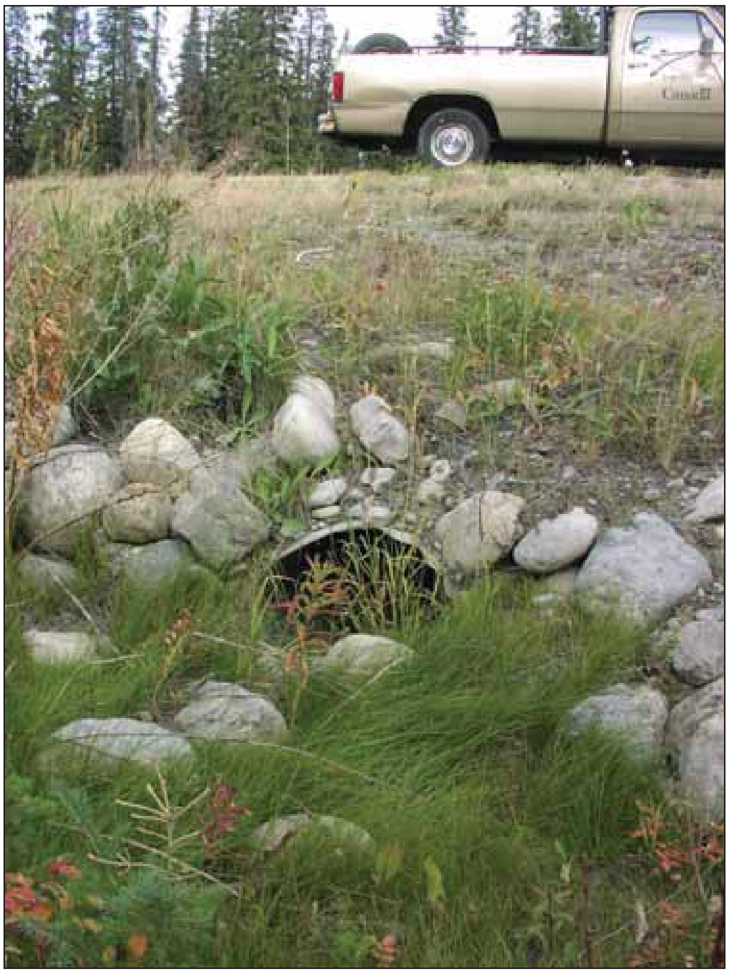


Figure 49. Photo. Small- to medium-sized mammal underpass (Credit: Tony Clevenger).

USE OF THE STRUCTURE

Exclusively for wildlife

GENERAL GUIDELINES

- To ensure performance and function, small to medium-sized mammal underpasses should be situated in areas with high landscape permeability, are known wildlife travel corridors and have minimal human disturbance.
- Underpass should be designed to conform to local topography. Design drainage features so flooding does not occur within underpass. Run-off from highway near structure should not end up in underpass.

DIMENSIONS - GENERAL GUIDELINES

Dimensions will vary depending on the target species. Structures generally range from 1 ft to 4 ft (0.4-1.2 m) diameter culverts or underpass structures.

TYPES OF CONSTRUCTION

Concrete bottomless arch

Circular multi-plate metal culvert

Prefabricated concrete box culvert

SUGGESTED DESIGN DETAILS

Crossing structure

- Structures should be designed to meet the movement needs of widest range of species possible that live in the area or might be expected to recolonize area, e.g., high and low mobility species.
- Maximize microhabitat complexity and cover within underpass using salvage materials (logs, root wads, rock piles, etc.) for sustained use by semi-arboreal mammals, small mammals, reptiles and species associated with rocky habitats.
- Preferable that the substrate of larger underpasses is of native soils. If construction type has closed bottom (e.g., concrete box culvert), a soil substrate $\geq$ 6 in (15 cm) deep must be applied to interior.
- Design underpass to minimize the intensity of noise and light coming from the road and traffic.
- On divided highways, underpass structure should be continuous, below-grade and not open up in the central median as the example in Figure 50 shows.

Figure 50. Photo. Continuous wildlife underpass on divided highway (Credit: Tony Clevenger).

Local habitat management

- Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within larger wildlife crossing structures that may be built during project.
- Attempt to provide continuous habitat leading to and adjacent to the structure.
- Encourage use of structure by using fencing, rock walls, or other barriers along road to direct wildlife into underpass. Use topography and natural features as much as possible.
- Encourage use of underpass by baiting and/or cutting trails leading to structure, if appropriate.
- Avoid building underpass in location with road running parallel and adjacent to entrance, as it will affect wildlife use.
- If traffic volume is high on the road above the underpass it is recommended that sound attenuating walls be place above the entrance to reduce noise and light disturbance from passing vehicles.

Possible Variations

Divided road (2 structures)
In-line:
Off-set:

Undivided road (1 structure)

MAINTENANCE

- If wildlife underpass/culvert is not being monitored on regular basis, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the underpass that might affect wildlife use.
- Fence should be checked, maintained and repaired periodically (minimum once per year, preferably twice per year).

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Carnivores

- Coyote, Fox1 – Generalist species' that occupy a variety of habitat types. Will typically use underpass or culvert designs sufficiently large enough so they can move through them.
- Fisher, Marten – Forest-dwelling species that tend to prefer structures that provide or have cover elements incorporated. Marten are known to readily use drainage culverts to cross 2- and 4-lane roads as captured in Figure 51. There is only anecdotal information on Fishers using drainage culverts. Design of culverts for these mustelid species should be slightly larger than their body size (ca. 2-3 ft diameter), thus providing cover and protection needed for travel. Larger size underpass structures should have continuous cover throughout to ensure regular use by individuals of all gender and age classes.
- Badger, Weasel – Species generally found in open areas and have been documented using drainage culverts to cross roads. Like Martens, Weasels readily use drainage culverts, particularly smaller ones (ca. 2 ft diameter). Badger tunnels have been designed in many countries and shown to be successful mitigation measures as shown in Figure 52. Design of tunnels or culverts for these species should be slightly larger than their body size (badgers, 2-3 ft (0.6-0.9 m) diameter; weasels, 1-2 ft (0.3-0.6 m) diameter), thus providing cover and protection needed for travel. Larger size underpass structures will not likely be sufficient to ensure regular use by individuals of all gender and age classes unless cover is added to them.

Figure 51. Photo. American marten using a drainage culvert to cross the Trans-Canada Highway, Banff National Park, Alberta (Credit: Tony Clevenger).

Figure 52. Photo. Badger tunnel in The Netherlands (Credit: Tony Clevenger).

Low mobility medium-sized mammals

- To encourage use from these species, structures should be designed for their body size. Small- and medium-sized mammals, particularly prey species, tend to use passages of a size that allow for their movement but may limit movement of their larger predators. In larger culverts (e.g., >4 ft (1.2 m) diameter circular or 4 ft x 4 ft [1.2 x 1.2 m] box culverts) the cover requirements of smaller fauna maybe met by placing pipes of varying diameter in the culvert that span the entire length.

Small mammals – (same as above for Low mobility medium-sized mammals)

Reptiles – (same as above for *Low mobility medium-sized mammals*)

Possible if adapted

Carnivores

- Fox2 – Species adapted to arid, open grassland habitats that generally experience high levels of mortality from roads and larger predators (e.g., Coyotes). Few documented cases of Foxes using a range of wildlife crossing sizes, but generally avoid them preferring to cross at grade-level. Design of culverts for these species should follow guidelines for *Low mobility medium-sized mammals* above. In larger structures (ca. 4 ft x 4 ft [1.2 x 1.2 m] culvert) artificial dens should be installed within structures and near entrances to provide escape cover for Swift/Kit Foxes generally shown in Figure 53.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species may be reluctant to use a wildlife underpass unless riparian habitat is present or nearby. Efforts should be made to site underpass structure in most suitable habitat for these species.

Amphibians

- Not likely to use crossing structure unless located in migratory route or in general area where dispersal may occur. Efforts should be made to site underpass structure in known routes of seasonal migration, dispersal or other movement events for the target species.

Not recommended or applicable

Ungulates

- Moose, Elk, Deer, Pronghorn, Bighorn Sheep, Mountain Goat

Carnivores

- Black Bear, Grizzly Bear, Wolf, Cougar, Bobcat, Lynx, Wolverine

Semi-arboreal mammals – all species.

Unknown – more data are required

None

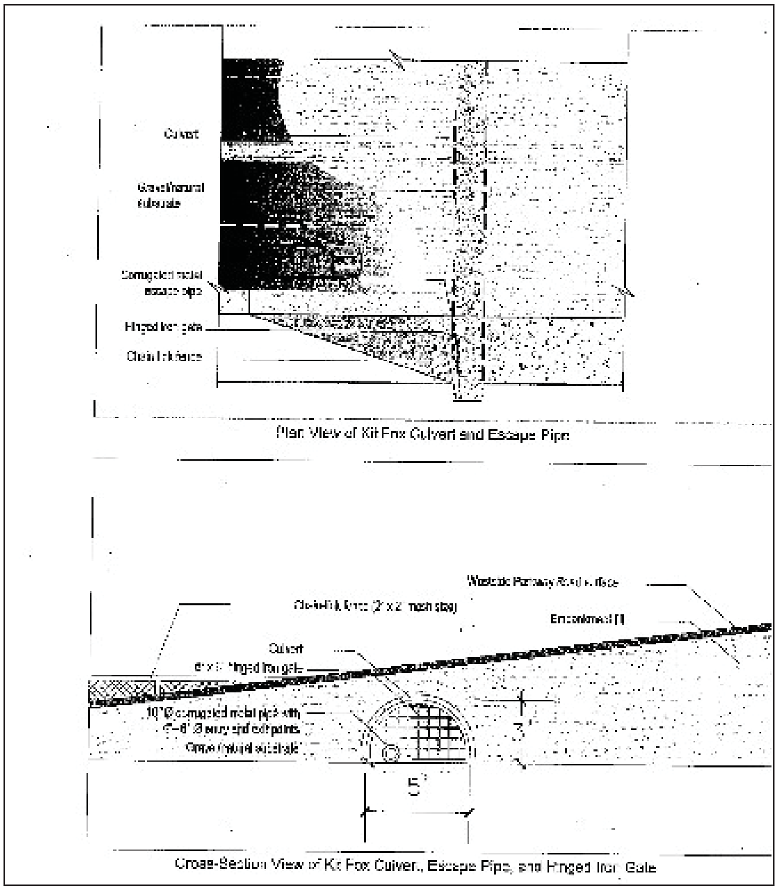


Figure 53. Schematic. Techical design plan for artificial kit fox den in culvert (Credit: US Fish and Wildlife Service).

HOT SHEET 10: MODIFIED CULVERT

GENERAL DESIGN

A crossing that is adaptively designed for use primarily by small and medium-sized wildlife associated with riparian habitats or irrigation canals. Designs to adapt canal bridges for wildlife crossings can take many forms. Dry platforms or walkways are typically constructed on the lateral interior walls of the bridge and above the high-water mark illustrated in Figure 54. Ramps from adjacent habitat and dry ground lead to the dry, elevated walkways inside the drainage structure.

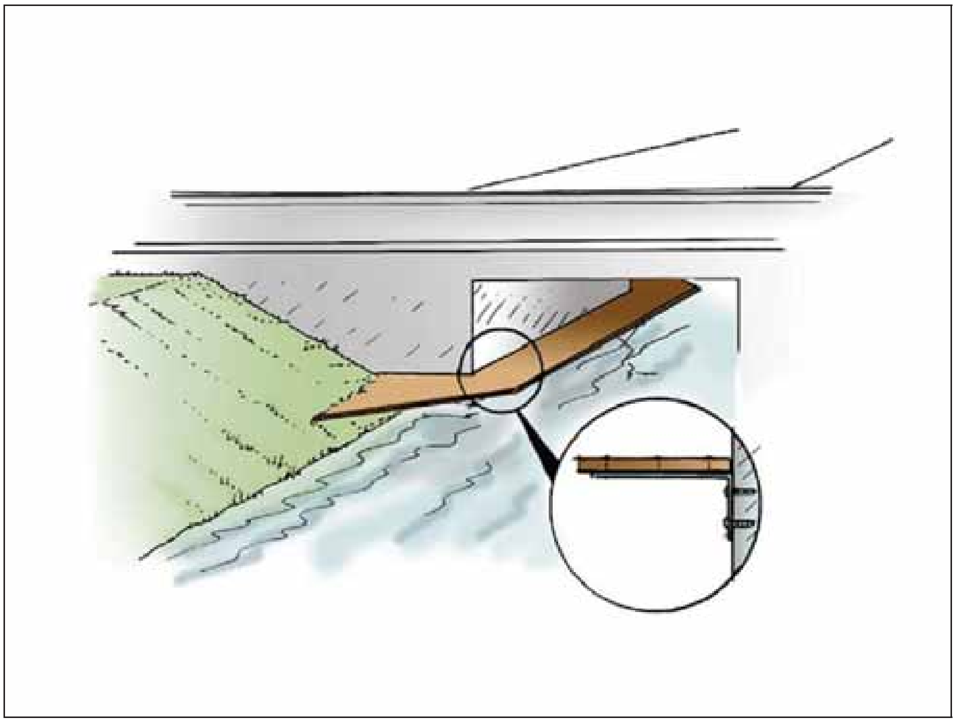


Figure 54. Schematic. Modified culvert (Reprinted with permission from Kruidering et al. 2005).

USE OF THE STRUCTURE

Movement of water and wildlife

GENERAL GUIDELINES

- Adapting drainages and canals for wildlife use is a cost-effective means to provide wildlife passage associated with wetlands and other habitats that are inundated year-round or seasonally.
- There is generally little human activity in these areas; nonetheless, to ensure performance and function a modified culvert should have minimal human disturbance.
- Little modifications are needed to adapt canal bridges for wildlife passage. Platforms made of sturdy materials (corrugated metal is not recommended) such as galvanized steel,

concrete or wooden boards ("2 x 10s") work well. It is important to keep the walkway platforms dry, above the high-water mark and accessible from adjacent dry habitat.
- Any work to adapt a bridge structure for wildlife passage should not impede or reduce the bridges hydrologic capacity or function.

DIMENSIONS - GENERAL GUIDELINES

- The dimensions of bridges for carrying water are a function of the hydrologic condition and needs of the area.
- Design and dimensions of walkways for wildlife will vary depending on the target species.
- Walkways: Recommended minimum > 1.5 ft (0.5 m) wide.
- Access ramps: Recommended ≤30 degrees slope.

TYPES OF CONSTRUCTION

- Concrete bottomless arch
- Prefabricated concrete box culvert
- Circular multi-plate metal culvert (these are least recommended, but can be adapted for wildlife passage using pre-fabricated metal shelves with service ramps (see Foresman 2003).

SUGGESTED DESIGN DETAILS

Crossing structure

- Structures should be designed to meet the movement needs of widest range of riparian-associated species that live in the area or might be expected to recolonize area.
- Wildlife walkways should run along both sides of the canal bridge. Walkways can be placed on only one side of the bridge interior in situations where wildlife habitat was primarily on one side of the bridge.

Local habitat management

- Attempt to provide continuous habitat leading to an adjacent to the structure. Re-vegetation of area may be needed after construction to restore habitat conditions.
- Encourage use of structure by using fencing, rock walls, or other barriers along road to direct wildlife into the modified culvert. Use topography and natural features as much as possible.
- If traffic volume is high on the road above the modified culvert it is recommended that sound attenuating walls be place above the entrance to reduce noise and light disturbance from passing vehicles.

POSSIBLE VARIATIONS

- Concrete platforms or walkways as an integral part of canal bridge structure.
- Platforms made of 2 in x 10 in wooden boards anchored to the interior wall of the structure.
- Pre-fabricated galvanized steel or metal shelves with service ramps installed in existing drainage culverts and bridges.

MAINTENANCE

- Periodic visits should be made to ensure that there is proper access, there are no material defects, or any obstacles in or near the underpass that might affect wildlife use. Checks should be made regularly but also after heavy rain events.
- Fences or other materials used to guide wildlife to the crossing should be checked, maintained and repaired periodically.

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Carnivores

- Fisher, Marten, Weasel sp. – Species adaptable in habitat use and associated with a mix of habitat types, including riparian habitats (especially Fisher). Use of modified culverts is likely if located in or near riparian habitats where they reside.

Low mobility medium-sized mammals

- To encourage use from these species, structures should be placed in or near habitats where they are found.

Semi-aquatic mammals

- Mink, River Otter, Muskrats and other riparian-associated species are ideal species for use of a modified culvert, particularly if situated in or near riparian habitat.

Small mammals – (same as above for *Low mobility medium-sized mammals*)

Amphibians

- Efforts should be made to site underpass structure in known routes of seasonal migration, dispersal or other movement events for the target species. Not likely to use structure unless located in migratory route or in general area where dispersal may occur.

Reptiles – (same as above for *Low mobility medium-sized mammals*)

Possible if adapted

Carnivores

- Coyote, Fox1, Bobcat – Species adapted to range of habitat types, including riparian and wetlands. Modified culverts should be designed to provide for wide walkways for these species when located in or near habitats they are found.
- Fox2 – Species adapted to arid, open and agricultural habitats, occasionally with irrigation canals. Few documented cases of Swift/Kit Foxes using a range of wildlife crossing sizes, but generally avoid them preferring to cross at grade-level. Artificial dens should be installed near entrances to provide escape cover for Swift/Kit Foxes.

Not recommended or applicable

Ungulates

- Moose, Elk, Deer, Pronghorn, Bighorn Sheep, Mountain Goat

Carnivores

- Black Bear, Grizzly Bear, Wolf, Cougar, Lynx, Wolverine, Badger

Semi-arboreal mammals – all species.

Unknown – more data are required

None

HOT SHEET 11: AMPHIBIAN/REPTILE TUNNEL

GENERAL DESIGN

Crossing designed specifically for passage by amphibians, although other small- and medium-sized vertebrates may use as well. One of these is shown in Figure 55. There are many different amphibian/reptile tunnel designs to meet the specific requirements of each species or taxonomic group. Amphibian walls or drift fences are required to guide amphibians and reptiles to location of crossing structure.

Figure 55. Photo. Construction and placement of amphibian tunnel in Waterton National Park, Alberta (Credit: Parks Canada).

USE OF THE STRUCTURE

Exclusively wildlife, primarily amphibians and reptiles

GENERAL GUIDELINES

- To ensure performance and function, amphibian/reptile tunnels should be situated in areas that are known amphibian migration routes and areas of reptile movements.
- Amphibians and reptiles have special requirements for wildlife crossing design since they are unable to orient their movements to locate tunnel entrances. Walls or fences play a critical function in intercepting amphibian and reptile movements and directing them to the crossing structure as Figure 56 shows.

Figure 56. Photo. Drift fence for amphibians and reptiles (Credit: Tony Clevenger).

- Main conflicts with amphibians are where roads intercept periodic migration routes to breeding areas (ponds, lakes, streams or other aquatic habitats). For some species the migration to these critical areas, including the dispersal of juveniles to upland habitats, is synchronized each year. This large movement event results in a massive migration of individuals in a specific direction during a short period of time. Amphibian/reptile tunnels should be located in these key sections of road that intercept their movements year after year. Without tunnels to provide safe passage over the road, huge concentrations of amphibians are run over by vehicles, in some cases causing dangerous driving conditions similar to "black ice."
- Large tunnels provide greater airflow and natural light conditions; however, smaller tunnels with grated slots for ambient light and moisture can be effective as Figure 57 shows. Grated tunnels are placed flush with the road surface. Distance between tunnels should be 150 ft (45 m) or less.

Figure 57. Photo. Grated slots on amphibian tunnels allows light and conservers ambient temperatures and humidity (Credit: Anonymous).

- Maximize continuity of native soils adjacent to and within the tunnel, if possible. Avoid importation of soils from outside project area.
- Tunnel should be designed to conform to local topography. Design drainage features' so flooding does not occur within amphibian/reptile tunnels. Run-off from highway near structure should not end up in tunnel.

DIMENSIONS - GENERAL GUIDELINES

- The width of amphibian/reptile tunnel will increase with tunnel length.
- The following recommended dimensions were adapted from Ministerio de Medio Ambiente (2006), Kruidering et al. (2005) and Jackson (2003).

Construction design		Tunnel	length (ft)		
	<65	65-100	100-130	130-165	165-200
Rectangular	3.2 x 2.5	5.0 x 3.2	5.75 x 4.0	6.5 x 5.0	7.5 x 5.75
Circular (diameter)	3.2	4.5	5.25	6.5	8.0

- Maximum distance between tunnels: 150 ft (45 m), but a 200 ft (60 m) distance could be used if guiding walls/fences are funnel-shaped to guide amphibians to tunnel.
- Minimum height of guiding wall/fence: 1.25 ft (0.4 m); 2.0 ft (0.6 m) for some jumping species.

TYPES OF CONSTRUCTION

- Rectangular and square/box (prefabricated concrete). This design is preferred because vertical walls facilitate movement of amphibians and reptiles through tunnel.
- Circular (prefabricated concrete, metal corrugated, steel, PVC piping, polymer surface product). Steel is not desirable because of its high conductivity and coldness during spring migratory periods.
- Open grated tunnels allow for more natural light and conditions of humidity inside tunnels.

SUGGESTED DESIGN DETAILS

Crossing structure

- Requirements for tunnel design and microhabitat differ among amphibian taxa (see Lesbarrères et al. 2003). Hesitancy and repeated unsuccessful entry attempts at tunnels is believed due to changes in microclimatic conditions, particularly temperature, light and humidity, that animals perceive as localized climate degradation. Larger tunnels (ca. 3 ft diameter) permit greater airflow and increased natural light at tunnel exits. Smaller tunnels can be effective if they are open-grated on top, increasing natural light and moisture. Sandy soil (sandy loam) should be used to cover the bottom of the tunnel to provide a more natural substrate for travel.
- Amphibians have been documented using tunnels that range in length from 22 ft (6.7 m) (Spotted salamanders, Massachusetts) to 125 ft (40 m) (Lausanne, Switzerland). The effectiveness of long tunnels spanning four-lane highways has not been tested.
- Tunnels should be situated at the base of the slope coming off the road grade. The shorter the length of tunnel the better for amphibian and reptile movement.
- Tunnels should be completely level, without slope of any kind at the entrances or within the tunnel.
- On divided highways, tunnels should be continuous, below-grade and not open up in the central median.
- Tunnels should have good drainage to avoid the flooding found in Figure 58. Amphibians are associated with mesic microhabitats but do not move through flooded tunnels.

Figure 58. Photo. Flooding in front of tunnel due to improper drainage design (Credit: Tony Clevenger).

Guiding wall/fence

- Wing walls should angle out from each end of the tunnel at approximately 45 degrees.
- Guiding wall/fence will be 1.25 ft (0.4 m) high and made of concrete, treated wood or other opaque material. Guiding walls/fences made of translucent material or wire mesh are not recommended because some amphibians try to climb over them instead of moving towards the tunnel.
- Bottom section of guiding wall/fence will be secured to ground, not leaving any gaps. Guiding wall/fence will tie into the tunnel entrance, avoiding any surface irregularities that might impede or distract movement towards the tunnel entrance. Any small gaps or defects at the base of the guiding wall will lead to individuals getting onto the road and reducing the efficacy and performance of the tunnel.
- Vertical walls/fences are preferred as bowed or curved walls are more difficult to mow grass and can obstruct the travel of some amphibians moving towards tunnel.
- Walls/fencing should extend out from the tunnel and flare out away from the road at terminal points to orient animals that move away from the tunnel towards natural environment.
- In Waterton National Park, Alberta, curbs were modified into ramps to allow Long-toed Salamanders to cross a road during their annual migration as Figure 59 shows. Without the ramp, salamanders were blocked at the curb and run-over by vehicles.

Figure 59. Photo. Construction of amphibian ramp to replace curb and allow cross-road movement of long-toed salamanders (Credit: Parks Canada).

Local habitat management

- Attempt to provide continuous habitat or vegetative cover leading to an adjacent to the structure. Re-vegetation of area may be needed after construction to restore habitat conditions and provide important cover during migrations and other movement events.
- If an open-grated tunnel, adapt substrate of tunnel to soil conditions and type located adjacent to tunnel.

POSSIBLE VARIATIONS

- Some experts suggest that natural light entering the tunnel from above will facilitate use by amphibians, thus recommending that a grill-type or grated cover be placed on tunnels shown earlier in Figure 57. There are no conclusive studies that demonstrate grates have a positive effect on movements of amphibians and reptiles.

Drift fences and translocations

- Due to the seasonality of amphibian movements across roads an option to a wildlife crossing structure consists of installing temporary system of amphibian protection that prevents animals from reaching the roadway. The system consists of constructing a temporary barrier or drift fence, made of a smooth and opaque fabric, staked down, for a predetermined length that impedes the movement of the majority of migrating amphibians towards the road as Figure 60 shows. The drift fence directs the amphibian to collection buckets where they are protected before being picked up and transported across the road. These systems are labor intensive and require collaboration from many people, usually agency and non-governmental organizations. Without citizen support these relatively inexpensive mitigation measures would usually not be possible.

Figure 60. Photo. Barrier or drift fence for amphibians and reptiles (Credit: Tony Clevenger).

- Drift fence material must be entirely opaque, of smooth fabric (rigid plastic, polythene, canvas) and a minimum height of 1.25 ft (0.3 m) to keep amphibians and reptiles from climbing or jumping over. Stakes should be placed on the road-side of the drift fence and not the opposite, which would obstruct amphibian movement. If target species is a burrower, such as a Mole Salamanders, steps should be taken to prevent animals from burrowing under the fence. Burying the bottom 2–4 in (5–10 cm) should discourage burrowing under the fence. To prevent breaching by climbing amphibians and reptiles, fence designs that curve inwards or create an overhang or lip have been used successfully. Overhanging vegetation close to the fence has resulted in animals climbing over the fence onto the road. Fencing should be clear of obstructions and vegetation.
- Collection buckets should be placed right up against the drift fence to maximize the "capture" of migrating amphibians into the buckets as documented in Figure 61. Buckets should be a minimum depth of 12–16 in (30–40 cm), buried, with tops of buckets at ground level. The distance between collection buckets should be approximately 30 ft (9

m) apart. A bucket at each end of the drift fence will keep amphibians from reaching the roadway.
- During the migration periods, buckets are checked, amphibians collected and transported across the road every 8 to 24 hours. The interval between checks will depend on the intensity of the movement event. During mass movements or migrations, buckets may need to be checked on an hourly basis.

Figure 61. Photo. Drift fence and collection buckets (Credit: Tony Clevenger).

MAINTENANCE

- Periodic visits should be made to ensure that there is proper access, there are no material defects, or any obstacles in or near the tunnel that might affect amphibian use. Checks should be made regularly but also after heavy rain events.
- Guiding walls/fences or other materials used to guide wildlife to the crossing should be checked, maintained and repaired periodically.
- Grass should be mowed within 2 ft (0.6 m) of the guiding wall/fence on the side that amphibians will travel. This task is important during the migratory period, which will

vary among species and environmental conditions. Herpetologists or local naturalists will be able to recommend the best time for mowing for each particular situation.

SPECIES-SPECIFIC GUIDELINES

Recommended/Optimum solution for wildlife species/groups

Amphibians

- Ideal crossing structure for this taxa. Requirements for tunnel design and microhabitat differ among amphibian taxa. Design of tunnel should meet the requirements of target species. Efforts should be made to site tunnel in known routes of seasonal migration, dispersal or other movement events for the target species. Not likely to use structure unless located in migratory route, within preferred habitat or in general area where dispersal events may occur.

Reptiles

- Ideal crossing structure for this taxa. Requirements for tunnel design and microhabitat differ among reptile taxa. Design of tunnel should meet the requirements of target species. Efforts should be made to site tunnel in known routes of seasonal movements, dispersal or other movement events for the target species. Not likely to use structure unless located in movement area, within preferred habitat or in general area where dispersal events may occur.

Possible if adapted

Low mobility medium-sized mammals

- To encourage use from these species, structures should be placed in or near habitats where they are found. Placement of cover near entrances and leading to adjacent habitat will increase the likelihood of use. If the tunnel is large, cover placed along inside walls will encourage use by these species.

Semi-aquatic mammals

- Their association with wetlands and aquatic habitat components will increase probability of tunnel use by these species, if located in or near habitats where they reside. Placement of adequate cover near entrances and leading to adjacent habitat will increase the likelihood of use by these species.

Small mammals – (same as above for *Low mobility medium-sized mammals*)

Not recommended or applicable

Ungulates – all species.

Carnivores – all species.

Semi-arboreal mammals – all species.

Unknown – more data are required

None

HOT SHEET 12: FENCING – LARGE MAMMALS

GENERAL PURPOSE

Wildlife exclusion fencing keeps animals away from roadways. However, fencing alone can isolate wildlife populations, thus creating a barrier to movement, interchange and limiting access to important resources for individuals and long-term survival of the population. Fencing like that in Figure 62, is one part of a two-part mitigation strategy—fencing *and* wildlife crossing structures. Fences keep wildlife away from the roadway, lead animals to wildlife crossings, thus allowing them to travel safely under or above the highway. Fences need to be impermeable to wildlife movement in order to keep traffic-related mortality to a minimum and ensure that wildlife crossings may be used. Defective or permeable fences result in reduced use of the wildlife crossings and increased risk of wildlife–vehicle collisions. Little research and best management practices exist regarding effective fence designs and other innovative solutions to keep wildlife away from roads.

Figure 62. Photo. Wildlife exclusion fencing and culvert design wildlife underpass (Credit: Tony Clevenger).

CONFIGURATIONS

Fencing configuration used to mitigate road impacts will depend on several variables associated with the specific location, primarily adjacent land use and traffic volumes. Both sides of the road must be fenced (not only one side) and fence ends across the road needs to be symmetric and not offset or staggered.

Continuous fencing

Most often associated with large tracts of public land with little or no interspersed private property or in-holdings.

Advantages: Long stretches of continuous fence have fewer fence ends and generally few problems of managing wildlife movement ("end-runs") around multiple fence ends, as with discontinuous fencing (below).

Disadvantages: Access roads with continuous fencing will need cattle guards (see Hot Sheet 14) or gates to block animal access to roads.

Partial (discontinuous) fencing

More common with highway mitigation for wildlife in rural areas characterized by mixed land use (public and private land). Generally installed when private lands cannot be fenced.

Advantages: Generally accepted by public stakeholders. Few benefits to wildlife and usually the only alternative when there is mixed land use.

Disadvantages: Results in multiple segments of fenced and unfenced sections of road, each fenced section having two fence ends. Additional measures need to be installed and carefully monitored to discourage end-runs at fence ends and hasten wildlife use of new crossing structures (see Terminations below).

INTERCEPTIONS

Fences invariably intersect other linear features that allow for movement of people or transport materials. This can include access roads, but also people (recreations trails) and water (creeks, streams). These breaks or interceptions in the fence require special modifications in order to limit the number of wildlife intrusions to the right-of-way.

Roads

- *Cattle guards* – Transportation and land management agencies commonly install cattle guards ("Texas gates" in Canada) shown by Figure 63, where fences intersect access roads. Many different designs have been used, but few if any have been tested. Designs of cattle guards vary in dimension, grate material (flat or cylindrical steel grates), and grate adaptations for safe passage by pedestrians and cyclists. Recently a grate pattern was developed that was 95% effective in blocking Key deer movement and was safe for pedestrians and cyclists (Peterson et al. 2003). A cattle guard roughly 6-8 ft (1.8-2.4 m) long and covering 2 lanes of traffic costs approximately $40,000 (Terry McGuire, Parks Canada, personal communication).

Figure 63. Photo. Cattle guard (Texas gate) in road (Credit: Tony Clevenger).

- *Electric cattle guards* – These electrified mats act like electric cattle guards to discourage wildlife from crossing the gap in the fence. Pedestrians wearing shoes and bicyclists can cross the mats safely, but dogs, horses and people without shoes will receive an electric shock. The electro-mats are generally 4 feet (1.2 m) wide and built into access roads where they breach fences. ElectroBraid™ and GapZapper® are two companies that currently design and sell electric cattle guards.
- *Painted crosswalks* – Highway crosswalk structures have been used to negotiate ungulates across highways at grade level (Lenhert and Bissonette 1997). White crosswalk lines are painted across the road to emulate a cattle guard. The painted crosswalk serves as a visual cue to guide ungulates directly across the highway. Painted crosswalks have not been tested, but if effective, they would be an inexpensive alternative to the more costly cattle guards.

Trails

- *Swing gates (fisherman, hikers)* – Where fences impede public access to popular recreation areas, swing gates can be used to negotiate fences. Gates must have a spring-activated hinge that ensures that even if the gate is left open it will spring back and close.

In areas of high snowfall, gates may be elevated and steps built to keep the bottom of the gate above snow as Figure 64 shows.

Figure 64. Photo. Step gate with spring-loaded door situated at trailhead in Banff National Park, Alberta (Credit: Tony Clevenger).

- *Canoe/Kayak landings* – There are no known simple gate solutions for transporting canoes/kayaks through fences. Swing gate described above is one solution, although the gate should be slightly wider than normal to allow wide berth while moving canoe/kayaks. Gates must have a spring-activated hinge that ensures they remain closed after use.

Watercourses

- *Rubber hanging drapes* – Watercourses pose problems for keeping fences impermeable to wildlife movement, as their flow levels tend to fluctuate throughout the year. When water levels are low, gaps may appear under the fence material allowing wildlife to easily pass beneath. Having fencing material well within watercourses will cause flooding problems, as debris being transported will not pass through the fence and can eventually obstruct water flow.

- A solution to this problem would require having a device on the bottom of the fence that moves up and down with the water levels. This could be done by attaching hinged strips of rubber mat-like material, draping down from the bottom of the fence material into the water. The rubber strips are hinged, so float on top of the water and move in direction of flow.

SUGGESTED DESIGN DETAILS

Mesh type, gauge & size

Fence material may consist of woven-wire (page-wire) or galvanized chain-link fencing. Fence material must be attached to the back-side (non-highway) of the posts, so impacts will only take down the fence material and not the fence posts.

- *Woven- or page-wire fencing* – Woven wire fences consist of smooth horizontal (line) wires held apart by vertical (stay) wires. Spacing between line wires may vary from 3 in (8 cm) at the bottom for small animals to 6-7 in (15-18 cm) at the top for large animals. Wire spacing generally increases with fence height. Mesh wire is made in 11, 12, 12 ½, 14, and 16 gauges and fences are available in different mesh and knot designs. The square-shaped mesh may facilitate climbing by some wildlife, such as bears. If climbing is a concern then use of a smaller mesh is recommended. Higher gauge wire mesh is more durable and will last longer than smaller gauge mesh. Wildlife fences along the Trans-Canada Highway in Banff National Park consisted of line wires with tensile strength of 1390 N/sq. mm and 12 ½ gauge. Stay wires had tensile strength of 850 N/sq. mm. All wires were Class 111 zinc galvanized coating at a minimum of 260 gms/sq. m.
- *Chain-link fencing* – Chain-link fence is made of heavy steel wire woven to form a diamond-shaped mesh. They can be made into fences and used in various applications, primarily industrial, commercial and residential. Chain-link was used for highway mitigation fencing along I-75 and SR 29 in Florida. There have been agency and public concerns about the visual aesthetics of chain-link fencing compared to woven-wire as it is less attractive and does not blend into the landscape. Steel posts are always used with chain-link fencing. Chain-link fence fabrics can be galvanized mesh, plastic coated galvanized mesh or aluminum mesh.
- Most wire sold today for fencing has a coating to protect the wire from rust and corrosion. Galvanizing is the most common protective coating. The degree of protection depends on thickness of galvanizing and is classified into three categories; Classes I, II, and III. Class I has the thinnest coating and the shortest life expectancy. Nine-gage wire with Class I coating will start showing general rusting in 8 to 10 years, while the same wire with Class III coating will show rust in 15 to 20 years.
- *Electrified fencing* – Electric fences are a safe and effective means to deter large wildlife from entering highway right-of-ways, airfields and croplands. The 7 ft (2 m) high fence will deliver a mild electric shock to animals that touch it, discouraging them from passing through. It is made of several horizontal strands of rope-like material about a ½ in (1 cm)

in diameter that can deliver a quick shock that is enough to sting, but not seriously harm humans. Wildlife respond differently to standard electric fences; high voltage fences are generally required to keep bears away. There are public safety issues of having electrified fencing bordering public roads and highways as there is high likelihood that people will come into contact with the fence (fishermen, hikers, motorists that run into fence).

Post types

- *Wood* – Wood posts are commonly used and can be less expensive than other materials if cut from the farm woodlot or if untreated posts are purchased. Post durability varies with species. For example, osage orange and black locust posts have a lifespan of 20 to 25 years whereas southern pine and yellow-poplar rot in a few years if untreated.
- The life expectancy of pressure-treated wooden posts is generally 20–30 years depending on the type of wood. Softwoods are the most common wood used for posts when fencing highways. Lodgepole pine and Jack pine are common tree species for fence posts. For Trans-Canada Highway wildlife fences all round fence posts were pressure treated with a chromate copper arsenate (CCA) wood preservative.
- Wood posts are highly variable in size and shape. For typical 2.4 m high fencing 12 ft (3.7 m) and 13.7 ft (4.2 m) long, non-sharpened wooden posts are supplied. Fence posts are sharpened and then installed by preparing a pilot hole approximately 5 in. (125 mm) in diameter, vibrating the post down to specified post height and backfilling with a compacted non-organic material around post to level of existing ground. Strength of wood posts increases with top diameter. Post strength is especially important for corner and gate posts, which should have a top diameter of at least 6.5 in (16 cm). Line posts can be as small as 5 in (13 cm) and should not need to be more than 6.5 in on top diameter, although larger diameter posts make fences stronger and more durable.
- *Steel* – Steel posts are used to support fences when crossing rock substrate. They weigh less and last longer than wood posts; the main disadvantage is they are more expensive than wood posts. Steel posts are supplied in 12 ft (3.7 m) lengths and installed in concreted 3.2 ft (1000 mm) long sleeves for the 12 ft x 3 in. steel posts.
- Tension – Tension between posts can consist of metal tubing on metal posts and reinforced cable on wooden posts.

REINFORCEMENTS

Unburied fence

Unburied fences are used in areas where resident wildlife are not likely to dig under the fence. The fence material should be flush with the ground to minimize animals crawling beneath the fence and reaching the right-of-way.

Buried fence

Strongly recommended in areas with wildlife capable of digging under the fence (e.g., bears, canids, badgers, wild boar). As illustrated in Figure 65, buried fence in Banff National Park significantly reduced wildlife intrusions to the right-of-way compared to unburied fence

(Clevenger et al. 2002). Buried fence consist of a 4-5 ft (1-1.2 m) wide section of galvanized chain-link fence spliced to the bottom of unburied fence material. The chain-link section is buried at a 45-degree angle away from the highway and is approximately 3.5 ft (1.1 m) below ground. Swing gates should have a concrete base to discourage digging under them as shown in Figure 66.

Figure 65. Photo. Wildlife exclusion fence with buried apron (Credit: Tony Clevenger).

Figure 66. Photo. Concrete base of swing gate to prevent animal digging under wildlife fence (Credit: Tony Clevenger).

Cable (protective)

Trees blown onto fences can not only damage fence material but provide openings for wildlife to enter the right-of-way. Typically a problem the inital years after construction, but can continue over time. A high-tensile cable shown in Figure 67 strung on top of fence posts to help break the fall of trees onto the fence material should reduce fence damage, repair costs and maintenance time.

Figure 67. Photo. High tensile cable designed to break fall of trees onto fence material (Credit: Tony Clevenger).

TERMINATIONS

Fence ends are notorious locations for wildlife movements across roads and accidents with wildlife. The problem is more acute soon after fence installation as wildlife are confused, unsure where to cross the road, and tend to follow fences to their termination, and then make end-runs across the road or graze inside the fence.

Each mitigation situation is different and will require a site-specific assessment, but as a general rule, fence ends should terminate at a wildlife crossing structure. If a wildlife crossing cannot be installed at the fence ends, then fences should be designed to terminate in the least suitable location or habitat for wildlife movement—i.e., places wildlife are least likely to cross roads. Some examples are:

- Steep, rugged terrain such as rock-cuts (Bighorn Sheep and Mountain Goats excluded).
- Habitats that tend to limit movement, e.g., open areas for forest-dwelling species.
- Areas with regular human activity and disturbance.

Another consideration is motorist visibility and speed at fence ends. Fences should end on straight sections of highway with good motorist visibility. Lighting at fence ends may improve motorist visibility and actually enhance road crossings by ungulate species; however, it may deter movement by wary carnivore species. Regardless of the situation, proper signage as Figure 68 shows must be installed to warn motorists of potential wildlife activity and crossings at fence ends.

Figure 68. Photo. Warning signage at end of wildlife exclusion fence (Credit: Tony Clevenger).

Because fence ends create a hazardous situation for motorist and wildlife, it is important to discourage wildlife movement towards fence ends. Having wildlife locate and use wildlife crossings as soon as possible after construction is the best recommendation to discourage end-runs. Cutting trails to wildlife crossings, baiting or use of attractants should help direct wildlife to crossings and hasten the adaptation process.

DIMENSIONS - GENERAL GUIDELINES

Highway fencing for large mammals, including most native ungulate species of Moose, Elk, Deer, Bighorn Sheep, should be a minimum of 8.0 ft (2.4 m) high with post separation on average every 14-18 ft (4.2-5.4 m). In some cases the fence height may not need to be designed for large ungulates. Alternate fence design and specifications will need to consider not only fence requirements for species present, but also species that may potentially recolonize or disperse into the area in the future.

POSSIBLE VARIATIONS

Boulders/terrain

Boulders as a substitute for wildlife fencing has not proved to be effective; however, boulder fields or aprons have been used to effectively discourage wildlife entering the highway right-of-way at fence ends. The boulder apron is positioned on both road shoulders and at the ends of fence (and median for four-lane highway) and can range from 165-325 ft (50-100 m) long (along roadway). The shoulder aprons vary in width from about 25-65 ft (8-20 m), depending on how close the fence is positioned to the roadway - the boulders must extend right from the edge of pavement up to the fence to preclude any path for wildlife to skirt the boulders. Boulder aprons are made of subangular, quarried rock, ranging in size from 10-25 in (20-60 cm), however most should be larger than 12 in (30 cm). The boulder apron, at a depth of about 16-20 in (40-50 cm), is installed on geofabric on sub-excavated smoothed ground. The boulders project about 10-12 in (20-30 cm) above local ground surface as shown in Figure 69.

Reduced fence height

Lower than average fence height may be prescribed where there are commercial or residential concerns of visual effects and aesthetics of fencing. Reducing the fence height (e.g., 6 ft [1.8 m]) with respect to the adjacent area by running the fence through a lowered or depressed area will make the fence appear lower and less obtrusive. Planting shrubs and low trees in front of the fence will also help the fence blend into the landscape.

Outriggers/overhangs

Although never formally tested, outriggers or fence overhangs could potentially discourage wildlife (bears, cat species) from climbing fences and reaching the right-of-way.

Figure 69. Photo. Boulder field at end of wildlife fence (Credit: Tony Clevenger).

Barbed wire overhangs

Similar to outriggers and fence overhangs, barbed wire overhangs are commonly used in urban areas to keep people out of areas. Overhangs of this type are found on Interstate-75 in Florida and have apparently been effective in keeping panthers and black bears from climbing the fence.

Gap below fence material for Pronghorn

The movement and migration of Pronghorn is affected by the network of fences they need to negotiate to meet their biological needs. Although not particular to wildlife fencing for wildlife crossing structures, it is worth noting that standard 4 ft (1.1 m) high road-side fencing, typically of barbed-wire, can be modified to improve Pronghorn movement. Pronghorn do not jump over fences, even 4 ft (1.1 m) fences, but generally try to crawl underneath. Transportation agencies have had success in getting Pronghorn to move through their preferred crossing areas by removing the bottom strand of barbed-wire.

MAINTENANCE

Fences are not permanent structures, neither are they indestructible. They are subject to constantly occurring damage from vehicular accidents, falling trees, and vandalism. Natural events also cause continually occurring damage and threaten the integrity of the fence: soil erosion, excavation by animals, and flooding can loosen fence posts and collapse portions of fence.

Fences must be checked every 6 months by walking entire fence line, identifying gaps, breaks and other defects caused by natural and non-natural events.

HOT SHEET 13: FENCING – SMALL AND MEDIUM VERTEBRATES

GENERAL PURPOSE

Most fencing for large mammals (see Hot Sheet 12) does not impede movement by small and medium sized mammals. These smaller mammals need a denser mesh fence material to keep them from entering the right-of-way. Fence design specifications for amphibians and reptiles are covered in Hot Sheet 11. Some small and medium-sized mammals are able to climb or dig under fence material, thus requiring a specific design in order to work effectively.

APPLICATION

- Generally recommended on sections of highway where high rates of mortality occur (or are predicted to occur) for one particular species.
- Designed to meet site- and species-specific needs of preventing animal movement through large mammal fences. Fencing should not be extensive, otherwise movements of non-target small mammals will be affected and populations will become isolated.
- Fencing for small and medium-sized mammals is joined to existing large mammal fencing (or installed simultaneously) and placed at ground level, shown in Figure 70. Fencing should be placed on the outside of the large mammal fence (non-highway side) and fastened to the large mammal fence material.
- Fencing for small and medium-sized mammals should always be used in conjunction with wildlife crossing structures designed for their specific use.

Figure 70. Photo. Small and medium-sized mammal fence material spliced to large mammal fence material (Credit: Nancy Newhouse).

SUGGESTED DESIGN DETAILS

Installation

- Fence material should be buried below ground 6-10 in (15-20 cm).
- Where fencing meets tunnels or other wildlife crossing structures it is advisable that fence material is well connected to the wing walls or sides of the structures, not allowing any gaps where they meet.
- Where fences meet drainage culverts they should either pass above or integrate the culvert into the fence.

Mesh types and sizes

- Fence material generally consists of hardware cloth or welded wire-mesh. The wire mesh comes in a variety of mesh sizes, colors and coatings to meet specific needs of each target species and objective.
- The standard mesh size is ½ in (1 cm), although larger mesh may be used for larger target species.
- The top 2-3 in (4-6 cm) of fence material should be doubled-back away from the highway at a 45-degree angle to discourage animals from climbing over the fence.

Dimensions

- The standard height of fencing is 2 ft (0.6 m) above the ground. This height can be adjusted depending on the target species and project objectives. For example, 16 in (40 cm) above the ground is sufficient for desert tortoises.

POSSIBLE VARIATIONS

For adept climbers (mink, weasels, martens) fences should be constructed at least 4 ft (1.2 m) high, ½-1 in (1-2 cm) welded wire mesh. The top portion should be 6-10 in (15-25 cm) in length and doubled-back away from the large mammal fence material in outrigger fashion.

MAINTENANCE

- Fences are not permanent structures, neither are they indestructible. They are subject to constantly occurring damage from vehicular accidents, falling trees, and vandalism. Natural events also cause continually occurring damage and threaten the integrity of the fence: soil erosion, excavation by animals, and flooding can loosen fence posts and collapse portions of fence.
- Fences must be checked every 6 months by walking entire fence line, identifying gaps, breaks and other defects caused by natural and non-natural events.

HOT SHEET 14: GATES AND RAMPS

GENERAL PURPOSE

If wildlife become trapped inside the fenced area, they need to be able to safely exit the highway area. The most effective means of escape are through a steel swing gate, hinged metal door or earthen ramp (or "jump-out") as Figure 71 shows. A low cost way to provide escape is to lay natural objects (tree trunks or limbs) against the fence. The number, type and location of escape structures will depend on the target species, terrain and habitat adjacent to the highway fence.

Figure 71. Photo. Escape ramp (jump-out) for wildlife trapped inside highway right-of-way (Credit: Tony Clevenger).

APPLICATION

Swing gates

Swing gates are generally used (with or without ramps) in areas where highways are regularly patrolled by wardens/rangers. As part of their job, if wildlife are found inside the fence, the nearest gates are opened and animals are moved towards the opened gate illustrated in Figure 72. Double swing gates are more effective than single swing gates, especially for larger mammals such as Elk or Moose. Swing gates are used to remove ungulates and large carnivores (e.g., bears) as smaller wildlife can escape by hinged doors at ground level (see below) or through large mammal fence material.

Figure 72. Photo. Single swing gate in wildlife exclusion fence (Credit: Tony Clevenger).

Earthen ramps or jump-outs

Earthen ramps or jump-outs allow wildlife (large and small) to safely exit right-of-ways on their own without aid of wardens or rangers. Typically wildlife find the ramps and exit by jumping down to the opposite side of fence shown in Figure 73. Deer and Elk are the most common users, but Moose, Bighorn Sheep, Bears and Cougars use these structures as well. The outside walls of the escape ramp must be high enough to discourage wildlife from jumping up onto the ramp and access the right-of-way. However, the walls should not be so high they discourage wildlife from jumping off. The landing spot around the outside wall must consist of loose soil or other soft material to prevent injury to animals. The outside walls must be smooth to prevent Bears or other animals from climbing up. For best use, escape ramps should be positioned in a set-back in the fence, in an area protected with dense vegetative cover, so animals can calm down and look over the situation before deciding to use the jump out or continue walking along the fence. A right-angle jog in the fence is recommended for positioning the escape ramp but not necessary.

Figure 73. Photo. Wildlife escape ramp (jump-out; Credit: Tony Clevenger).

Small hinged doors

For small- and medium-sized mammals, natural objects (for climbing species) or small, hinged doors at ground level as shown in Figure 74 allow them to escape the right-of-way on their own.

Natural objects

Natural objects can be used simply, and cost-effectively to help small and medium-sized mammals exit the right-of-way. Stacking of brush and woody debris against the fence line and to fence height will allow climbers to exit safely.

Like fences, escape structures need to be carefully planned for the wildlife they are targeted, their location, design and maintenance over time.

MAINTENANCE

Like fences, gates and ramps are not permanent structures, neither are they indestructible. They are subject to constantly occurring damage from vehicular accidents, falling trees, and vandalism. Natural events also can cause damage, obstruct gates and affect how well they perform.

Like fences, escape structures must be checked every six months to ensure that they are functioning properly and perform when needed. Maintenance checks should take place at the same time as fence inspections (see Hot Sheets 12 and 13).

Figure 74. Photo. Hinged door for escape of medium-sized mammals (Credit: Tony Clevenger).

APPENDIX D – FRAMEWORK FOR MONITORING

Framework for evaluating the performance of measures designed to reduce wildlife–vehicle collisions and barrier effects of roads on wildlife movement. Numbers for monitoring questions relate to one another across columns. Black text = Monitoring generally associated with highway corridor; Blue text = Monitoring and research needed to answer management questions from the project area at the landscape scale.

MONITORING OBJECTIVES	Monitoring question	Methods	Study design	Targets
WILDLIFE–VEHICLE COLLISION REDUCTION (PRE- AND POST-CONSTRUCTION)	1. Do crossing structures reduce mortality rates? 1.a. Compared to baseline levels of road mortality; 1.b. Compared to adjacent "control" areas post-construction; 2. Compared to other sections of highway without crossing structures 3. What is the incidence of mortality among a marked sample? [Addressing this question will require large sample sizes and representative sampling of population]	Road-kill data collection: 1 & 2. Road-kill surveys on highway sections with and without crossing structures. Surveys must be extensive in length (see Feldhamer et al. 1986) and systematically conducted at frequent intervals Radiotelemetry: 3. Standard capture-mark-release techniques. Transmitters may consist of VHF transmitters or global positioning system (GPS) transmitters with the latter providing more spatial accuracy in identifying how and where animals cross highways.	Road-kill data collection: 1.a. (1) Pre- vs post-construction comparison of mortality rates on "treatment" areas (crossing structures) with "controls" (BACI[1] design) 1.a. (2) Pre- vs post- construction comparison of mortality rates on "treatment" areas (crossing structures) and those without "controls (BA[1] design)" 1.b. Post-construction comparison of mortality rates using "treatment" (crossing structures) sections vs. adjacent sections without crossing structures (CI[1] design) 2.a. Multivariate logistic regression analysis 2.b. Comparison of mortality rates on sections with and without crossing structures, standardized by highway length Radiotelemetry: 3. Proportion of marked sample killed on highway compared to control sections	1 & 2. Reduction in mortality rates compared with baseline conditions (i.e., without crossing structures). Reductions should either be statistically significant or deemed biologically meaningful. 3. Significant (statistical or biological) proportion of the marked sample survives and reproduces in highway environment with crossing structures.

MONITORING OBJECTIVES	Monitoring question	Methods	Study design	Targets
RESTORING MOVEMENTS IN PROJECT AREA (PRE- AND POST-CONSRUCTION)	1. What is the frequency of movement across highway with crossing structures and without? 2. What factors influence crossing activity? 3. Do animals cross above-grade or use existing below-grade structures? 4. Where do animals cross the highway 5. What is the genetic structure of focal populations and what are barriers to gene flow? 6. Is the demographic structure of focal population affected by the highway?	Telemetry (radio or GPS): 1.2.3.4. (See above) Observational data: 3 & 4a. Remote cameras that detect and record animal activity in highway environment over 24-hr period. Remote digital 35mm or video cameras installed on preferably straight and level sections of highway. Some video cameras detect and record animal activity on sections up to 1.0 mile in length 3 & 4b. Trackpads on right-of-way (Hardy et al. 2007) 3 & 4c. Fluorescent dye marking. Method allows for follow-up "tracking" of small animal using ultraviolet light at night (McDonald and Cassady St Clair 2004) 5. Non-invasive genetic sampling methods (e.g., hair snares, scat dogs) 5a/5b. Genetic sampling and genotyping; assignment tests and other spatial genetics modeling approaches 5c. Genetic sampling and genotyping; genetic health analyses (inbreeding, allelic diversity, heterozygosity values);	Telemetry: 1. Frequency of radio-marked animal movements across highway sections using treatment/control; BACI & CI designs or treatment; BA design 2. Frequency of radio-marked animal movements across highway related to traffic volumes and time of day 3 & 4. Radio monitor closely movements in highway environment and existing below-grade passage structures Observational data: 5. Non-invasive genetic sampling surveys on established survey points or transects in study area. 5a/5b. Model (based on maternally inherited mitochondrial markers) landscape resistance that correlate with the genetic structure of the target species 5c. Compare the genetic diversity of treatment (highway) populations to control populations (that are stable or declining)	1. Greater number of marked individual movements occur on treatment sections (crossing structures) 2. Traffic volume, intra-group behavior and time of day may help explain movement behavior and crossing success 3 & 4. Significant (statistically or biologically) greater number of individual movements of radio marked individuals occur on treatment sections (wildlife crossing structures) 4. Greater number of observed crossings occur on treatment sections (crossing structures) compared to control sections 5a. Landscape resistance models will identify both barriers to dispersal and corridors for gene flow (pre- and post-construction) 5b. Distinguish exploratory movements from the successful reproduction and reveal the resistance of a landscape to gene flow 5c. Reveal whether genetic variability has reached critically low levels

MONITORING OBJECTIVES	Monitoring question	Methods	Study design	Targets (Applications)
POPULATION VIABILITY (POST-CONSTRUCTION)	Do project connectivity measures affect key life-history attributes (e.g., mortality, fertility, survival to reproduction, connectivity) and provide for natural sustaining populations in the project area?	Spatially-explicit population viability modeling: Development of spatially-explicit, individually-based population viability (PV) models using demography data and habitat data collected for other project objectives or obtained from the scientific literature. Use of custom or commercially available PV modeling software (e.g., RAMAS-GIS). Robust demography and spatially-explicit landscape suitability information will be required for such an approach.	Spatially-explicit population viability modeling: Modeling of PV under (a) baseline conditions, (b) highway without wildlife crossings, (c) highway with wildlife crossings	Spatially-explicit population viability modeling: Determination of the mean and variation of demographic parameters necessary to maintain viable populations over the long term; provides different modeling scenarios by varying performance targets, refining target parameters and creating new monitoring questions based on predictions, and future PV models

MONITORING OBJECTIVES	Management question	Methods	Study design	Targets
FENCE INTRUSIONS (POST-CONSTRUCTION)	1. How often do individual animals breach the fence and access the right-of-way? 2. Where do fence intrusions occur, for what species, and how frequently?	Observational data: 1 & 2. Road surveys or opportunistic observations of wildlife inside the highway fence. Can be conducted by both WTI researchers or DOT personnel using PDA/GPS ($ROCS^2$) units	Observational data: 1 & 2. Summary of fence intrusion data by species, frequency, and location	1. Minimize number of fence intrusions by wildlife 2. Evaluate effectiveness of fence construction and design at various points in study area, including effects of physical and biological factors (e.g., terrain, habitat, snowfall) on intrusion frequency
JUMP-OUTS (POST-CONSTRUCTION)	1. When wildlife breach the fence and access the right-of-way, do they find the jump-outs? (see “fence intrusions”) Of those that visit the jump-out, what proportion exit the right-of-way by using the jump-out? 2. What species visit the jump-outs, how frequently, and how often are they successfully used?	Observational data: 1 & 2. Systematic visits to jump-outs when monitoring wildlife use of crossings. Can be conducted by both WTI researchers or DOT personnel using PDA/GPS ($ROCS^2$) units	Observational data: 1 & 2. Summary of jump-out visits and use data, by species, frequency, and jump-out location	1. Minimize the number of wildlife visits to jump-outs (see “fence intrusions”) 2. Maximize the use of jump-outs for safe exit from the highway right-of-way

MONITORING OBJECTIVES	Management question	Methods	Study design	Targets
WILDLIFE CROSSING DESIGN (POST-CONSTRUCTION)	1. Are animals crossing highway using existing below-grade structures (culverts)? 2. Do animals use the wildlife crossing structures? With what frequency? 3. What are the attributes of existing below-grade structures and wildlife crossings that influence species-specific passage?	Observational data: 1 & 2. Noninvasive detection methods (e.g., track beds, track plates, hair snares, remote cameras) to quantify species-specific use. 3a. Detection stations and/or transects 3b. Data summary; multivariate analysis; occupancy modeling	Observational data: 1 & 2. Employ non-invasive survey methods with sufficient ability to detect species with high probability. 3. Develop species-specific expected use values for calculating performance indices	1. Level of connectivity afforded by existing below-grade structures 2. Level of connectivity afforded by wildlife crossings 3a/3b. Data on species-specific design requirements of below-grade structures (culverts) and wildlife crossings 3c. Adaptive management of future connectivity design plans
SPECIES OCCUPANCY (project-level) (PRE- AND POST-CONSTRUCTION)	1. What species are present - absent in the highway corridor project area? 2. How are species" distributed and what are their relative abundances? How do distribution and relative abundance change over time? 3. Can species occupancy models be developed to accurately predict occurrence in subregions of the project area?	Species detection surveys: 1. 2. 3. Species occupancy methodology. Detection stations and transects located at project-level 1a 2a 3a. Non-invasive detection methods (e.g., track plates, hair snares, remote cameras, scat detection dogs) 3. Species occupancy modeling	Species detection surveys: 1. 2. 3. Fixed system of survey points-transects in highway corridor and adjacent habitats. Repeat monitoring within a relatively short time period (e.g., 10-14 d) to ensure demographic closure. Conduct surveys 1-3 times each year (season?) over long-term.	1. Assess species presence-absence or use of project area 2. Evaluate (a) which species are present in project area and, (b) site colonization and extinction estimates if multiple-year datasets are compiled 3. Occupancy assessment provides (a) information related to "expected" use of wildlife crossings and more accurate performance indices for design-related analysis; (b) species occurrence probability surfaces

MONITORING OBJECTIVES	Research question	Methods	Study design	Targets
SPECIES OCCUPANCY (landscape-level) (PRE- AND POST-CONSTRUCTION)	1. What species are present - absent in the greater project area? 2. How are species" distributed and what are their relative abundances? How do distribution and relative abundance change over time? 3. Can species occupancy models be developed to accurately predict occurrence across the greater project area?	Species detection surveys: 1. 2. 3. Species occupancy methodology. Detection stations and transects located at landscape-level 1a 2a 3a. Non-invasive detection methods (e.g., track plates, hair snares, remote cameras, scat detection dogs) 3. Species occupancy modeling	Species detection surveys: 1. 2. 3. Fixed system of survey points-transects in study area. Repeat monitoring within a relatively short time period (e.g., 10-14 d) to ensure demographic closure. Conduct surveys 1-3 times each year (season?) over long-term.	1. Assess species presence-absence or use of greater study area 2. Evaluate (a) which species are present in greater study area and, (b) Site colonization and extinction estimates if multiple-year datasets are compiled 3. Occupancy assessment provides (a) information related to "expected" use of wildlife crossings and more accurate performance indices for design-related analysis; (b) species occurrence probability surfaces

[1] BACI: Before-After-Control-Impact; BA: Before-After; CI: Control-Impact (see Roedenbeck et al. 2007).
[2] ROCS: See description in Chapter 3.

APPENDIX E – MONITORING TECHNIQUES

REMOTE DIGITAL STILL OR VIDEO CAMERAS

Digital still cameras or video cameras equipped with infrared sensors record images of wildlife entering, within, or exiting crossing structures. These "passive-type" sensors detect moving warm objects and can be set to only detect species larger than a predefined threshold size. Such cameras can be deployed outside of culverts attached to trees or posts as shown in Figure 75 or attached directly to culvert walls. Newer generation cameras are weatherproof, can be operated in all seasons, and can record an almost limitless number of images. Video versions provide information on crossing behavior (e.g., degree of animal willingness to cross, speed of crossing), and some still models can also be set to capture multiple photos in a rapid burst, providing some information on crossing behavior.

Figure 75. Photo. Remote digital infrared-operated camera (Credit: Tony Clevenger/WTI).

Benefits

Unambiguous species identification; low labor cost; can be deployed during all seasons and in locations with running water; some (limited in North America) potential for differentiating individuals; permanent record; photos valuable for outreach to public.

Constraints

Low ability to detect all sizes of species—most effective for medium to large species; risk of theft; high initial cost.

Estimated Cost

High initial cost (but lower labor cost during surveys) of $550-$800 per camera (including protective, theft-resistant box and data cards).

Applications

Assess use/effectiveness of wildlife crossing structures (existing and proposed)

- Assess rate of wildlife at grade highway crossings (cameras deployed randomly)
- Assess rate of wildlife, at grade, highway crossings (cameras deployed at targeted locations)
- Monitor wildlife use of locations throughout and adjacent to the project area (cameras deployed at scent stations)
- Evaluate effectiveness of jump-outs (cameras deployed on top of jump-outs).

REMOTE DIGITAL STILL OR VIDEO CAMERAS DEPLOYED SPECIFICALLY FOR EVALUATING AT GRADE, WILDLIFE HIGHWAY CROSSINGS

Remote cameras can also be deployed along roadsides with "active-type" sensors composed of "break the beam" components. When an animal approaching the side of the highway breaks the beam between two sensors, a photo is taken or a video camera is turned on. Sensors can be separated by up to 100 ft, can be combined to monitor longer stretches, and can be set-up to fire multiple still cameras.

Benefits

Unambiguous species identification; low labor cost; permanent record; photos/video valuable for outreach to public.

Constraints

High level of complexity with setup and untested for this purpose; likely difficulty in discerning species at greater distances from camera location; low ability to detect all sizes of species—most effective for larger species; only detects crossing attempts, not successful crossings; risk of theft; high initial cost.

Estimated Cost

High initial cost (but lower labor cost during surveys) of $1000-$2000 per 200 ft stretch of road (including protective, theft-resistant box and data cards).

Applications

- Assess rate of at grade, wildlife highway crossings (cameras deployed randomly)
- Assess rate of at grade, wildlife highway crossings (cameras deployed at targeted locations).

TRACK BEDS

Track beds are constructed from a mixture of sand and silt deposited in a linear bed (typically about 2 yards in width) across culvert entrances or within the culvert itself as Figure 76 shows. Such beds are raked smooth and are generally checked every three to four days for tracks that indicate animal crossings: species, direction of travel, number of individuals, etc.

Figure 76. Photo. Raking of track bed in culvert Banff National Park, Alberta (Credit: Tony Clevenger/WTI).

Benefits

Detect wide-variety of animal sizes (but generally coyote-size and larger); can provide back-up in case remote camera malfunctions or is stolen; relatively low up-front cost; Generally not affected by weather events that may obliterate tracks if structure is covered (e.g., underpass or culvert).

Constraints

Unable to deploy at locations with running water unless natural banks or engineered pathways are constructed in structures; occasionally problems with species identification; trampling of tracks (i.e., many overlapping tracks) can make interpretation difficult if not checked regularly; difficult to confirm that an individual animal passed completely through the structure or simply crossed the bed and returned.

Estimated Cost

Low cost (field vehicle and labor cost during surveys for personnel to check track pads regularly); personnel costs: $1300 for one month of monitoring @ 10 days of work per month @ $130/day [$16/hr]; low equipment costs: rake, personal data assistant (PDA), digital camera, tape measure, field guide to animal tracks.

Applications

- Assess use/effectiveness of wildlife crossing structures (existing and proposed)
- Monitor wildlife use of locations throughout and adjacent to the project area (beds deployed as round "plots" and used in conjunction with a bait or scent lure
- Evaluate effectiveness of jump-outs (beds deployed on top and around the base of jump-outs).

TRACK BEDS DEPLOYED SPECIFICALLY FOR EVALUATING AT GRADE, WILDLIFE HIGHWAY CROSSINGS

Track beds can also be deployed along highway shoulders or in medians, providing a means to detect animals approaching the side of the highway or in the median.

Benefits

Detect wide variety of large mammals; can provide back-up in case remote camera malfunctions or is stolen;

Constraints

Unable to deploy at locations with little or no shoulder, where shoulder is steep or inundated with water, where shoulder is mostly vegetation, or in locations where monitoring and maintenance would be a safety risk to personnel; ambiguous species identification common; tracks cannot easily be collected and reviewed later; over-tracking (i.e., many overlapping tracks) can make interpretation difficult; difficult to confirm that animals leaving tracks actually attempted to cross highway or had simply crossed the bed and returned; only detects crossing attempts, not successful crossings; installation requires heavy machinery and coordination with Department of Transportation; high labor cost (must be maintained frequently).

Estimated Cost

High initial cost: $350–$400 for materials and installation of one 100 ft bed (depends largely on access to sand and machinery); low operational cost: labor cost to conduct surveys=$1300 for one month of monitoring @ 10 days of work per month @ $130/day [$16/hr]; low equipment costs: rake, PDA, digital camera, tape measure, field guide to animal tracks (same as “track bed” monitoring above).

Applications

- Assess rate of at grade, highway wildife crossings (cameras deployed randomly)
- Assess rate of at grade, highway wildlife crossings (cameras deployed at targeted locations).

UNENCLOSED TRACK PLATES

A metal plate covered partially with a thin layer of soot and then a section of light-colored contact paper with the sticky side up. Animals crossing the plate first walk over soot and then track the soot on the contact paper, leaving a print as captured in Figure 77. Plates are checked for prints every five to seven days and soot/paper is replaced. Contact paper with prints is removed and stored in plastic page protector.

Figure 77. Photo. Sooted track plate with tracks of small and medium-sized mammals (Credit: Robert Long/WTI).

Benefits

Detect wide-variety of animal sizes; provides a high-resolution print that makes identification of species likely; print can be collected, reviewed later, and stored indefinitely; low initial cost.

Constraints

Unable to deploy at locations with running water; difficult to deploy effectively in wide structures (>6 ft); must be deployed under cover or in very dry climate conditions.

Estimated Cost

Low up-front cost (but labor cost during surveys); $200 for materials; $800 for one month of monitoring (6 days of work per month @ $16/hr).

Applications

- Assess use/effectiveness of smaller wildlife crossing structures (existing and proposed)
- Monitor wildlife use of locations throughout and adjacent to the project area (used in conjunction with a bait or scent lure).

ENCLOSED TRACK PLATES

Similar to an unenclosed track plate (Figure E-3) but where the metal plate is typically smaller and inserted (with soot and contact paper) into a rectangular or triangular enclosure. Enclosed plates permit deployment in light rain or snow and can also be fitted with hair collection devices.

Benefits

Readily used by many smaller species (e.g., fisher, marten, raccoon, and smaller); provides a high-resolution print that makes identification of species likely; print can be collected, reviewed later, and stored indefinitely; ability to incorporate hair collection devices; protected from some weather; low up-front cost.

Constraints

Unable to deploy at locations with running water; limited to small species; can only be deployed in very small structures unless used with bait or scent lures.

Estimated Cost

Low up-front cost (but labor cost during surveys); $200 for materials; $800 for one month of monitoring (6 days of work per month @ $16/hr).

Applications

- Assess use/effectiveness of smaller wildlife crossing structures (existing and proposed)
- Monitor wildlife use of locations throughout and adjacent to the project area (used in conjunction with a bait or scent lure).

HAIR COLLECTION DEVICES WITH DNA METHODS

Various hair collection devices are available and selection typically depends on species of interest and specific objectives. Most hair collection at crossing structures is conducted via two barbed-wire strands stretched across the mouth of the structure at heights appropriate for the target species of interest as sketched in Figure 78.

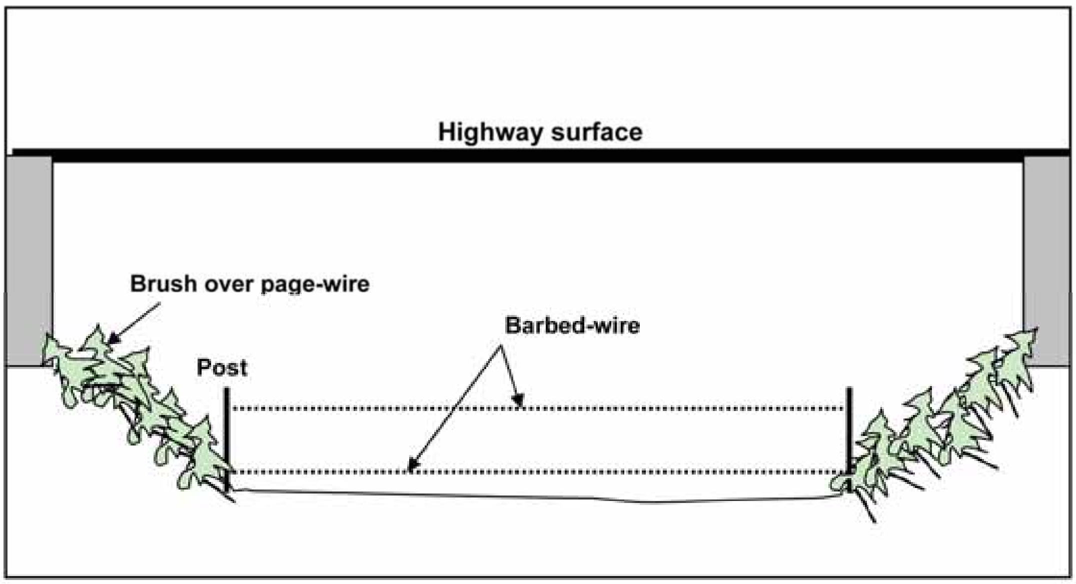


Figure 78. Schematic. Diagram of hair-snagging system at a wildlife underpass used in DNA-based research of population-level benefits of crossing structures (Source: Tony Clevenger/WTI).

Animals using the crossing structure are forced to slide under or between the wires, or step over the top wire, and in the process leave tufts of snagged hair on one or more barbs as Figure 79 shows. If enclosed track plates are used for small and medium mammals, hair snagging devices can be installed that will collect hair in addition to prints. Other options for locating hair snares within or adjacent to crossing structures are available, but most would require a scent lure to entice animals to either rub or interact with a device.

Figure 79. Photo. Grizzly bear passing through hair-snagging device at wildlife overpass in Banff National Park, Alberta (Credit: Tony Clevenger/WTI).

Benefits

Provide both confirmation of animal presence and DNA sample for further analyses; low up-front cost and fairly low labor cost to maintain.

Constraints

Fairly species-specific; some DNA analyses can be relatively expensive; should be used in conjunction with track bed/plate or remote camera.

Estimated Cost

Depends on objectives—identifying a hair sample to species can cost from $15–25, whereas more detailed DNA analyses (e.g., microsatellite analysis to identify individuals) can cost from $50–$120 per sample. In all cases, per-sample costs are highly dependent on the sample quality and specific lab.

Applications

- Assess use/effectiveness of wildlife crossing structures (existing and proposed)
- Monitor wildlife use of locations throughout and adjacent to the project area (used in conjunction with a bait or scent lure)

- Determine relatedness of individuals using crossing structures
- Determine whether numerous crossings are by the same individual or by many individuals.
- Collection of DNA samples for Tier 2 objectives.

TRAP, TAG, AND RECAPTURE/RESIGHT

Animals such as amphibians/reptiles and small mammals that are relatively easy to capture can be trapped or hand-captured and tagged as shown in Figure 80, on both sides of the highway. Subsequent capture efforts can permit the estimation of highway crossing rates.

Figure 80. Photo. Digital barcode tag for frogs (Source: Steve Wagner/CWU).

Benefits

Only effective method for monitoring some species (e.g., amphibians, reptiles, small mammals); direct confirmation that animals have successfully crossed highway; relatively low cost for some species.

Constraints

Difficult to confirm whether individuals are crossing at grade or through crossing structures; labor intensive; potential negative effects on captured/tagged individuals; typically results in few recaptures unless number of tagged individuals is very large.

Estimated Cost

Low to moderate, depending on species.

Applications

- Assess use/effectiveness of wildlife crossing structures (existing and proposed)
- Assess rate of at grade, wildlife highway crossings (in locations without crossing structures)
- Monitor wildlife use of locations throughout and adjacent to the project area

SNOW TRACK TRANSECTS

Snow tracking can be used to detect species that are active during winter. Snow tracking can be conducted while driving the road, traveling off-road parallel to and at close distances (e.g., within 150 ft) from the roadside, or on secondary roads or off-road transects away from the road.

Benefits

Fairly high effectiveness for detecting some species; easily tailored for use in many locations; low cost.

Constraints

Limited to locations with consistent snowfall; short time window to conduct surveys after each snowfall; difficult to schedule surveys; can be labor-intensive to collect substantial amounts of data during relatively few snowfalls (i.e., many personnel may be required to cover multiple transects within a short timeframe); difficult to confirm species unless track and snow conditions are ideal; tracks cannot easily be collected and reviewed later; traffic safety concerns when conducting road surveys;

Estimated Cost

Low to moderate; limited to cost of labor, one-time purchase of skis/snowshoes, and winter safety and avalanche training.

Applications

- Assess use/effectiveness of wildlife crossing structures (existing and proposed)
- Assess rate of at grade, wildlife highway crossings
- Monitor wildlife use of locations throughout and adjacent to the project area (used in conjunction with a bait or scent lure)

SCAT DETECTION DOGS WITH DNA METHODS

Professionally trained dogs can now be used to effectively and efficiently locate scats from target species. A single dog, working with a handler and an "orienteer," as Figure 81 shows, typically searches a predefined transect or grid. Located scats are collected for DNA analysis.

Figure 81. Photo. Scat-detection dog working to locate scat (Credit: Robert Long/WTI).

Benefits

High degree of effectiveness and cost efficiency (i.e., cost per detection); does not require site preparation before survey; can be easily tailored to specific locations and can quickly adapt to changes in protocol; can be used in most conditions and on most types of topography; provides scat sample for multiple analyses (e.g., species and individual identification, diet, hormone analysis).

Constraints

High initial cost; substantial logistical issues; each dog limited to detecting a fairly discrete number of target species; in most cases requires DNA confirmation, or at least some DNA testing.

Estimated Cost

High up-front cost for training and dog leasing; actual cost depends largely on whether dogs are leased or purchased and whether handlers are hired professionals or are existing personnel that can be trained.

Applications

- Monitor wildlife use of locations throughout and adjacent to the project area
- Collection of DNA samples for Tier 2 objectives.

GPS COLLARING

Some species can be captured and fitted with collars containing a GPS tracking device. Very high-resolution data on movements are recorded and either remotely downloaded by researchers or, more often, downloaded after the collar has either been shed or recovered on recapture.

Benefits

Very high resolution data allows assessment of fine-scale movement and reaction to crossing structures; ability to collect additional data such as mortality and behavioral data; ability to collect information on genetics and demographic parameters of population if sample sizes are large.

Constraints

High initial cost and capture of animals is very labor intensive; substantial logistical issues; generally results in small sample sizes which may not be representative of populations; potential negative effects on captured/tagged individuals.

Estimated Cost

High initial cost for purchase of GPS collars and animal capture; actual cost depends on how long the collars stay on the animal; occasional malfunction of GPS transmitting and receiving system.

Applications

- Assess use/effectiveness of wildlife crossing structures (existing and proposed)
- Assess rate of at grade, wildlife highway crossings
- Monitor wildlife use of locations throughout and adjacent to the project area
- Evaluate effectiveness of wildlife fencing.

DOT MAINTENANCE CREW REPORTING

Data on road-killed wildlife are currently collected during regular work conducted by DOT highway crews. After highway construction is completed, maintenance crews would also be asked to collect data on fence condition and to report wildlife intrusions on the highway right-of-way. Data recording is facilitated by a Roadkill Observation Collection System (ROCS)—a combined PDA–GPS device shown in Figure 82. Regular contacts by monitoring personnel with road crews to emphasize the importance of collecting data will be important to ensure consistent survey effort.

Figure 82. Photo. Roadkill Observation Collection System (ROCS) (Credit: WTI).

Benefits

Can be tailored to include any species that can be recognized as either live or road-killed wildlife; DOT Maintenance crews are regularly traveling the highway and may receive direct reports of wildlife–vehicle collisions or carcasses.

Constraints

Method requires both spatially and temporally consistent survey effort by crews for data collected to be valid and useful for analyses.

Estimated Cost

Low - consisting of training DOT Maintenance crews to operate ROCS units and routine refresher training and meeting with crews to encourage regular use of ROCS units.

Applications

- Assess wildlife–vehicle collision rate
- Evaluate effectiveness of wildlife fencing

STATE PATROL REPORTING

Currently, in many states and provinces information on wildlife–vehicle collisions resulting in vehicle damage (>$1000) is collected by State patrols and may also be requested from other agencies that collect such data.

Benefits

Effort is consistent and will likely remain so into the future; cost is relatively minimal; species monitored are limited; can be cross-referenced with DOT maintenance crew reports and monitoring personnel.

Constraints

Mortality data are limited to collisions with > $1000 in property damage (generally Elk and Deer).

Estimated Cost

Negligible.

Applications

- Assess wildlife–vehicle collision rate
- Evaluate effectiveness of wildlife fencing

MONITORING PERSONNEL ROAD-KILL AND FENCE INTEGRITY SURVEYS

Monitoring personnel can collect information on wildlife–vehicle collisions during systematic drives through the project area (e.g., every 1-7 days). Fencing can be visually examined during regular course of work and field-examined twice per year by DOT maintenance crews and/or monitoring personnel.

Benefits

Provides spatially and temporally consistent effort that can be closely controlled; all species coyote-size and larger can be monitored.

Constraints

Relatively high rate of survey (e.g., daily or minimally twice per week) may be required to locate carcasses, especially of small animals; does not detect instances when animals are injured and die undetected at a later time, or where carcasses leave the roadway and are not seen; single drive through may provide little chance of detecting carcasses; limited number and distribution of safe-stopping locations may make carcass identification impossible; slow required driving speeds often unsafe.

Estimated Cost

Low during seasons when other survey work is being conducted; moderate at other times.

Applications

- Assess wildlife–vehicle collision rate
- Evaluate effectiveness of wildlife fencing

APPENDIX F – OTHER HANDBOOKS AND GUIDELINES

UNITED STATES

Bissonette, J.B. 2007. Evaluation of the use and effectiveness of wildlife crossings. National Cooperative Highway Research Program (NCHRP) 25-27 final report. Transportation Research Board, Washington DC.

Huijser, M.P., J. Fuller, M.E. Wagner, A. Hardy, & A.P. Clevenger. 2007. Animal–vehicle collision data collection: a synthesis of highway practice. National Cooperative Highway Research Program Synthesis 370. Transportation Research Board, Washington, D.C.

Huijser, M.P., A. Kociolek, P. McGowen, A. Hardy, A.P. Clevenger, and R. Ament. 2007b. Wildlife–vehicle collision and crossing mitigation measures: A toolbox for the Montana Department of Transportation. Report no. FHWA/MT-07-002/8117-34. Helena, MT.

Huijser, M.P., P. McGowen, J. Fuller, A. Hardy, A. Kociolek, A.P. Clevenger, D. Smith and R. Ament. 2007. Wildlife–vehicle collision reduction study. Report to US Congress. U.S. Department of Transportation, Federal Highway Administration, Washington D.C.

Southern Rockies Ecosystem Project. No date. Safe passage: A users guide to developing effective highway crossings for carnivores and other wildlife. Southern Rockies Ecosystem Project, Denver, Colorado.

EUROPE

English Language

Iuell, B. (ed.). 2003. Wildlife and traffic: A European handbook for identifying conflicts and designing solutions. KNNV Publishers, Utrecht, The Netherlands.

Trocme, M. (ed.). 2003. Habitat fragmentation due to transportation infrastructure: The European review. European Commission, Directorate General for Research, COST Action 341. Publication EUR 20721. Luxembourg.

Other Languages

Ministerio de Medio Ambiente. 2006. Prescripciones tecnicas para el diseno de pasos de fauna y vallados perimetrales. Documentos para la reduccion de la fragmentacion de habitats causada por infraestructuras de transporte, numero 1. Ministerio de Medio Ambiente, Madrid, Spain.

Rosell, C. and Velasco Rivas, J. 1999. Manual de prevencio i correcio dels impactes de les infrastructures viares sobre la fauna. Documents dels Quaderns de Medi Ambient, 4. Generalitat de Catalunya, Department de Medi Ambient. 95pp. Barcelona, Spain.

Service d'etudes sur les transport, les routes et leurs amenagements (SETRA) et Centre d'Etudes Technique de l'Equipement (CETE) 2006. Route et passage à faune. 40 ans d'évolution. Rapport. 57 p.

APPENDIX G – PROFESSIONAL AND TECHNICAL JOURNALS

GENERAL ROAD ECOLOGY

Biological Conservation
Canadian Journal of Civil Engineering
Conservation Biology
Earth Surface Processes and Landforms
Ecological Engineering
Ecology and Society (online)
Environmental Management
Journal of Applied Ecology
Journal of Environmental Management
Journal of Environmental Planning
Landscape Ecology
Landscape and Urban Planning
Transportation Research Record
Wildlife Biology
Wildlife Society Bulletin (now Journal of Wildlife Management)

TERRESTRIAL WILDLIFE

Biological Conservation
Canadian Journal of Zoology
Conservation Biology
Journal of Applied Ecology
Journal of Wildlife Management
Landscape Ecology
Landscape and Urban Planning
Transportation Research Record
Wildlife Biology
Wildlife Society Bulletin (now Journal of Wildlife Management)

TRAFFIC SAFETY

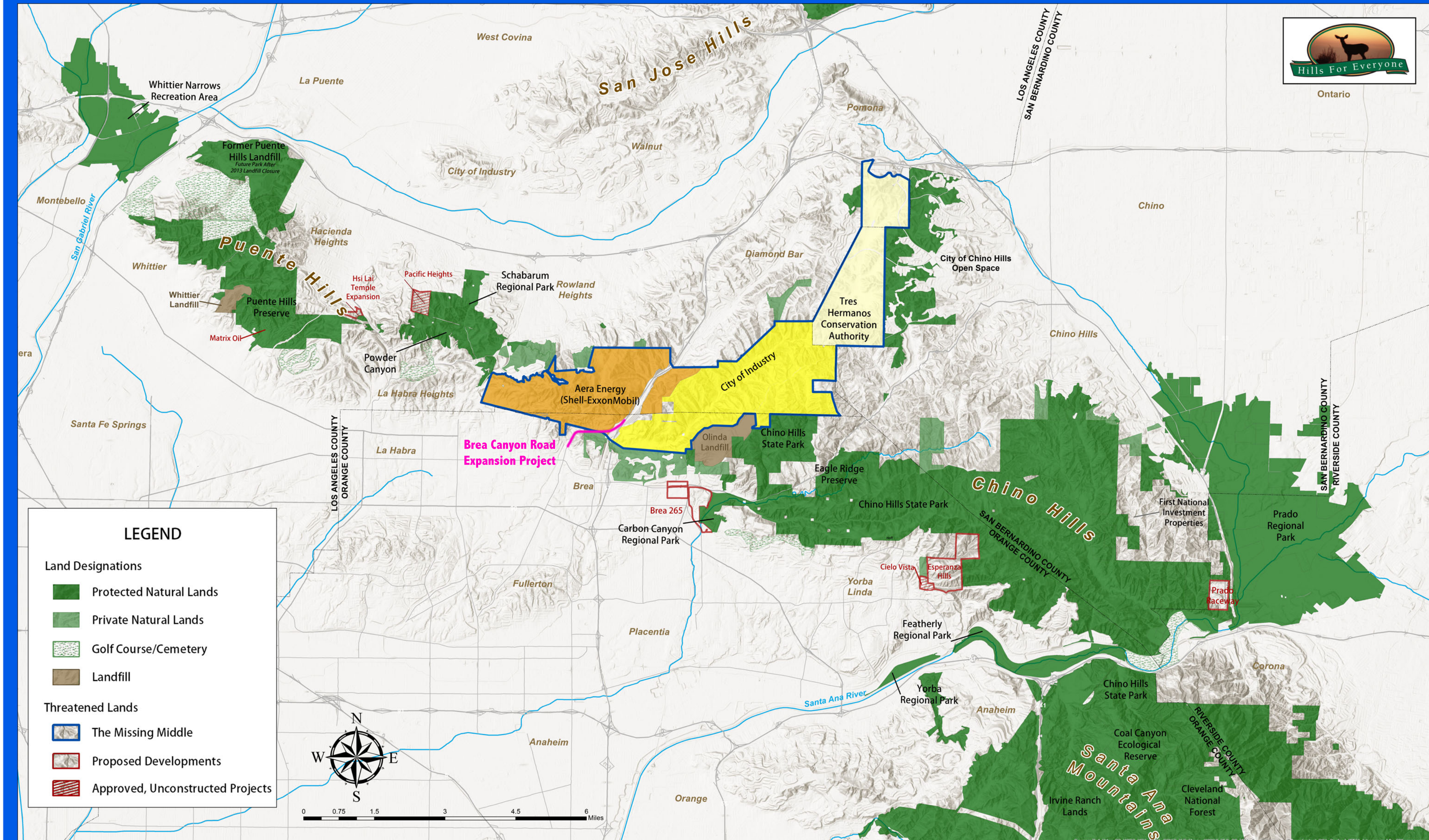
Accident Analysis and Prevention
Canadian Journal of Civil Engineering
Ecological Engineering
Ecology and Society (online)
Journal of Safety Research
Transportation Research Record
Wildlife Society Bulletin (now Journal of Wildlife Management)

Exhibit H

Brea Canyon Road and Neighboring Ownerships
Proposed Wildlife Bridge
Brea Blvd
S Brea Canyon Rd
Orange Fwy
Un Rd
Tonner Canyon Rd
Tonner Canyon
57
Balsa Ave
LEGEND
City of Brea
City of Industry
CalResources (Aera)
Brea Hills LLC
Tonner Hills LLC
Hills For Everyone
Map Created: December 14, 2022
N
1000 ft
Google Earth

Exhibit I

Natural Lands Within the Puente-Chino Hills Wildlife Corridor



Data Provided by First American Title.
Last Updated January 2023

Projection: Lambert Conformal Conic
Datum: North American 1983
Scale: 1: 60,000

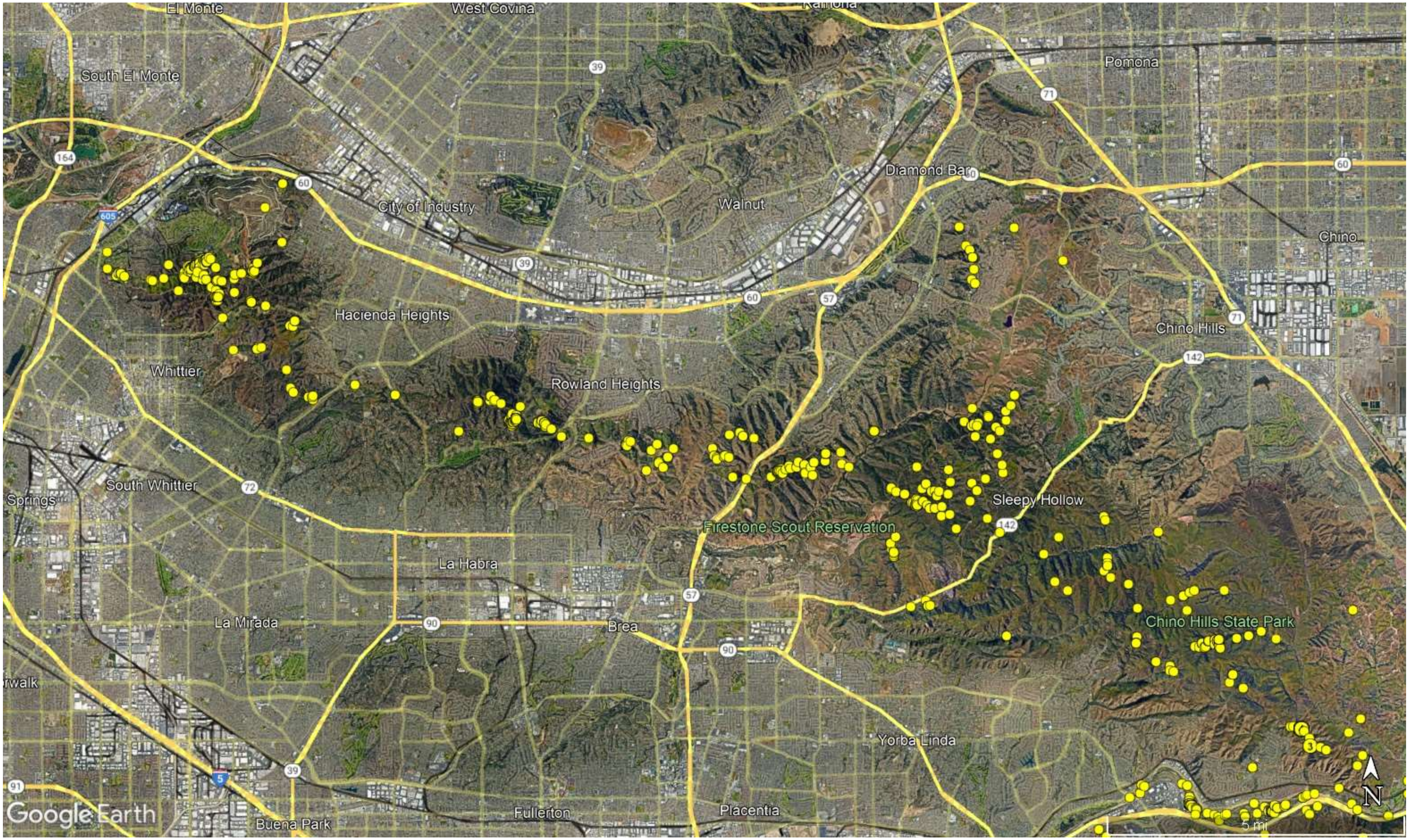
Exhibit J

Public Agency Acquisition Investments in the Puente-Chino Hills Wildlife Corridor				
Public Agency Landowner	**Acquisition Date(s)**	**Total Acreage**	**Actual Public Investment**	**Estimated Current Value of Properties**
State and Federal Agencies				
U.S. Army Corps of Engineers	N/A	124	$0	$1,850,000
California Department of Parks and Recreation	1982-'98	11,770	$62,169,274	$62,443,972
	2005-2006*	1,594	$0	$6,420,000
California Department of Parks and Recreation and US Fish and Wildlife Service	2000-2001	685	$53,500,000	$63,500,000
California Department of Parks and Recreation	Restoration	TBD	TBD	TBD
Regional Agencies				
Los Angeles County Department of Parks and Recreation	1960-'80	583	$3,735,000	$7,000,000
Los Angeles County Department of Public Works	N/A	35	$0	$700,000
Los Angeles County Sanitation Districts*	N/A	225	$0	$2,700,000
Orange County Transportation Authority	2011	301	$2,960,000	$2,960,000
	Restoration	27	$440,500	$440,500
Orange County Parks	N/A	729	$0	$14,580,000
Local Agencies				
City of Chino Hills	1990 - 2022	3,000	$20,000,000	$20,000,000
City of Brea*	Tonner Hills CE	TBD	TBD	TBD
City of Yorba Linda*	N/A	170	$0	$2,550,000
City of Whittier	1994 - 2007	1,756	$15,086,500	$15,336,500
Joint Powers Authority				
Puente Hills Habitat Preservation Authority	1996-2022	3,886	$32,726,028	$35,760,000
	Restoration	37	$4,500,000	$4,500,000
Tres Hermanos Conservation Authority**	2019	2,445	$24,450,000	$24,450,000
Mountains Recreation and Conservation Authority	1997	200	$2,250,000	$2,250,000
	2019	40	TBD	TBD
	2020-2021	400	$3,160,000	$3,160,000
	2021	320	$2,560,000	$2,560,000
	2021	9	$165,000	$165,000
Private Entities & Non-Profits				
Rivers and Lands Conservancy	2021	300	TBD	TBD
TOTAL ACQUIRED ACREAGE:		**28,572**	**$222,761,802**	**$232,625,472**
TOTAL RESTORED ACREAGE:		**64**	**$4,940,500**	**$4,940,500**
TOTAL INVESTMENT:			**$227,702,302**	**$237,565,972**

* Property dedicated for free as public open space as a result of the regulatory process.

** Property has no legal conservation mechanism

Exhibit K


El Monte
West Covina
Ramona
South El Monte
Pomona
Diamond Bar
City of Industry
Walnut
Chino
Hacienda Heights
Chino Hills
Whittier
Rowland Heights
South Whittier
Springs
Sleepy Hollow
Firestone Scout Reservation
La Habra
La Mirada
Brea
Chino Hills State Park
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Yorba Linda
Google Earth
Buena Park
Fullerton
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Exhibit L

February 1, 2023

Ms. Kristi Bascom
Shute, Mihaly & Weinberger LLP
396 Hayes Street
San Francisco, CA 94102-4421

Subject: Review of Draft Environmental Impact Report (SCH# 2017051005)
Brea Boulevard Corridor Improvement Project, Orange County, California

Dear Ms. Bascom:

I am a hydrologist with over thirty years of technical and consulting experience in the fields of geology, hydrology, and hydrogeology. I have been providing professional hydrology and geomorphology services in California since 1989 and routinely manage projects in the areas of surface- and groundwater hydrology, water supply, water quality assessments, water resources management, and geomorphology. Most of my work has been in the Coast Range watersheds of California. My areas of expertise include: characterizing and modeling watershed-scale hydrologic and geomorphic processes; evaluating surface- and ground-water resources/quality and their interaction; assessing hydrologic, geomorphic, and water quality responses to land-use changes in watersheds and causes of stream channel instability; assisting and leading in the development of CEQA environmental compliance documents and project environmental permits; and designing and implementing field investigations characterizing surface and subsurface hydrologic and water quality conditions. I earned a Master of Science degree in Geology, specializing in sedimentology and hydrogeology as well as an A.B. in Geology from Miami University, Oxford, Ohio. I am a Certified Hydrogeologist (CHG #360) and a registered Professional Geologist (PG #5737) in the state of California. A copy of my resume is attached.

I have been retained by Shute, Mihaly & Weinberger LLP (SMW) to review the Draft Environmental Impact Report (DEIR) for the Brea Boulevard Corridor Improvement Project, Orange County, California, and evaluate if the project may impact surrounding properties and the environment. Specifically, I have reviewed the DEIR, technical appendices, and related project documents. Based on my review of these materials, it is my professional opinion that the DEIR is inadequate in evaluating the potential significant impacts of project actions on Brea Creek channel stability, water quality and biological resources.

The bridge replacement designs at two locations that remove the concrete base could lead to accelerated natural channel bed erosion and channel instability along with increased turbidity and sediment transport to downstream receiving waters. Results of the Hydraulic analysis of the project also indicate significantly higher flow velocity along long-stretches of the creek upstream of each bridge replacement location, which increases channel erosion potential that can: a) reduce channel bed and bank stability; b) increase turbidity and sediment transport to downstream reaches of the creek; and c) adversely alter aquatic habitat conditions along the creek corridor via erosion and sediment deposition. It also appears that hydraulic analyses underestimate the potential safety risk associated with flood overtopping of at least one bridge. These concerns are discussed in greater detail below.

1. Replacement of Bridges 2 and 3 May Promote Channel Incision

The DEIR project description states (bottom of page 3-5), "The creek underneath Bridge 2 and Bridge 3 will be converted from concrete to a natural soft bottom and Bridge 1 will remain a natural soft bottom." Based on my professional experience it is likely that the concrete bottom at Bridge 2 and 3 is currently acting as a channel grade control, preventing channel incision (deepening by bed scour and erosion) under these bridges. Replacing the concrete bottoms with a natural "soft" bottom will create the opportunity for the channel to incise during peak, high energy flows. The resulting incised channel can propagate upstream (head-cutting) as well as downstream from the former concrete bottom. The act of bed erosion and sediment transport will impair downstream water quality. Incised channels can also lead to over-steepened banks that become unstable and erode, further impacting downstream water quality. The resulting modifications to the channel form due to channel incision also could adversely alter the quality of aquatic and riparian habitat.

Appendix M of the DEIR contains the Final Design Hydraulic Study in support of replacement bridge foundation design. The study includes the results of a scour study at the proposed bridges under the 100-year discharge and a natural sediment bed substrate beneath the bridges (pages 24-28 of Appendix M). The scour study results for localized scour depths at the bridges includes: 9-feet at Bridge 1; 16-feet at Bridge 2; and 9-feet at Bridge 3. Although scour depths may be less during lower magnitude storm flows, these results support the increased channel incision potential resulting from replacement bridges. However, the DEIR does not quantify the lateral extent of these potential impacts nor how these likely channel changes will impact water quality and aquatic/riparian habitats along Brea Creek. Sediment that is scoured at these locations will become suspended in the water column thereby increasing turbidity. These suspended sediments will also be transported and ultimately deposited downstream. The increased turbidity and suspended solids concentrations could exceed water quality standards. Excessive sediment that is mobilized and transported downstream could fill and bury in-channel and floodplain habitats, displacing sensitive species that rely on those habitats.

2. Project Results in Increased Potential for Channel Erosion Upstream of New Bridges

Appendix M of the DEIR also presents the results of a hydraulic modeling analysis for Brea Creek through and adjacent to the project improvement corridor under existing and project conditions. The results of this analysis demonstrate how bridge replacement will increase flow conveyance capacity through the bridge crossings, resulting in lower peak flow water surface elevations at and adjacent to the new bridges. Appendix C to the hydraulic study presents the hydraulic model (HEC-RAS model code) results, which also include simulated flow velocities at representative model nodes along the simulated Brea Creek reach. In addition to simulated water surface elevations, these results include simulated channel velocities. A comparison of simulated channel velocities for existing and project conditions during the 50- and 100-year design discharges on Brea Creek are plotted in Figures A and B, respectively. As seen for both design discharges, the creek flow velocities increase significantly at and upstream of the project bridges as compared to existing conditions (e.g., almost double at river station 8400 upstream of Bridge 2). The increase in flow velocity also occurs at least 500 feet upstream of each bridge and possibly farther.

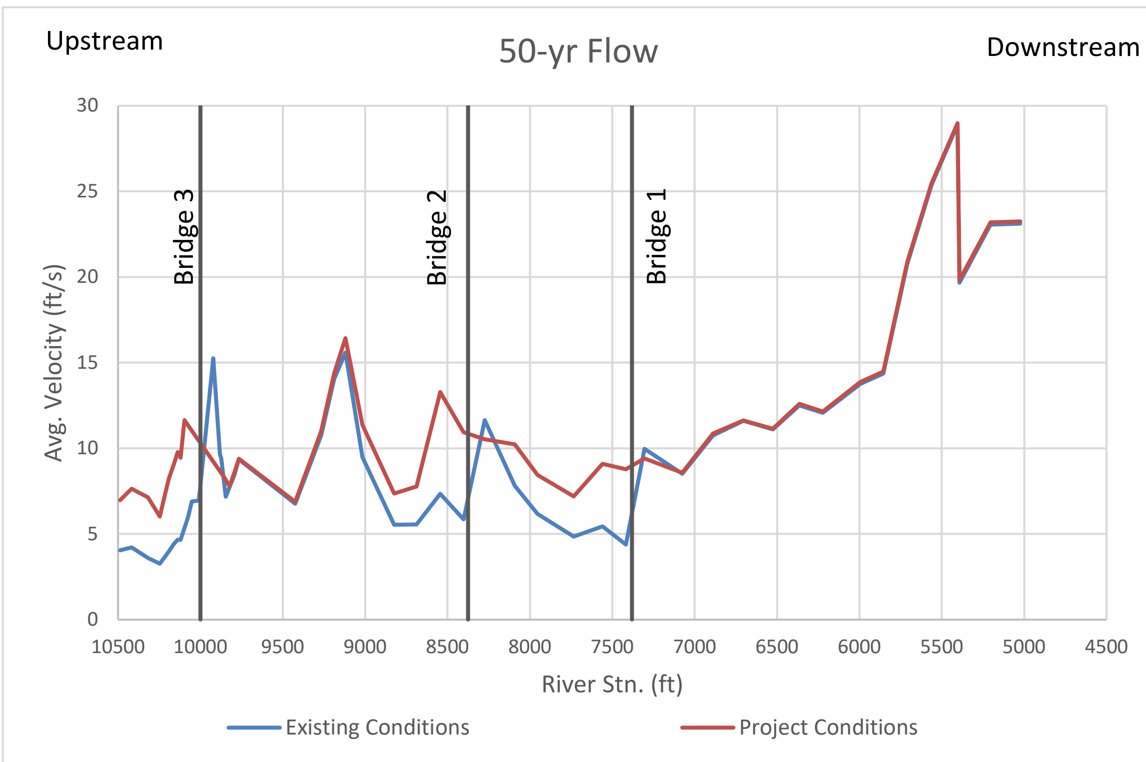

FIGURE A: Velocity profile for 50-year design discharge from HEC-RAS model results in DEIR Appendix M

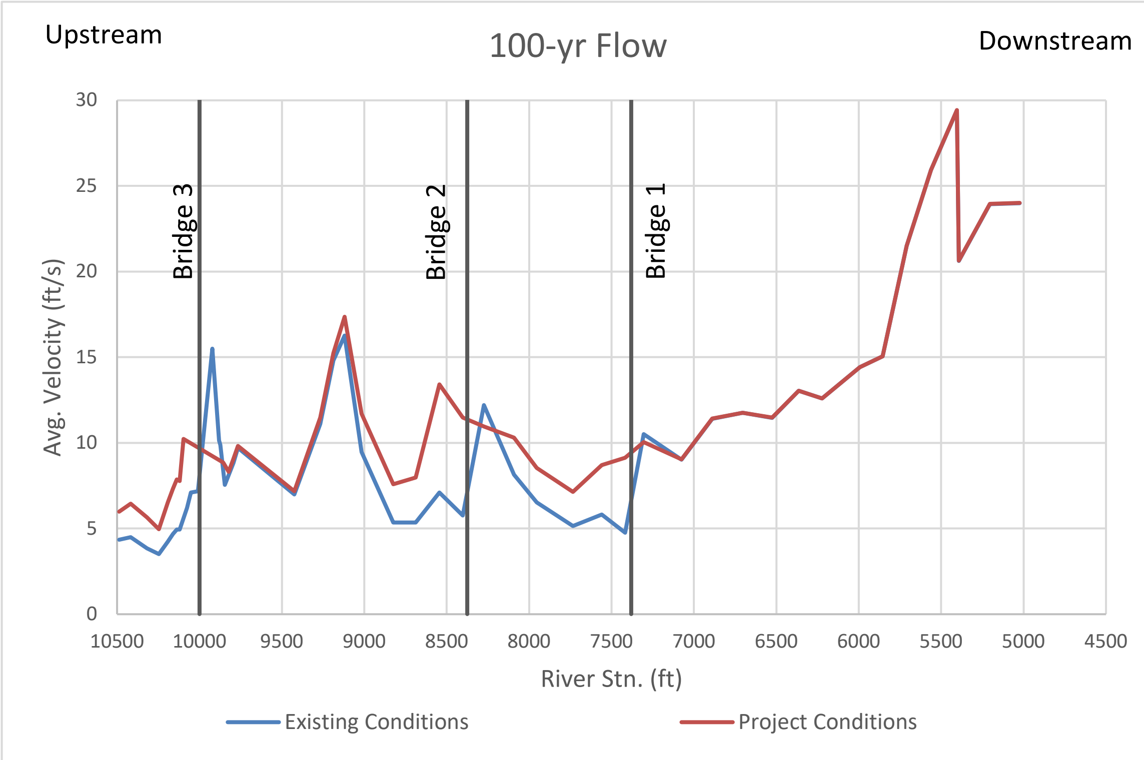

FIGURE B: Velocity profile for 100-year design discharge from HEC-RAS model results in DEIR Appendix M

It has been demonstrated that increasing stream flow velocities result in increased erosion potential of natural channel bed materials (Fischenich, 2001[1]). The size of material mobilized also increases with increasing flow velocity (ibid). The DEIR does not evaluate the potential impacts of the increased flow velocities and, in turn, erosion potential through hundreds, if not thousands of feet of Brea Creek channel under project conditions. The change in velocity over long reaches of the channel could lead to increased bed and bank erosion and sediment transport, adversely impacting downstream water quality, local aquatic habitat conditions, as well as downstream aquatic habitat conditions. Again, the mechanism behind these potential impacts is associated with the downstream transport and deposition of sediment mobilized due to construction of the project as described above.

3. Underestimation of 100-year Peak Flow Rate Used in Hydraulic Model Analysis

Appendix M to the DEIR contains several estimates for the magnitude of the 100-year design discharge used in the hydraulic modeling analysis for bridge design. The authors of the study present a standard rainfall-runoff modeling approach, which yielded a 100-year design discharge of 11,700 cfs. Appendix M also presents an independent 1986 analysis completed by the County Flood Projects Planning Section, Flood Program Division that yielded a 100-year design discharge of 11,800 cfs. However, the Orange County Public Works Department requested that a 100-year design discharge value of 8,030 cfs be used in the Final Hydraulic Design Study. Similar discontinuities in the 50-year design discharge estimates

[1] https://apps.dtic.mil/sti/pdfs/ADA392430.pdf

occur. The rationale for using the 8,030 cfs 100-year design discharge presented on page B-12 of Appendix M is as follow.

METHOD 3: Discharges provided by Orange County Public Works

The following table of discharges was provided by OC Public Works:

Node	Location	Tributary Area (ac)	Peak Discharge (cfs)						
			100-yr HC	100-yr EV	50-yr EV	25-yr EV	10-yr EV	5-yr EV	2-yr EV
20U	Upstream of Confluence with Tonner Canyon Channel (A09)	4,020	7,050	5,220	4,740	4,200	3,210	1,590	800
20T	A09 Upstream of Confluence with Brea Canyon Channel (A04)	7,600	8,700	5,920	5,310	4,630	3,420	1,620	770
20C	Confluence of A04 and A09	11,620	11,800	8,030	7,180	6,230	4,670	2,190	1,040
30	Memory Garden Storm Channel (A04S01)	13,510	12,400	8,230	7,330	6,340	4,670	2,190	1,040
40	Brea Flood Control Reservoir	13,990	12,400	8,300	7,330	6,340	4,670	2,190	1,040

The node and discharges of interest are shown in blue. In the table, there are two discharges for the 100-yr event; 1) the High Confidence (HC), and 2) Expected Value (EV). The difference between HC and EV is the precipitation value used in the analysis. The precipitation value used for the HC discharge represents the upper bound of the 90% confidence interval from the frequency analysis of partial duration series. According to OC Public Works, the HC discharge is considered the most conservative and is used for their primary drainage facilities. The EV discharges are less conservative and used for secondary facilities. The results of the 1986 study by OC Public Works represent the HC discharge for the 100-yr event. OC Public Works asked that the EV discharges be used for the hydraulic analysis for this project and provided their runoff hydrographs. The 50-yr EV and 100-yr EV hydrographs provided are shown below and were used for the unsteady flow analysis.

Hydraulic modeling water surface elevation results for the 50- and 100-year design storms indicate that the County freeboard[2] requirements at Bridges 1 and 3 are barely met using the EV values (page 23 of Appendix M). It is my opinion that freeboard requirements at these bridges would not be met based on simulation results using the HC values. The importance of freeboard is that it provides a margin of safety from bridge overtopping in the event of unknown factors (e.g., debris accumulation) that can cause flood heights to rise above the designed or modeled height. Therefore, where use of the more conservative 100-year event HC value would show that the freeboard requirements necessary to protect health and safety would *not* be met, it is misleading to use the less conservative EV values. To adequately inform decisionmakers and the public about the potentially significant impacts of the 100-year flood event on run-off—and potential ways to mitigate or avoid those impacts—the DEIR must use

[2] In the case of bridges, the Orange County Flood Control District Design Manual (2020) defines freeboard as, "Freeboard is the vertical distance from the design hydraulic-grade line (plus wave height, super-elevation, and any other factors required to be separately evaluated) to the low point of the soffit of bridges." Appendix M uses the model simulated water surface elevations as the "hydraulic-grade line".

the 100-year design discharge of 11,800 cfs that the County's own analysis shows is necessary to address these impacts with "high confidence."

Please feel free to contact me with any questions regarding the material and conclusions contained in this letter.

Sincerely,

Greg Kamman, PG, CHG
Senior Ecohydrologist

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Greg Kamman, PG, CHG
Senior Ecohydrologist

Education

MS, 1989, Geology, Sedimentology and Hydrogeology, Miami University, Oxford, OH

BA, 1985, Geology, Miami University, Oxford, OH

Professional Registration

1993, Professional Geologist, California, #5737

1995, Certified Hydrogeologist, California, #360

Professional Experience

cbec, inc., eco-engineering, West Sacramento, CA, Senior Ecohydrologist, 2020-present

Kamman Hydrology & Engineering, Inc., San Rafael, CA, Principal Hydrologist/Vice President, 1997-2020

Balance Hydrologics, Inc., Berkeley, CA , Sr. Hydrologist/ Vice President, 1994-1997

Geomatrix Consultants, Inc., San Francisco, CA, Project Geologist/Hydrogeologist, 1991-1994

Environ International Corporation, Princeton, NJ, Sr. Staff Geologist/Hydrogeologist, 1989-1991

Miami University, Oxford, OH, Field Camp Instructor and Research Assistant, 1986-1989

Greg Kamman is a professional geologist and certified hydrogeologist with over 30 years of technical and consulting experience in the fields of geology, hydrology, and hydrogeology. He specializes in directing and managing projects in the areas of surface and groundwater hydrology, stream and tidal wetland habitat restoration, water supply and water quality assessments, water resources management, and geomorphology. Mr. Kamman has worked extensively throughout California's coastal watersheds and estuaries, and on multiple projects in Oregon and Hawaii.

Mr. Kamman's experience and expertise includes evaluating surface and groundwater resources and their interaction, stream and wetland habitat restoration assessments and design, characterizing and modeling basin-scale hydrologic and geologic processes, assessing watershed hydraulic and geomorphic responses to land-use change , and designing and conducting field investigations characterizing surface and subsurface hydrologic and water quality conditions. Greg commonly works on projects that revolve around sensitive fishery, wetland, wildlife, and/or riparian habitat enhancement within urban and rural environments. Mr. Kamman performs many of these projects in response to local, state (CEQA) and federal statutes (NEPA, ESA), and other regulatory frameworks. Mr. Kamman frequently applies this knowledge to the review and expert testimony on state and federal water operation plan EIR/EIS reports, Groundwater Sustainability Plans, Habitat Conservation Plans, and biological assessments.

Mr. Kamman is accustomed to working multi-objective projects as part of an interdisciplinary team including biologists, engineers, planners, architects, lawyers, and resource and regulatory agency staff. Mr. Kamman is a prime or contributing author to over 360 technical publications and reports in the discipline of hydrology, the majority pertaining to the protection and enhancement of aquatic resources. Mr. Kamman has taught the following courses: stream restoration through U.C. Berkeley Extension (2001-2008); wetland hydrology through San Francisco State University's Romberg Tiburon Center (2007 and 2012-2014); and presented webinars (2020) to California Water Boards staff on hydrologic and hydraulic modeling. He has devoted his career to the protection, enhancement and sustainable management of water resources and associated ecosystems.

SELECTED EXPERIENCE

Floodplain Management Projects

Flood Reduction, Mitigation Planning, and Design on Yreka Creek, Siskiyou County, CA
City of Yreka as subcontractor to WRA, Inc., 2008-2010

Mr. Kamman completed a series of field and hydraulic model investigations for restoration planning and design along Yreka Creek to reduce flood hazards and potential damage to the City's water treatment plant and disposal field infrastructure. This work also addresses and satisfies dike repair mitigation conditions stipulated by state resource agencies. While achieving these goals, Mr. Kamman tailored analyses and study objectives to assist the City in: enhancing the ecological floodplain restoration along Yreka Creek; providing opportunities for expanded public access and trail planning consistent with the goals of the Yreka Creek Greenway Project; and improving the water quality of Yreka Creek.

Key elements of this work included: review and synthesize existing information; identify and analyze the feasibility for three conceptual alternatives; and conceptual design and report preparation. Funding for implementation of restoration work over such a large area was a significant concern to the City. Therefore, designs identify and define phasing in a fashion that gives the City flexibility in implementation.

SELECTED EXPERIENCE *(CONTINUED)*

West Creek Drainage Improvement Assessment, Marin County, CA
Marin County Flood Control, 2006-2008

Mr. Kamman prepared a study focused on characterizing existing flood conditions and developing and evaluating flood reduction measures along West Creek in Tiburon. The work was completed through the implementation of hydrologic and hydraulic feasibility and design assessments. The conceptual design and analysis of potential flood reduction strategies (alternatives) was completed through the development of a HEC-RAS hydraulic model that simulates historic, existing and proposed project flood conditions. It was intended that the conceptual design developed under this scope of work would be of sufficient detail and quality to initiate project permitting and the environmental compliance process and documentation. Opportunities for riparian corridor and aquatic habitat enhancement were also considered and integrated into the conceptual design. Mr. Kamman also developed and assessed six alternative flood hazard reduction measures. The hydraulic model results for each alternative were compared against baseline conditions in order to evaluate their ability to alleviate flood hazards.

Gallinas Creek Restoration Feasibility Assessment, Marin County, CA
San Francisco Bay Institute, 2003-2005

Mr. Kamman completed a feasibility assessment for restoration of Gallinas Creek in northern San Rafael. Restoration will require removal of a concrete trapezoidal flood control channel and replacement with an earthen channel and floodplain in a “green belt” type corridor. Work included the collection of field data and development of a HEC-RAS hydraulic model to evaluate and compare existing and proposed project conditions. Designs must continue to provide adequate flood protection to the surrounding community. The study also includes and evaluation of existing habitat values, potential habitat values, and restoration opportunities and constraints.

Hydrologic and Hydraulic Evaluation for Trinity County Bridge Replacement, Trinity County, CA
Trinity County Planning Department, 2002

Mr. Kamman completed technical peer review of peak flow estimates and hydraulic design parameters associated with the replacement of 4 bridges across the upper Trinity River in Trinity County, California. A primary study component was accurately predicting the magnitude and frequency of flood releases from Trinity Dam. Numerous flood frequency analytical approaches were evaluated and used throughout this study.

Restoration of Lower Redwood Creek Floodway and Estuary, Humboldt County, CA
California State Coastal Conservancy and Humboldt County DPW, 2002-2003

Mr. Kamman provided technical review for the development of a hydraulic model to evaluate river and estuary restoration alternatives along the lower portions of Redwood Creek between Orrick (Highway 1) and the Pacific Ocean. This work was completed to evaluate the feasibility for creek/estuary restoration alternatives developed by the County, and effects on flood hazards along this flood-prone reach.

In order to better address and evaluate the current flood hazards along the entire floodway and identify potential flood hazard reduction measures, Mr. Kamman was retained to update HEC-2 models previously prepared by the Army Corps, and to evaluate the impacts of vegetation encroachment (increased roughness) and sediment deposition on floodway conveyance. Mr. Kamman expanded the Corps hydraulic model with newly completed channel surveys and channel roughness observations. The impetus for this work was to assist the County in identifying mutually beneficial strategies for ecosystem restoration and flood hazard reduction. Technical work was completed under close coordination and communication with county engineers. Study results and findings were presented at public meetings of local area landowners and stakeholders.

Tembladero Slough Small Community Flood Assessment, Monterey County, CA
Phillip Williams & Associates, Ltd., 1997

Mr. Kamman completed a flood information study of Tembladero Slough near Castroville on behalf of the San Francisco District Corps of Engineers. The purpose of this work was to identify and document local flood risks existing in the community and propose potential floodplain management solutions as part of the Corps 1995/1997-flood recovery process. Work centered on conducting a field reconnaissance, reviewing available historical data, and conducting discussions/ interviews with local landowners and agency personnel.

Fluvial Projects

Muir Woods National Monument Bank Stabilization Plan for Conlon Creek, Marin County, CA
Golden Gate National Parks Conservancy (GGNPC), 2018-present

Mr. Kamman developed a grading and drainage plan for the Conlon Avenue Parking Lot, located adjacent to Redwood Creek and sensitive Coho salmon habitat. More recently, he has assisted GGNPC and the NPS in assessing the planning and design for creek bank stabilization and ecological enhancement at a failed culvert on a tributary channel at the project site. This work includes constructing a HEC-RAS model to evaluate: culvert removal and channel design; fish passage; and water quality impacts. Work is currently in development of 50% engineering design.

Hydrology and Hydraulic Assessments for Design of Butte Sink Mitigation Bank Project, Colusa County, CA
WRA, Inc., 2017-2018

Mr. Kamman was retained to provide hydrology and hydraulic modeling support in the development of design and Draft Prospectus for the Butte Sink Mitigation Bank (Bank). This work entailed developing the necessary hydrology information, hydraulic model and documentation to support further design, environmental compliance and agency approvals/permitting of the Bank. The main objective of work was to develop a design that provides the necessary ecological conditions and functions for successful establishment and operation of the Bank.

Lagunitas Creek Salmonid Winter Habitat Enhancement Project, Marin County, CA
Marin Municipal Water District, 2013-2018

Mr. Kamman designed and led a study to evaluate opportunities to enhance winter habitat for coho and other salmonids in Lagunitas Creek and its largest tributary - Olema Creek. This work was done as a two-phase assessment and design effort. The first phase (completed in 2013) included a winter habitat assessment to evaluate existing juvenile salmonid winter habitat in Lagunitas Creek and lower Olema Creek. The results of this assessment were used to prioritize winter habitat needs, and identify opportunities for winter habitat enhancement to increase

SELECTED EXPERIENCE *(CONTINUED)*

the winter carrying capacity of coho salmon and steelhead. The second phase (completed in 2017) consisted of a designing winter habitat enhancements. These enhancements focused on restoring floodplain and in-channel habitat structures. Winter habitat enhancement work also needed to consider potential impacts to or benefits for California freshwater shrimp (Syncaris pacifica), a federally endangered species.

This work included field reconnaissance, topographic surveys and the preparation of final design drawings at nine different project sites. An overall self-maintaining design approach was developed to guide individual project plan, with minimal earthwork and disturbance to existing riparian and wetland habitat. Self-sustained, natural evolution of a multi-thread channel within a more active floodplain is a desired outcome of project actions. Design elements and structures are intended to enhance or restore natural hydrologic processes to promote geomorphic evolution of more active high flow (side) channels and floodplain. Design elements include construction of 24 individual log structures.

Lower Miller Creek Management and Channel Maintenance, Marin County, CA
Las Gallinas Valley Sanitary District, 2013-2015

Mr. Kamman was commissioned to formulate and implement a plan for sediment removal and improved flood flow conveyance in the Lower Miller Creek channel. The need for improved flood and sediment conveyance is driven by the following factors. Progressive accumulation of course sediment in the project reach had reduced area wide discharge efficiencies along Miller Creek and at District outfalls. The District had an immediate need to dredge Lower Miller Creek to protect existing operations and facilities. Miller Creek supports a population of federally listed Steelhead, and adjacent wetland areas potentially support other state and federally listed special status species. Therefore, permitting requirements and cost efficiency required minimizing the extent and frequency of channel excavation/maintenance that may adversely impact habitats in the wetland and riparian corridor.

The design objective of the project was to define and optimize an integrated channel maintenance, flood, and sediment management plan, that protects existing facilities from stream and coastal flood hazards. The plan's objective was to minimize costs and ecological impacts of future anticipated and designed maintenance activities required under District operations. Working with District Staff, Mr. Kamman developed a suite of potential project alternatives and identified a preferred approach. Mr. Kamman completed all CEQA compliance (IS/MND) and permitting. Mr. Kamman also managed and directed development of engineered drawings and assisted in bid document preparation.

Mr. Kamman provided site assessment, long term management planning and channel maintenance support to the Sanitary District to maintain flood conveyance, manage sediment aggrading at District outfalls, and improve ecological values in the intertidal Bayland reaches of Miller Creek. The creek supports multiple federal and state listed endangered species. Initial work included completing hydraulic and geomorphic assessments to characterize causes of channel aggradation, and quantify sediment yields. Assessments included evaluation of climate change impacts on habitat and flood hazards, and water quality modeling of District outfalls to quantify tidal exchange and dilution. Based on this analysis and supporting biological resource assessments, Mr. Kamman identified alternatives for channel maintenance, performed a cost benefit assessment of dredging alternatives, and is assisted the District in developing short and long term management objectives. Mr.Kamman also led a multidisciplinary design team in the preparation of engineering plans and specifications as well as permits and environmental compliance documents.

Vineyard Creek Channel Enhancement Project, Marin County, CA
Marin County Department of Public Works, 2007-2013

Mr. Kamman managed the preparation of designs and specifications for a flood conveyance and fish habitat and passage improvement project on Vineyard Creek. Creek corridor modifications included replacing the box culvert at the Center Road crossing with a free span bridge or bottomless arch culvert (civil and structural design by others), providing modifications to the bed and bank to eliminate erosion risks to adjacent properties and improve water quality, promoting active channel conveyance of both water and sediment, and providing improved low and highflow fish passage, improved low flow channel form and enhanced in-stream habitat, repairing eroding banks, and expanding/enhancing adjacent channel floodplains. The riparian corridor was replanted to provide a low-density native understory, "soft" bank erosion protection, and increased tree canopy along the tops of banks. Mr. Kamman prepared the JARPA for the project and conducted permit compliance and negotiations with all participating resource agencies. Designs and permitting also address the known presence of Native American artifacts. This work was contracted under an expedited design schedule and phased construction was initiated the summer of 2008 and continued the summer of 2009.

Bear Valley Creek Watershed and Fish Passage Enhancement Project, Marin County, CA
The National Park Service and Point Reyes National Seashore Association, 2005-2013

Working on behalf of the NPS and PRNSA, Mr. Kamman completed a watershed assessment and fish passage inventory and assessment for Bear Valley Creek. Work included a geomorphic watershed assessment and completing field surveys and hydraulic modeling (including flood simulations) of ten road/trail crossings to identify and prioritize creek and watershed restoration efforts while considering and addressing current flooding problems at Park Headquarters – a major constraint to channel restoration efforts that would likely exacerbate flooding. Mr. Kamman also completed a suite of conceptual restoration designs (Phase 1) including: the replacement of two county road culvert crossings with bridges; channel creation through a ponded freshwater marsh (former tidal marsh); and replacement of 4 trail culverts with prefabricated bridges; and associated in-channel grade control and fishway structures. Engineered drawings and specifications were also developed for some of these sites to assist PORE with emergency culvert replacements after damages sustained during the New Year's Eve flood of 2005. Mr. Kamman also directed geotechnical, structural and civil design of project components.

Two projects were completed in 2006 on emergency repair basis resulting from flood damages suffered during the New Year's Eve storm of 2005. The two most recent projects were constructed in 2013, consisting of a large bank repair and adjacent to main access road/trail and culvert replacement further upstream on same road. The bank repair utilized bioengineering approaches including engineered log revetments and log diversion vanes.

SELECTED EXPERIENCE *(CONTINUED)*

Kellogg Creek Restoration Project, Contra Costa County, CA
Olberding Environmental on behalf of the Contra Costa County Water District, 2012-2013

Mr. Kamman led the development of PS&E to restore 3,000 linear feet of riparian and associated creek corridor habitat. Project was designed as compensatory mitigation for direct and indirect impacts to jurisdictional waters from the Los Vaqueros Reservoir Expansion Project that Contra Costa Water District. Work included field investigations and data analysis to characterize hydrologic/ geomorphic conditions and numerical modeling to optimize desired inundation and hydroperiods. Work was completed under subcontract to.

Miller Creek Sanitary Sewer Easement Restoration, Marin County, CA
Las Gallinas Valley Sanitary District, 2010

Working on behalf of the District, Mr. Kamman completed field surveys and technical feasibility studies to develop engineering plans and specifications for a stream bank restoration project to protect an exposed sanitary sewer pipeline, stabilize incised banks, and promote an ecologically healthy stream corridor along an approximately 50 linear foot damaged reach of Miller Creek. The design includes backfill and materials to accommodate construction of a vegetated stabilized slope. The eroded bank repair included design of a 1:1 Envirolok vegetated slope with geogrid reinforced soil lifts extending eight to ten feet back from the slope face. One-quarter-ton rock will be placed in front of the Envirolok wall at the toe of the reconstructed bank to provide added scour protection. In order to perform the work, the project site will be dewatered. An existing felled tree perpendicular to the creek flow will be relocated and secured into the right creek bank with root wad remaining in active channel. All work on the bank and within the creek bed must be completed pursuant to project permits due to presence of steelhead trout.

California Coastal Trail Planning and Design at Fitzgerald Marine Reserve, San Mateo County, CA
WRA, Inc., 2008-2009

Mr. Kamman provided hydrology and hydraulics expertise in the planning and design for the 0.25-mile segment of the California Coastal Trail at the Fitzgerald Marine Reserve. The project was overseen by the San Mateo County Parks Department. This segment of Coastal Trail provides improved access from the trailhead to the beach as well as a free span bride over Vicente Creek. Greg completed the field surveys and hydraulic modeling to assist an interdisciplinary team to design the project. Understanding the hydrology of Vicente Creek and quantifying flood conditions was critical to successfully designing and constructing the free span bridge. He also evaluated how creek hydrology and coastal wave processes interact at the beach outfall in order to identify opportunities and constraints to beach access improvements (which will include crossing the creek on the beach) during both wet and dry season conditions in order to evaluate both permanent and seasonal crossing design alternatives.

Hydrologic Assessment and Conceptual Design for Conservation and Wetland Mitigation Bank Project, Stanislaus County, CA
WRA, Inc., 2009

Working as a subcontractor to WRA, Inc., Mr. Kamman provided hydrology, geomorphology and engineering support for the planning and design for a Conservation and Wetland Mitigation Bank on the San Joaquin River, in the Central Valley near Newman, California. The property is currently owned by the Borba Dairy Farms. The primary objective of the study was to characterize the hydrologic and geomorphic controls on the spatial distribution of habitat types. To meet this objective, Mr. Kamman's assessment included: (1) collecting and synthesizing hydrologic data to characterize existing and historic streamflow, geomorphic and shallow groundwater conditions; (2) filling a data gap by collecting topographic data of hydrologic features; (3) developing a hydraulic model capable of predicting water surface profiles for a range of design flows; and (4) quantifying the linkage between surface water/groundwater conditions and specific vegetation communities and habitat types through implementation of reference site assessments. Mr. Kamman also provided conceptual design and permitting support in evaluating habitat enhancement and creation opportunities on the site.

Redwood Creek Floodplain and Salmonid Habitat Restoration, Marin County, CA
Golden Gate National Recreation Area and Golden Gate Parks Conservancy, 2005-2008

Mr. Kamman lead development of a preferred project alternative and final project design drawings and specifications for a floodplain and creek restoration and riparian corridor enhancement effort on lower Redwood Creek above Muir Beach at the Banducci Site. A primary objectives of the project was to: improve salmonid passage/rearing/refugia habitat; riparian corridor development to host breeding by migratory song birds; and wetland/pond construction to host endangered red-legged frog. The preferred design includes: excavation along the creek banks to create an incised flood terrace; engineered log deflector vanes; removing and setting back (constructing) approximately 400-feet of levee; creating in- and off-channel salmonid rearing and refugia habitat; reconnecting tributary channels to the floodplain; and creating California red-legged frog breeding ponds. Designs were completed in 2007 and the project constructed in the summer of 2007.

Considerable hydraulic modeling was completed to evaluate and develop means to help reduce chronic flood hazards to surrounding roadways and properties. Alternatives that included set-back levees and road raising were developed and evaluated. Detailed and careful hydraulic (force-balance) analyses and computations were completed as part of engineered log deflector designs. These were unique and custom designed structures, building on past project efforts and in consultation with other design professionals.

This project demonstrates Mr. Kamman's ability to work closely with the project stakeholders to develop a preferred restoration alternative in a focused, cost-effective and expedited fashion. This was achieved through close coordination with the NPS and the effective and timely use of design charrette-type meetings to reach consensus with participating stakeholders. Conceptual through full PS&E were completed on-time and on-budget in 2007 and was project constructed in the fall of 2007. Mr. Kamman worked closely with NPS staff to "field fit" the project, by modifying grading plans to protect existing riparian habitat. Mr. Kamman also provided construction management and oversight to floodplain grading and installation of engineered log structures. Based on field observations, the project is performing and functioning as desired.

Pilarcitos Creek Bank Stabilization Project, San Mateo County, CA
TRC Essex, 2006-2007

Mr. Kamman directed field surveys and technical modeling analyses to develop restoration design alternatives for a Bank Stabilization Project on Pilarcitos Creek

SELECTED EXPERIENCE *(CONTINUED)*

in unincorporated San Mateo County, California. This work included hydrology and hydraulic design and preparation of plan sheets and technical specifications as well as a revegetation plan. Due to the importance of protecting an existing gas mainline, the design package will be completed in close coordination with TRC Essex geotechnical staff and revegetation subcontractor and PG&E civil staff. Design feasibility analyses focused on developing hydraulic design criteria for the project, including: estimates of design flood flow magnitudes (2-, 5-, 10-, 25-, 50- and 100-year floods); water surface elevation estimates for a suite of design floods; associated average channel velocities and shear stresses; and estimates for riprap sizing for channel bank toe protection. Plan sheets, technical specifications and cost estimates were provided for review and approval.

Watershed Assessments

Evaluation of Project Impacts on Oregon Spotted Frog, Klamath County, OR
Oregon Water Watch and Earthjustice, 2016-2019

Mr. Kamman designed a suite of hydrologic, hydraulic and geomorphic studies to evaluate proposed change operations of the Crane Prairie, Wickiup and Crescent Lake dams and reservoirs as related to harm to Oregon spotted frogs. Work began with analyzing impacts associated with proposed water delivery operations and developing a proposed alternative prioritizing protection and enhancement of frog habitat. This work followed with a technical review and critique of the USFWS's Biological Assessment. Work included preparation of four declarations for the clients.

Tennessee Hollow Creek Riparian Corridor Restoration, San Francisco County, CA
Presidio Trust, 2001-present

Mr. Kamman has been leading and assisting the Trust and Golden Gate National Recreation Area (GGNRA) in the planning and design on over a dozen multi-objective riparian corridor restoration and watershed management projects in the Tennessee Hollow/Crissy Marsh watershed since 2001. Specific project objectives include: daylighting creeks; riparian corridor restoration; expanding Crissy Marsh; enhancing recreation, education, archeological, and cultural resource opportunities; improving water quality discharges to San Francisco Bay; and remediation of numerous landfills within the watershed. Typical initial phases of work focus on characterizing surface and groundwater conditions within each project area and identifying opportunities and constraints to restoration of natural wetlands and creek/riparian corridors. Notable challenges of this work include restoring heavily disturbed natural resources in an urban setting while integrating designs with recreation, archeology/cultural resources, education and remediation programs. Mr. Kamman has acted as lead hydrologist and designer on eight separate reaches in the 271-acre Tennessee Hollow Creek watershed and several other projects within and in the vicinity of Mountain Lake.

All task authorizations under these on-call and individual design contracts and included hydrology and water quality assessments and conceptual restoration planning and design. The project areas overlapped both the Presidio Trust and NPS-GGNRA management areas. Preliminary construction cost estimates for project alternatives within the Tennessee Hollow watershed range from $10- to $20- million. Several restoration projects are also tied to providing mitigation for the current San Francisco Airport expansion and Doyle Drive Seismic Improvement projects. Several projects have been constructed since 2012 (Thompson's Reach, El Polin Loop), two projects (East Arm Mtn. Lake and YMCA Reach) were constructed in 2014, and MacArthur Meadow restoration in 2016.

This work illustrates the Mr. Kamman's ability to complete a broad variety of hydrologic analyses, including: multiple years of rigorous and thorough surface water and groundwater hydrologic and water quality monitoring throughout the entire watershed to characterize and quantify existing hydrologic conditions; development of a detailed watershed-scale water budget for existing and proposed land-used conditions (capturing existing and proposed vegetation cover types and land use activities) to calculate groundwater recharge estimates input into the numerical watershed model; preparation of EA sections on water resources and water quality (NEPA compliance) regarding Environmental Conditions, proposed Impacts, and Proposed Mitigations associated with the project; preparing detailed alternative plans; and coordination and preparation of engineered plans/specifications for construction. All work was completed on budget and in a timely fashion.

Mountain Lake Water Budget, San Francisco County, CA
Presidio Trust, 2012-2017

Mr. Kamman was retained to develop a water balance model for Mountain Lake in the Presidio of San Francisco. Through development of a water balance model, the Trust seeks to understand: the major source(s) of inflow to both Mountain Lake; anticipated seasonal (monthly) changes in water level relative to various outflow assumptions; and the relationship of surface and groundwater interaction. This information gained from this study will be used to: 1) better understand and manage lake levels for ecological habitats; 2) identify flood storage capacity of Mountain Lake and fluctuations in lake level under various storm conditions; 3) better understand and maintain wetland habitat in the east arm; and 4) complete mass balance calculations to assess water quality in and feeding into the lake.

To implement this study, Mr. Kamman developed a water budget model to identify and quantify the primary water inputs and outputs to the lake and determine major controls over water storage. Primary water budget variables analyzed includes: precipitation; evaporation/evapotranspiration; groundwater exchange; and surface runoff. This study also included a long-term field investigation completed between 2012 and 2016 to: identify all point source inputs such as culverts and drainage outlets; identify diffused surface runoff inputs from surrounding lands, including a golf course; better characterizing the function and performance of the primary lake outfall structure; monitor groundwater levels surrounding the lake; and continuously monitor lake water level and storage over a mult9i-year period. These data were used to quantify water budget variables used to build the water budget model. Precipitation and barometric pressure data used in the model was provided by the Trust maintained weather station. Model daily evaporation estimates came from a variety of local area gauges maintained by state agencies.

The water budget model developed for this study is successful in accurately simulating historic water level conditions. The model using a daily time-step appears more accurate than model using a weekly time-step, but both provide reasonable agreement with observed conditions. The model is highly sensitive to groundwater exchange with the lake. The water budget is also a proven useful tool for the design and analysis of improvements to the lake outfall structure and establishing flood storage needs to protect the adjacent highway.

SELECTED EXPERIENCE *(CONTINUED)*

Cordilleras Creek Hydrologic Assessment, San Mateo County, CA
City of Redwood City, 2002-2003

Mr. Kamman assisted the Cordilleras Creek Watershed Coordinator in planning, seeking funding, and implementing a hydrologic and biologic assessment of the Cordilleras Creek watershed. Work completed included completing a full creek reconnaissance and channel stability assessment, preparation of a watershed assessment work plan, presentations at public meetings, and study/review of flooding issues in the watershed. Challenges faced in this predominantly privately owned watershed include removal of numerous fish passage barriers and educating/coordinating property owners.

Capay Valley Hydrologic and Geomorphic Watershed Assessment, Yolo County, CA
Yolo County RCD, 2008-2010

Mr. Kamman designed and supervised a hydrologic, geomorphic watershed assessment, and conceptual restoration design for the Capay Valley segment of Lower Cache Creek . Funding for the project was from a CALFED Watershed Program grant. The Capay Valley reach of Cache Creek experiences considerable stream bank erosion, which contributes to downstream sedimentation. The channel instability also threatens adjacent homes and can negatively impact the riparian habitat along the creek that functions as an important wildlife corridor from the Western Coastal Range to the Yolo Bypass. Additionally, a significant proportion of methylmercury transported into the Bay-Delta originates from the Cache Creek watershed. The main goal of this proposed study is to address both the causes and the aforementioned consequences of bank erosion.

The assessment was designed to evaluate and quantify changes in hydrologic and geomorphic conditions in response to historical changes in land-use and water development (e.g., diversions, reservoir construction, groundwater pumping, etc.). This assessment also evaluated how historic human induced changes in hydrologic and geomorphic conditions affect riparian ecology in terms of the lost or altered floodplain area, character, and inundation frequency. A key product of this assessment was to distinguish between “natural” and “accelerated” bank erosion, and to identify the underlying causes (both natural and anthropogenic) so that appropriate solutions can be developed. Desired outcomes of the study included: reduce bank erosion by developing restoration designs for typical trouble sites; produce a ranking system to prioritize sites for stabilization and restoration; contribute to community education through watershed science education and the Yolo STREAM Project outreach program; improve water quality through reduction in accelerated erosion; and contribute to riparian corridor restoration and support the RCD’s Wildlife Conservation Board funded efforts to remove non-native tamarisk and around from the creek corridor. Work was completed through a broad spectrum of field and analytical investigations that received close review by the RCD, stakeholders, and a Technical Advisory Committee.

Ventura River Unimpaired Flow and Habitat Assessment, Ventura County, CA
City of Buenaventura and Nautilus Environmental, 2006-2007

Mr. Kamman completed a hydrology feasibility assessments as part of evaluating the reuse of Ojai Valley Sanitary District (OVSD) effluent for other beneficial uses. Currently, OVSD discharges treatment plant effluent to the lower Ventura River. The City and OVSD recognize that the reduction in the discharge of treated effluent to the Ventura River could have an environmental effect on sensitive and endangered species. In light of these concerns, this study was conducted to determine if a reuse project is feasible without significant environmental harm.

The assessment included hydrologic and geomorphic field and analytical assessments of past (unimpaired), current and proposed surface and groundwater flow conditions over a wide range of dry- through wet water year-types. The main objective if these analyses was to determine the linkage to water quality and aquatic habitat conditions including: flow durations; extent of gaining vs. losing reaches; low flow inundation/wetted area; and influence on barrier beach dynamics. Mr. Kamman collaborated with a team of other professionals to prepare a facility plan documenting the analyses and conclusions of respective water recycling investigations.

Hydrologic Analysis of FERC Minimum Flows on Conway Ranch Water Rights, Mono County, CA
Law Office of Donald Mooney, 2001-2002

Mr. Kamman completed a hydrologic analysis to evaluate if FERC’s proposed Minimum Flow Plan for Mill Creek would interfere with the exercise of the Conway Ranch’s water rights from Mill Creek. The approach to this analysis was to quantify the duration of time the Conway Water right was met under historic gaged and simulated proposed Minimum Flow Plan conditions. The primary objective of the analysis was to evaluate impacts during the winter period when flows are typically limited due to water storage as snow pack. Minimum Flow Plan conditions were simulated by developing a spreadsheet model that redistributes actual (historic) Lundy Lake releases in a fashion that maintains a minimum flow of 4 cfs to Mill Creek to accommodate the downstream Southern California Edison’s (SCE) power plant. The analysis period for both historic and simulated Minimum Flow Plan conditions consisted of water years (WY) 1990 through 1998 to capture an exceptionally diverse range of wet and dry year-types.

The primary method used to quantify changes in flow between historical and simulated Minimum Flow Plan conditions was to prepare and compare flow duration curves for each condition during both the winter and summer periods during a variety of water year types. Model results were tabulated for each conditions to determine the differences in the percentage of time target flows were equaled or exceeded. Based on these findings, Greg was contracted to complete more in-depth monthly modeling.

Groundwater Management Projects

Assessments of Groundwater-Surface Water Interaction, Stanislaus County, CA
The Law Offices of Thomas N. Lippe, APC and California Sportfishing Protection Alliance, 2015-present

Since 2015, Mr. Kamman has been assessing groundwater conditions within Stanislaus County and evaluating potential impacts of groundwater pumping on surface water flow and aquatic habitat of the Stanislaus, Tuolumne and San Joaquin Rivers. Mr. Kamman completed a comprehensive review and synthesis report of available groundwater and interconnected surface water (ISW) reports and data. Using available soils, geology and hydrology information, Mr. Kamman also delineated and mapped subterranean streams and Potential Stream Depletion Areas (PSDAs) to identify stream corridors susceptible to adverse impacts from groundwater pumping. This information is intended to help Groundwater Sustainability Agencies identify potential impacts to ISW.

SELECTED EXPERIENCE *(CONTINUED)*

Most recently, Mr. Kamman has been retained to review and comment on 7 Groundwater Sustainability Plans (GSPs) for critically overdraft groundwater subbasins within or adjacent to Stanislaus County. This review focused on how GSPs address Groundwater Dependent Ecosystems (GDE) and ISW. Comments included recommendations on monitoring and study plans to identify and quantify impacts of groundwater pumping on stream flow rates and associated ecological habitats.

Assessment of Surface Water-Groundwater Interaction, Humboldt County, CA
Friends of the Eel River (FOER), 2020-present

Mr. Kamman is currently providing technical assistance in understanding surface water-groundwater interactions in the Lower Eel River Valley. Work includes reviewing and synthesizing available reports and hydrologic data and providing a science-based opinion on the role groundwater plays in supporting stream flow and aquatic habitats. This analysis addresses conditions and changes associated with seasonal and long-term wet-dry cycles. Data gaps will be identified and documented during the analysis.

This work is being completed to support FOER efforts at protecting aquatic resources within the framework of current water management practices and the public trust doctrine under California law. Additionally, this work includes providing hydrologic and hydrogeologic review, comment and recommendations during development of the basin's Groundwater Sustainability Plan (GSP) under the California Sustainable Groundwater Management Act (SGMA).

Scott Valley Subbasin Technical Hydrogeologist Assistance, Siskiyou County, CA
Klamath Tribal Water Quality Consortium and Quartz Valley Indian Reservation, 2019-present

Mr. Kamman is providing technical review and comment on the groundwater models and associated studies in the Scott Valley groundwater subbasin under the Sustainable Groundwater Management Act (SGMA) process. Work includes: review of groundwater models; synthesis and review of available groundwater quality data; assisting to identify constituents of concern; and review of the planning and technical studies being used to develop a basin Groundwater Sustainability Plan (GSP).

Middle Russian River Valley Shallow Groundwater Storage Enhancement Study, Sonoma County, CA
Friends of the Eel River, 2016

Working on behalf of Friends of the Eel River, Mr. Kamman completed a study to identify and quantify the volume of recoverable aquifer storage along two independent 6-mile reaches within the alluvial fill valley of the Russian River. The approach to this study was to quantify how channel incision has reduced shallow groundwater levels and quantify how much aquifer storage can be increased if channel bed elevations are restored to historic levels. The goal of this investigation was to identify feasible approaches to increase groundwater storage that would off-set losses associated with the termination of out-of-basin diversions from the Eel River. This work was completed through: intensive review and mapping of available groundwater level data; quantification of aquifer hydraulic properties; and calculating the shallow aquifer storage volume. In total, reclaiming the shallow aquifers within these two areas yield a total added storage volume of over 20,000 AF.

Green Gulch Farm (GGF)/Zen Center Water Resources Investigation, Marin County, CA
Green Gulch Farm, 1998-2019

Mr. Kamman completed a multi-phase study to evaluate the short- and long-term water uses and resources at GGF. Work was initiated by developing comprehensive water usage/consumption estimates and assessing available water resources, including spring, surface water, and ground water sources. Water demand estimates included quantifying potable and agricultural water usage/demands. Once reliable water supplies were identified and water usage/demand figures calculated, Mr. Kamman provided recommendation for improvements to water storage and distribution systems, land-use practices, conservation measures, treatment methods, waste disposal, and stream and habitat restoration. The initial phase of work included: in-depth review of available reports and data; review of geology maps and aerial photography; review of water rights and historic land use records; field reconnaissance including year-round spring flow monitoring; mapping and quantifying existing runoff storage ponds; and surface water peak- and base-flow estimates.

The second phase of work included identification of possible groundwater sources and siting and installation of production wells. This included sighting three drilling locations, obtaining County and State well drilling permits for a domestic water supply; coordination and oversight of driller; and directing final well construction. Upon completion of a well, Mr. Kamman directed a well pumping yield test and the collection and analysis of water quality samples (including Title 22) for small water supply system use. The final phase of work included assisting GGF with water treatment system options at the well head and integration of the groundwater supply into an existing ultra-violet light treatment system servicing spring water sources. Work was completed in 2000 with a budget of approximately $25,000, including all driller and laboratory subcontracting fees.

Stanford Groundwater Assessments, Santa Clara County, CA
Stanford University Real Estate Division, 2012-2016

Mr. Kamman provided technical hydrogeologic services to evaluate groundwater conditions and drainage requirements associated with the construction of several new facilities on or near Page Mill Road. The main objective of this study is to determine the seasonal depth to groundwater beneath the project site under existing and potential future conditions and provide an opinion on if the project is required to comply with the City of Palo Alto, Public Works Engineering Basement Exterior Drainage Policy (effective October 1, 2006). This work included obtaining and reviewing available technical reports, maps and literature pertaining to groundwater conditions in the project vicinity. Based on this review, we have prepared a letter report of findings and recommendations.

Bodega Bay Wetland Water Supply, Sonoma County, CA
Friends of Bodega Bay, 2007

Mr. Kamman Conducted an evaluation of the groundwater underflow feeding a large coastal wetland in Bodega Bay and recommended mitigation measures for potential losses in supply associated with proposed residential development in recharge areas. Work included: long-term monitoring of ground water quality and supply; monitoring surface water and spring flow and water quality; assessing and characterizing the interaction between surface and subsurface water sources during different seasons and water year-types; developing a detailed water budget for the site to assess impacts to recharge areas; and developing a number of physical solutions to mitigate for recharge losses.

SELECTED EXPERIENCE *(CONTINUED)*

L.A. Department of Water and Power, Groundwater Recharge Facility Operation Study, Los Angeles County, CA
ICF Consulting, 2006

Working as a subcontractor to ICF Consulting of Laguna Niguel, California, Mr. Kamman provided technical assistance in the hydraulic modeling of sediment accumulation in selected spreading ground facilities owned and operated by the Los Angeles Department of Public Works. The object of this work is to evaluate changes in infiltration and groundwater recharge rates over time within the spreading grounds in association with sediment accumulation from turbid waters.

Corde Valle Golf Club Surface-Groundwater Interaction Study, Santa Clara County, CA
LSA Associates, 2004

On behalf of LSA Associates of Pt. Richmond, CA, Mr. Kamman completed a 3rd party independent review of available reports and data sets (boring logs, well water levels, groundwater quality, aquifer pump-test, and surface water monitoring) to evaluate if pumping of the Corde Valle irrigation well is adversely impacting flow in West Llagas Creek. This investigation was implemented in response to a concern expressed by California Department of Fish and Game staff regarding the potential for differential drying of the West Branch of Llagas Creek along Highland Avenue. The analysis was also complicated by the likely effects of pumping from surrounding off-site wells.

Aquifer Testing for Tennessee Hollow Watershed Project, San Francisco County, CA
Presidio Trust, 2002

The Mr. Kamman assisted in the design and implementation of an aquifer test at the Presidio of San Francisco. We prepared an aquifer test work plan and conducted step-drawdown and constant-rate aquifer tests at the site using both manual and electronic data collection methods. This work included interpretation of the aquifer test results using software-based solution methods and prepared a written summary of methods and findings. In addition, Mr. Kamman located, coordinated and managed a drilling effort for the logging and installation of several groundwater monitoring wells in the project area to address identified data gaps.

San Joaquin River Riparian Corridor Restoration Project, San Joaquin Valley, CA
McBain-Trush, 2002

Mr. Kamman completed an assessment of historic and existing shallow groundwater conditions beneath and adjacent to the San Joaquin River between Friant Dam and the Merced River. This work focused on reviewing available reports and flow/groundwater- level data to characterize surface water and groundwater interaction and implications for riparian vegetation, water quality and fishery habitat restoration. Hydrologic analyses were performed to identify the location and seasonal evolution of losing and gaining reaches an implication on future restoration planning and design efforts. The main deliverable for this analysis was a report section focused on describing the historical changes in regional and local groundwater conditions in the San Joaquin Valley and evolution of anthropogenic activities (e.g., groundwater withdrawals, irrigation drainage systems and return flows, development of diversion structures, changes in land-use; and introduction of CVP/State Water Project deliveries) and associated impacts on deep/shallow groundwater levels, surface water flows, and surface and groundwater quality.

Tidal, Estuarine & Coastal Projects

Quartermaster Reach Wetland Restoration Project, San Francisco County, CA
Presidio Trust, 2006-present

Mr. Kamman was retained in 2006 as part of a multi-disciplinary team to develop restoration alternative designs for a 10-acre filled and paved site marking the historic confluence of Tennessee Hollow Creek and Crissy Marsh adjacent to San Francisco Bay. The Trust's planning documents define the main objectives for Tennessee Hollow restoration as: a) "Restoration [of Tennessee Hollow] will expand riparian habitat and allow for an integrated system of freshwater streams and freshwater, brackish, and tidal marsh, re-establishing a connection to Crissy Marsh" and b) "Restore and protect Tennessee Hollow as a vibrant ecological corridor". The project is located within the setting of a National Park and a National Historic Landmark District. Thus, another goal for the project is to protect the area's historic buildings and sensitive cultural and archeological resources to the extent possible, to enhance visitor experience to the area, and to integrate creek restoration with other urban land uses.

Mr. Kamman provided H&H technical input and consultation to the design team to develop a restoration project consisting of a creek-brackish marsh-salt marsh interface and associated upland habitats. His work included evaluating surface water, groundwater and tidal sources. In addition, the development of a hydrodynamic model has informed and guided a preferred project design, including evaluation of storm surge, road crossing and Tsunami impacts to the project. A technical challenge addressed with the use of the model included predicting and quantifying salt/brackish marsh habitat zones within the restored wetland in response to periodically but prolonged closed-inlet conditions to Crissy Marsh - a water body that serves as the downstream connection to the proposed project.

Another unique challenge to this project includes integrating restoration planning and design efforts with the replacement and retrofit of Doyle Drive, the main on/off-ramp for the Golden Gate Bridge, being replaced along the entire northern boundary of the Presidio. Mr. Kamman is providing long-term technical review of this project to the Trust with respect to impacts to water resources and associated existing ecological habitats. The Quartermaster project also falls within the managerial jurisdiction of both the Presidio Trust and NPS-GGNRA, requiring work in close cooperation with both Presidio Trust and National Park Service (NPS) staff.

Salt River Ecosystem Restoration Project, Humboldt County, CA
Humboldt County RCD, 2005-2019

Mr. Kamman provided hydrology, engineering and environmental compliance services towards the planning and design of river and tidal wetland restoration on the Salt River (Eel River Delta plain) near Ferndale, California, in Humboldt County. The purpose of the Salt River Ecosystem Restoration Project (SRERP) is to restore historic processes and functions to the Salt River watershed. These processes and functions are necessary for re-establishing a functioning riverine, riparian, wetland and estuarine ecosystem as part of a land use, flood alleviation, and watershed management program. The Salt River Project has three components: 1) dredging the lower Salt River and lower Francis Creek from near the Wastewater Treatment Plant downstream for 2.5 miles; 2) restoring 247 acres of wetland estuary habitat in the lower Salt River within the 440-acre former

SELECTED EXPERIENCE *(CONTINUED)*

dairy; and 3) reducing sediment inputs from tributary watersheds. The Salt River Project was designed using an "ecosystem approach" to address hydrology, sedimentation, and fish and wildlife habitat.

As part of project feasibility assessment, Mr. Kamman completed a hydrologic and water quality monitoring program, and developed a MIKE11 hydrodynamic model of the lower Salt River and Eel River estuary in Humboldt County, for the Humboldt County RCD. The purpose of this work was to complete a hydrologic, geomorphic, and hydraulic modeling assessments of the character and dominant physical processes controlling flow of water and sediment through the lower Salt River. Land use changes in the area have caused significant aggradation and infilling of the Salt River, significantly reducing tidal exchange, fish passage, and exacerbating flooding in upland areas. A primary goal of this study is to evaluate the feasibility of proposed restoration elements intended to increase tidal prism and exchange and in-channel sediment scour and transport. The desired outcome is a sustained increase in river conveyance capacity to improve drainage of surrounding flood-prone lands and improve aquatic, wetland, and riparian habitat.

As part of project development and feasibility assessment, Mr. Kamman completed a hydrologic and water quality monitoring program and MIKE11 hydrodynamic model development of the lower Salt River and Eel River estuary in Humboldt County for the Humboldt County RCD. The purpose of this work is to complete a hydrologic, geomorphic, and hydraulic modeling assessments of the character and dominant physical processes controlling flow of water and sediment through the lower Salt River. Land use changes in the area have caused significant aggradation and infilling of the Salt River, significantly reducing tidal exchange, fish passage, and exacerbating flooding in upland areas. A primary goal of this study is to evaluate the feasibility of proposed restoration elements intended to increase tidal prism and exchange and in-channel sediment scour and transport. The desired outcome is a sustained increase in river conveyance capacity to improve drainage of surrounding flood-prone lands and improve aquatic, wetland and riparian habitat.

Western Stege Marsh Restoration Project, Contra Costa County, CA
Tetra Tech, 2008-2010

Mr. Kamman provided technical hydrology and wetland hydraulics support to post-project monitoring of the Western Stege Marsh Restoration Project. His involvement began by providing an independent technical review of previous year's hydrologic monitoring results to evaluate the proposed monitoring success criteria and the rationale used to develop these criteria. This work entailed reviewing historic monitoring data and available natural slough channel geometry data-sets for San Francisco Bay area marshes. Mr. Kamman's study approach was to independently develop desired and sustainable channel geometry relationships for natural, healthy San Francisco Bay salt-marshes and compare them to the published success criteria. Greg was also retained to implement the Year 4 post-project hydrologic monitoring, with modifications to aid in better linking hydrologic processes to ecological conditions and function within the restored marsh. This work consisted of completing more targeted water level monitoring and channel geometry surveys in reference marsh areas containing desired physical and ecological attributes. These data were used to develop geomorphic success criteria (target channel geometry) more tailored to the project marsh and augment the criteria provided in available literature. Working closely with the project team of scientists, Mr. Kamman compared these hydrologic monitoring results to available vegetation surveys to better assess the overall success and evolutionary trend of the marsh.

Giacomini Wetland Restoration Project, Marin County, CA
The National Park Service and Point Reyes National Seashore Association, 2003-2012

Mr. Kamman managed a multi-year project for the NPS in the design and feasibility analysis of a tidal wetland, riparian, and freshwater marsh complex, on the 500-acre Giacomini Dairy Ranch, at the south end of Tomales Bay. The project began in 2003 and included hydraulic, hydrologic, and geomorphic assessments to characterize existing physical conditions, developing restoration alternatives, and completing hydrologic feasibility analyses. Restoration alternatives evaluated creation of a mosaic of subtidal through upland wetland and riparian habitat zones, as well as improvements to salmonid passage, red-legged frog habitat, tidewater goby habitat, and clapper-rail habitat. Emphasis was placed on completing detailed studies to quantify project-induced changes in flood frequency, magnitude and duration, impacts on water quality to local groundwater supply wells, and changes in sediment and water quality conditions in Tomales Bay.

Beginning in 2006, Mr. Kamman managed and assisted design engineers, preparing plans, specification, and cost estimates for a three phased construction schedule, that was completed in the summer of 2008. This project illustrates Mr. Kamman's ability to complete a broad variety of hydrologic feasibility analyses, including flood frequency analyses for contributing watersheds, reproducing historic flood events through numerical modeling, flow duration analysis and evaluation of environmental flow regimes, development of a water budget for created freshwater marsh and frog breeding ponds, sediment yield estimates, completing field monitoring (flow, water level, groundwater level, sediment, and water quality monitoring) to characterize existing site hydrologic and geomorphic conditions (fluvial and tidal), wind-wave setup and run-up for levee stability determination and construction design, coordinating and performing topographic and hydrographic surveys, performing hydrodynamic and water quality modeling of existing and alternative conditions, developing detailed construction cost estimates preparation of technical reports and design drawings and specifications in support of NEPA/CEQA environmental compliance, and public meeting presentation and participation. In addition, Mr. Kamman managed staff in the generation of DEM and TIN models of the existing site and all action alternatives. All work was completed on budget and in a timely fashion, despite repeated expansions to the project boundary and last minute changes driven by endangered species issues.

Critical Dune Habitat Restoration to Protect Threatened and Endangered Species, Marin County, CA
The National Park Service, 2009-2010

Mr. Kamman provided and managed engineering, design, and implementation planning support for the restoration of 300 acres of critical dune habitat at Abbots Lagoon within the NPS Point Reyes National Seashore. He developed engineered drawings, technical specifications and engineer's cost estimates, and assisted NPS in defining a range of methodologies suitable to local conditions and sensitive flora and fauna. This area of the park supports the best remaining intact dune habitat, including some of the largest remaining expanses of two rare native plant communities: American dune grass (Leymus mollis) foredunes, and beach pea (Lathyrus littoralis). European beach grass and iceplant were removed from

SELECTED EXPERIENCE *(CONTINUED)*

the project site using mechanical removal and hand removal techniques. The project goal was to remove these invasive species from approximately 135 acres of prime dune habitat in the 300-acre project site, while not impacting sensitive species and habitats. The intended result was to remobilize this historic dune field and restore their natural form and migratory processes.

This project illustrates Mr. Kamman's ability to work closely with NPS staff to balance habitat protection and restoration across the landscape. As part of project design, he developed grading plans, and specified work flow, equipment movement and access routes which minimize impacts to special status species. Extensive fencing and exclusions zone planning was required to protect existing native habitats, and minimize tracking of plant stock to or through restored sties. In addition work elements had to be structured and prioritized to maximize ground work subject to budgetary constraints and work flow uncertainties. All work has been completed on budget and in a timely fashion, even with repeated expansions to the project boundary and affected area and last minute changes driven by endangered species issues.

Lower Gualala River and Estuary Assessment and Management Plan, Mendocino County, CA
California State Coastal Conservancy and Gualala River Watershed Council, and Sotoyome RCD, 2002-2005

Mr. Kamman worked with fisheries biologists to evaluate the hydrologic and water quality conditions in the lower Gualala River and estuary and identify and evaluate potential impacts to summer rearing habitat for salmonids and other aquatic organisms. This work included: assessing how the impacts of upstream land use (logging and water diversions) have altered water delivery and water quality to the Lower River and estuary over time; characterizing the physical coastal and riverine processes controlling opening and closure of the estuary inlet and lagoon morphology; monitoring and characterizing real-time and seasonal changes in lagoon water level and water quality; and evaluating the sediment transport capacity and geomorphic condition of the lower river and estuary. Mr. Kamman took the lead in developing and editing a management plan for the lagoon, prescribing actions to preserve, protect and enhance ecological habitats (with emphasis on salmonids) within the lagoon and lower Gualala River.

This project was completed on-time and on-budget and demonstrates Mr. Kamman's ability to integrate physical, water quality and biological data and information into a coherent and understandable description of the interrelated processes controlling the aquatic ecology of a lagoon system. A big challenge on this project was completing a high-quality and defensible field monitoring program on a "shoe-string" budget. The outcome of this study provides important understanding on how and why steelhead are surviving in a heavily logged (95% private ownership) watershed. The management plan prescribes recommendations to preserve and protect the lagoon as primary rearing habitat for steelhead.

Suisun Bay Tidal Wetland Restoration Design, Contra Costa County, CA
East Bay Regional Park District and LSA Associates, 1999-2005

Mr. Kamman provided hydrologic design services to the restoration of a 55-acre tidal wetland on Suisun Bay. The design will maximize habitat for special status fish species, and (to the extent possible) habitat for other special status animal and plant species. Working with a multi-disciplinary design team, Mr. Kamman assisted in developing a design based on analysis of habitat needs, tidal hydrodynamic and geomorphic processes, sedimentation rates and soil characteristics. Project tasks included: a site analysis defining existing ecological and hydrologic conditions; a hydrologic and biological restoration opportunities and constraints analysis to define restoration and management objectives; and hydrodynamic and sedimentation modeling to evaluate design alternatives. The final restoration and management plan included a grading plan, landscape revegetation plan and monitoring and maintenance plans. This work again illustrates his capabilities in the characterization of physical site conditions, development and feasibility analysis of project alternatives, and preparation of preliminary designs of sufficient detail to allow for environmental compliance through the CEQA/NEPA process.

Santa Clara River Estuary and Lower River Assessment, Ventura County, CA
Nautilus Environmental on behalf of the City of Ventura, Public Works Department, 2003-2004

Mr. Kamman directed a hydrologic and geomorphic assessment of the lower Santa Clara River and estuary. This work was completed for prime contractor in an effort to assist with re-permitting of treated effluent discharges to the estuary. The proposed study entailed characterizing existing and historic hydrologic and physiographic conditions and an assessment of historic changes in inflow to the estuary. This task included a comprehensive review and evaluation of available hydrologic reports and flow data within the watershed to characterize changes in flow associated with development of numerous water projects within the Santa Clara River basin. The main deliverable from this analysis was the development of a historic unimpaired flow record to the estuary based on regional regression analyses and water operations modeling. Within the estuary, Mr. Kamman designed and conducted a multi-year monitoring program of water levels, water quality (temperature, dissolved oxygen, salinity, and pH), and sand-spit morphology in order to evaluate inlet opening/closure frequency and associated changes in aquatic habitat (esp. tidewater goby) and other ecologic communities. A considerable portion of this subtask included detailed coastal process analysis (including wave power analyses and littoral sand transport), which, considered with the inflow analysis, provides a basis to evaluate the seasonal cycle of barrier beach buildup and destruction.

This project illustrates Mr. Kamman's ability to complete a broad variety of hydrologic and coastal process analyses under strict regulatory oversight. A premier study completed on this project was the development of a detailed water and salinity budget model for the estuary to evaluate the impacts of a wide variety of proposed and modified estuary inflow regimes to determine potential future water level and salinity conditions in the lagoon and impact on frequency of inlet breaching. In addition to coordinating and implementing a variety field monitoring and surveys, Mr. Kamman also provided real-time information and input to informational and negotiation meetings with state resource and regulatory agencies.

Eden Landing Ecological Reserve Restoration, Alameda County, CA
East Bay Regional Park District, 2000-2003

Mr. Kamman developed and completed hydraulic and hydrodynamic modeling assessments for the design of an approximately 1000-acre tidal marsh restoration in former Cargil salt manufacturing ponds, located a mile inland of San Francisco Bay. The restoration goals required balancing the desires to restore tidal marsh conditions to the site, while maintaining and enhancing the open water and salt

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panne habitats preferred by resident and migratory shorebirds. The restoration plan also needed to incorporate restoration objectives with remediation of high soil salinities resulting from past salt production, subsided ground elevations, dredging of new channels to the bay, existing infrastructure constraints, public access for the San Francisco Bay Trail, and preservation of several important cultural and historical sites. Hydraulic design objectives include maximizing both interior circulation and tidal exchange between the restoration parcel and the bay. A series of one-dimensional unsteady hydrodynamic models (MIKE11) were used to design the channel network, identify high velocity areas requiring erosion protection, and characterize expected habitat conditions. An important component of this design and feasibility assessment was to translate desired ecological habitat conditions identified in the EIR into specific hydrologic design criteria, considering channel velocities, scour, sediment transport, tidal water inundation frequencies and seasonality of ponding. Mr. Kamman worked closely with EBRPD civil engineers, assisting with the translation of hydraulic design criteria into final engineered drawings and specifications.

Wetland & Pond Projects

Design of California Red-Legged Frog Breeding Ponds, San Francisco Bay Area (various), CA
The National Park Service and Golden Gate National Parks Conservancy, 1997-present

Mr. Kamman has lead or provided hydrologic and engineering design assistance to the sighting and design of nearly two dozen breeding ponds for California red-legged frog throughout the San Francisco Bay Area. Work has been completed in Marin, Sonoma, Solano, Contra Costa, Alameda, and Santa Clara Counties under the auspices of numerous federal, state, and local county/city agencies. A common study approach consists of an initial site reconnaissance of watershed conditions and identification of potential sites. The reconnaissance is followed by a surface water hydrologic sufficiency analysis using available meteorologic and stream flow information. An important variable sought during pond sighting is the presence of migration corridors between known breeding areas and/or perennial water sources. Based on in-depth research and post-project monitoring, Mr. Kamman has refined or developed site-specific evapotranspiration estimates, which commonly do not match standard applied values. Accurate evapotranspiration rates are necessary if ponds are intended to periodically dry-down as a means to preclude undesired species such as bullfrog or mosquito fish. In many instances, a seasonal groundwater-monitoring program is implemented in order to better investigate and quantify potential and seasonal groundwater contributions. Other design challenges we commonly experience include: design of impermeable liners for ponds located in upland areas or highly permeable soils; hydraulic analyses and design of outfalls/spillways; sedimentation management/maintenance approaches; and requirements of inoculum and water used to line and fill the pond, respectively.

Hydrologic Feasibility Assessment for Mana Plain Wetland Restoration Project, Kauai, HI
State of Hawaii Department of Land and Natural Resources, 2010-2019

Working on behalf of the Mana Plain Wetland Restoration Partnership, Mr. Kamman completed a hydrologic feasibility assessment for the Mana Plain Wetland Restoration Project proposed by the State of Hawaii Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) on the island of Kauai. The Mana Plain Wetland Restoration Project site is approximately 105 acres of low-lying abandoned sugarcane fields immediately north of the Kawaiele Waterbird Sanctuary and east of the Pacific Missile Range Facility. The purpose of the Mana Plain Wetland Restoration Project is to maximize the area of constructed wetlands within the restoration site. Palustrine emergent wetlands within the project will create habitat for four species of endangered Hawaiian waterbirds and other sensitive species, including: Hawaiian stilts; Hawaiian ducks; Hawaiian coots; Hawaiian moorhen; migratory waterfowl; and migratory shorebirds. The Mana Plain is of vital importance for the recovery of endangered waterbirds species. This restoration project will be designed to provide important breeding and feeding wetland habitats on an island where; 1) wetlands have been severely degraded, and 2) mongoose, an introduced predator, have not been established.

Mr. Kamman's work on this project included technical assessments and development of proposed restoration alternatives. Analyses completed included: a synthesis of the physical site setting (topography, geology, hydrogeology and soil); reviewing available data to characterize site meteorology, surface water drainage, water quality, and groundwater conditions; preparing a detailed water budget to describe the characteristics and processes of surface water and groundwater movement into and through the project area; evaluating project feasibility, water supply alternatives and costs; and completing a flood hazard impact assessment to evaluate potential project benefits and impacts to local area flooding. Working with the project partners, Mr. Kamman developed a preferred project alternative and supported in preparation of the project Environmental Assessment document. Mr. Kamman's firm was also retained by the State of Hawaii to develop engineering designs of the project.

MacArthur Meadow Wetland Restoration, San Francisco County, CA
Presidio Trust, 2013-2016

Mr. Kamman has been working on over a dozen independent wetland and creek restoration planning and design efforts within the Presidio of San Francisco since 2001. Most recently (2016), he developed a wetland restoration grading plan for the MacArthur Meadow Wetland Restoration Project in the central portion of the Tennessee Hollow watershed. As part of the site assessment, Greg characterized and modeled surface and groundwater interactions and identified a unique opportunity to restore 4 acres of mixed meadow, natural wetlands and creek/riparian corridor. This was possible due to the discovery of shallow groundwater conditions beneath this historically disturbed landscape. Various design components were integrated into the grading plan in order to enhance groundwater recharge and storage in the Meadow, while retarding runoff and drainage out of the wetland, including: daylighting storm drain runoff into the Meadow; reconfiguring internal channel alignments to enhance channel habitat and groundwater recharge; creation of wetland depressions to retain and recharge surface water; and removal of fill material to decrease the depth to the water table. Notable challenges of this work include restoring heavily disturbed natural resources in an urban setting while integrating designs with archeology/cultural resources, education and remediation programs.

Dragonfly Creek Restoration Project, San Francisco County, CA
Presidio Trust, 2007-2011

Mr. Kamman designed and managed hydrologic monitoring and analysis studies in support of planning and design for riparian and wetland habitat restoration along approximately 500-linear feet of the Dragonfly Creek corridor near Fort Scott of the Presidio of San Francisco. Work has included completing subsurface

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investigations including the installation of shallow wells and a sharp-crested weir with recorder to gauge creek flows. Mr. Kamman assisted in the development and selection of a preferred project alternative, considering on-site cultural resource protection, education and resource management issues (including flood control). Mr. Kamman prepared permit applications. Major components of the project included removal of significant fill and building foundations and installation of a new creek road crossing that will maintain the historical alignment, function and architectural character of a culturally significant roadway. Mr. Kamman oversaw development of PS&E for this project, which will create mitigation wetlands for a highway earthquake retrofit project that passes through the Park.

This project illustrates Mr. Kamman's ability to complete a broad variety of hydrologic analyses, including: surface water and groundwater hydrologic monitoring to characterize and quantify existing hydrologic conditions; rainfall-runoff modeling; hydraulic modeling of flood and scour conditions (including road crossing); preservation of existing wetland habitat and vegetation communities; integration with other Presidio Trust programs; and contracting flexibility to assist in conceptual planning and environmental compliance without increasing project design costs.

Mori Point Sensitive Species Habitat Enhancement Project, San Mateo County, CA
Golden Gate National Recreation Area and Golden Gate National Parks Conservancy, 2005-2011

Mr. Kamman provided hydrologic analyses, sighting and engineering design (PS&E) for three California red-legged frog breading ponds within the 105-acre Mori Point area. These efforts were completed in association and collaboration with a larger Coastal Trail improvement and ecosystem restoration effort. Quarrying and off-road vehicle use have left this site heavily scarred. The focus of restoration work was to protect the endangered San Francisco garter snake and the threatened red-legged frog. Most of this work will be focused on invasive species removal and enhancing endangered species habitat. As part of species habitat improvement, Mr. Kamman worked with project ecologists to design the ponds to optimize breeding habitat for California red-legged frog.

Work started with an initial site reconnaissance and study of watershed conditions and identification of potential sites. The reconnaissance was followed by a surface water hydrologic sufficiency analysis using available meteorological and stream flow information and installation and monitoring of shallow piezometers to quantify the proximity and seasonal variability in depth to water table. An important variable sought during pond sighting was the presence of migration corridors between known breeding areas and/or perennial water sources. Based on in-depth research and post-project monitoring for other ponds they created in the San Francisco Bay area, Mr. Kamman refined site-specific evapotranspiration estimates. Accurate evapotranspiration rates are necessary if ponds are intended to periodically dry-down as a means to preclude undesired species such as bullfrog or mosquito fish.

Other design challenges experienced included: design of impermeable liners for ponds located in upland areas or highly permeable soils; hydraulic analysis and design of outfalls/spillways; sedimentation management/maintenance approaches; and requirements of inoculum and water used to line and fill the pond, respectively. Mr. Kamman has designed numerous ponds for the NPS and affiliates within the Bay Area, including Mori Point (constructed 2007), Banducci (constructed 2007) and Giacomini (Phase I and Phase II constructed in 2007 and 2008) project sites.

Hydrologic Assessment and Restoration Feasibility Study for Shadow Cliffs Regional Recreation Area, Alameda County, CA
East Bay Regional Park District, 2009-2010

Mr. Kamman developed and implemented an assessment to identify groundwater levels and supplemental water supplies that will sustain seasonal wetland restoration areas and riparian habitats under an altered future hydrologic regime. This work will inform a forthcoming Land Use Plan Amendment for park occupying a series of former gravel quarry pits. Work included: obtaining and synthesizing available surface water and groundwater data to characterize existing hydrologic and water supply conditions and seasonal variability; quantifying the likely changes in groundwater conditions and quarry pit lake levels in association with changes in regional water transmission and groundwater recharge operations; and identifying, developing and evaluating a suite of ecosystem restoration alternatives. Other important project objectives include: improving habitat for waterfowl and wildlife; broadening recreational use; enhancing visitor education and wildlife interpretation; improve park aesthetics. Mr. Kamman evaluated a preferred park and ecosystem enhancement alternative that involves diverting high winter flows from an adjacent arroyo. This project demonstrates Greg's ability to characterize hydrologic conditions and quantify the relationship between groundwater, surface water and wetland habitat conditions, both under existing conditions and in predicting future hydrologic and ecologic conditions under an altered hydrologic regime (i.e., lower groundwater table).

Laguna Salada Marsh and Horse Stable Pond Restoration Project, San Mateo County, CA
Tetra Tech, 2007-2009

Mr. Kamman provided technical hydrology and hydraulics support to the planning and conceptual restoration design of Laguna Salada marsh and Horse Stable Pond, located adjacent to Sharp Park Golf Course in the town of Pacifica, California. The primary objectives of the project are: to reduce flood impacts within the project vicinity; improve sustainable ecological habitat for the endangered San Francisco garter snake and the threatened California red-legged frog; better understand and characterize the hydrologic and water quality conditions/processes affecting flood and ecological habitat conditions within the project vicinity; provide an effective pumping operation plan to meet ecological objectives; and develop appropriate hydrologic analytical approaches and models to assist Tetra Tech and the San Francisco Recreation and Park Department in the planning and design for marsh, pond, and creek restoration. The project is also a unique opportunity to connect this resource with the California Coastal Trail, the Bay Area Ridge Trail, and the surrounding GGNRA lands.

Mr. Kamman's work included completing a comprehensive review of available hydrologic and site information and implementing selected field investigations to develop and calibrate an integrated hydrology-flood routing-pond water operations model that will quantify the volume and depth of water moving through the project system. The investigation will also further characterize shallow groundwater conditions and water quality with respect to effects on Laguna Salada and Horse Stable Pond. Analytical and numerical modeling tools are being used to better characterize existing hydrologic and water quality conditions and to assist in identifying project opportunities and constraints as well as evaluate potential restoration design components - all necessary to inform a sustainable

SELECTED EXPERIENCE *(CONTINUED)*

and successful restoration design.

Tolay Lake Restoration Feasibility Assessment, Sonoma County, CA
Sonoma County Agricultural Preservation and Open Space District, 2003

Mr. Kamman completed a detailed hydrologic feasibility analysis to evaluate a suite of potential freshwater lake and wetland restoration alternatives. Sites were evaluated under existing watershed land-use practices and under existing and forecasted water demands (in the form of existing water rights/applications). Analysis consisted of developing a detailed water budget model to simulate alternative restored lake inundation areas and depths under median and dry year conditions, as well as a 50-year historic period (1947-1997) displaying highly variable rainfall and runoff supplies. Three lake restoration alternatives were evaluated based on existing topography and likely historic lake configurations. The restoration alternatives include lakes with storage volumes equivalent to 136-, 1100-, and 2550-acre feet.

Haypress Pond Decommissioning and Riparian and Channel Restoration, Marin County, CA
Golden Gate National Recreation Area (GGNRA), 2001-2002

This project restored 170 meters of historic creek and riparian habitat through removal of Haypress Pond dam in Tennessee Valley within GGNRA. The goals of the project were to alleviate long-term maintenance needs and eliminate non-native bullfrog habitat threatening native California red-legged frog habitat in adjacent watersheds.

Working with the Park biologist, Mr. Kamman developed designs to decommission the dam and restore natural riparian and meadow habitat. This work included: characterization of existing topographic conditions; design of a channel profile through the proposed restoration project reach; preparation of a grading plan for the restoration project; and hydrologic and hydraulic analyses to evaluate the performance of the creek channel and flood plain below the former dam during a variety of flows. Challenges of this work included integrating sediment reuse into plans and construction phasing.

Damon Slough Site Seasonal Wetland Design, Alameda County, CA
Port of Oakland, 1999-2001

Working on behalf of the Port of Oakland, Mr. Kamman completed extensive surface and groundwater monitoring and data analyses to develop a detailed water budget to assist in the evaluation and design of a 7.5 acre seasonal freshwater wetland. Primary project objectives included a design that would provide shorebird/waterfowl roosting habitat, minimize impacts to existing seasonal wetland areas, and lengthen the duration of ponding through the end of April to promote use by migratory birds. In addition to developing hydrologic design criteria, responsibilities included development of grading plans to accommodate a local extension of the Bay Trail and wetland outlet works.

Water Quality Projects

Chicken Ranch Beach Soil and Groundwater Quality Investigation and Restoration Planning, Marin County, CA
Tomales Bay Watershed Council, 2007-present

Mr. Kamman is leading scientific and engineering efforts for a wetland and riparian corridor restoration project on Third Valley Creek and Chicken Ranch Beach in Inverness, California. The main project goals are to create a self-sustaining riparian and wetland system (requiring minimal operation and maintenance) and eliminate public exposure to high levels of bacteria that exist in a site drainage ditch discharging to the beach. The design will likely include establishing a blend of habitats, including: riparian stream corridor, seasonal/perennial freshwater marsh, and tidal/saltwater marsh.

Current efforts have included the development and implementation of a soil and groundwater quality investigation to delineate the source of elevated bacteria levels. This work includes: the collection and testing of depth-discrete soil samples; groundwater well installation, sampling and testing; and surface water sampling and testing; analysis of laboratory results; and reporting, including recommendations for further/expanded investigations. Mr. Kamman coordinated this time-sensitive sampling and analysis (six hour hold times) with Brulje and Race Laboratories in Santa Rosa.

Lower Miller Creek Channel Maintenance and Material Reuse Sampling Analysis Plan, Marin County, CA
Las Gallinas Valley Sanitary District, 2015

Mr. Kamman was commissioned to formulate and implement a plan for sediment removal and improved flood flow conveyance in the Lower Miller Creek channel. Accumulation of course sediment in the project reach had reduced discharge efficiencies at District outfalls. Miller Creek supports a population of federally listed Steelhead and adjacent wetland/marsh areas potentially support other state and federally listed special status species. Working with District Staff, Greg developed a suite of potential project alternatives and identified a preferred approach. Mr. Kamman completed all CEQA compliance (IS/MND), permitting and oversaw development of engineered plans and specifications.

In order to evaluate if reuse of excavated material from 2,655 feet of creek corridor in upland areas was feasible, Mr. Kamman developed and implemented a Sampling Analysis Plan (SAP) pursuant to U.S. Army Corps Guidance for Dredging Projects within the San Francisco District. Sample collection, sample handling, and analysis were performed in accordance with the SAP. Results for analytes were compared to a variety of screening criteria to determine the material's suitability for reuse in aquatic environments. A full suite of chemical and physical analyses were performed on soil samples collected from 16 locations, including: metals, PAHs, PCBs, pesticides, TOC, specific conductance, pH, sulfides, percent moisture and grain-size. Mr. Kamman managed all aspects of this effort including reporting and presentations/negotiations at multi-agency meetings through the Corps Dredge Materials Management Office (DMMO).

Lower Pitkin Marsh Hydrologic and Water Quality Monitoring, Sonoma County, CA
Sonoma Land Trust, 2008-2010

Mr. Kamman was retained to develop and implement a hydrologic and water quality monitoring program at Lower Pitkin Marsh outside of Forestville, California. The Pitkin Marsh area is one of the most valuable complexes of mixed riparian woodland and thicket, freshwater marsh, wet meadow, oak woodland and grassland in Sonoma County. The complex interaction of surface water, ground water, and scattered seeps and springs on the site creates unusual hydrologic conditions that promote a rare assemblage of plant species which includes several endemics. The primary objective of the hydrologic monitoring program was to understand the annual and season sources of both surface and ground water supplying wetlands. Hydrologic and water quality monitoring was

SELECTED EXPERIENCE *(CONTINUED)*

initiated during the winter wet season of 2008/09 and will be conducted for a 12-month period through the ensuing summer dry-down and into the following wet season. Understanding how groundwater levels, spring flow and creek flow rates recede from winter wet to summer dry conditions will provide an important understanding and quantification of the seasonal variability in water supplies feeding selected wetland types. General water quality parameters (temperature, pH, specific conductance, and ORP) are measured at all monitoring locations during each visit. Nutrients (N and P) are measured in selected surface water and groundwater samples collected during at least three monitoring events, including a winter high flow, spring high base flow and summer low baseflow.

Pescadero Lagoon Restoration and Enhancement, San Mateo County, CA
California State Coastal Conservancy, 2005-2006

Mr. Kamman was retained to support restoration and water quality enhancement planning efforts in Pescadero Lagoon. In 2005-2006, he completed a synthesis of available hydrologic and water quality information in responding to requests for development of a hydrodynamic and water quality model of the lagoon. This model was considered as a means to identify causes for repeated fish-kills in the lagoon that occurred during initial breaching of the inlet. Mr. Kamman assisted in preparing a synthesis and model development feasibility report from this effort.

Water Temperature Simulations for Trinity River Fish and Wildlife Restoration Project, Trinity County, CA
Trinity County Planning Department, 1994-2004

For over a decade, Mr. Kamman completed a number of hydrology and water quality investigations in support of alternative feasibility studies on the Trinity River Fish and Wildlife Restoration Project in direct support of the Trinity River Restoration EIR/EIS. Studies involve assessing the effects of proposed flow alternatives on water temperature within and downstream of Lewiston Reservoir. Mr. Kamman was responsible for data collection, processing, and flow/temperature modeling of Lewiston Reservoir as part of a coordinated evaluation including other Trinity River system models. Another study included evaluating how project operations could be implemented or modified to optimize Lewiston Lake release temperatures to meet downstream temperature criteria and compensate for increased warming of the river associated with side channel and feather edge restoration activities. Mr. Kamman continues to evaluate how more recent water projects (raising Shasta Dam, Sites Reservoir, and the Waterfix tunnels) consider and integrate with the Trinity Restoration Project.

Upper Eel River Unimpaired Flow and Water Temperature Assessments, Humboldt County, CA
CalTrout, 1997-1999

Mr. Kamman evaluated changes in the natural flow regime of the upper Eel River, and developed an Upper Eel River proposed release schedule to enhance downstream Chinook and Steelhead spawning and rearing habitat. This work was triggered by proposals set forth by PG&E as part of their Potter Valley Project FERC relicensing process. Work consisted of two main investigations. The first included reviewing results of a ten year PG&E study and development of multivariate regression and stream reach (SSTEMP) temperature models to assess the effects proposed flow alternatives would have on downstream temperatures. The second investigation consisted of characterizing unimpaired flow conditions and developing a daily unimpaired flow record for use in project operation models.

Selected Litigation Support Projects

Kamman, G.R., 2019, Review of Deschutes Basin Habitat Conservation Plan (DBHCP) and Associated Draft Environmental Impact Statement (DEIS). Prepared for: Water Watch of Oregon, Center for Biological Diversity and Associates for the West, November 22, 55p.

Kamman, G.R., 2019, Review of Draft PEIR, California Vegetation Treatment Program (CalVTP). Prepared for: Shute, Mihaly & Weinberger LLP, August 2, 8p.

Kamman, G.R., 2019, Oral Testimony of Greg Kamman for Agricultural Order 4.0 requirements discussion, Public meeting before the Central Coast (Region 3) California Water Board, Watsonville City Council Chambers, Watsonville, CA, March 21.

Chartrand, A.B., and Kamman, G.R., 2019, Comments to Central Coast Regional Water Quality Control Board Ag. Order 4.0 regulatory requirement options and proposed Requirement Options Tables. Prepared for: The Otter Project and Monterey Coastkeeper, January 22, (8p.), 5 tables and Monitoring Reporting Plan (MRP; 26p.).

Kamman, G.R., 2019, Review of Draft Environmental Impact Report/Statement, Sites Reservoir Project. Prepared for: Pacific Coast Federation of Fisherman's Association (PCFFA) and Save California Salmon, January 21, 45p.

Kamman, G.R., 2018, Review of Amendments to the Sonoma County Cannabis Ordinance, California. Prepared for: Shute, Mihaly & Weinberger LLP, August 3, 10p.

Kamman, G.R., 2018, Written Testimony of Greg Kamman for Part 2 of the California Waterfix Change of Diversion Hearing before the State Water Resources Control Board, November 28, 10p.

Kamman, G.R., 2018, Oral Testimony of Greg Kamman for Part 2 of the California Waterfix Change of Diversion Hearing before the State Water Resources Control Board at Joe Serna Jr.-CalEPA Building, Sacramento, CA, April 16.

Kamman, G.R., 2017, Review Comments: PAD and SD1, FERC Relicensing of Potter Valley Project (PVP). Professional declaration prepared for: Friends of Eel River, July 31, 8p.

Kamman, G.R., 2017, Review Comments, Draft Environmental Impact Report, Fish Habitat Flow and Water Rights Project. Professional declaration prepared for: Friends of Eel River, March 8, 18p.

Kamman, G.R., 2016, Review of Draft General Waste Discharge Requirements for Vineyard Dischargers in the Napa River and Sonoma Creek Watersheds. Prepared for: Law Offices of Thomas N. Lippe APC, December 12, 4p.

Kamman, G.R., 2016, Review of Middle Green Valley Specific Plan Project, Second Revised Recirculated Draft Environmental Impact Report, Solano County, CA, Sch# 2009062048. Professional Declaration Prepared for: Law Offices of Amber Kemble, October 25, 3p.

SELECTED EXPERIENCE *(CONTINUED)*

Kamman, G.R., 2016, Review of Draft EIR for General Waste Discharge Requirements for Vineyard Dischargers in the Napa River and Sonoma Creek Watersheds. Prepared for: Law Offices of Thomas N. Lippe APC, September 14, 81p.

Kamman, G.R., 2016, Second Declaration of Greg Kamman Plaintiff's Joint Motion for Preliminary Injunction, Prepared for Center for Biological Diversity (Plaintiff) v. U.S. Bureau of Reclamation, Case No. 6:16-cv-00035-TC (Recovery for Oregon Spotted Frog, Upper Deschutes Basin, Oregon) , March 11, 11p.

Kamman, G.R., 2016, Declaration of Greg Kamman Plaintiff's Joint Motion for Preliminary Injunction, Prepared for Center for Biological Diversity (Plaintiff) v. U.S. Bureau of Reclamation, Case No. 6:16-cv-00035-TC (Recovery for Oregon Spotted Frog, Upper Deschutes Basin, Oregon) , February 4, 8p.

Kamman, G.R., 2015, Sharp Park Project Impacts to Laguna Salada. Prepared for National Parks Conservation Association and Wild Equity Institute, April 14, 1p.

Kamman, G.R., 2014, Review of Middle Green Valley Specific Plan Project, Revised Recirculated Draft Environmental Impact Report, Solano County, CA, Sch# 2009062048. Professional Declaration Prepared for: Law Offices of Amber Kemble, August 11, 11p.

Kamman, G.R., 2012, Deposition of Gregory Richard Kamman, R.G., C.H.G., Schaefer vs. City of Larkspur, CA, Superior Court of the State on California, County of Marin. August 23, 2012.

Kamman, G.R., 2012, Technical review comments to Biological Assessment, Sharp Park Safety, Infrastructure Improvement and Habitat Enhancement Project. Prepared for Wild Equity Institute, August 3, 11p.

Kamman, G.R., 2012, Proposed Hardy-based Environmental Water Allocation (EWA) Input for WRIMS Model Simulation, Klamath River Basin. Prepared for: Yurok Tribe, July 20, 5p.

Kamman, G.R., 2012, Review of groundwater conditions and modeling report by S.S. Papadopulos & Associates, Inc., Scott Valley, California. Prepared for: Yurok Tribe, 4p.

Kamman, G.R., 2011, Supplemental Declaration of Greg Kamman regarding Laguna Salada, Wild Equity Institute v. City and County of San Francisco, et al., Case No.: 3:11-CV-00958 SI, United States District Court, Northern District of California, San Francisco Division. Prepared for Wild Equity Institute, November 4, 50p.

Kamman, G.R., 2011, Declaration of Greg Kamman regarding Laguna Salada, Wild Equity Institute v. City and County of San Francisco, et al., Case No.: 3:11-CV-00958 SI, United States District Court, Northern District of California, San Francisco Division. Prepared for Wild Equity Institute, September 23, 7p.

Kamman, G.R., 2010, Review of Sonoma County Water Agency NOP (issued 9/29/10) Fish Habitat Flow and Water Rights Project. Professional declaration prepared for: Friends of Eel River, November 8, 7p.

Kamman, G.R., 2007, Independent Model Review for Klamath Settlement Negotiations, Klamath Independent Review Project (KIRP). Prepared for Northcoast Environmental Center, November 9, 19p.

Kamman, G.R., 2007, Review of Negative Declaration for File No. UPE04-0040, Gualala Instream Flow. Professional declaration prepared for Friends of the Gualala River, October 21, 2p.

Kamman, G.R., 2003, Evaluation of potential hydrologic effects, Negative Declaration for THP/Vineyard Conversion, No. 1-01-171 SON, Artesa Vineyards, Annapolis, CA. Professional declaration prepared for Friends of the Gualala River, May 19, 9p.

Kamman, G.R., 1999, Review of Final Supplemental Environmental Assessment, Cirby-Linda-Dry Creek Flood Control Project. Professional declaration prepared for: Monty Hornbeck, Sunrise Office Park Owners Association; Bill Kopper/John Gabrielli, Attorneys at Law; and Sharon Cavello/Cathie Tritel, Placer Group Sierra Club, May 24, 10p.

Kamman, G.R., 1995, Variable Water Resources Available in the Area of Salinas, California. Declaration prepared for Price, Postal, and Parma, Santa Barbara, California, May, 6p.

Conference Presentations

Kamman, G.R., 2018, Water is Life! A hydrologist's eye on the Gualala River. Presented to: Friends of the Gualala River and public, Gualala Arts Center, Gualala, CA, May 3.

Kamman, G.R. and Kamman, R.Z., 2015, Landscape Scale Urban Creek Restoration in Marin County, CA - Urban Creek Restoration: Interfacing with the Community. 33rd Annual Salmonid Restoration Conference, March 11-14, Santa Rosa, CA.

Kamman, G.R., 2015, Enhancing Channel and Floodplain Connectivity: Improving Salmonid Winter Habitat on Lagunitas Creek, Marin County, CA - Beyond the Thin Blue Line: Floodplain Processes, Habitat, and Importance to Salmonids. 33rd Annual Salmonid Restoration Conference, March 11-14, Santa Rosa, CA.

Kamman, G.R., 2012, The role of physical sciences in restoring ecosystems. November 7, Marin Science Seminar, San Rafael, CA.

King, N. and Kamman, G.R., 2012, Preferred Alternative for the Chicken Ranch Beach/Third Valley Creek Restoration Project. State of the Bay Conference 2012, Building Local Collaboration & Stewardship of the Tomales Bay Watershed. October 26, Presented by: Tomales Bay Watershed Council, Inverness Yacht Club, Inverness, CA.

King, N. and Kamman, G.R., 2010, Chicken Ranch Beach Restoration Planning by TBWC. State of the Bay Conference 2010, A Conference about Tomales Bay ant its Watershed. October 23, Presented by: Tomales Bay Watershed Council, Inverness Yacht Club, Inverness, CA.

SELECTED EXPERIENCE *(CONTINUED)*

Higgins, S. and Kamman, G.R., 2009, Historical changes in Creek, Capay Valley, CA. Poster presented at American Geophysical Union Fall Meeting 2009, Presentation No. EP21B-0602, December.

Kamman, G.R. and Higgins, S., 2009, Use of water-salinity budget models to estimate groundwater fluxes and assess future ecological conditions in hydrologically altered coastal lagoons. Coastal and Estuarine Research Federation 20th Biennial Conference, 1-5 November, Portland, OR

Bowen, M., Kamman, G.R., Kaye, R. and Keegan, T., 2007, Gualala River Estuary assessment and enhancement plan. Estuarine Research Federation, California Estuarine Research Society (CAERS) 2007 Annual Meeting, 18-20 March, Bodega Marine Lab (UC Davis), Bodega Bay, CA

Bowen, M. and Kamman, G.R., M., 2007, Salt River Estuary enhancement: enhancing the Eel River Estuary by restoring habitat and hydraulic connectivity to the Salt River. Salmonid Restoration Federation's 25th Salmonid Restoration Conference, 7-10 March, Santa Rosa, CA.

Magier, S., Baily, H., Kamman, G., and Pfeifer, D, 2005, Evaluation of ecological and hydrological conditions in the Santa Clara River Estuary with respect to discharge of treated effluent. In: Abstracts with Programs, The Society of Environmental Toxicology and Chemistry North America 26th Annual Meeting, 13-17 November, Baltimore Convention Center, Baltimore, Maryland.

Baily, H., Magier, S., Kamman, G., and Pfeifer, D, 2005, Evaluation of impacts and benefits associated with discharge of treated effluent to the Santa Clara River Estuary. In: Abstracts with Programs, The Society of Environmental Toxicology and Chemistry North America 26th Annual Meeting, 13-17 November, Baltimore Convention Center, Baltimore, Maryland.

Kamman, G.R., Kamman, R.Z., and Parsons, L., 2005, Hydrologic and Hydraulic Feasibility Assessments for Ecological Restoration: The Giacomini Wetland Restoration Project, Point Reyes National Seashore, CA. In: Abstracts with Programs, The Geological Society of America, 101st Annual Cordilleran Section Meeting, Vol.37, No. 4, p. 104, Fairmont Hotel, April 29-May1, 2005, San Jose, CA.

Kamman, G.R., 2001. Modeling and its Role in the Klamath Basin – Lewiston Reservoir Modeling. Klamath Basin Fish & Water Management Symposium, Humboldt State University, Arcata, CA, May 22-25.

Kamman, G.R., 1998, Surface and ground water hydrology of the Salmon Creek watershed, Sonoma County, CA. Salmon Creek Watershed Day, May 30, Occidental, CA.

Kamman, G.R., 1998. The Use of Temperature Models in the Evaluation and Refinement of Proposed Trinity River Restoration Act Flow Alternatives. ASCE Wetlands Engineering and River Restoration Conference Proceedings, Denver, Colorado (March 22-23, 1998).

Hecht, B., and Kamman, G.R., 1997, Historical Changes in Seasonal Flows of the Klamath River Affecting Anadromous Fish Habitat. In: Abstracts with Programs Klamath Basin Restoration and Management Conference, March 1997, Yreka, California.

Hanson, K.L, Coppersmith, K.J., Angell, M., Crampton, T.A., Wood, T.F., Kamman, G., Badwan, F., Peregoy, W., and McVicar,T., 1995, Evaluation of the capability of inferred faults in the vicinity of Building 371, Rocky Flats Environmental Technology Site, Colorado, in Proceedings of the 5th DOE Phenomena Hazards Mitigation Conference, p. 185-194, 1995.

Kamman, G.R. and Mertz, K.A., 1989, Clay Diagenesis of the Monterey Formation: Point Arena and Salinas Basins, California. In: Abstracts with Programs, The Geological Society of America, 85th Annual Cordilleran Section Meeting, Spokane Convention Center, May 1989, Spokane, Washington, pp.99-100.

Exhibit M

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Widening Highways Doesn't Fix Traffic. So Why Do We Keep Doing It?

With billions of dollars available to improve transportation infrastructure, states have a chance to try new strategies for addressing congestion. But some habits are hard to break.

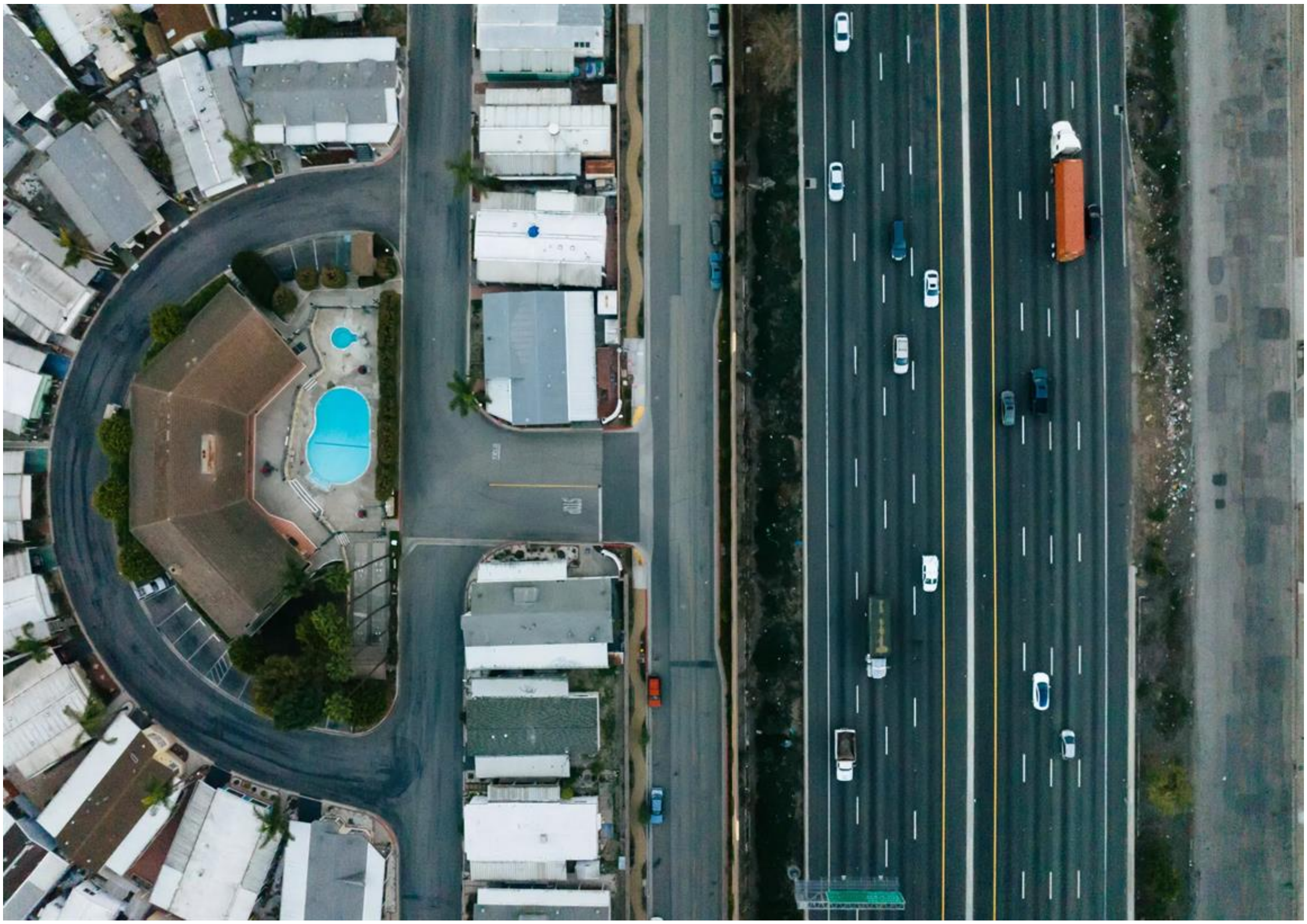
By Eden Weingart **Photographs and Video by Alyssa Schukar**
Jan. 6, 2023

Interstate 710 in Los Angeles is, like the city itself, famous for its traffic. Freight trucks traveling between the city and the port of Long Beach, along with commuters, clog the highway. The trucks idle in the congestion, contributing to poor air quality in surrounding neighborhoods that are home to over one million people.

The proposed solution was the same one transportation officials across the country have used since the 1960s: Widen the highway. But while adding lanes can ease congestion initially, it can also encourage people to drive more. A few years after a highway is widened, research shows, traffic — and the greenhouse gas emissions that come along with it — often returns.

California's Department of Transportation was, like many state transportation departments, established to build highways. Every year, states spend billions of dollars expanding highways while other solutions to congestion, like public transit and pedestrian projects, are usually handled by city transit authorities and receive less funding.

Over the next five years, states will receive $350 billion in federal dollars for highways through the infrastructure law enacted last year. While some have signaled a change in their approach to transportation spending — including following federal guidelines that encourage a "fix it first" approach before adding new highway miles — many still are pursuing multibillion dollar widening projects, including in Democratic-led states with ambitious climate goals.



Traffic on I-710 passing by the Thunderbird Villa Mobile Home Park in South Gate, Calif.

The Biden administration has suggested that states should be more thoughtful in their solutions to congestion. Sometimes widening is necessary, Transportation Secretary Pete Buttigieg said, but other options for addressing traffic, like fixing existing roads or providing transit options, should be considered. "Connecting people more efficiently and affordably to where they need to go," he said, "is a lot more complicated than just always having more concrete and asphalt out there."

Some communities and government officials are pushing back on widening plans. In Los Angeles, this opposition had an impact. After $60 million was spent on design and planning over two decades, the Route 710 expansion was canceled last May.

“We don’t see widening as a strategy for L.A.,” said James de la Loza, chief planning officer for Los Angeles County’s transportation agency.

It remains to be seen if the cancellation is the start of a trend or an outlier. Widening projects are still in the works for highways in Texas, Oregon and Maryland, to name a few. New York City is even considering re-widening the traffic-choked Brooklyn Queens Expressway.

Morning traffic passing through Compton on the I-710 in Los Angeles.

LOS ANGELES

A Change in Approach to Congestion

The cancellation of the Route 710 expansion came after California learned the hard way about the principle of “induced demand.”

In 2015, a $1 billion project to widen a 10-mile stretch of Interstate 405 through Los Angeles was completed. For a period, “congestion was relieved,” said Tony Tavares, the director of Caltrans, California’s Department of Transportation.

But that relief did not last. Rush hour traffic soon rebounded, he said.

When a congested road is widened, travel times go down — at first. But then people change their behaviors. After hearing a highway is less busy, commuters might switch from transit to driving or change the route they take to work. Some may even choose to move farther away.

Traffic on I-710 in Long Beach, Calif., as Saturday morning soccer games were underway in Coolidge Park.

Isaac Morales, 18, used a sound barrier wall running along I-710 to practice soccer at Coolidge Park.

"It's a pretty basic economic principle that if you reduce the price of a good then people will consume more of it," Susan Handy, a professor of environmental science and policy at the University of California, Davis, said. "That's essentially what we're doing when we expand freeways."

The concept of induced traffic has been around since the 1960s, but in a 2009 study, researchers confirmed what transportation experts had observed for years: In a metropolitan area, when road capacity increases by 1 percent, the number of cars on the road after a few years also increases by 1 percent.

For years, critics of the Route 710 plan had voiced concerns that the widened highway would lead to more greenhouse gas emissions and the bulldozing of the communities around it.

Los Angeles I-710 Corridor

The 2018 proposal for this segment of Route 710 would have widened the roadway to four lanes in either direction, added two truck bypass lanes in either direction and widened the road shoulders.

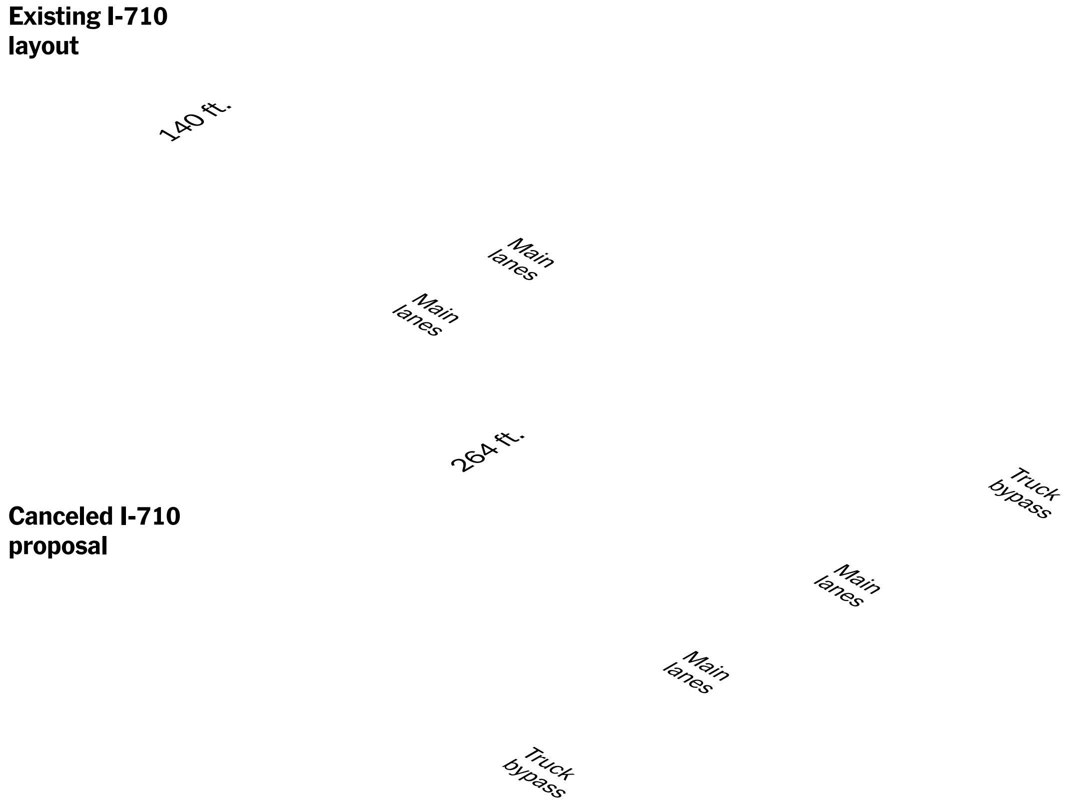


Diagram shows a segment of I-710 between Willow Street and I-405. Width of lanes and shoulder areas are based on guidance from a Metro official. • Source: Metro, the transportation agency for Los Angeles County • The New York Times

In late 2020, the E.P.A. ruled that the widening plan violated the federal Clean Air Act, and officials paused the project. Then last spring, Caltrans canceled the project altogether. Mr. Tavares said it was "probably the most significant" cancellation in the agency's history.

Caltrans is considering alternatives to address traffic on the Interstate, including moving freight to a rail line.

"Caltrans in the past was very focused on dealing with congestion primarily," Mr. Tavares said. "We have since pivoted, completely done a 180."

State transportation agencies said they have shifted their focus to providing people with options other than driving and were planning to divert money to projects that would benefit communities surrounding Route 710. Options include improving air filtration in schools, providing better access to green spaces and investing in a zero-emissions truck program.

Yet there are still plans to widen other highways in the state. "One size does not fit all for transportation, and California is definitely not one size," Mr. Tavares said.

Morning rush hour on the New Jersey Turnpike and highway 139 near Jersey City.

JERSEY CITY, N.J.

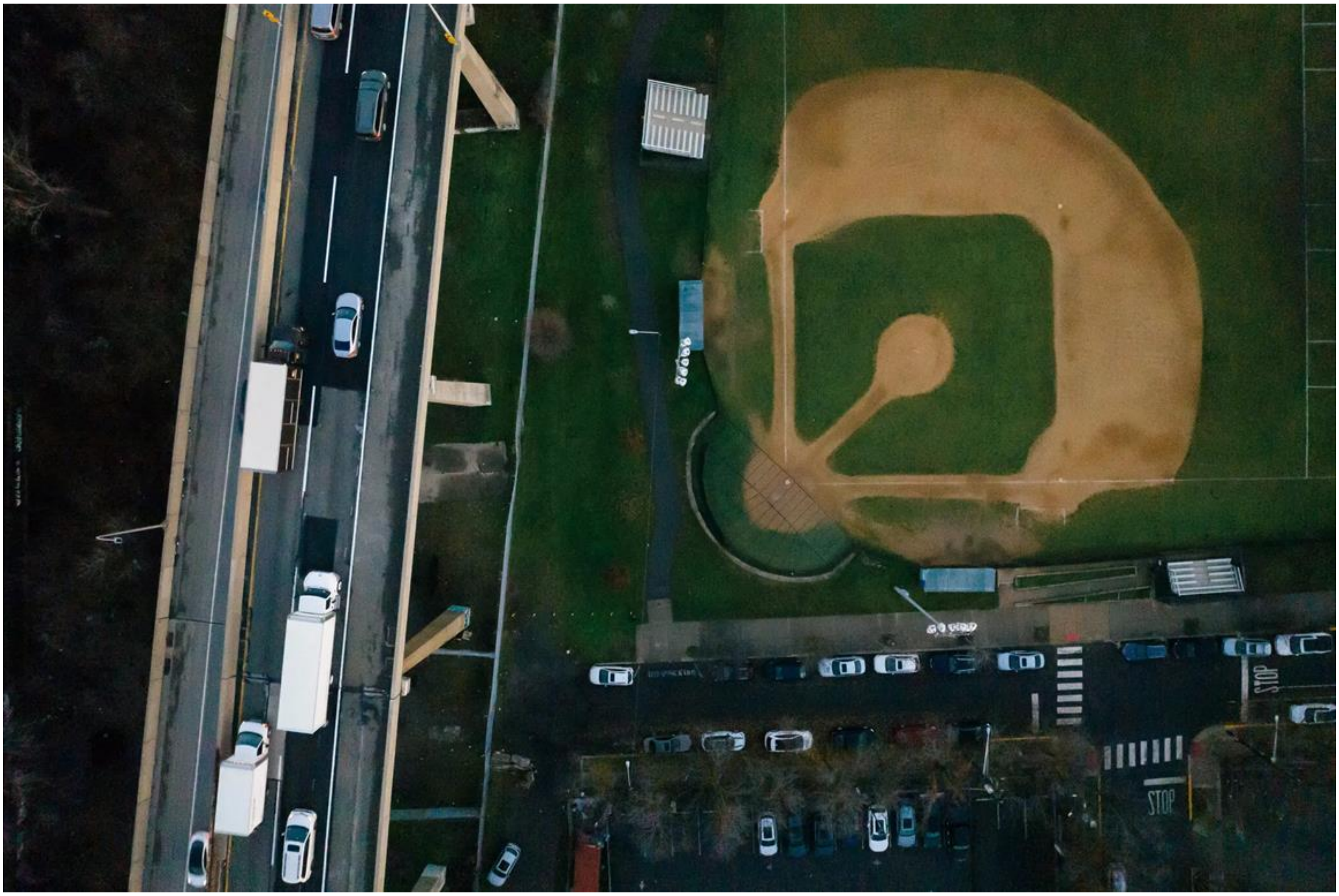
Air Quality vs. the Economy

On an unseasonably warm day last November, dozens of northern New Jersey residents gathered in the shadow of a highway overpass in Jersey City, just across the Hudson River from New York. In a densely populated state with expansive transit infrastructure, many in attendance wondered why officials were planning to widen the highway.

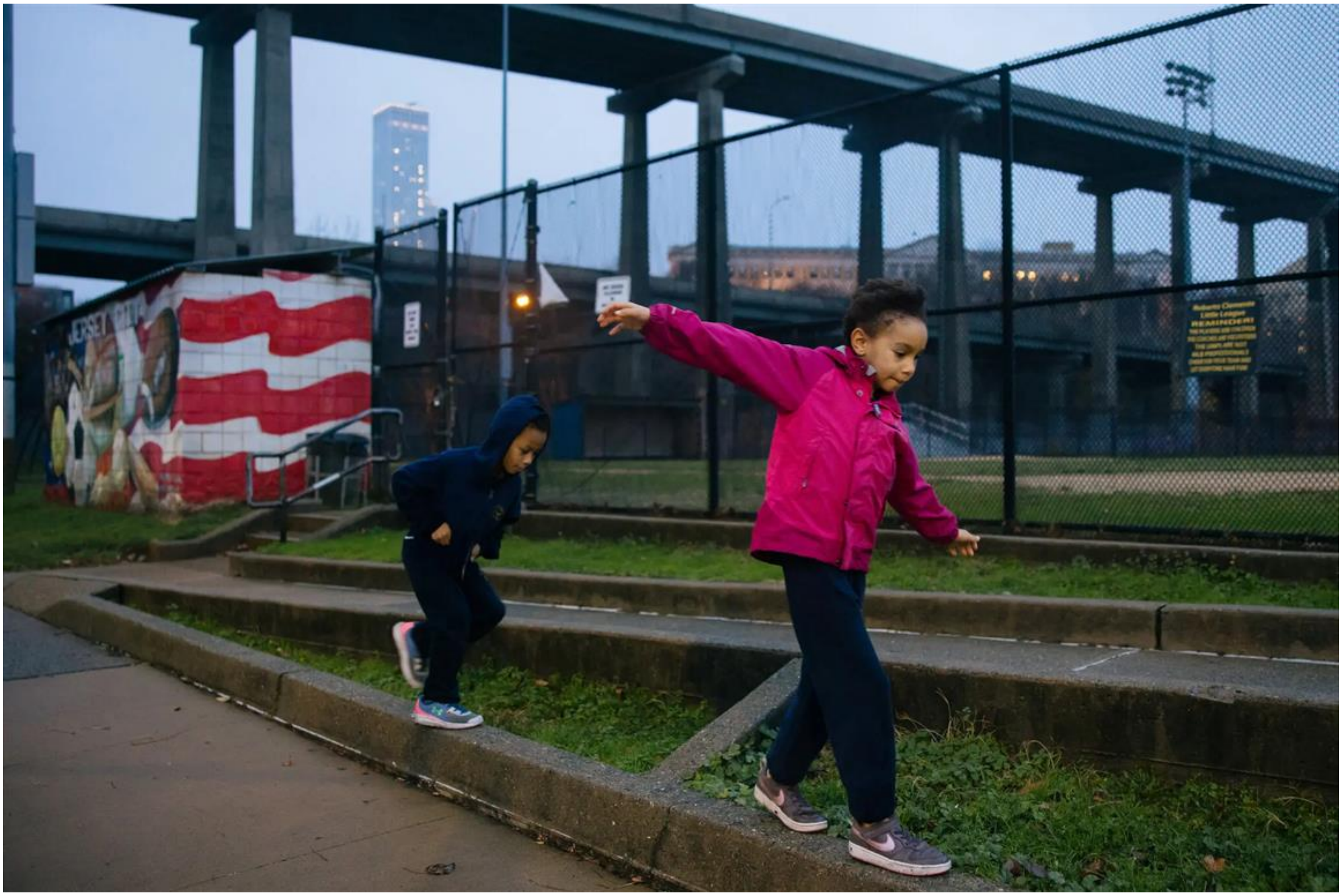
“If we want to be a leading state, look at what Colorado is doing in ending their highway expansions. Look at Los Angeles,” Jimmy Lee, president of Safe Streets JC, said.

New Jersey transportation officials plan to reconstruct and add up to four lanes to sections of the New Jersey Turnpike leading to the Holland Tunnel. In addition to carrying traffic into Manhattan, the turnpike is, like Route 710 in Los Angeles, an artery heavily trafficked by freight trucks carrying goods between ports and warehouses in the area.

The project, which will cost an estimated $10.7 billion, includes rebuilding elevated roadways and the bridge over Newark Bay on the 66-year-old highway.



Traffic on the New Jersey Turnpike by Enos Jones Park in Jersey City.



Alexandra Charles, 7, and her brother Jonathan, 5, played at Enos Jones Park alongside the turnpike.

Diane Gutierrez-Scaccetti, commissioner of New Jersey’s transportation department, said the project was long overdue. A flurry of new residential buildings and commercial warehouses in the area has crowded the highway with more vehicles. The expansion is needed, she said, to make the highway safer and ensure the ports, critical pieces of New Jersey’s economy, remain viable.

“Congestion is not safe,” Ms. Gutierrez-Scaccetti said. “I don’t advocate widening roads just for the sake of widening.”

The project has the support of New Jersey’s governor, Philip D. Murphy, a Democrat who set ambitious climate goals for the state, and local labor leaders. Mark Longo, director of an organization representing heavy equipment operators, said the expansion is “the single most important road project for the economic future of New Jersey.”

New Jersey Turnpike Extension

The proposed expansion would add two lanes in either direction on the bridge over Newark Bay, one lane in either direction on segments in Bayonne and Jersey City and widen the road shoulders. The last segment leading up to the Holland Tunnel would remain at two lanes in each direction but be widened to add shoulders.

Existing New Jersey Turnpike layout

84 ft.

Main lanes

Proposed New Jersey Turnpike layout

116 ft.

Main lanes

Main lanes

Diagram shows a segment of the New Jersey Turnpike between exits 14A and 14C. Width of lanes and shoulder areas are based on guidance from a New Jersey Turnpike Authority official. • The New York Times

Critics of the plan say the congestion can be addressed in other ways, including investing in public transit. Officials in Hoboken and Jersey City, which surround the highway and have some of the worst air quality in the country, have denounced the plan.

“There are other types of mobility that people value instead of just cars,” Jersey City Mayor Steven Fulop said.

The expansion of the Katy Freeway in Houston was initially hailed as a success. But within five years, peak hour travel times were longer than before the expansion. Alyssa Schukar for The New York Times

HOUSTON

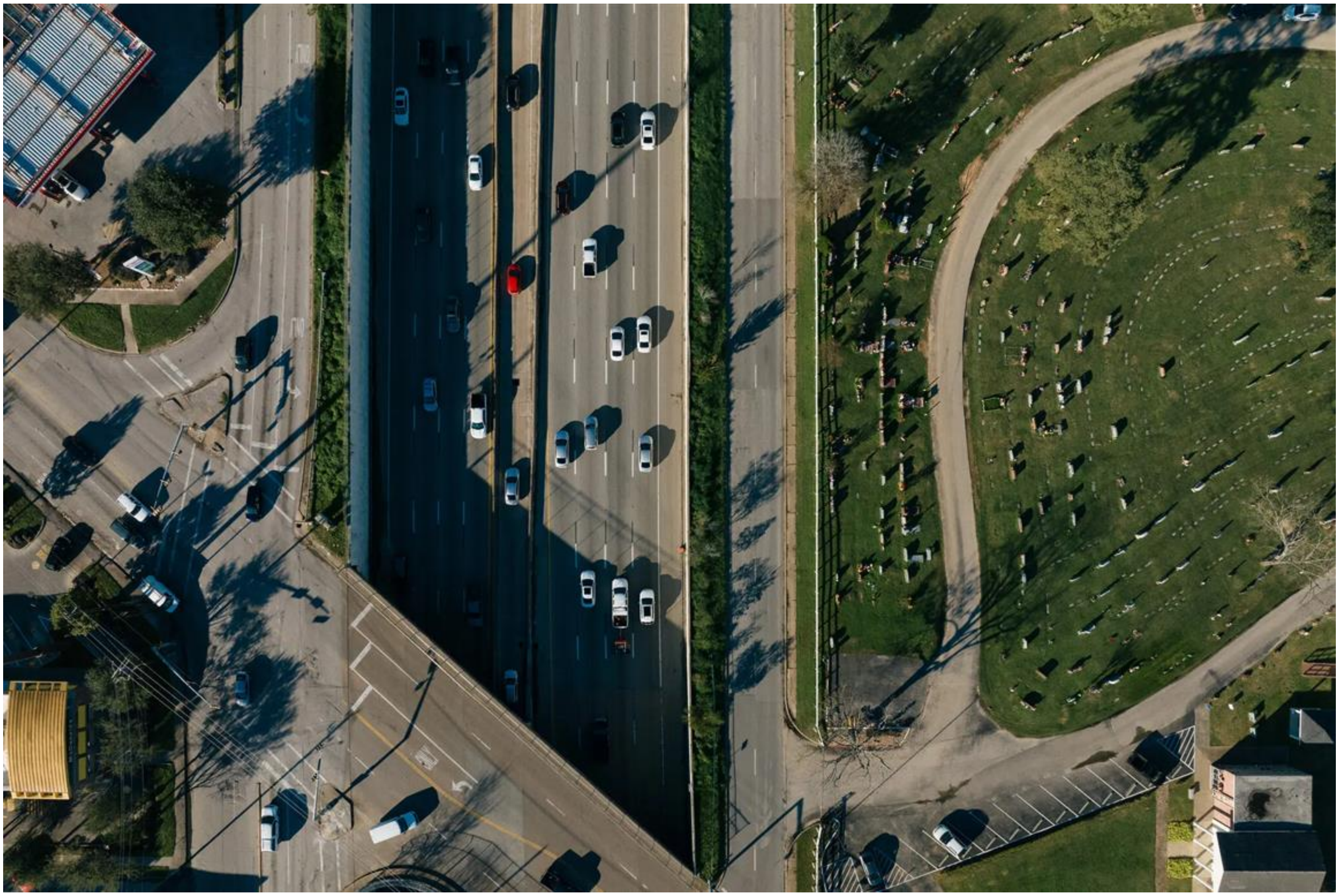
A Commitment to Expansion

For critics of widening projects, the prime example of induced demand is the Katy Freeway in Houston, one of the widest highways in the world with 26 lanes.

Immediately after Katy's last expansion, in 2008, the project was hailed as a success. But within five years, peak hour travel times on the freeway were longer than before the expansion.

Matt Turner, an economics professor at Brown University and co-author of the 2009 study on congestion, said adding lanes is a fine solution if the goal is to get more cars on the road. But most highway expansion projects, including those in progress in Texas, cite reducing traffic as a primary goal.

"If you keep adding lanes because you want to reduce traffic congestion, you have to be really determined not to learn from history," Dr. Turner said.



Cars on the I-45 in Houston passing the Historic Hollywood Cemetery.

Daleyza Almendarez, 3, and her father, Juan Serna, visited the grave of an uncle and aunt at the cemetery.

Officials from the Texas Department of Transportation said the Katy expansion provided the capacity needed to keep up with projected population growth in the Houston area.

“Expanding roads does not create more congestion,” transportation officials said in a statement. Rather, they said, it “helps to manage new travel demand.”

The Texas Constitution mandates that the majority of transportation funds go to improving the highway system. Over the next year, the state plans to spend about 86 percent of its budget on highway projects.

One of those is a $9 billion plan to reconstruct and widen a section of Interstate 45, which crosses paths with the Katy Freeway. Transportation officials said the project would improve safety, reduce congestion and address flooding along the roadway.

Houston I-45

The project runs from suburban Greenspoint to downtown Houston. The proposed design for this segment would replace the H.O.V. lane with two managed lanes in each direction, add a lane to the frontage roads in each direction and widen the road shoulders.

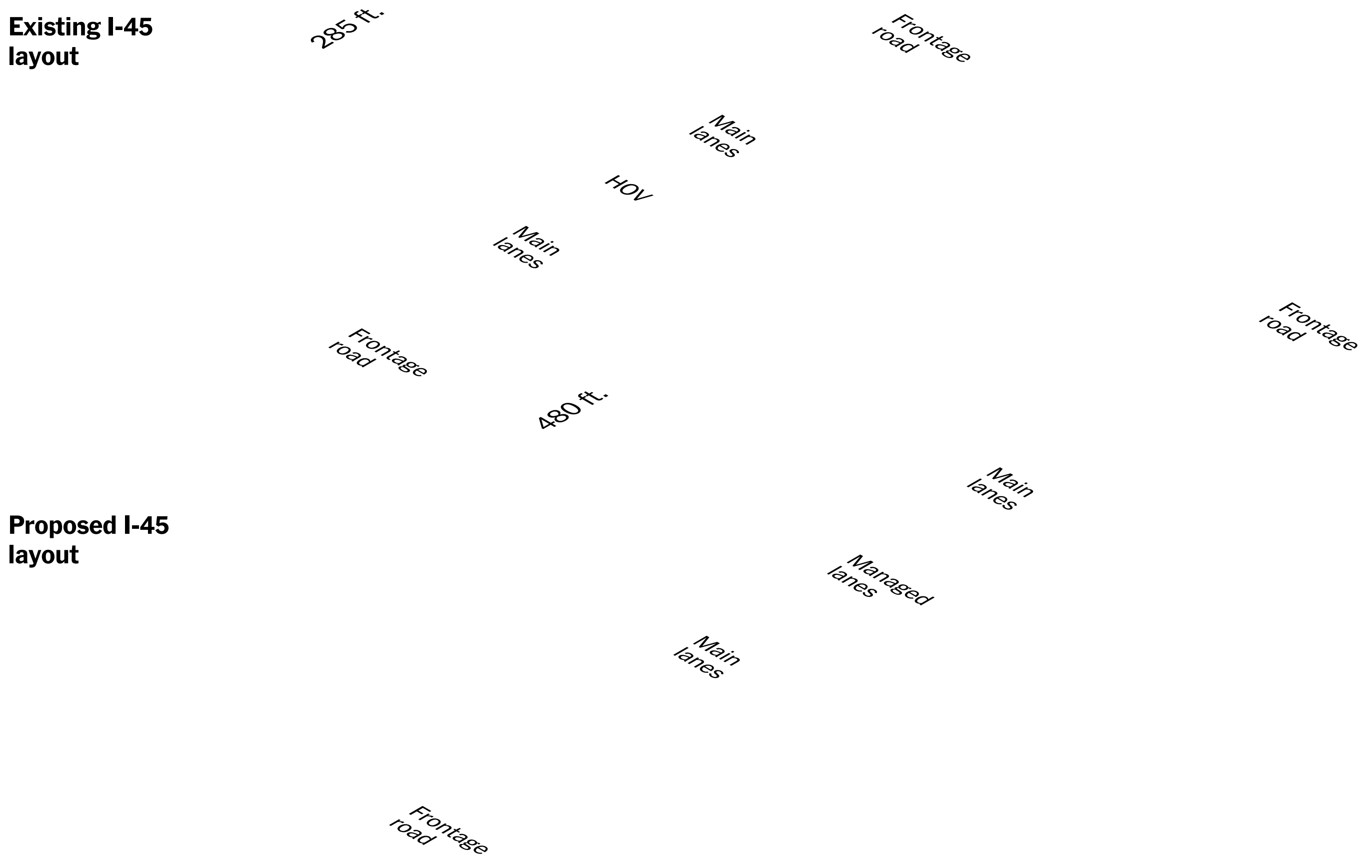


Diagram shows a segment of I-45 from West Road to Aldine Bender Road. Width of lanes and shoulder areas are based on diagrams from the Texas Department of Transportation. • Source: Texas Department of Transportation • The New York Times

The plan for Route 45, Dr. Handy said, is another project being sold as congestion reduction. “But what’s especially troubling about that project is the destruction to the neighborhood that it will cause.”

The Texas transportation department estimates more than 1,000 people and 300 businesses in the surrounding neighborhoods, where most residents are Black and Hispanic, would be displaced by the expansion.

At the same time, officials at Houston’s public transportation agency are pulling together funding from bonds and federal grants for an additional way to address congestion and growth: 500 miles of improvements to public transit.

Additional production by Stephen Reiss.

Exhibit N

EAST SAN GABRIEL VALLEY
Mobility Action Plan

EAST SAN GABRIEL VALLEY
MOBILITY ACTION PLAN

DRAFT PLAN

Prepared for **County of Los Angeles Department of Regional Planning**
by **IBI Group**, with **Evan Brooks Associates** and **HereLA**
May 26, 2022

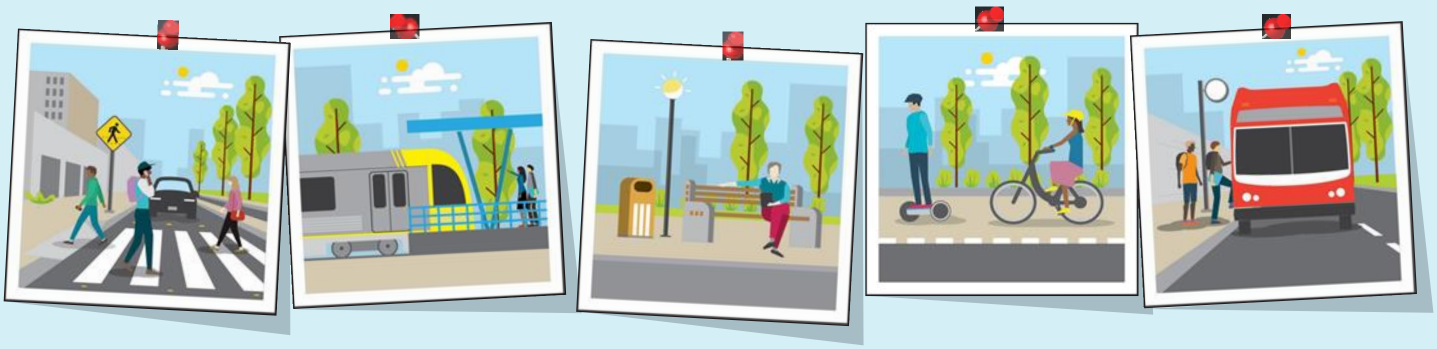
SCAG
INNOVATING FOR A BETTER TOMORROW

CONTENTS

1

EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY



Plan Overview

The purpose of the East San Gabriel Valley (ESGV) Mobility Action Plan (MAP) is to identify ideas and projects to make it easier and safer to walk, bike, and use transit in and between the 24 unincorporated communities located in the East San Gabriel Valley. These communities are:

Avocado Heights	North Claremont	South San Jose Hills
Charter Oak	Northeast La Verne	South Walnut
Covina Islands	Northeast San Dimas	Unincorporated South El Monte
East Azusa	North Pomona	Valinda
East Irwindale	North Whittier	West Claremont
East San Dimas	Pellissier Village	Walnut Islands
Glendora Islands	Rowland Heights	West Puente Valley
Hacienda Heights	South Diamond Bar	West San Dimas

The County of Los Angeles recognizes that its residents face challenges related to equity, systemic racism, climate change, disparate access to opportunity, and the impacts of traffic congestion and emissions from transportation sources. By acknowledging these challenges and the people they impact, the MAP outlines strategies to improve mobility in a sustainable, equitable, and achievable way.

Mobility Indicators

Mobility needs vary for different groups of people. Demographic indicators can provide insight regarding not only who lives in the study area, but also their mobility needs and propensity to use certain modes of travel. Some key demographic mobility indicators in the ESGV include:

- **Senior Populations** - Senior residents make up as much as 60 percent of the total population in areas between Pomona and Walnut, beside the SR-57, and east of La Verne along Foothill Boulevard.
- **Youth Population** – Youth make up about a quarter of the population in some of the easternmost communities of the ESGV including Unincorporated South El Monte, West Puente Valley, Hacienda Heights, Valinda, and Covina Islands, as well as Northeast La Verne, North Claremont, and North Pomona.
- **People of Color** - Areas with the highest concentrations (around 75 percent or higher up to 97 percent) of non-white population include the areas in and around the unincorporated communities of Rowland Heights and Hacienda Heights, and the cities of Walnut, West Covina, Baldwin Park, and Diamond Bar.
- **Low-Income Households** - Areas with particularly high percentages (over 50 percent) of low-income households include the areas around the unincorporated communities of Walnut Islands and Rowland Heights, as well as the cities of Pomona, Baldwin Park, La Puente, and Azusa.
- **Education Attainment** - Broadly, the areas with the highest percentage of Bachelor's degree attainment include the communities in and around the cities of Glendora, La Verne, Claremont, Walnut, and Diamond Bar, as well as the unincorporated communities of Rowland Heights and Hacienda Heights.
- **Zero-car Households** - As many as about 40 percent of all households do not own a vehicle in some areas in the East San Gabriel Valley, and therefore may rely on transit or active modes of transportation. These households are dispersed throughout the region, showcasing reliance on different travel modes throughout the region.
- **Disadvantaged Communities** – According to CalEnviroScreen, areas with the greatest concern include the unincorporated communities of West Puente Valley and Hacienda Heights, as well as the cities of Baldwin Park and Pomona. The western portion of the unincorporated West Puente Valley community falls within the 96 to 100 percentiles, thus indicating the highest environmental concern.

Policy Priorities

The policies recommended for the ESGV MAP are:

✔ Policy 1

Prioritize connections to food systems, health care facilities, parks, and other locations that support public well-being.

✔ Policy 2

Prioritize mobility improvements that link transit, schools, parks, and other key destinations in the community.

✔ Policy 3

Utilize technology to implement more flexible transportation options that supplement existing service or address gaps in the existing network.

✔ Policy 4

Incorporate sustainable design components into street treatments that increase safety for pedestrians, bicyclists, and sensitive groups such as youth and older adults while supporting environmental stewardship.

✔ Policy 5

Implement and connect safe bicycle- and pedestrian-friendly streets, sidewalks, paths and trails that promote active transportation and transit use.

✔ Policy 6

Reduce car dependency by supporting the implementation of safe and convenient active transportation infrastructure that connects with and compliments the transit network.

✔ Policy 7

Support integrated land use and transportation planning to support a more sustainable and multimodal East San Gabriel Valley.

✔ Policy 8

Support mode shift to lower- or zero-emission travel modes that can balance increased emissions that may derive from increased travel/mobility.

✔ Policy 9

Identify locations for innovative traffic safety features that support safety, accessibility, and sustainability.

✔ Policy 10

Address inequities created by a history of car-centric design in the ESGV by prioritizing the mobility and safety needs of priority populations such as youth, older adults, zero car households, and residents living in areas with environmental justice concerns.

✔ Policy 11

Address real and perceived safety concerns, and identify barriers to walking and rolling.

Mobility Gaps and Needs

Residents in the East San Gabriel Valley are impacted by limited transit and multi-modal transportation options and significant amounts of traffic, resulting from the subregion's location as a crossroads for traffic traveling between Los Angeles County, the Inland Empire, and Orange County. As described in Section 7, analysis of the region identified several key mobility gaps:

Need for Enhanced Fixed Route Transit Services	Information and Other Assistance
Need for Enhanced Paratransit (Access) Services	Transportation for Youth and Children
Connectivity Between Transit Services	Affordability and Access to Autos
Transit Service	Bicycle and Pedestrian Network Gaps
Transit Experienced	First/Last Mile Connectivity
Transit Alternatives	Land Use

Figure E-1 displays a half-mile buffer around the fixed-route transit services in the study area. The darkest gray areas do not have access to fixed-route transit within a half-mile. These areas include the communities of Glendora Islands, Northeast San Dimas, North and West Claremont, Walnut Islands, South Diamond Bar, and portions of Hacienda Heights and Rowland Heights.

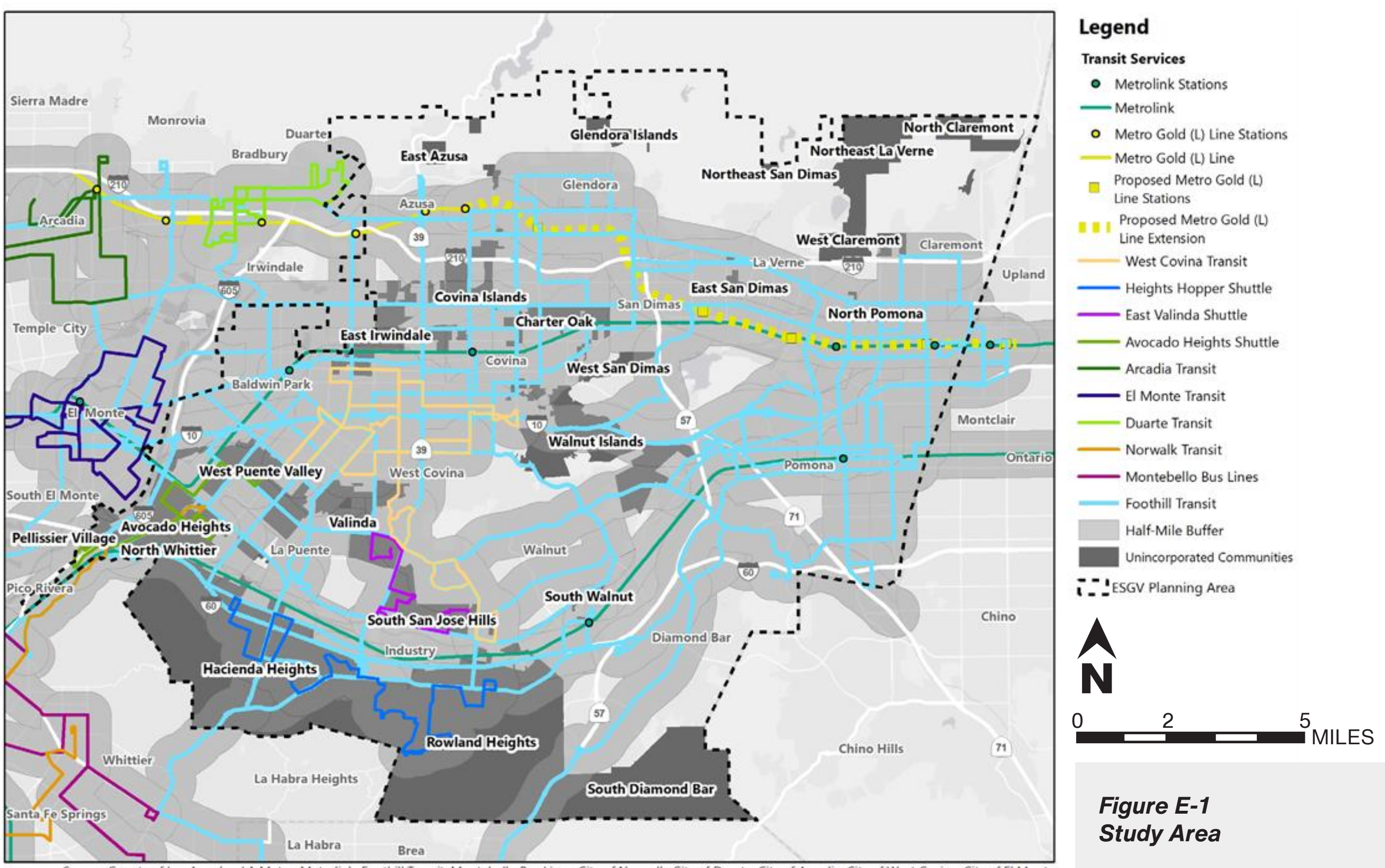


Figure E-1
Study Area

Technical analysis revealed a high density of pedestrian collisions in the eastern portion of the study area in Pomona, along Colima Road in Rowland Heights, Baldwin Park, and along SR 39 in Azusa. The density of pedestrian collisions is low to moderate, but still considerable in Covina at the interchange of I-10 and SR 39, in West Puente Valley, along SR 66 in Hacienda Heights, Rowland Heights, and Valinda. Similarly, bicyclist collision density was highest in the City of Pomona, south of I-10. Bicyclist collision density was moderate to high in East Azusa along SR 33, in the City of Baldwin Park along I-10, and in La Puente. Bicyclist collision density was low to moderate, but still significant, in North Pomona, Claremont, Glendora, East Irwindale, Covina, West Puente Valley, and Rowland Heights. Additionally, areas of high bicyclist and pedestrian-involved collisions should be prioritized for improvement.

Recommendations to Improve Mobility

In order to address these mobility gaps, needs, and safety issues, the technical team analyzed a range of solutions, such as Personal Mobility on Demand (PMoD), on-demand micromobility, scheduled micro-mobility, active transportation vehicle sharing, mobility technologies (trip discovery, trip booking, and cashless payment systems), and active transportation infrastructure improvements. The three primary mobility solutions recommended are:

- **Flexible Microtransit** – a type of transit service that uses smaller vehicles in a defined service area, with routing based on customer demand
- **Personal Mobility on Demand (PMoD)** – a lower-capacity service that pairs individuals or small groups with a ride to their destination and that helps address need during off-peak periods such as early mornings or late at night
- **Active Transportation Improvements** – improved bicycle and pedestrian infrastructure along key corridors and designed to close existing gaps

2

INTRODUCTION

2. INTRODUCTION

2.1 MAP Purpose

The purpose of the East San Gabriel Valley (ESGV) Mobility Action Plan (MAP) is to identify strategies and projects to make it easier and safer to walk, bike, and use transit in and between the 24 unincorporated communities located in the East San Gabriel Valley. These communities include:

Avocado Heights	North Claremont	South San Jose Hills
Charter Oak	Northeast La Verne	South Walnut
Covina Islands	Northeast San Dimas	Unincorporated South El Monte
East Azusa	North Pomona	Valinda
East Irwindale	North Whittier	West Claremont
East San Dimas	Pellissier Village	Walnut Islands
Glendora Islands	Rowland Heights	West Puente Valley
Hacienda Heights	South Diamond Bar	West San Dimas

These communities border several different incorporated cities in the ESGV region, including Azusa, Baldwin Park, Claremont, Covina, Diamond Bar, El Monte, Industry, La Puente, La Verne, San Dimas, and West Covina.

The County of Los Angeles recognizes that its residents face challenges related to equity, systemic racism, climate change, disparate access to opportunity, and the impacts of traffic congestion and emissions from transportation sources. By acknowledging these challenges and the people they impact, the MAP outlines strategies to improve mobility in a sustainable, equitable, and achievable way.

2.2 MAP Relationship to Area Plan

Planning in the County of Los Angeles takes place at multiple scales. At the highest level, the General Plan establishes countywide values and a vision for the future, and is based on a primary goal to foster healthy, livable, and sustainable communities. The General Plan establishes a Planning Areas Framework, whereby unincorporated communities are subdivided into eleven areas—each receiving its own Area Plan. These Area Plans build on the General Plan goals, priorities, and programs at a more local scale, identify strategies that fit the planning areas, shape communities to provide diverse housing, jobs, and services, and are coordinated with adjacent jurisdictions.

The ESGV Area Plan covers nine elements: land use, economic development, community character and design, mobility, natural resources and open space, environmental justice, health and safety, public services and facilities, and cultural and historic resources. Although the MAP is one component of the Area Plan, and was produced separately from the other elements, the two efforts included coordination between the technical teams to ensure that the recommendations and implementation strategies related to land use and mobility are aligned and mutually supportive.

2.3 County Priorities

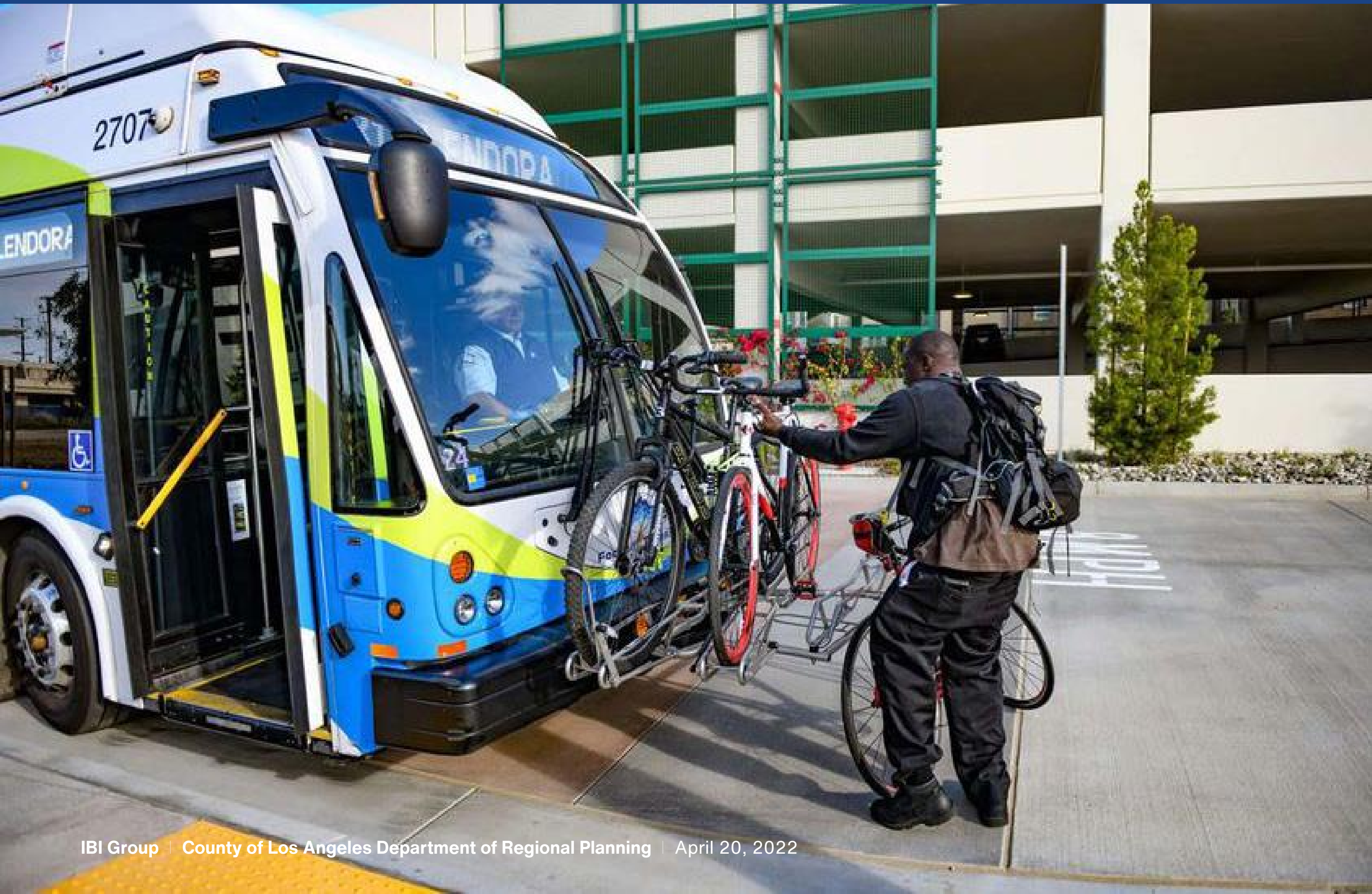
The MAP and the Area Plan were guided by policy priorities from the County of Los Angeles, the Department of Regional Planning, and other County agencies that will help achieve the goal of providing healthy, livable, and sustainable communities. These priorities and their definitions are as follows:

- **Environmental Justice** - Defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.
- **Sustainability** - Broadly refers to a long-term approach to human activity that balances economic, social, and environmental needs.
- **Climate Change** - The phenomenon of changing climate patterns and global temperature increases accelerated by increased greenhouse gas (GHG) emissions in particular, and the County's efforts to slow and counteract its impacts.
- **Equity** - An approach to decision making and the distribution of resources that is inclusive to individual and community needs, focused on alleviating past and present barriers to accessing resources needed to succeed and thrive.

Improved access to a greater diversity of safe, convenient, and affordable mobility options can help address each of these policy priorities and support the wellbeing of County residents.

3

MOBILITY DEMAND



3. MOBILITY DEMAND

3.1 Existing Transit Services and Active Transportation Infrastructure

Owing to its proximity to Downtown Los Angeles, the ESGV enjoys access to quality transit services provided primarily by Metro and Foothill Transit. These services are complemented by other intercity transit services including Montebello Transit and Norwalk Transit. Further, there are several local fixed route and community based (dial-a- ride and on-demand) transit/mobility services serving the ESGV study area.

3.1.1 Inter-City Transit Services

The following transit services provide inter-city bus and/or rail service in the study area, as well as the immediately surrounding area. These routes generally align with where population and employment is densest in the region.

TRANSIT SERVICE	ROUTES	SERVICE FREQUENCY (RANGE)
Metro	Gold (L) Line	12 to 20 minutes
Metro	Multiple bus routes	6 to 60 minutes
Access	Paratransit service	Demand-response
Foothill Transit	Multiple Express, Local, and School Supplementary bus routes	12 to 60 minutes
Montebello Bus Lines	Multiple bus routes	8 to 55 minutes on weekdays 18 to 65 on weekends
Norwalk Transit	Multiple bus routes	30 to 80 minutes

3.1.2 Municipal Transit Services

Municipal transit services in and around the study area include local fixed-route and/or dial-a-ride, including taxi/ transportation network company (TNC) partnerships, but typically within a prescribed service area aligning with city limits. These services often provide transportation for seniors, persons with disabilities, commuters, or other specialized populations, but are sometimes also available to the general public. These services often provide transportation for seniors, persons with disabilities, commuters, or other specialized populations, but are sometimes also available to the general public.

TRANSIT SERVICE	ROUTES	SERVICE AREA	SERVICE FREQUENCY (RANGE)
Montebello Bus Lines	Dial-A-Taxi (seniors and persons with disabilities)	Within Montebello, medical trips allowed outside city boundaries	Demand-response
Montebello Link Service	Five semi-fixed routes	To and from Montebello Metrolink Station	Reservation-based

TRANSIT SERVICE	ROUTES	SERVICE AREA	SERVICE FREQUENCY (RANGE)
City of Claremont	Dial-A-Ride (general public)	Within Claremont (can travel outside service area for additional fee)	Demand-response
Pomona Valley Transportation Authority (Claremont, La Verne, Pomona, San Dimas)	Get About (seniors and persons with disabilities)	Within Claremont, La Verne, Pomona, and San Dimas (can travel to adjacent areas for additional fee)	Demand-response
City of Duarte (DuartEBus Powered by Foothill Transit)	Line 860 Duarte Blue and Line 861 Duarte Green	Within Duarte	60 minutes
City of Covina	Dial-A-Ride (seniors and Access Services members)	Within Covina and within 3 mile radius of Covina	Demand-response
City of Arcadia Transit	Green Line, Blue Line, Red Line	Within Arcadia	50-15 minutes
City of Arcadia Transit	Dial-A-Ride (seniors and persons with disabilities)	Within Arcadia	Demand-response
GoMonrovia	GoMonrovia subsidized Classic Lyft rides	Within Monrovia, to Target in Duarte (connection to Duarte Transit), within three miles of city limits for medical	Demand-response
El Monte Transit	Five fixed-route trolley lines	Within El Monte	50 minutes
City of El Monte	5 commuter shuttles	Within El Monte (to and from El Monte Metrolink Station)	60-27 minutes
West Covina Transit	Red Line, Green Line, Blue Line	Within West Covina	56-52 minutes (Red Line) 30 minutes (Green Line) 65 minutes (Blue Line)
Los Angeles County	Avocado Heights Shuttle	Avocado Heights/Bassett/ West Valinda	100-60 minutes
Los Angeles County	Heights Hopper Shuttle	Rowland Heights, Hacienda Heights	90 minutes
Los Angeles County	East Valinda Shuttle	East Valinda	115-70 minutes

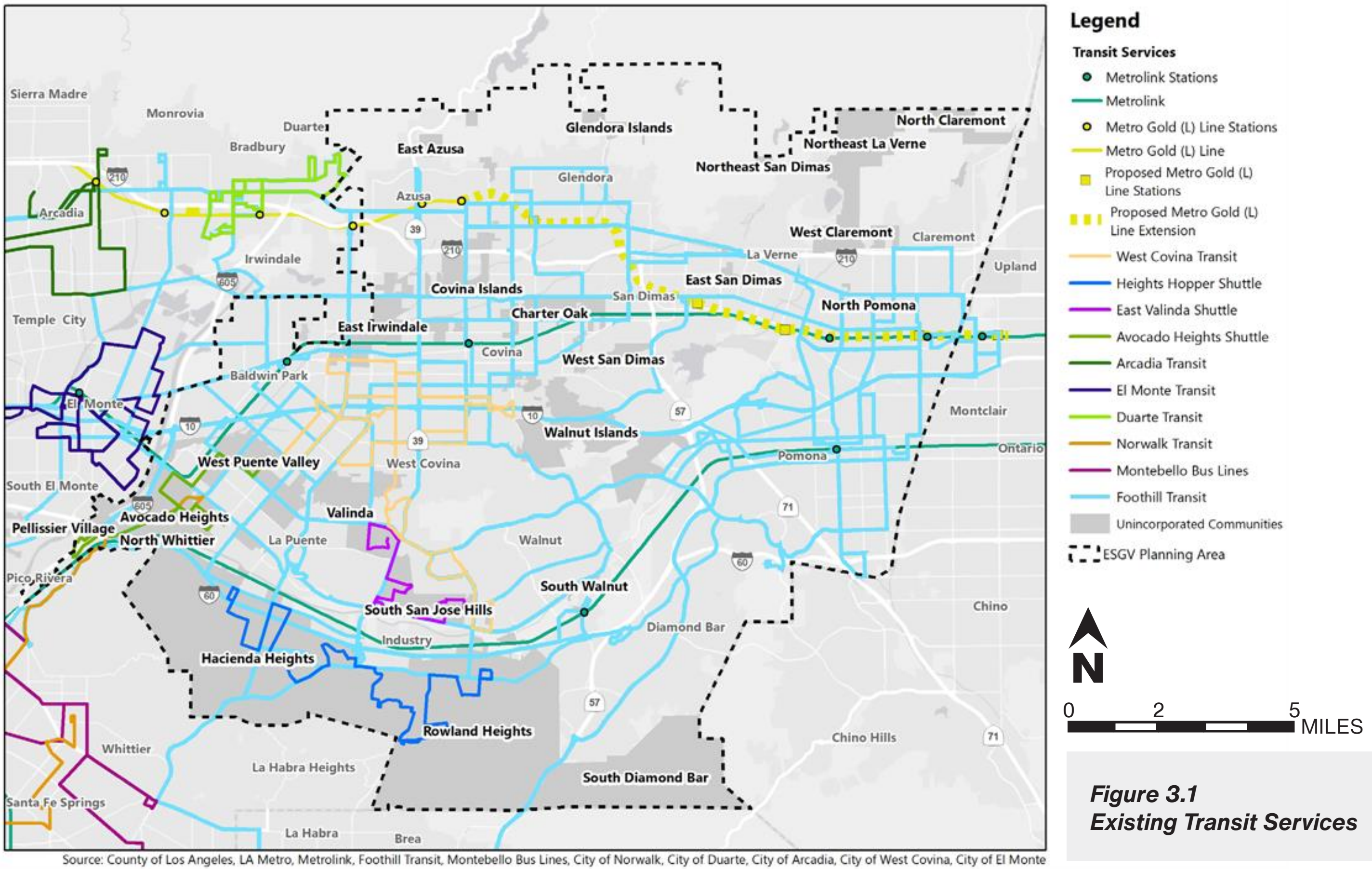


Figure 3.1
Existing Transit Services

3.1.3 Active Transportation Infrastructure

There are a number of existing bikeways in the ESGV. Figure 3.2 displays the locations of the Class I, Class II, and Class III bikeways in the study area. There are no Class IV bikeways in the unincorporated areas currently. While there are a number of new bikeways planned within the ESGV through the East San Gabriel Active Transportation Plan and Los Angeles County Bicycle Master Plan that is expected to be updated in 2025, among others, the current network is fragmented. A disconnected network makes travel via active transportation modes difficult and not welcoming, especially in areas with high densities of populations who are more likely to use and would benefit the most from active transportation infrastructure improvements. These include seniors, youth, residents without access to a car, and disadvantaged populations.

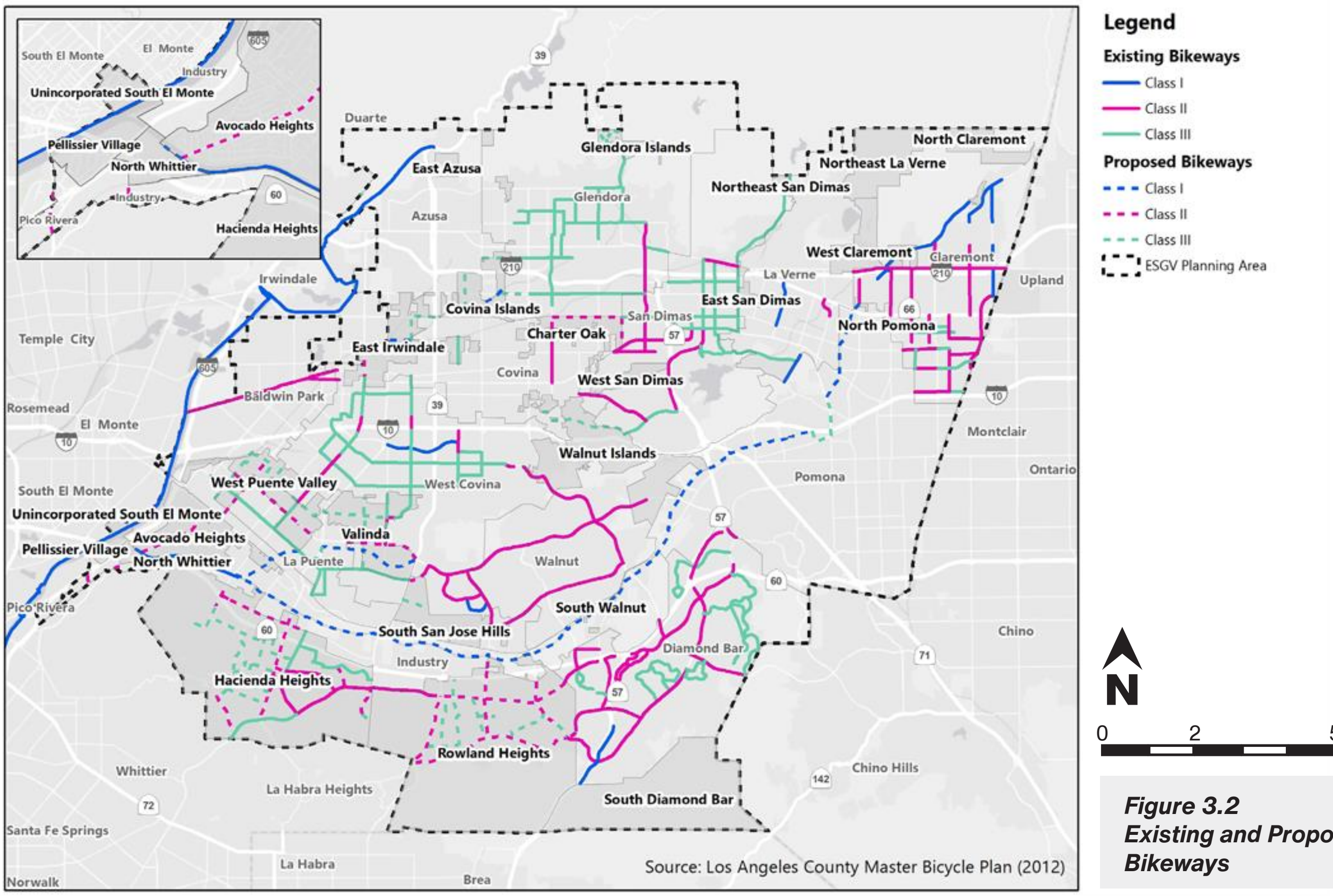


Figure 3.2
Existing and Proposed Bikeways

3.2 Transit Propensity Score

An analysis of transit propensity considers an area's characteristics to determine if residents of the area have a higher likelihood or predisposition to use transit. Metro developed a transit propensity index that considered the following three major components of predisposition to ride transit:

1. Elements of demand: Population and employment densities, including seniors, persons aged 18-34, persons that are attending grades K-12, low-income workers.
2. Market segments: Commuters, transit-dependent persons, choice riders.
3. Built environment: Walkability, square footage of built development, housing density.

A higher transit propensity score (TPS) correlates to a higher likelihood of taking transit. According to this index, much of the region has relatively low transit propensity scores (Figure 3.3). Further, current high order public transit bus and rail services exist in key corridors and are supplemented by local and community based services.

It is important to note that notwithstanding relatively low transit propensity scores as developed by Metro's TPS, there are many pockets of the study area that are beyond a reasonable walking distance to transit - usually defined as a half-mile, or 10-minute walk – particularly in the unincorporated areas. Hence, these areas specifically would not only benefit by the availability of transit/ mobility solutions but would also provide an opportunity to influence travel behavior by providing additional mobility options.

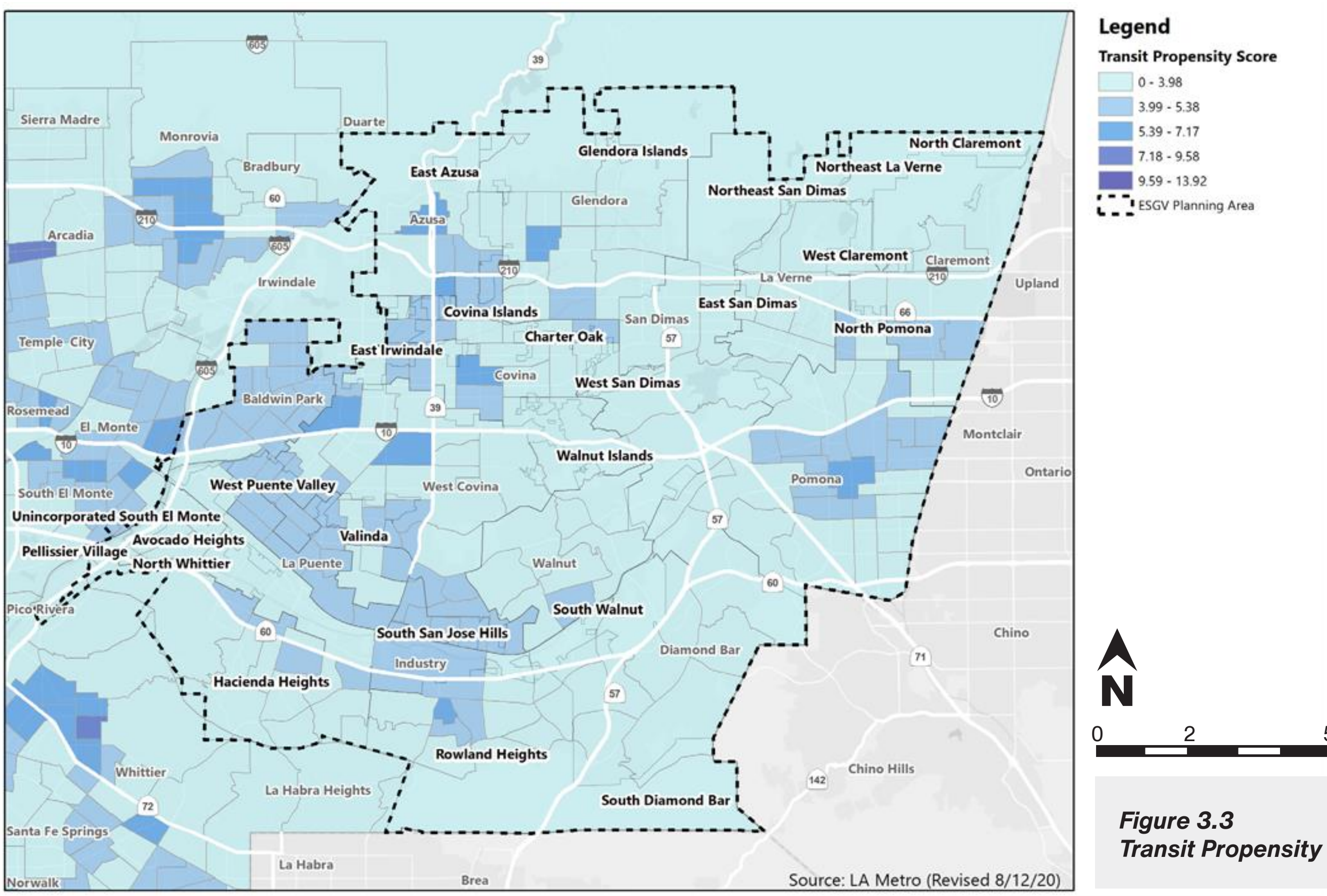


Figure 3.3
Transit Propensity Score

3.3 Transit Equity Score

Similar to the TPS, Metro's Transit Equity Score (TES) indicates where transit is of most need based on key socioeconomic indicators within Los Angeles County. TES consists of seven measures:

1. Zero Car Households per Acre
2. Poverty/Low Income Households per Acre
3. School Age Students (age 10 -19) per Acre
4. Seniors over 55 as of 2010 per Acre
5. Single Mothers per Acre
6. Disabled Persons per Acre
7. Minorities per Acre

There are relatively low transit equity scores as developed by Metro's NextGen Data Center, specifically in the unincorporated areas of the study area (Figure 3.4). Communities with low TES in the study area include: Glendora Islands; Northeast San Dimas and La Verne, North Claremont, Walnut Islands, Diamond Bar and South Diamond Bar, and Hacienda Heights.

These areas, as determined by the above listed seven measures, are considered transportation disadvantaged populations, and they are concentrated in the higher density areas of the study area. This may suggest mobility gaps reflecting availability by time of day, day of week, affordability, excessive travel times, etc.

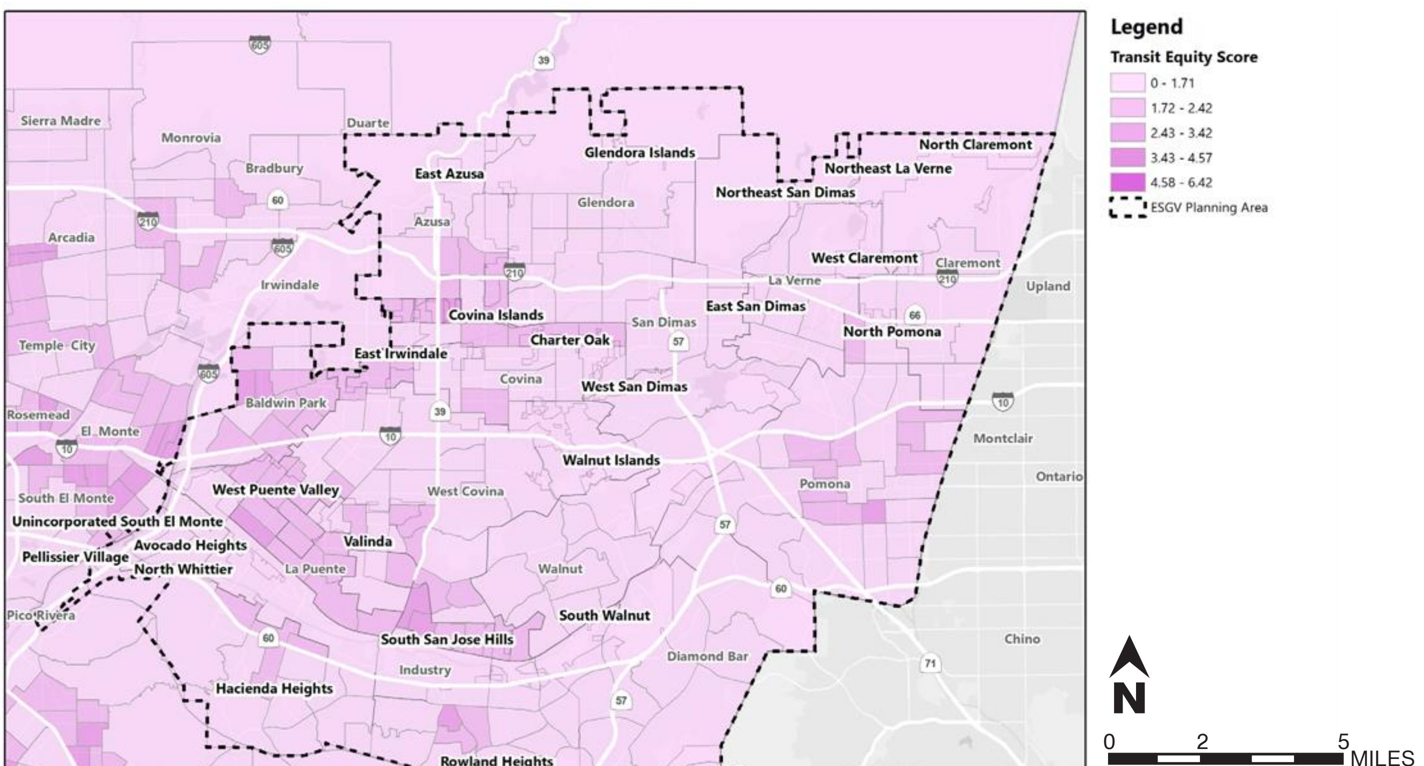


Figure 3.4
Transit Equity Score

4

MOBILITY GAPS

4. MOBILITY GAPS

4.1 Gaps and Opportunities

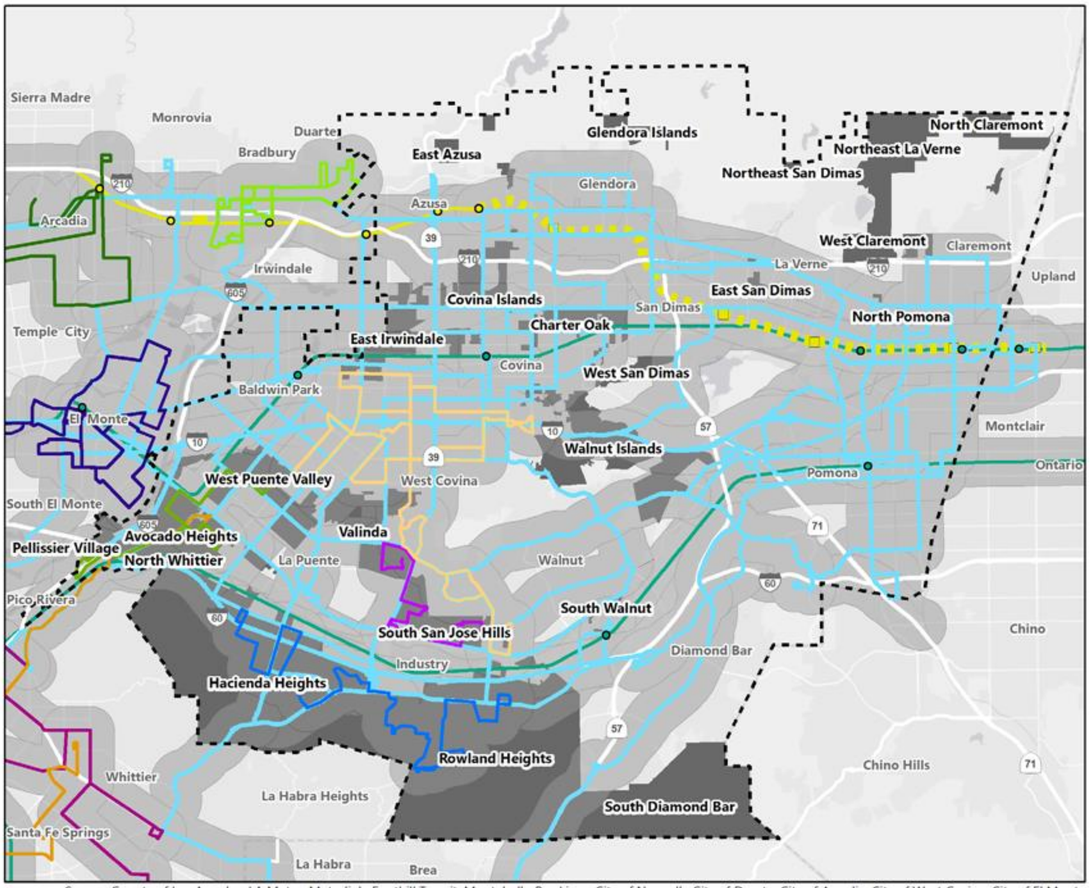
Residents in the ESGV are impacted by limited access to transit and multi-modal transportation options and significant amounts of traffic, resulting from the subregion's location as a crossroads for traffic traveling between Los Angeles County, the Inland Empire, and Orange County.

The area's relatively concentrated pockets of population and employment density along some of the most-utilized corridors in the region indicate the need for special attention to the residents of unincorporated communities living along the major highways in the region, and particularly west of SR-39, to ensure that sufficient mobility options are planned and the mobility needs of those communities are met. Additionally, the less dense central areas indicate a potentially high usage of vehicle travel in these communities, further supported by the area's mode share being primarily vehicle-dominant, as well as disconnected bicycle facilities. These findings, along with the region's continuing growth, present challenges to addressing traffic congestion and providing opportunities for non-vehicular travel to key destinations in the region.

While there are various types of mobility options available to travelers within the ESGV study area, they are not without their limitations reflecting geographic/spatial, temporal, infrastructure, and technology constraints.

Figure 4.1 displays a half-mile buffer around the fixed-route transit services in the study area. The darkest gray areas do not have access to fixed-route transit within a half-mile. These areas include the communities of Glendora Islands, Northeast San Dimas, North and West Claremont, Walnut Islands, South Diamond Bar, and portions of Hacienda Heights and Rowland Heights. These areas also tend to have high concentrations of seniors and households without access to a vehicle who may rely on transit to get around.

Additionally, areas of high bicyclist and pedestrian-involved collisions should be prioritized for improvement. Areas with high densities of collisions may indicate a lack of safe infrastructure and a need for further analysis to determine the need for physical improvements to either provide the infrastructure or slow vehicle traffic. An analysis of pedestrian collision density indicated that between 2014 and 2018, a high density of pedestrian collisions appears in the eastern portion of the study area in Pomona, along Colima Road in Rowland Heights, Baldwin Park, and along SR 39 in Azusa (Figure 4.2). The density of pedestrian collisions is low to moderate, but still considerable, in Covina at the interchange of I-10 and SR 39, in West Puente Valley, along SR 66 in Hacienda Heights and Rowland Heights, and in Valinda. Similarly, bicyclist collision density was highest in the City of Pomona, south of I-10 (Figure 4.3). Moreover, bicyclist collision density was moderate to high in East Azusa along SR 39, in Baldwin Park along I-10, and in La Puente. Bicyclist collision density was low to moderate, but still significant, in North Pomona, Claremont, Glendora, East Irwindale, Covina, West Puente Valley, and Rowland Heights. These areas tend to align with areas of high concentration of youth and disadvantaged populations, and may indicate a need for improvements to better protect these vulnerable populations while they walk or bike to their everyday destinations.



Source: County of Los Angeles, LA Metro, Metrolink, Foothill Transit, Montebello Bus Lines, City of Norwalk, City of Duarte, City of Arcadia, City of West Covina, City of El Monte

Figure 4.1
Half-Mile Buffer Around Fixed-Route Transit

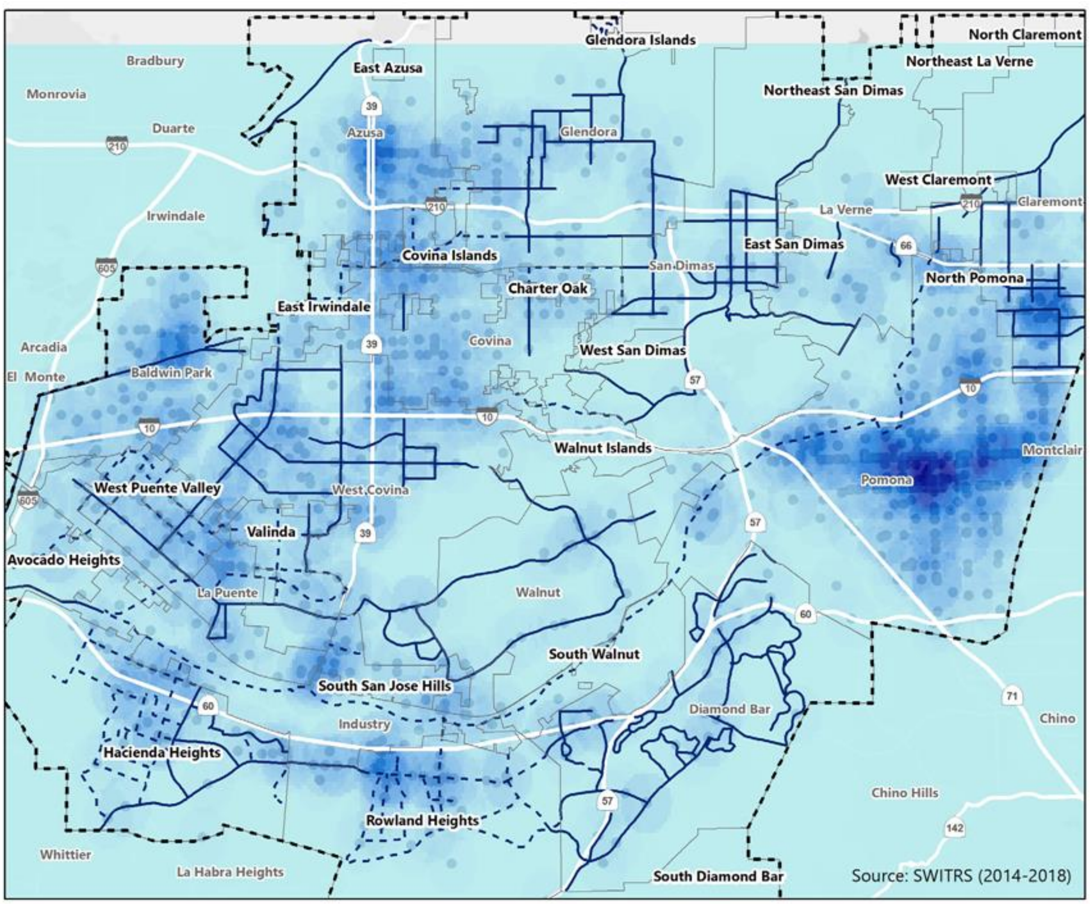


Figure 4.2
Pedestrian Collision Density

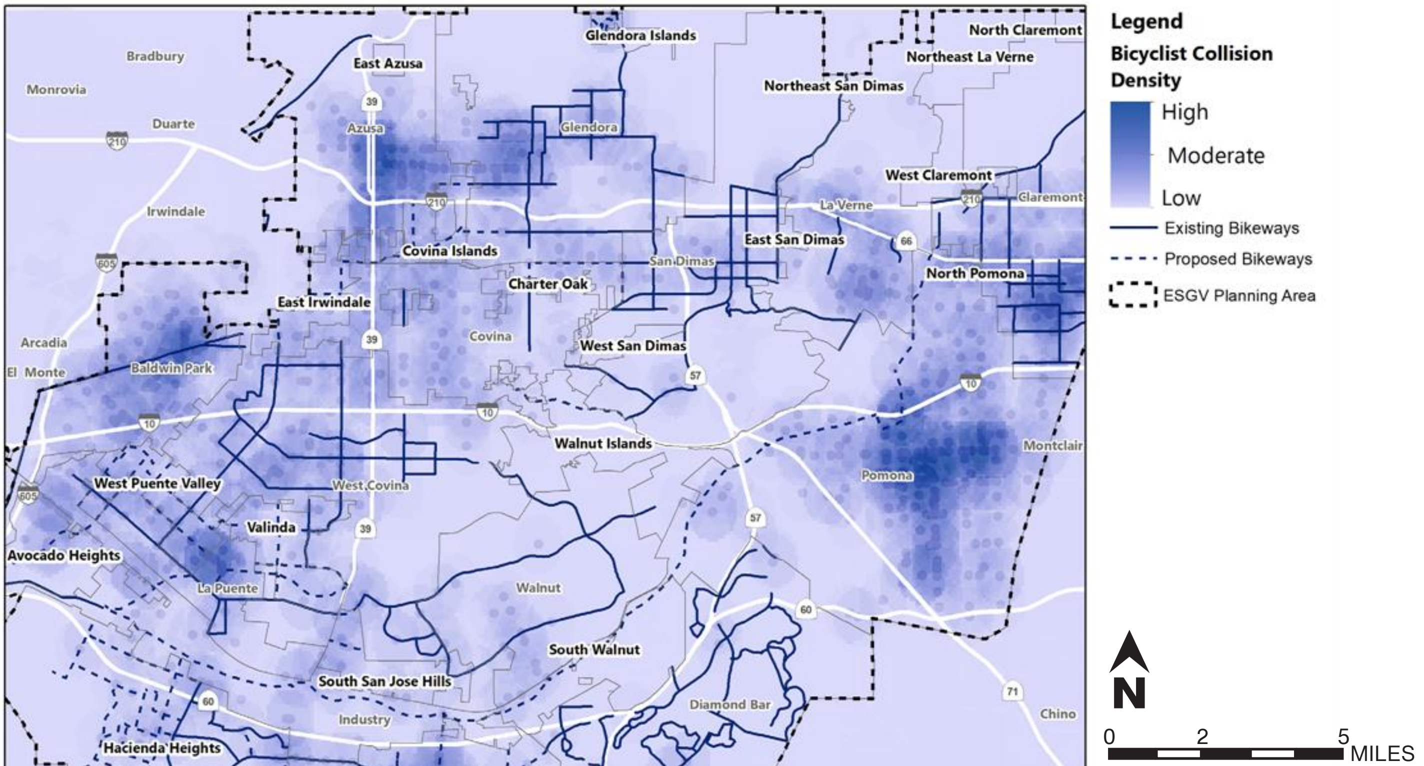


Figure 4.3
Bicyclist Collision Density

Based on the analysis of existing conditions and feedback received through the public engagement process, the following were identified as mobility gaps to be addressed by the MAP:

- **Enhanced Fixed Route Transit Services -** For persons who can and do use the fixed route transit system, there may be a need for additional service in the ESGV study area not currently served, and for more direct service to key activity centers.

- **Enhanced (Access) Paratransit Services -** Paratransit users may need a level of service above and beyond what is required by the Americans with Disabilities Act (ADA), such as service provided on the same day it is requested (e.g. taxis or Transportation Network Companies (TNCs)), where and when the fixed route service does not operate, or the ability to accommodate “uncommon” wheelchairs or other mobility devices. Some paratransit users who are parents may note that it is difficult to transport children to school and other activities via ADA paratransit.

- **Connectivity between Transit Services -** The need for better connectivity between service providers, both for inter-regional and intra-ESGV travel, whether using paratransit or fixed-route service. To promote more seamless travel, customers may need better shelters and bus stops as well as other amenities at transfer sites. Some persons with wheelchairs may have difficulty making effective use of the system due to accessibility barriers and may have a need for enhanced accessibility of vehicles and related infrastructure, such as shelters and stops. The cost of transferring between systems may be noted as an issue for both paratransit and fixed-route service. In addition, there may be a need for loading and waiting zones at transit stations for taxis, TNCs, or vans, and facilities at stations that drivers of such vehicles can use while they wait for their passengers.

- **Transit Service -** Gaps related to transit service may be identified (or validated), including hours of operation (some transit service may not run early enough in the morning, late enough at night, or on the weekends); frequency (some transit riders may prefer more frequent service than currently provided); reliability (some transit routes may not stay on-schedule or are overcrowded); connections (transit routes may not always transfer or connect with other services); spatial gaps (transit may not always serve destinations that people need to reach, such as schools, employment, medical care or grocery stores); and travel time (travel time between stops and to destinations may be too long, particularly when transfers are required to complete the trip).

- **Transit Experience -** Potential issues related to transit amenities, including bus shelters, bus stop seating if a bus stop cannot accommodate a shelter, and lighting to promote safety at bus stops and at rail stations, especially at night. Safety on transit vehicles may be raised as a concern.

- **Transit Alternatives -** For those who need transportation where public transit (fixed-route or complementary ADA paratransit) is unavailable or unsuitable, alternatives may be needed that enable people to live independently, such as ride-sharing, volunteer-driver programs, short-term medical transportation, or mobile programs that bring support services to people's homes.

- **Information and Other Assistance -** There is a need to clearly articulate information about the availability of transit/mobility services in a variety of formats (including signage) so that older adults and persons with disabilities can learn about the availability and how to use public transit and its accessible features. Similarly, there is a need to ensure drivers, dispatchers, other transit personnel, and the general riding public are sensitive to passenger needs, and know how to provide assistance on-board the vehicle as needed.

  In advancing education and information dissemination, ensure to address any problems with the accuracy of transit route schedules; information at bus stops; transit information in languages other than English; information about fares; transfer policies; fares; and routes; and publicized information about local shuttle services.

- **Transportation for Youth and Children -** Transportation gaps specifically related to youth and children may include the cost of transportation for youth, and particularly for a family with multiple children; buses may be over crowded - additional service may be needed in the morning before school starts, and after school; safety for students who ride the bus; and, if no school bus service is available, working parents using transit who drop children off at school or daycare before work can have lengthy and costly trips.

- **Affordability and Access to Autos -** Low-income individuals and families may report that transportation, whether using transit or owning a car, is costly. Fares, monthly passes requiring high-up front costs, and certain transit transfer policies, may be cited as expensive, especially for families with children who rely mainly on transit. Taxi or TNC fares may be cited as unaffordable. Cost is the primary barrier to auto ownership for low-income individuals and families.

- **Bicycle and Pedestrian Network Gaps -** Bicycle and pedestrian networks can often be disconnected, especially where infrastructure, such as bikeways or sidewalks, cross different jurisdictions. A comprehensive look at the existing and planned network and key destinations, and areas of bicyclist- and pedestrian-involved collisions, can help determine where gaps need to be closed and prioritized in order to provide continuity for bicyclists and pedestrians.

- **First/Last Mile Connectivity -** The first and last part of the journey that transit riders walk, bike, or roll to and from their nearest station or bus stop is called the "first/last mile connection." Infrastructure surrounding transit stops and transfer stations should be accessible by multiple modes of transportation in order to ensure first/last mile connectivity. That includes adding or improving bikeways, bicycle amenities, sidewalks, curb cuts, curb ramps, crosswalks, etc. to provide accessible paths of travel.

- **Land Use -** Transportation decisions typically affect land use patterns and resulting economic, social, and environmental impacts. These include direct impacts on land used for transportation facilities, and indirect impacts caused by changes to land use development patterns.

  County land use strategies in past decades have contributed to mobility gaps. The lack of vibrant, mixed community nodes is partially to blame for the lack of transit use.

  These challenges highlight opportunities to address them by planning for suitable land uses, expanding transit use and alternative modes of transportation by improving the network, and innovative approaches to mobility services and technology. While the MAP is focused on the unincorporated communities in the ESGV, coordination with surrounding cities will ensure a successful and cohesive regional approach to mobility.

5

EVALUATION AND RECOMMENDATIONS

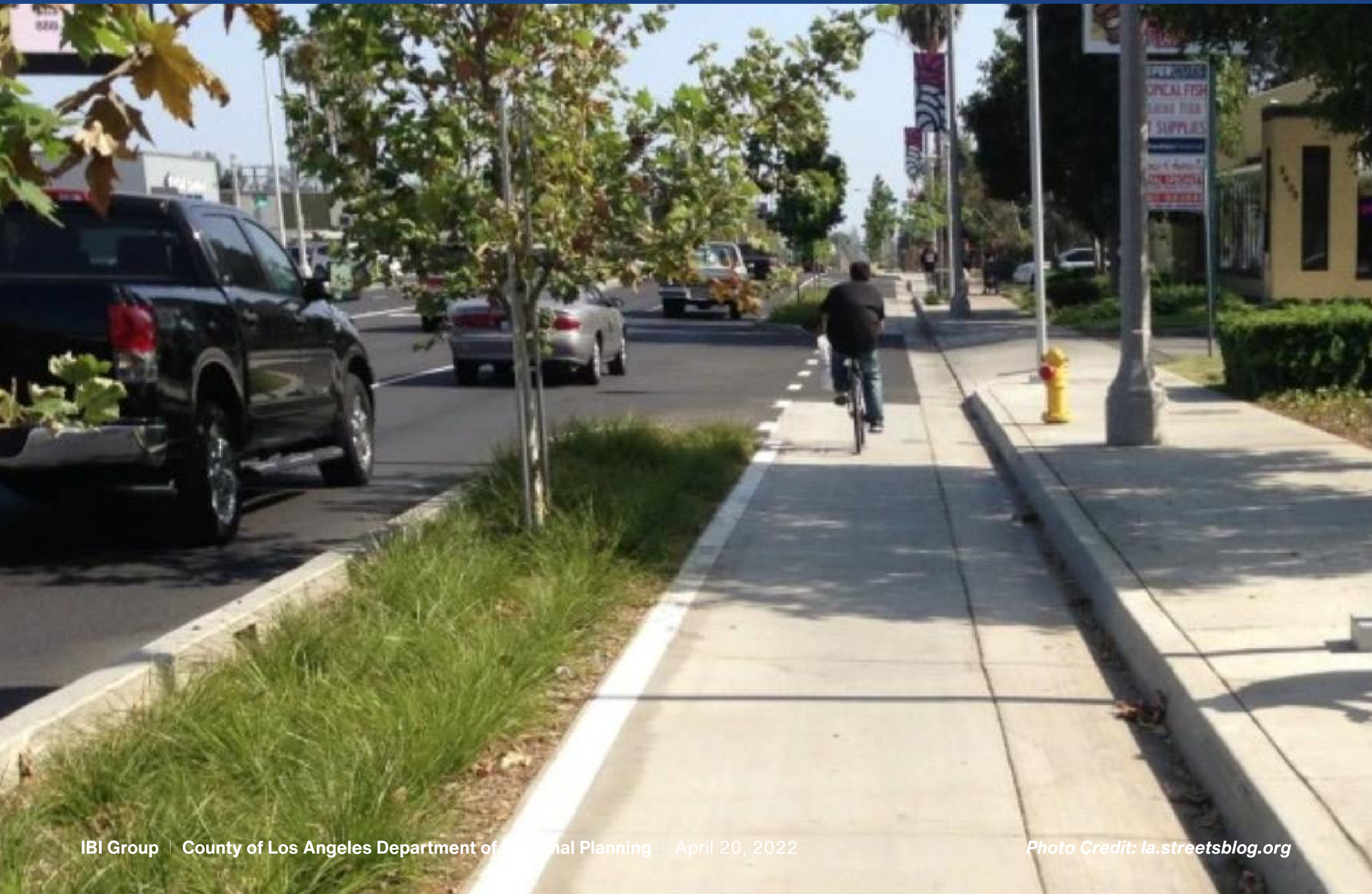


Photo Credit: la.streetsblog.org

5. EVALUATION AND RECOMMENDATIONS

Informed by an understanding of industry practice with next-generation mobility solutions, combined with detailed profiles of the ESGV service area, stakeholder and project management team input, this section presents an evaluation of mobility solutions for select communities in the unincorporated areas. This section presents opportunities for the County and its project partners to pilot alternative mobility schemes for transit service in select unincorporated areas. In addition, this section presents opportunities to plan for a more complete active transportation network and proposed 72 corridors for bicycle/pedestrian improvements. Concepts and assumptions used for this evaluation can be found in the Appendix.

5.1 Evaluation of Transit Services

The Decision Framework is intended to guide both internal discussions as well as conversations with key external stakeholders. The Decision Matrix is shown in Figure 5.1.

The Decision Framework may be used to guide discussion where there is expressed interest in advancing a mobility service. Decisions affecting service design characteristics, service mode, and a potential role for County/Foothill/Municipal Providers may be determined based on consideration of the needs of a particular community and the characteristics of the candidate service modes. While community engagement pursuits generate the initial interest in the project, there may be select communities and/or specific trip attractors or generators that are not interested in participating in initial mobility deployments. Strategies to mitigate this are two-fold: 1) Advancing deployment in alternate communities; and/or 2) Additional dialogue to explore under what conditions they might be interested in participating.

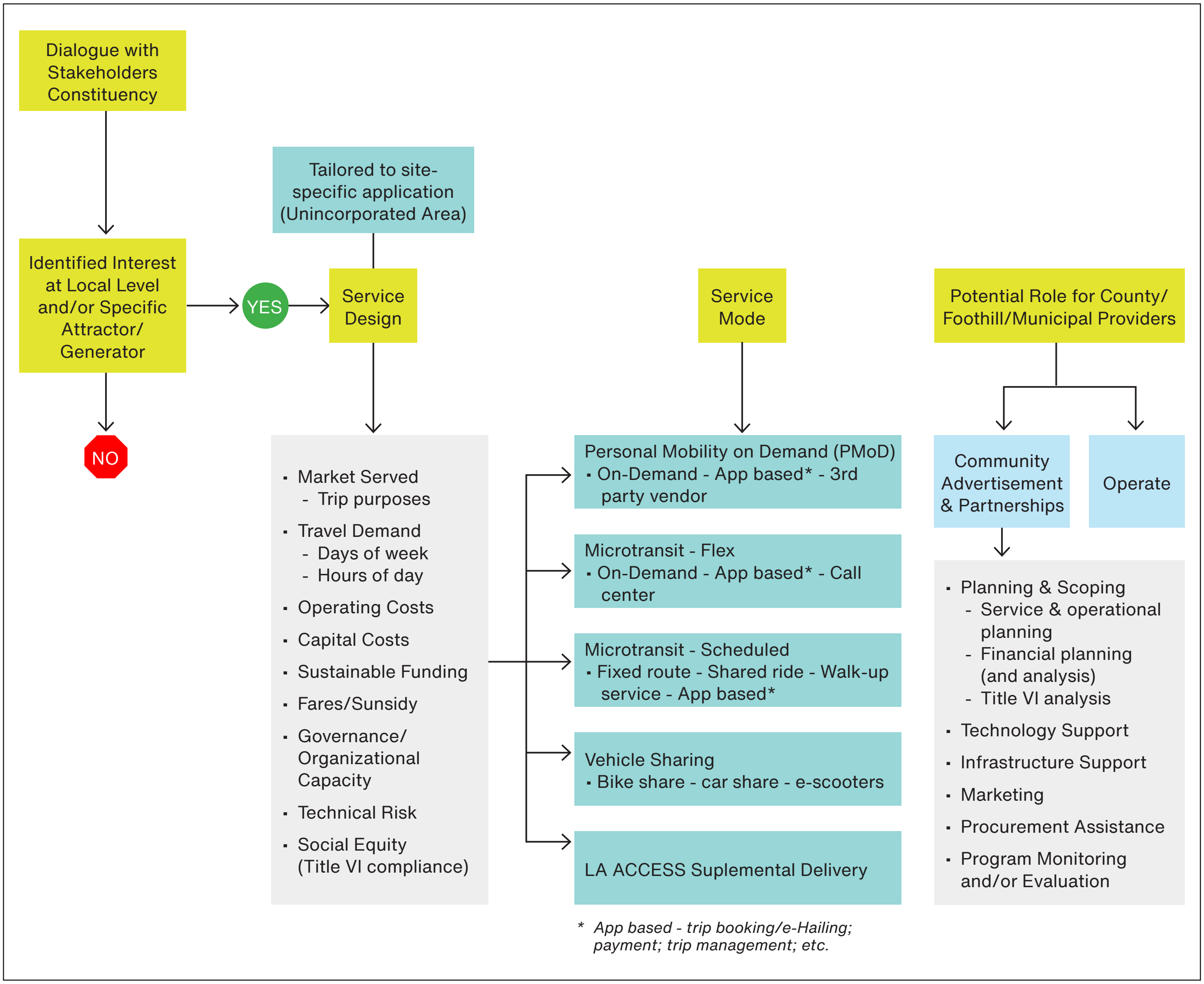


Figure 5.1 Transit Decision Matrix

5.1.1 Transit Service Mode Evaluation Framework

The Evaluation Criteria used is presented below in Figure 5.2.

Figure 5.2 Service Mode Evaluation Matrix

EVALUATION CRITERIA	SERVICE AREA - SERVICE MODE EVALUATION	BIKE/PED INFRASTRUCTURE EVALUATION
Effectiveness - population served & ridership potential	✔	
Effectiveness - propensity for bicyclists/ pedestrians		✔
Economy - total cost of service	✔	
Economy - total cost		✔
Efficiency - cost per trip, per vehicle hour	✔	
Efficiency		✔
Reduce Vehicle Miles Traveled (VMTs) Per Capita	✔	✔
Level of Service	✔	
Quality of Service	✔	
Socio-economic factors	✔	✔
Civil Rights Implications	✔	
Organizational - operational flexibility, control, accountability	✔	
Ease of Implementation	✔	✔
Technical Risk	✔	✔
Political Risk	✔	✔
Financial Risk	✔	✔
Addresses high density of bicyclist/ pedestrian collisions		✔
Closes a gap in infrastructure/service		✔
Improves bicycle or pedestrian facilities		✔
Connects to a community with limited vehicle availability		✔
Increases access to key desttinations		✔

Figure 5.3 presents the Service Mode Evaluation Matrix reflecting the 'scoring' of select Evaluation Metrics that help measure the County's guiding principles, Implementation Considerations, and Criteria for each of the Service Alternatives and Mobility Technologies considered.

Figure 5.3 Service Mode Evaluation Matrix

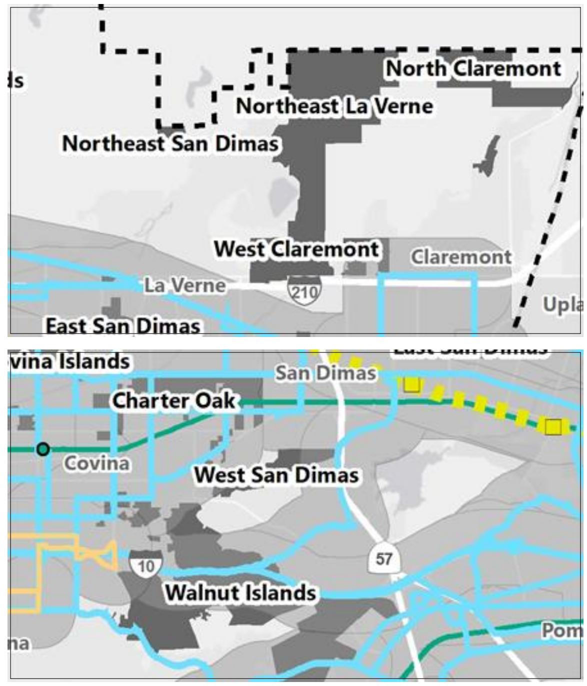
ESGV-MAP - Strategies Evaluation Matrix

	Evaluation Metrics					Implementation Considerations				Evaluation Criteria													
Weight (1-5)																							
MoD Strategies	Reduce GHG Emissions	Increase Transit Ridership/Expand Reach of Fixed-Route Network	Contribute to Regional Economic Development	Equitable Access	Actively engage in regional Smart Mobility Initiative	Diversity Service Offering	Synergy with Transit	Technologies - Enhance Customer Experience	Transition Marginal Fixed-Route (Foothill and/or municipal services) Segments to Flexible Services	Effectiveness - population served & ridership potential	Economy - total cost of service	Efficiency - cost per trip, per hehicle hour	Reduce Vehicle Miles Traveled (VMTs) Per Capita	Level of Service	Quality of Service	Socio-economic factors	Civil Rights Implications	Organizational - operational flexibility, control, accountability	Ease of Implementation	Technical Risk	Political Risk	Financial Risk	Overall Rating
SERVICE ALTERNATIVES																							
PMoD / RideShare	1	2	2	1	2	2	2	2	2	2	2	2	0	1	2	1	1	1	1	2	0	1	32
On-Demand Micro-Mobility (flexible)	1	2	2	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	-1	-1	1	34
Scheduled Micro-Mobility	1	2	2	1	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	-1	-1	1	28
Active Transportation - Vehicle Sharing (bicycle, e-scooters)	2	2	1	-1	2	2	2	0	2	1	2	2	2	2	2	2	0	2	1	2	2	2	34
MOBILITY TECHNOLOGIES																							
Trip Discovery (trip planning)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	-1	-1	-1	34
Trip Booking (e-Hailing)	2	2	2	1	2	2	2	2	2	1	2	2	0	2	2	2	2	2	1	-1	-1	-1	30
Cashless (mobile) Payments	0	1	1	2	2	0	2	2	0	1	1	1	0	1	2	0	2	2	1	-1	-1	-1	18

LEGEND

2	Positive
1	Somewhat positive
0	Neutral / no significant change
-1	Somewhat negative
-2	Negative

5.1.2 Potential Pilot Projects



Informed by the Existing Conditions Analysis and Policy/Literature Review and Mobility Gaps, technical memoranda including consideration of community demographic and socio-economic characteristics, transit equity and propensity scores, proximity to current transit services, etc. two prospective service areas were identified for potential pilot programs to deploy alternate mobility services. These pilot projects are designed to test the concept of operations, including performance monitoring, for the potential application of these alternate mobility types in other unincorporated areas in the ESGV study area.

Two potential pilot service areas are:

1. Northeast La Verne & San Dimas; West & North Claremont; and
2. West San Dimas; Walnut Islands.

While both areas would serve locations with identifiable gaps in transit service, the first pilot service area also aligns with higher densities of the senior population and would provide more options for seniors living in those areas to travel using transit. The second service area aligns with some of the higher concentrations of youth residents as well as households without access to a vehicle.

Recognizing that desired trip patterns include destinations outside of each of the above identified service areas including connectivity to higher-order transit (i.e., Foothill Transit), specific service area design should be inclusive of places where people already want to go. Further, these services will likely require cross-jurisdictional partnerships to achieve improved community-specific circulation.

In advancing potential pilot projects, specifics to service area design, operating/performance characteristics, etc. may incorporate such considerations as using fare policy to influence travel behavior. For example, one (lower) fare for trips providing connectivity to higher order transit (i.e., Foothill routes), and a ‘premium’ fare for direct travel intra and inter-community travel.

Factors to consider in replicability, based on pilot outcomes, include trip densities; travel patterns (trip origin/destination data); community socio-economic characteristics; opportunities to complement existing mobility services including higher-order transit, to address safe streets infrastructure, complement active transportation initiatives; etc. Future consideration of microtransit deployments may include other high-need communities including West Puente Valley, Valinda (enhancements to PW’s current East Valinda Shuttle operations), South San Jose Hills, etc.

5.1.3 Pilot Project Analysis Summary

This section provides an overview of the costs and ridership estimates for each of the two service area candidates for possible pilot deployments. For each area, the following tables present:

- Service Characteristics – level of service[3]
- Coverage and Ridership Estimate[4]
- Costs and Subsidies[5]

Table 5.1 Service Characteristics – Level of Service

SERVICE AREA	RECOMMENDED LEVEL OF SERVICE - MON. - FRI.	SERVICE MODE(S)	OPERATING SPAN WEEKDAY (HOURS)	OPERATING SPAN SATURDAY (HOURS)	OPERATING SPAN SUN/HOL (HOURS)	WEEKDAY AVERAGE VEHICLES IN SERVICE	SATURDAY AVERAGE VEHICLES IN SERVICE	SUN/HOL AVERAGE VEHICLES IN SERVICE
Northeast La Verne & San Dimas; West & North Claremont	5AM - 6AM, 8:30AM - 1PM, 9PM - 12AM	Personal Mobility on Demand	8.5	19	18	3	2	2
	6AM - 8:30AM & 1PM - 9PM	On-Demand/ Flexible - Microtransit	10.5	0	0	1	0	0
West San Dimas; Walnut Islands	5AM - 6AM, 10AM - 3PM, 7PM - 12AM	Personal Mobility on Demand	11	19	18	3	2	2
	6AM - 10AM & 3PM - 7PM	On-Demand/ Flexible - Microtransit	8	0	0	1	0	0

Table 5.2 Coverage and Ridership Estimates

SERVICE AREA	SERVICE MODE(S)	ANNUAL COVERAGE HOURS	CAPACITY PER COVERAGE HOUR	MAXIMUM ANNUAL SERVICE CAPACITY	LOW DEMAND	HIGH DEMAND	LOW ANNUAL RIDERSHIP ESTIMATE	HIGH ANNUAL RIDERSHIP ESTIMATE
Northeast La Verne & San Dimas; West & North Claremont	Personal Mobility on Demand	9,917	3	29,750	0.33	0.50	9,817	14,875
	On-Demand/ Flexible - Microtransit	2,678	8	21,420	0.50	0.67	10,710	14,351
	Total						**20,527**	**29,226**
West San Dimas; Walnut Islands	Personal Mobility on Demand	12,219	3	36,657	0.33	0.50	12,097	18,329
	On-Demand/ Flexible - Microtransit	2,040	8	16,320	0.50	0.67	8,160	10,934
	Total						20,257	**29,263**

[3] Level of service assumes: (a) PMoD operating early morning, late night, and some mid-day service, with up to three vehicles available for the span of service as indicated; and (b) Micotransit assumes one vehicle for span of service as indicated.

[4] Low and high demand ridership estimates are based on an assumed utilization ranging from 0.33 to 0.50 to 0.67 for microtransit, of available capacity for each span of service hour. Coverage hours refer to the maximum number of potential revenue service hours that could be deployed if necessary, to meet demand.

[5] PMoD costs: The net cost of service is calculated on an assumed maximum $5.00 per trip flat subsidy. Assumes that the customer pays an initial fare equivalent to a regular transit fare; followed by the subsidy; after which the customer is responsible for the cost of longer trips. Flexible microtransit costs: Assumes $1.00 to transit stop, $3.00 to any location within the pilot service area.

Table 5.3 Costs and Subsidy

SERVICE AREA	RECOMMENDED LEVEL OF SERVICE - MON. - FRI.	SERVICE MODE(S)	COST PER HOUR	ANNUAL COST	FARE REVENUE LOW DEMAND	FARE REVENUE HIGH DEMAND	NET COST OF SERVICE - LOW DEMAND	NET COST OF SERVICE - HIGH DEMAND	SUBSIDY PER TRIP LOW DEMAND	SUBSIDY PER TRIP HIGH DEMAND
Northeast La Verne & San Dimas; West & North Claremont	5AM - 6AM, 8:30AM - 1PM, 9PM - 12AM	Personal Mobility on Demand	NA	NA	NA	NA	$49,087	$74,374	$5.00	$5.00
	6AM - 8:30AM & 1PM - 9PM	On-Demand/ Flexible - Microtransit	$84.68	$226,731	$10,710	$14,351	$216,021	$212,379	$20.17	$14.80
		Total					$265,107	$286,753	$12.91	$9.81
West San Dimas; Walnut Islands	5AM - 6AM, 10AM - 3PM, 7PM - 12AM	Personal Mobility on Demand	NA	NA	NA	NA	$60,484	$91,643	$5.00	$5.00
	6AM - 10AM & 3PM - 7PM	On-Demand/ Flexible - Microtransit	$84.68	$172,747	$8,160	$10,934	$164,587	$161,813	$20.17	$14.80
		Total					$225,071	$253,455	$11.11	$8.66

5.1.4 Recommended Mode Alternatives

This section provides a summary of the two mobility mode alternatives that are recommended for pilot projects. The two recommended services are described in Table 5.4.

Table 5.4 Recommended Services

SERVICE	DESCRIPTION
On-Demand/Flexible Microtransit	▪ Route is based entirely on customer demand ▪ Customer pickups are based on customer requests through an online/mobile app or a customer call center ▪ Suited to service areas that lack a strong linear transit corridor and that have dispersed trip origins and destinations
Personal Mobility on Demand (PMoD)	▪ Is a low-capacity service designed for individuals and small groups (up to five persons) traveling between various origins and destinations. ▪ Is located along a dynamic itinerary formed in response to customer reservations. ▪ Like microtransit, reservations are made through an online/mobile application or a call center. ▪ The key advantage of PMoD is the cost structure based on service consumed (i.e., fixed subsidy per ride) versus cost based on hours of service provided (i.e., cost per revenue hour). This means that service coverage can be provide at off-peak periods, such as early mornings and evenings, at a far lower cost that other modes including fixed-route and paratransit service. ▪ Highly convenient and responsive to customer needs because PMoD is customer demand driven.

5.2 Evaluation of Active Transportation Improvements

While there are a number of new bikeways planned with the East San Gabriel Valley, an assessment of existing conditions in the area found that the current network is fragmented. There are opportunities to close the gaps within the existing and planned network and provide a more continuous network for both bicyclists and pedestrians by including improvements for all non-vehicular users.

As noted in the previous section evaluating transit service alternatives, evaluation of potential corridors for active transportation improvements was conducted using the same evaluation metrics, implementation considerations, and evaluation criteria.

The project team also considered any planned infrastructure according to the Los Angeles County Bicycle Master Plan (2012), East San Gabriel Valley Active Transportation Plan (2019), and the San Gabriel Valley Greenway Network initiative.

Additionally, the team reviewed considerations such as areas with a high number of bicycle or pedestrian collisions, areas with disadvantaged community status, high densities of population/employment/seniors/youth/households without access to a car, areas nearby transit/high quality transit areas or key destinations/community nodes, and nearby planned land use changes and proposed growth areas identified as part of the East San Gabriel Valley Area Plan.

5.2.1 Summary of Proposed Corridors for Improvement

The project team identified a total of 72 corridors for active transportation infrastructure improvement within the unincorporated ESGV. Of these, 46 corridors (highlighted in green in the table below) are either new recommendations or recommendations to upgrade the infrastructure currently proposed by the County. The other 25 corridors were recommendations carried over from the ESGV Active Transportation Plan, completed by Public Works in 2019.

As described in the California Department of Transportation (Caltrans) Highway Design Manual (HDM), bikeways are categorized into four classes. The table below describes each of the four facility types as well as conditions and locations where they are most appropriate. These bikeway types were applied in the list of proposed bikeways displayed in Figure 6.4 and described in Table 5.5.

Table 5.5 Bikeway Classes

CLASS	DESCRIPTION	SITING
Class I (Bike Path or Shared-Use Path)	An off-street bikeway that provides a completely separate right of way for the exclusive use of bicycle and pedestrians with minimal cross-flow.	These are commonly installed along riverbeds, along shorelines, utility or railroad rights-of-way, within school campuses or parks. They often support recreational and commute travel. The state design standard recommends a minimum 8-foot-wide paved path plus a 2 foot wide shoulder.
Class II (Bike Lane or Buffered Bike Lane)	An on-street bikeway that provides a striped lane for one-way bike travel on a street or highway. A buffered bikeway provides greater separation from an adjacent traffic lane on streets with higher speeds by using chevron or diagonal markings.	These are installed alongside vehicle traffic lanes to designate bike travel. The HDM Mandatory Standard requires a minimum width of 4 feet, 5 feet when adjacent on-street parking, and 6 feet when posted speeds are greater than 40 miles per hour.

CLASS	DESCRIPTION	SITING
Class III (Bike Route or Greenway)	A signed, shared roadway that provides for shared use with pedestrians or motor vehicle traffic. A bike route has signs posted identifying it as a bike route and may have shared lane markings (sharrows). Greenways are shared roadways that prioritize bicycle travel for people of all ages and abilities.	Bike routes are appropriate for roadways with lower traffic speeds and volumes. Greenways are best sited on streets without large truck or transit vehicles, and where low traffic volumes and speeds can be further reduced through traffic calming measures.
Class IV (Separated Bikeway or Cycle Track)	An on-street bikeway for the exclusive use of bicycles, requiring a separation via a vertical feature between the bikeway and the through vehicular traffic.	These are appropriate along roadways where features such as on-street parking can provide physical separation or other vertical features such as grade separation, flexible posts, or inflexible physical barriers can be installed.

The map below presents the locations of all 72 corridors. The locations of these corridors help to address gaps in the current network, and also align generally with areas with high concentrations of youth, disadvantaged communities, and households without access to a car. These populations are most likely to travel by active transportation and would benefit from improvements to bicycle and pedestrian infrastructure. To show the corridors' potential connectivity to transit, the map also displays both a half-mile and a three-mile radius around the high-quality transit stops and corridors in the study area, as defined by SCAG[6]. The half-mile radius represents the typical maximum walking distance for people to access a transit stop, while the three-mile radius represents the corresponding maximum radius for bicycle travel to a transit stop.

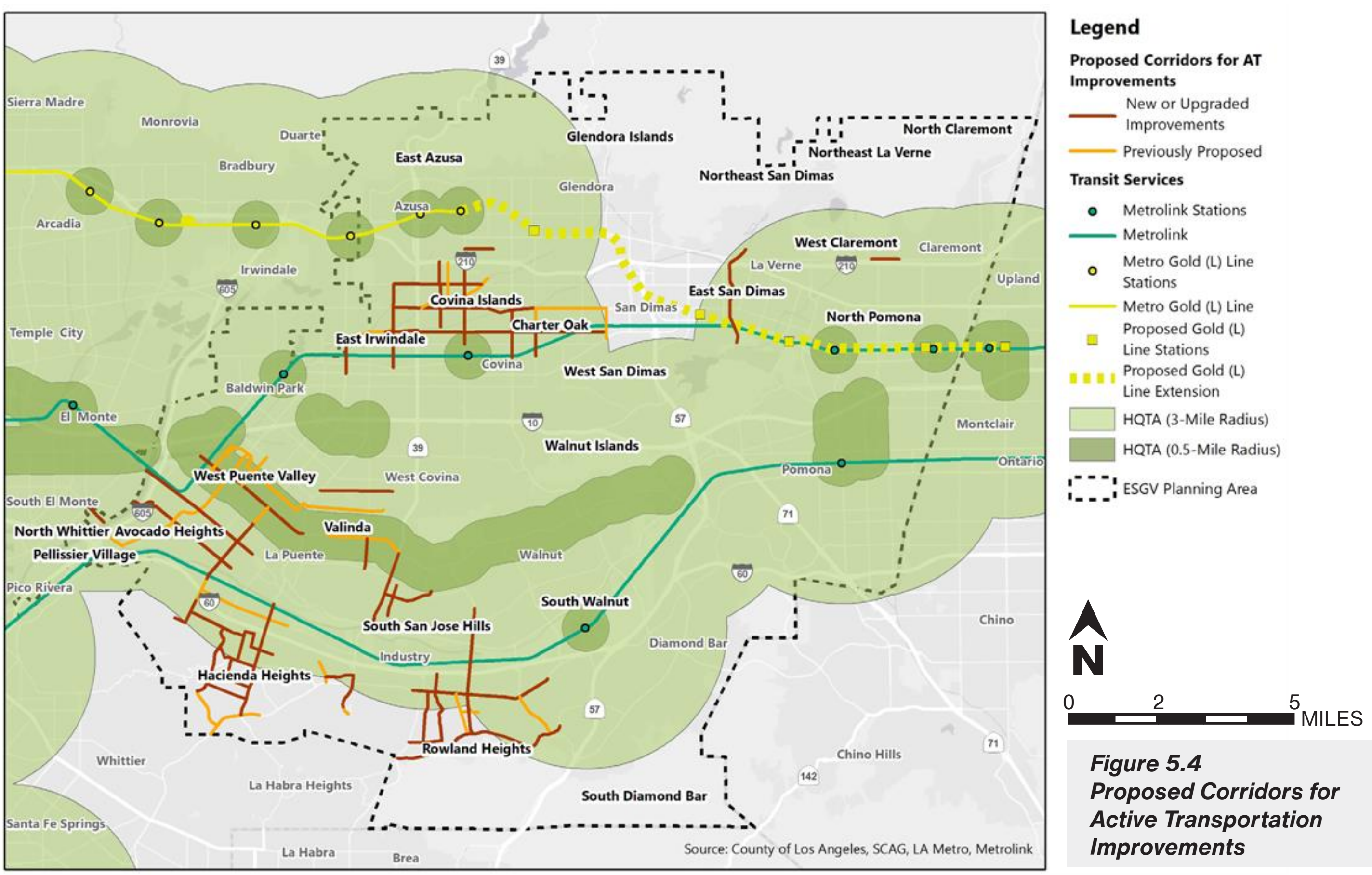


Figure 5.4
Proposed Corridors for Active Transportation Improvements

Table 5.6 presents a detailed list of each of the corridor segments, along with a description of the recommended bicycle and/or pedestrian improvements.

Table 5 Proposed Active Transportation Improvements

ID	CORRIDOR	FROM	TO	UNINCORPORATED AREA	PREVIOUSLY PROPOSED		NEW PROPOSED IMPROVEMENT
					TYPE	SOURCE	
1	7th Ave	Clark Ave	Palm Ave	Hacienda Heights	Class IV	East San Gabriel Valley ATP (2019)	Class IV
2	7th Ave	Palm Ave	Orange Grove Ave	Hacienda Heights	Class III	East San Gabriel Valley ATP (2019)	Greenway
3	7th Ave/ Sunset Ave	Temple Ave	Clark Ave	Avocado Heights			Class II or IV (through industrial areas)
4	Aguiro St	Fullerton Rd	Los Padres Dr	Rowland Heights	Class III	East San Gabriel Valley ATP (2019)	Greenway
5	Amar Rd	Baldwin Park Blvd	Hacienda Blvd	West Puente Valley	Class II between Baldwin Park Blvd and Unruh Ave	LA County Public Works	Class II & ped improvements
6	Amar Rd	Alieron Ave	Azusa Ave	Valinda	Class II & ped improvements	East San Gabriel Valley ATP (2019)	Class II & ped improvements
7	Angelcrest Dr	Newton Ave	La Subida Dr	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Greenway
8	Arrow Hwy	Glendora Ave	Valley Center Ave	Charter Oak	Class IV & ped improvements	East San Gabriel Valley ATP (2019)	Class IV & ped improvements
9	Arrow Hwy	Azusa Ave	Glendora Ave	Covina Islands and Charter Oak			Class II buffered bike lane or Class IV & ped improvements
10	Arrow Hwy	Lark Ellen Ave	Azusa Ave	East Irwindale			Class II
11	Azusa Ave	Amar Rd	San Jose Creek Proposed Bicycle Path	South San Jose Hills			Class IV protected bikeway & ped improvements
12	Azusa Ave	Pepperbrook Way	Glenfold Dr	Hacienda Heights	Class IV between Colima and Glenfold Dr	East San Gabriel Valley ATP (2019)	Class IV & ped improvements
13	Azusa Ave	Glenfold Dr	Tomich Rd	Hacienda Heights	Class III	East San Gabriel Valley ATP (2019)	Class III

[6] High quality transit areas (HQTA) are areas within one-half mile from major transit stops and high quality transit corridors and developed based on the language in SB375. A major transit stop is a site containing an existing rail transit station, or the intersection of two or more major bus routes with a frequency of service interval of 15 minutes or less during the morning and afternoon peak commute periods (CA Public Resource Code Section 21064.3). High-Quality Transit Corridor (HQTC) have a fixed route bus service with service intervals no longer than 15 minutes during peak commute hours.

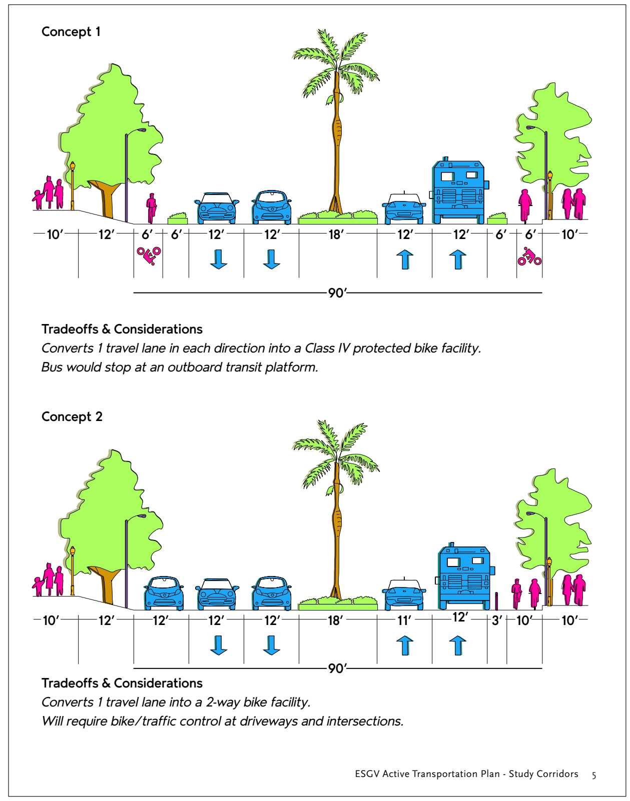
ID	CORRIDOR	FROM	TO	UNINCORPORATED AREA	PREVIOUSLY PROPOSED		NEW PROPOSED IMPROVEMENT
					TYPE	SOURCE	
14	Base Line Rd	Webb Canyon Rd	Mountain Ave	West Claremont			Class IV & ped improvements
15	Batson Ave	Colima Rd	Aguiro St	Rowland Heights	Class III	East San Gabriel Valley ATP (2019)	Greenway
16	Big Dalton Wash	Barranca Ave	Arrow Hwy	Covina Islands	Class I	East San Gabriel Valley ATP (2019)	Class I
17	Big Dalton Wash	Irwindale Ave	Lark Ellen Dr	East Irwindale	Class I	East San Gabriel Valley ATP (2019)	Class I
18	Brea Canyon Cut Off Rd	Balan Rd	Pathfinder Rd	Rowland Heights	Class III & ped improvements	East San Gabriel Valley ATP (2019)	Class III & ped improvements
19	Camino del Sur	Vallecito Dr	Colima Rd	Hacienda Heights	Class IV	East San Gabriel Valley ATP (2019)	Class IV
20	Citrus Ave	I-210	Cypress St	Covina Islands			Class IV & ped improvements
21	Colima Rd	Larkvane Rd	Tierra Luna	Rowland Heights	Class II buffered bike lane	East San Gabriel Valley ATP (2019)	Class IV & ped improvements
22	Colima Rd	Hacienda Blvd	Allenton Ave	Hacienda Heights	Class IV & ped improvements	East San Gabriel Valley ATP (2019)	Class IV & ped improvements
23	Colima Rd	Arroyo San Miguel Open Space Preserve	Hacienda Blvd	Hacienda Heights	Class IV & ped improvements	East San Gabriel Valley ATP (2019)	Class IV & ped improvements
24	Countrywood Ave	Wedgeworth Dr	Colima Rd	Hacienda Heights	Class II	East San Gabriel Valley ATP (2019)	Class II
25	Covina Blvd	Citrus Ave	Valley Center Ave	Charter Oak			Ped improvements
26	Covina Blvd	Big Dalton Wash	Citrus Ave	Covina Islands			Class IV & ped improvements
27	Don Julian Rd	San Gabriel River Trail	Puente Creek Proposed Bicycle Path	Avocado Heights			Greenway
28	Fairway Dr/ Brea Canyon Cut Off Rd	Colima Rd	Balan Rd	Rowland Heights	Class II & ped improvements	East San Gabriel Valley ATP (2019)	Class II & ped improvements
29	Farmstead Ave	Three Palms St	Lujon St	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Greenway
30	Francisquito Ave	Hacienda Blvd	Lark Ellen Ave	Valinda			Greenway
31	Gale Ave	7th Ave	Stimson Ave	Hacienda Heights	Class II & ped improvements	East San Gabriel Valley ATP (2019)	Class II & ped improvements

ID	CORRIDOR	FROM	TO	UNINCORPORATED AREA	PREVIOUSLY PROPOSED		NEW PROPOSED IMPROVEMENT
					TYPE	SOURCE	
32	Gemini St	Azusa Ave	Shadow Oak Dr	South San Jose Hills			Greenway
33	Gladstone St	Vernon Ave	Big Dalton Wash	Covina Islands			Class IV & ped improvements
34	Glendora Ave	Cienega Ave	Wingate St	Charter Oak			Class II & ped improvements
35	Glendora Ave	Arrow Hwy	Cienega Ave	Charter Oak	Class II & ped improvements	East San Gabriel Valley ATP (2019)	Class II & ped improvements
36	Grand Ave	Arrow Hwy	Wingate St	Charter Oak			Class II or IV & ped improvements
37	Hacienda Blvd	San Jose Creek	Colima Rd	Hacienda Heights	Class II	LA County Bicycle Master Plan (2012)	Class II buffered bike lane or Class IV & ped improvements
38	Hollenbeck Ave/Cerritos Ave	I-210	San Dimas Wash	Covina Islands			Class II & ped improvements
39	Irwindale Ave	Big Dalton Wash	Badillo St	East Irwindale	Class III & ped improvements	East San Gabriel Valley ATP (2019)	Class II & ped improvements
40	Jellick Dr/Los Padres Dr	Greenbay Dr	Aguiro St	Rowland Heights	Class III & ped improvements	East San Gabriel Valley ATP (2019)	Class III & ped improvements
41	Killian Ave/ Honore St	Paso Real Ave	Otterbien Ave	Rowland Heights	Class III & ped improvements	East San Gabriel Valley ATP (2019)	Class III & ped improvements
42	Kwis Ave	Three Palms Ave	Newton St	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Class II
43	La Subida Dr	Vallecito Dr	Hacienda Blvd	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Class II
44	Lark Ellen Ave	San Bernardino Rd	Gladstone St	East Irwindale	Class III (between Arrow Hwy and Big Dalton Wash)	East San Gabriel Valley ATP (2019)	Class II or IV & ped improvements
45	Las Lomitas Dr/Newton St	Vallecito Dr	Hacienda Blvd	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Class II
46	Los Altos Dr	Vallecito Dr	Hacienda Blvd	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Class II
47	Los Padres Dr/ Jellick Ave	Aguiro St	Greenbay Dr	Rowland Heights			Greenway
48	Los Robles Ave	7th Ave	Kwis Ave	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Class II

ID	CORRIDOR	FROM	TO	UNINCORPORATED AREA	PREVIOUSLY PROPOSED		NEW PROPOSED IMPROVEMENT
					TYPE	SOURCE	
49	Lujon St	Farmstead Ave	Stimson Ave	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Class II
50	Mauna Loa Ave	Citrus Ave	La Serena Dr	Covina Islands	Class III	East San Gabriel Valley ATP (2019)	Greenway
51	Nogales St	Arenth Ave/ San Jose Creek	Pathfinder Rd	Rowland Heights			Class IV & ped improvements
52	Nogales St	Amanda St	Arenth Ave/ San Jose Creek	South San Jose Hills			Class IV & ped improvements
53	Orange Grove Ave	7th Ave	Beech Hill Ave	Hacienda Heights	Class III	East San Gabriel Valley ATP (2019)	Greenway
54	Paso Real Ave	Colima Rd	Pathfinder Rd	Rowland Heights	Class III	East San Gabriel Valley ATP (2019)	Class III
55	Pathfinder Rd	Fullerton Rd	Canyon Ridge Rd	Rowland Heights	Class II	LA County Bicycle Master Plan (2012)	Class IV
56	Pepper Brook Way	Countrywood Ave	Azusa Ave	Hacienda Heights			Greenway
57	Puente Ave	Barrydale St	Valley Blvd	West Puente Valley	Class II	East San Gabriel Valley ATP (2019)	Class II
58	Puente Ave/ Workman Mill Rd	Valley Blvd	San Jose Creek Proposed Bicycle Path	West Puente Valley	Class IV	East San Gabriel Valley ATP (2019)	Class IV
59	Rath Ave/ Stichman Ave/ Barrydale Ave/ Fairgrove Ave/ Maplegrove Dr	Vineland Ave	Lark Ellen Ave	West Puente Valley	Class III & ped improvements	East San Gabriel Valley ATP (2019)	Class III & ped improvements
60	Riverbed between San Dimas Canyon & Ramona	Los Encinos Park	Puddingstone Dr	East San Dimas			Class I
61	Rockvale Ave	I-210	Woodcroft St	Covina Islands	Class III	East San Gabriel Valley ATP (2019)	Class III
62	Rush St	Durfee Ave	San Gabriel River Trail	South El Monte Island			Class II
63	San Jose Creek	San Gabriel River Trail	Workman Mill Rd	Unincorporated North Whittier/Pellisier Village	Class I	East San Gabriel Valley ATP (2019)	Class I
64	Sandalwood Ave	Winton Ave	Salais St	South San Jose Hills			Greenway

ID	CORRIDOR	FROM	TO	UNINCORPORATED AREA	PREVIOUSLY PROPOSED		NEW PROPOSED IMPROVEMENT
					TYPE	SOURCE	
65	Sunset Ave	Amar Rd	Temple Ave	West Puente Valley	Class II	East San Gabriel Valley ATP (2019)	Class II
66	Three Palms St	Kwis Avenue	Farmstead Ave	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Greenway
67	Valinda Ave	Amar Rd	Temple Ave	Valinda			Class II & ped improvements
68	Vallecito Dr	Los Robles Ave	Camino del Sur	Hacienda Heights	Class III	LA County Bicycle Master Plan (2012)	Class II
69	Valley Blvd	San Gabriel River Trail	Puente Creek Proposed Bicycle Path	Avocado Heights			
70	Valley Center Ave	Arrow Hwy	Badillo St	Charter Oak	Class II	East San Gabriel Valley ATP (2019)	Class II
71	Vineland Ave	Walnut Creek	Temple Ave	West Puente Valley	Class III	East San Gabriel Valley ATP (2019)	Class III
72	Willow Ave	Francisquito Ave	Amar Rd	West Puente Valley	Class III & ped improvements	East San Gabriel Valley ATP (2019)	Class III & ped improvements

5.3 Complete Streets and Green Streets



The concept of a Complete Street is a street that is safe and accessible for all users: pedestrians, bicyclists, transit users, and motor vehicle drivers. Complete Streets accommodate people of all ages and abilities. To take this concept further, Green Streets, specifically, prioritize active transportation users. Through a variety of design and operational treatments, a Green Street is a street that gives priority to bicycle and pedestrian circulation and open space over other transportation uses. This may include sidewalk widening, clearly-marked bikeways, landscaping, traffic calming, and other pedestrian-oriented features.

Out of the 46 corridors proposed for new or upgraded active transportation improvements, 12 were selected for further study, based on whether the corridors were suited for more extensive overhauls using complete street and green street design. The intent is to provide visual representations of recommended improvements to visualize what the proposed corridors could look like once recommendations are implemented. The methodology for selecting these corridors included the following:

1. Select the corridors with both bicycle and pedestrian recommendations proposed.
2. From that list, select the corridors proposed as either a Class I shared-use path, Class III greenway, or Class IV separated bikeway.
3. Select 12 of those corridors based on the following qualitative criteria:
    - General opportunities for Complete Street improvements (width, bus interface, commercial corridor, modes, etc.)
    - Opportunity for greening (area for bioswales, bulb-outs, trees, permeable paving, etc.)
    - Nearby destinations (if the corridor is notable or important due to destinations around it)
    - Nearby transit stops (if the corridor serves transit)
    - Regional connector (if the corridor provides connections regionally)
    - Geographic coverage (to ensure the corridors represent various parts of the county)
    - Project Type Diversity (to ensure the corridor drawings represent various types of improvements)
    - Equity Considerations (to ensure the corridors selected include representation of neighborhoods that need improvements the most)

Based on the above methodology, the following 12 corridors were selected:

CORRIDOR	FROM	TO	COMMUNITY
Azusa Ave	Amar Rd.	San Jose Creek Proposed Bicycle Path	South San Jose Hills
Colima Rd.	Larkvane Rd.	Tierra Luna	Rowland Heights
Hacienda Blvd/ Colima Rd	San Jose Creek	Arroyo San Miguel Trail Head	Hacienda Heights

CORRIDOR	FROM	TO	COMMUNITY
Arrow Hwy	Azusa Ave.	Glendora Ave.	Covina Islands/ Charter Oak
Citrus Ave	I-210	Cypress St.	Covina Islands
Don Julian Rd	San Gabriel River Trail	Puente Creek Proposed Bicycle Path	Avocado Heights
Grand Ave	Arrow Hwy	Wingate St	Charter Oak
Covina Blvd	Big Dalton Wash	Citrus Ave.	Covina Islands
Batson Ave.	Colima Rd.	Aguiro St.	Rowland Heights
Nogales St.	Amanda St.	Arenth Ave/San Jose Creek	South San Jose Hills
Lark Ellen Ave.	San Bernardino Rd.	Gladstone St.	East Irwindale
Gemini St.	Azusa Ave.	Shadow Oak Dr	South San Jose Hills

The goal of this analysis was to select corridors for study that offered regional connectivity to commercial areas and nearby destinations and/or transit, corridors that traveled through neighborhoods with lower Disadvantaged Communities or CalEnviroScreen scores, and corridors that showed promise from a street improvement perspective because they were missing many of the elements that would make them green, pleasant, and multi-modal.

5.4 Vignettes and Renderings

This section presents recommended streetscape enhancements along the 12 corridors selected above. While not prescriptive in nature, these illustrations show how these corridors (and others like them) can be better designed to accommodate all roadway users, including people walking, biking, and rolling. The goal is to make a full network of streets available to active transportation users, by ensuring that streets that are safe, more pleasant to be on, and easier to navigate. On streets with high vehicular volumes, this could mean reallocating roadway space to protected and buffered bicycle facilities. On neighborhoods streets, this could mean adding “Greenway” enhancements, like small traffic circles or slow speed signage and infrastructure that benefits people walking and rolling along the street.

Recommendations are not exhaustive and are conceptual in nature, without survey or utility analysis. For each study corridor, a set of possible improvements is outlined. Actual design and layout may vary from block to block and will need to be designed. Dimensions shown are approximate. The goal of the document is to showcase a set of improvement types that can be used throughout the ESGV to improve connectivity and access for active transportation users.

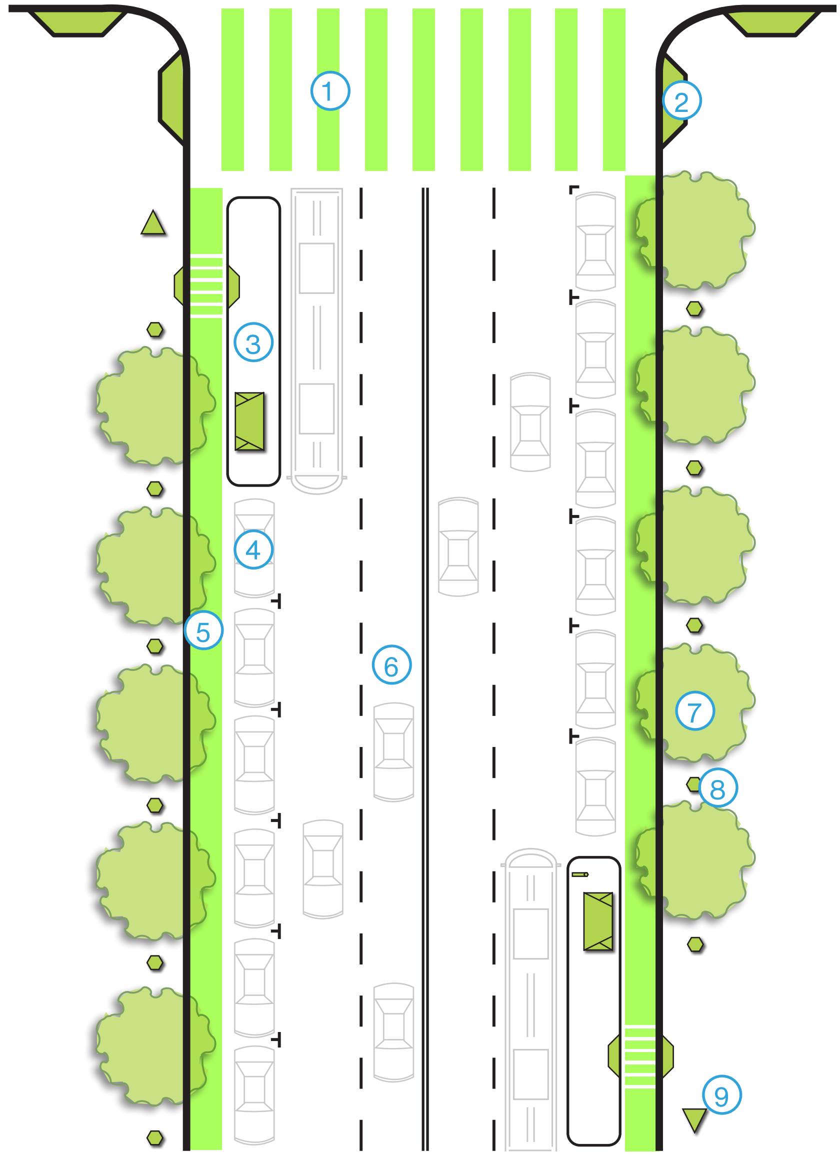
Improving Wide Arterials

Example Streets:*
Azusa Hwy, Colima Rd, Hacienda Rd, Arrow Hwy, Citrus Ave, Covina Blvd, and Nogales St.

Typical Conditions (Before):
Existing arterials are often busy and feel unsafe for people walking and biking due to their wide right-of-way, swiftly moving vehicles, limited sidewalk space, infrequent pedestrian amenities (like trees and sidewalk lighting), and long blocks.

Improvements Recommended:
Protected bicycle facilities can be added, including bicycle lanes that are protected behind vertical bollards or tucked in between the parking lane and the curb. For streets with buses, bus stops can be placed outboard of the bicycle lane, on platforms with bus shelters, real-time signage, and seating (see diagram, right). In addition, sidewalks are enhanced with trees and landscaping, pedestrian lighting, and wayfinding signage that is oriented to people walking and biking. Sidewalks can be widened where possible. The number of travel lanes may be reduced and/or narrowed to accommodate these improvements.

* *Each street may not accommodate all of the proposed enhancements. Detailed design work would need to be completed to evaluate the most appropriate treatments for each street. The ideas included here showcase a range of possible improvements.*



1. High visibility crosswalk
2. Dual curb ramps
3. Outboard bus platform
4. Outboard parking
5. Bike lane color
6. Reduced lane/lane width
7. Trees and planting
8. Pedestrian lights
9. Wayfinding signage

Typical Conditions (Before)

Improvements Recommended

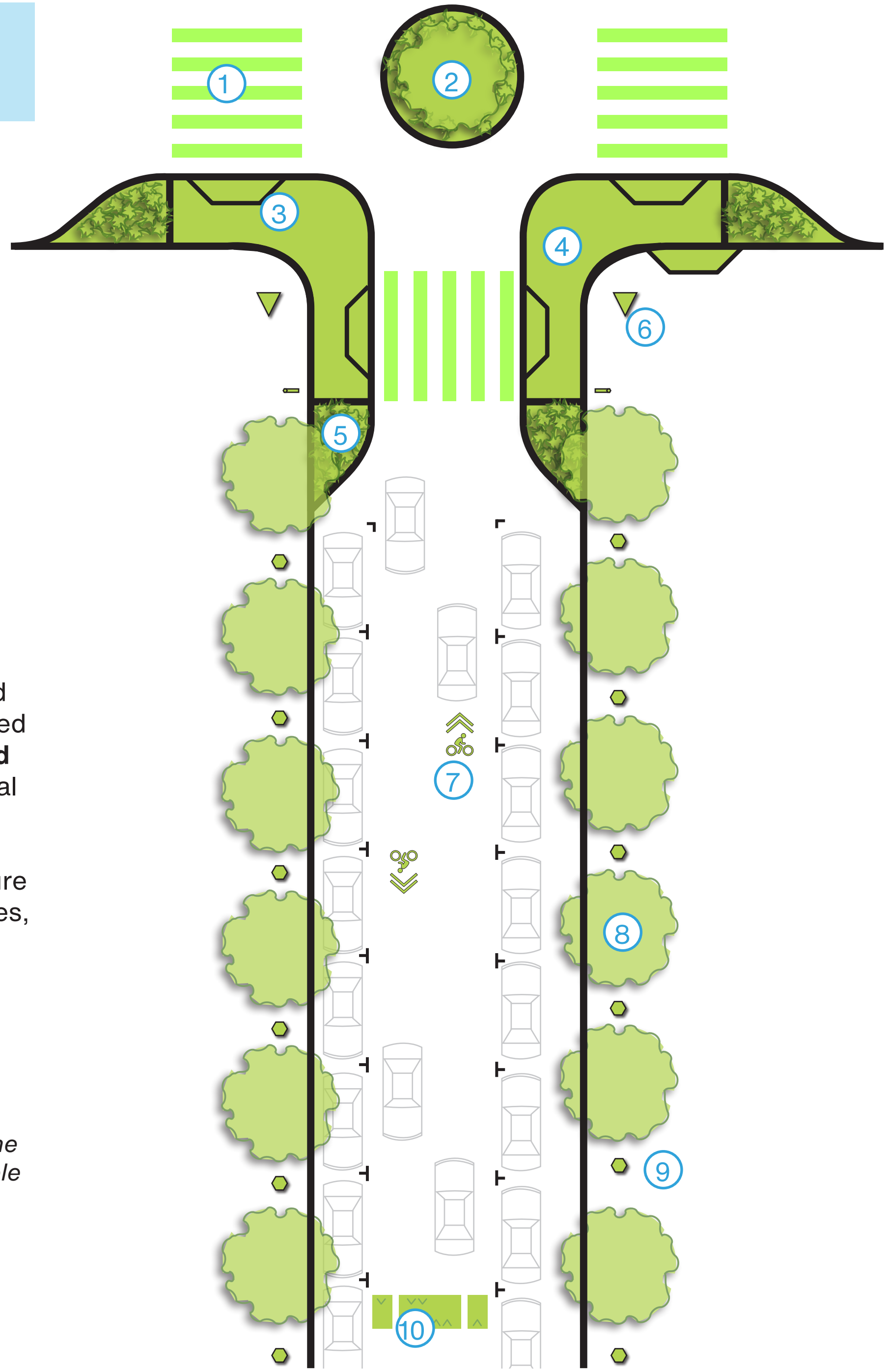
Improving Neighborhood Streets

Example Streets:*
Batson Ave, Don Julian Rd, and Gemini St.

Typical Conditions (Before):
While existing neighborhood streets tend to have less vehicular traffic and are generally more comfortable for people walking and biking, compared to wide arterials in the San Gabriel Valley, neighborhood streets can be further enhanced for comfort and safety. Typical neighborhood streets are 3-4 lanes wide, often with parking. Some streets have sidewalks and others do not. Blocks can be long and tree cover is spotty.

Improvements Recommended:
Neighborhood streets can be enhanced for people walking and biking, and transformed into Neighborhood Greenways. **Neighborhood Greenways** are low traffic, primarily residential streets that are enhanced with trees and landscaping, pedestrian lighting, wayfinding signage, slow speed signage and infrastructure (such as speed humps, traffic circles, chicanes, and splitter islands), sharrow markings, and crossing enhancements (e.g. crosswalks and corner bulb-outs)

* *Each street may not accommodate all of the proposed enhancements. Detailed design work would need to be completed to evaluate the most appropriate treatments for each street. The ideas included here showcase a range of possible improvements.*



1. High visibility crosswalk
2. Traffic circle
3. Dual curb ramps
4. Corner bulb-outs
5. Bioswales/greening
6. Wayfinding signage
7. Sharrow markings
8. Shade trees
9. Pedestrian lights
10. Speed humps

Typical Conditions (Before)

Improvements Recommended

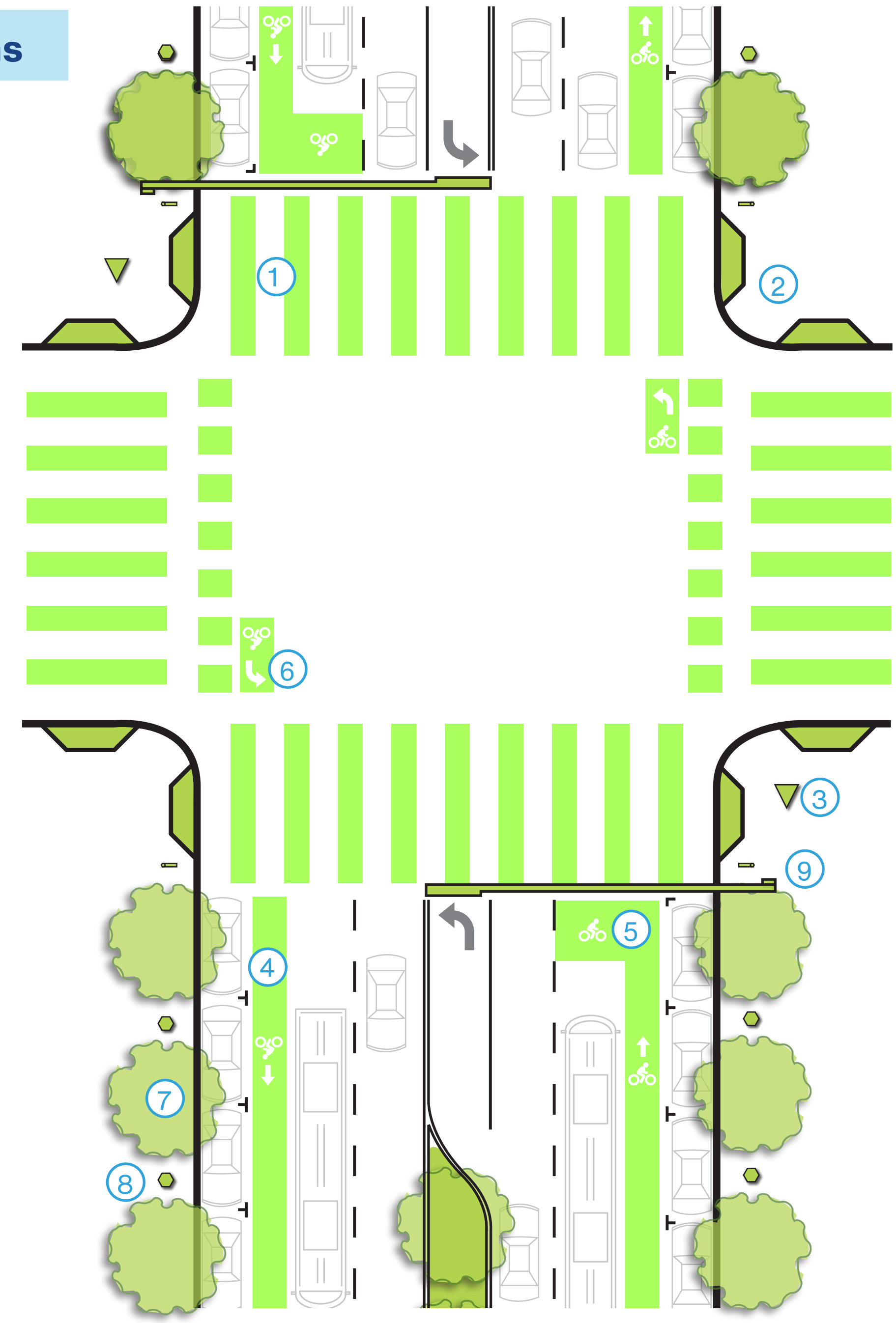
Improving Wide Intersections

Example Streets:*
Azusa Hwy, Colima Rd, Hacienda Rd, Arrow Hwy, Citrus Ave, Covina Blvd, and Nogales St.

Typical Conditions (Before):
When two wide and busy arterials intersect, the crossing experience for people on foot or on bike can be challenging. Traffic is quickly moving, crossing times can be difficult for people who need more time or are in wheelchairs, and crossing on a bike can be difficult.

Improvements Recommended:
Bike boxes at intersections can be added, along with two-stage queue left turn boxes. These improvements make it easier for people riding bikes, to cross the street as well as turn left. For pedestrians, enhancements such as high-visibility crosswalks, leading pedestrian intervals (LPIs), trees and landscaping, pedestrian lighting, and wayfinding signage, can be added.

* *Each street may not accommodate all of the proposed enhancements. Detailed design work would need to be completed to evaluate the most appropriate treatments for each street. The ideas included here showcase a range of possible improvements.*



1. High visibility crosswalk
2. Dual curb ramps
3. Wayfinding signage
4. Bike lane color
5. Bike box
6. Two-stage left turn box
7. Trees and planting
8. Pedestrian lights
9. Leading pedestrian interval (LPI)

Typical Conditions (Before)

Improvements Recommended

6

POLICY RECOMMENDATIONS

6. POLICY RECOMMENDATIONS

The policies recommended for the MAP are responsive to the technical analysis completed over the course of the project and meet at least one of the following three primary criteria:

1. They address mobility gaps and needs as defined in the technical analysis.
2. They are broadly consistent with the regional or state-level goals of partner agencies and may support the County's pursuit of funding for mobility improvements.
3. They are an innovation proven elsewhere that is not currently implemented in the ESGV.

The policies recommended for the ESGV MAP are:

- **Policy 1:** Prioritize connections to food systems, health care facilities, parks, and other locations that support public well-being.
- **Policy 2:** Prioritize mobility improvements that link transit, schools, parks, and other key destinations in the community.
- **Policy 3:** Utilize technology to implement more flexible transportation options that supplement existing service or address gaps in the existing network.
- **Policy 4:** Incorporate sustainable design components into street treatments that increase safety for pedestrians, bicyclists, and sensitive groups such as youth and older adults while supporting environmental stewardship.
- **Policy 5:** Implement and connect safe bicycle- and pedestrian-friendly streets, sidewalks, paths and trails that promote active transportation and transit use.
- **Policy 6:** Reduce car dependency by supporting the implementation of safe and convenient active transportation infrastructure that connects with and compliments the transit network.
- **Policy 7:** Support integrated land use and transportation planning to support a more sustainable and multimodal East San Gabriel Valley.
- **Policy 8:** Support mode shift to lower- or zero-emission travel modes that can balance increased emissions that may derive from increased travel/mobility.
- **Policy 9:** Identify locations for innovative traffic safety features or pilot programs that support safety, accessibility, and sustainability.
- **Policy 10:** Address inequities created by a history of car-centric design in the ESGV by prioritizing the mobility and safety needs of priority populations such as youth, older adults, zero car households, and residents living in areas with environmental justice concerns.
- **Policy 11:** Address real and perceived safety concerns to encourage walking and rolling, and identify barriers to walking and rolling in unincorporated areas.

7

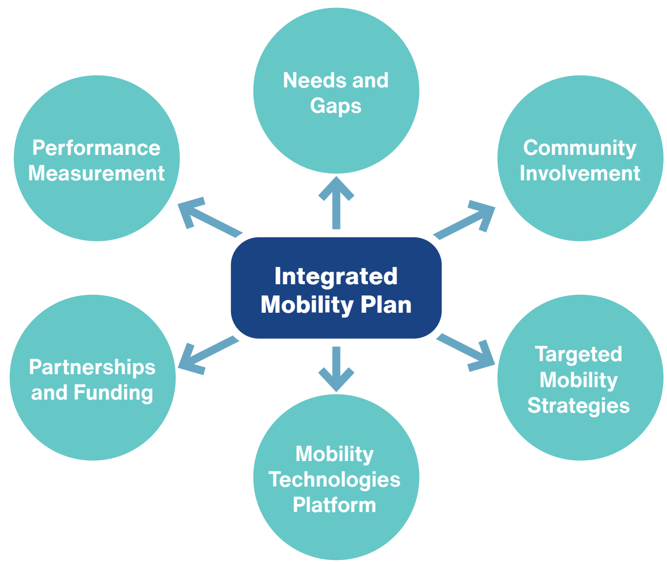
IMPLEMENTATION

Photo Credit: ACTIVESGV

7. IMPLEMENTATION

7.1 Next Steps: Mobility Plan

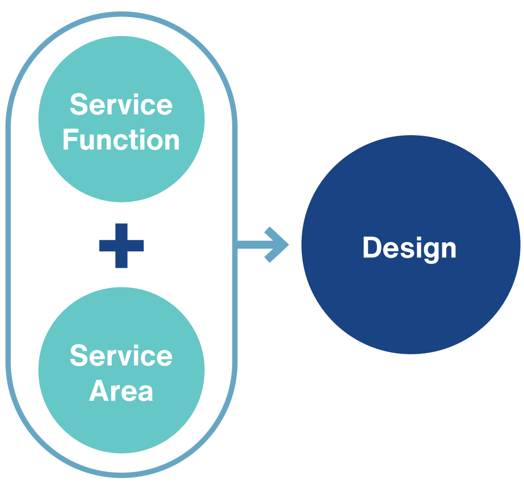
The recommendations (integrated mobility solutions) provide the foundation for the Mobility Action Plan.



7.1.1 Implementation of Mobility Alternatives

The foregoing analysis is based on preliminary service planning assumptions and intended for planning and comparative purposes. Further service planning will be required as a next step to refine operational parameters, develop run-cutting, confirm fleet requirements, and improve operations and maintenance cost forecasts. There are also service optimization opportunities, such as sharing vehicles among the select pilot areas during off-peak periods, which were beyond the scope of this analysis. Coordination with future fixed-route scheduling, to facilitate convenient transfers at transit connection hubs, is another future consideration.

It is anticipated that service plan refinement will also involve further engagement of external stakeholders to fine-tune service delivery, adjust service area boundaries or service routing, and finalize hours of service and fare policy.



Further community engagement may also identify business partnership opportunities to support service deployment or to address specific needs. Such partnerships may have an impact on service plan development, fleet requirements, etc.

User comprehension is an important element of the success of new mobility options. This includes where it goes, how to use the service, and what to pay. Adjustments to service area boundaries to ensure user comprehension (e.g., alignment with political boundaries, inclusion of local landmarks) is likely to be a topic of ongoing discussion with community stakeholders.

Finally, an initial service plan launch should be revisited based on community response. Realized customer demand after the service launch will merit a re-evaluation of service levels within each deployment zone, including coverage, frequency, service span, etc.). Should customer response be less than initially anticipated, the County may wish to make clear to external stakeholders that it reserves the right to redeploy resources to more productive uses.

7.1.2 Operational and Organizational Readiness

As a new mode, implementation of the mobility alternatives will require organizational/staffing capacity, development of policies and standard operating procedures, process re-engineering, and training. These changes will impact senior management, support departments, and front-line customer service personnel including drivers.

An important aspect of organizational change is establishment of a call center function to support customer trip requests and other questions or concerns.[4]

Modal integration is another consideration to ensure that new mobility alternatives are integrated appropriately with fixed route and paratransit operations at transit connection hubs for the convenience and safety of transferring passengers.

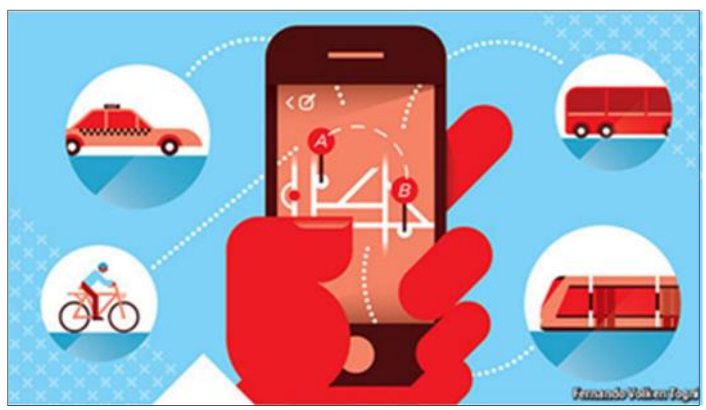
7.1.3 Marketing and Branding

As a new service offering, it is important to consider the branding, marketing, and roll-out of the new mobility services.

Several peer agencies have opted to create a unique sub-brand for their mobility services, to create a more visible brand presence and to generate interest around the new service. That said, it is important to communicate that any new service offerings are an integral part of the overall transit network.

User awareness and training is a key aspect of a successful launch. Existing and potential customers must understand what the service is, where it goes, and how to use it. Customers must also be familiarized with the technology tools that support the service, as well as the options available to them if they cannot access those tools.

7.1.4 Technology Procurement and Implementation



As a technology-enabled mode, the new mobility experience is highly dependent on the quality and functionality of technology systems.

Project partners have experience with advanced technology implementation for fixed route and microtransit services; a lesson learned is the significant amount of time and effort that is required to ensure successful technology implementation that meets the operational requirements of the system and the expectations of increasingly tech-savvy customers.

The following are technology systems that will be required to support new mobility implementation:

- Trip planning/trip discovery application and/or integration with enterprise systems
- Mobility dispatch and operations management system
- Customer reservations/trip booking system
- Customer service/call center reservations support system
- Fare system integration and/or mobile or in-app fare payment options.

[4] The cost center functionality may be incorporated in the PMod and/or microtransit contractor procurement. Other options for a call center may include incorporating in an existing call center service (e.g.. Foothill Transit, existing Dial-a-Ride operation, etc.)

7.1.5 PMoD and Microtransit Operator Procurement

Both PMoD and microtransit service deployment are envisioned as contract-operated services. PMoD payment will be based on service consumed, not hours of service provided. Conversely, the delivery of on-demand/flexible microtransit service will be based on an hourly rate.

It is assumed that both PMoD and microtransit service operation will be through a competitive procurement process. There is an increasing body of transit agency experience with procurement, contracting, and performance monitoring for PMoD and microtransit services.

7.2 Funding Opportunities

Potential funding sources for the implementation of mobility improvements in the ESGV include a mixture of Federal, State, and local sources. The matrix presented below as Table 7.1 provides an overview of the various funding sources currently available, a high-level description of the grant/funding source requirements, and discussion of the types or projects and/or project phases that are eligible for funding under each program.

Table 7.1: Funding Sources

FUNDING SOURCE	PROGRAM PURPOSE
Federal Programs	
Surface Transportation Block Grants – Transportation Alternatives (STBG-TA)	Creates long-term funding for surface transportation, focusing on smaller scale transportation projects, including pedestrian and bicycle facilities, recreational trails and Safe Routes to School projects.
Highway Safety Improvement Program (HSIP)	Helps fund projects that reduce fatalities and serious injuries on all public roads.
Congestion Mitigation and Air Quality Improvement Grant (CMAQ)	Federal initiative that supports a range of projects aimed at reducing transportation-related air emissions in air quality nonattainment areas.
Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Transportation Discretionary Grant	Previously known as the TIGER and BUILD programs, the RAISE Discretionary Grant Program funds nearly $10 billion over thirteen rounds of investment in projects with significant local or regional impact.
Land and Water Conservation Fund (LWCF)	Originally established in 1964 by President Lyndon B. Johnson, the annual LWCF program provides federal support for the acquisition and development of outdoor recreation space.
Recreational Trails Program	FHWA offers local jurisdictions funding for active transportation infrastructure, focusing primarily on multi-use trails in open space areas.

FUNDING SOURCE	PROGRAM PURPOSE
The Transportation Infrastructure Finance and Innovation Act (TIFIA)	Provides credit assistance for qualified large-scale surface transportation projects of regional and national significance, including pedestrian and bicycle infrastructure networks. The TIFIA credit program is designed to fill market gaps and leverage substantial private co-investment by providing supplemental and subordinate capital.
State Programs	
The Road Repair and Accountability Act of 2017 (SB 1)	This legislative package invests $54 billion over the next decade to fix roads, freeways and bridges in communities across California and puts more dollars toward transit and safety. These funds will be split equally between state and local investments.
Caltrans Active Transportation Program	A leading source of funding for bicycle,pedestrian and Safe Routes to School projects in the State of California, the ATP program was created in 2013 and consolidated existing federal and state transportation programs. Under SB 1, the ATP has been expanded to provide an additional $100M to cities, counties and regional transportation agencies for bike lanes, pedestrian paths, sidewalks, safe routes to schools, and other projects that help reduce reliance on cars. The additional funding represents an 83 percent increase to the ATP program after adoption of SB 1
Local Partnership Program (LPP)	LPP supplements voter-approved transportation tax investments made by local communities by providing matching funds. The California Transportation Commission (CTC) intends for this program to balance the priority of directing increased revenues to areas of the state with the highest level of transportation need while maintaining fair distribution of grant funds statewide.
State Transportation Improvement Plan (STIP)	A multi-year capital improvement program for transportation projects on and off the State Highway System funded by revenues from the Transportation Investment Fund and other federal sources.
State Highway Operation and Protection Program (SHOPP)	SHOPP is the State's "fix-it first" funding mechanism for the rehabilitation and reconstruction of all state highways and bridges. SHOPP also provides the opportunities to address other vital State priorities, such as the reduction of transportation related greenhouse gas (GHG) emissions and implementation of Complete Streets elements like pedestrian and bicycle facilities.
Local Streets and Roads Program (LSRP)	SB 1 dedicates approximately 1.5$ billion per year in new formula revenues to cities and counties for basic road maintenance, rehabilitation, and critical safety projects on the local streets and roads system.
Solutions for Congested Corridors Program (SCCP)	Provides funding to achieve a balanced set of transportation, environmental, and community access improvements to reduce congestion throughout the state. Initiated in 2017 through the passage of SB 1, the program offers 250$ million annually for projects that implement specific transportation performance improvements and are part of a comprehensive corridor plan, such as providing more transportation choices while preserving the character of local communities and creating opportunities for neighborhood enhancement.
Adaptation Planning Grant	Allocates funds to local and regional agencies for climate change planning and related improvements. This funding is intended to advance adaptation planning on California's transportation infrastructure, including but not limited to roads, railways, bikeways, trails, bridges, ports, and airports. Note that funding may be provided by another source outside of SB1- in the future.
Office of Traffic Safety Grants (OTS)	The California Office of Traffic Safety (OTS) administers federal grant funds allocated to California under the National Highway Safety Act. The OTS has several priority areas for grant funding, including Pedestrian and Bicycle Safety.

FUNDING SOURCE	PROGRAM PURPOSE
Environmental Enhancement and Mitigation (EEM) Grant Program	The EEM Grant Program is a State fund established by the Legislature to fund beautification improvements to roadsides to mitigate the effects of transportation projects. It offers funding to local, state, and federal governmental agencies and to nonprofit organizations for projects to mitigate the environmental impacts caused by new or modified public transportation facilities.
Proposition 68 Greening Infrastructure Grant Program	Proposition 68 authorized the Legislature to appropriate 18.5$ million to the California Natural Resources Agency for competitive grants for multibenefit green infrastructure investments in or benefiting disadvantaged or severely disadvantaged communities.
Affordable Housing and Sustainable Communities Program (AHSC)	The AHSC Program is a joint effort by the Strategic Growth Council and California Department of Housing and Community Development. The Program assists affordable housing developments, sustainable transportation infrastructure, transportation-related amenities, and multi-modal transit promotion.
Systemic Safety Analysis Report Program (SSARP)	Provides local agencies with funding assistance to perform collision analyses, identify roadway safety issues, and develop cost-effective collision countermeasures. SSARP exchanges federal Highway Safety Improvement Program (HSIP) funds for State Highway Account (SHA) funds, simplifying the application process and improving participation by agencies that are less familiar with federal requirements.
Urban and Community Forestry Program	Provides grant funding for projects that result in a net reduction of greenhouse gases through reforestation efforts.
Mobile Source Air Pollution Reduction Review Committee (MSRC)	The program awards funding to projects that deliver clean vehicles to school districts and funds transit agencies to obtain alternative fuel buses. MSRC also accepts grant applications for a variety of complete street projects, including goods movement and first/last mile solutions. The program provides funding to projects that help commuters reduce the number of miles they drive, including purchase incentives for electric-assist bicycles, bike racks on buses, and bicycles for law enforcement patrols.
Transportation Development Act (TDA)	TDA funds a wide variety of transportation programs, including planning and program activities, pedestrian and bicycle facilities, community transit services, public transportation, and bus and rail projects.
California Endowment Grants/PRIs/DCA/ SPGs	The California Endowment's grantmaking is guided by their Building Healthy Communities (BHC) effort, awarding single- and multi-year grants and Direct Charitable Activity (DCA) contracts.
Caltrans Sustainable Transportation Planning Grant Program	The Sustainable Transportation Planning Grant Program includes two programs - (1) Sustainable Communities, to encourage local and regional planning that furthers state goals, including the Regional Transportation Plan Guidelines adopted by the California Transportation Commission. (2) Strategic Partnerships, to identify
Regional Programs	
Measure M	Passed by LA County voters in 2016, Measure M is a half-cent sales tax measure designed to ease traffic, repair local streets and sidewalks, expand public transportation, earthquake retrofit bridges and subsidize transit fares for students, seniors and persons with disabilities. It partially funds many Metro projects and makes funding available to local jurisdictions via the Metro Subregional Program (MSP); Metro Active Transportation, Transit and First/Last Mile (MAT) Program, and Local Return.
Sustainability Planning Grant Program	As a key source in funding active transportation and multi-modal plans in Orange County and Southern California, SCAG provides funding for projects that promote and implement regional sustainable community strategies through planning and policy.

FUNDING SOURCE	PROGRAM PURPOSE
Air Pollution Control Projects that Reduce/ Mitigate Emissions/ Toxic Exposure	On a semi-regular basis, the South Coast Air Quality Management District (SCAQMD) releases a Request for Proposals (RFP) for projects that reduce emissions in the SCAQMD monitoring area.
RMC Grant Program	The San Gabriel and Lower Los Angeles Rivers and Mountain Conservancy (RMC) awards approximately 30$ million each year to projects that protect open space, preserve or restore natural habitat, and encourage low-impact uses. RMC's jurisdiction includes eastern Los Angeles County and western Orange County. There are a total of 68 cities within the RMC jurisdiction.
Fostering Healthy Environments	Funded by the California Wellness Foundation (Cal Wellness), Fostering Healthy Environments grants are available to nonprofit organizations and public organizations interested in promoting environmental justice, equitable access to healthy food, and park equity for low-income communities.

7.3 Local and Regional Agency Partnerships

Transportation and mobility are based fundamentally on networks: interconnected systems and lines of roads, bridges, transit services, bicycle and pedestrian infrastructure, and the flow of people and goods from one place to another. The recommendations in the MAP are designed with partnership in mind and will require coordination with local and regional agencies to implement. These agencies include incorporated cities in the ESGV (along with their departments of transportation and public works), as well as regional transit agencies that operate in the ESGV, including Metro, Foothill Transit, and Metrolink. Additional coordination and support may come from SCAG or local offices of agencies from the State of California (such as Caltrans District 7). Partnerships with these agencies are often essential to the successful pursuit of grant funding opportunities.

7.4 Community Partnerships

Long-range planning is most effective when community-based organizations (CBOs) and the public at large are engaged in the planning process, when their feedback and needs are incorporated into the plan's recommendations, and when the recommendations contain opportunities to partner with and support CBOs and the public. Community partnerships that could support delivery of the projects recommend in the MAP may include:

- **Farmer's markets, food banks, and community gardens** – to ensure that projects allow for greater access to nutritious, healthful food.
- **Mobility-limited groups, such as seniors and people with disabilitie**s – to ensure that projects connect those who may not be able to drive with the places they need to go.
- **Schools and universities** – to ensure that students can travel to and from school safely and independently, and that young people and returning students have increased access to opportunity as a result of education.
- **Hospitals and health care facilities** – to ensure that essential workers and the people for whom they care can access treatment and preventative care.
- **Environmental justice and mobility advocacy groups** – whose local knowledge and expertise can support equity-focused delivery of projects.

APPENDIX A
POLICY PRIORITIES

A. GOALS AND POLICIES

A.1 Policy Priorities

In order to evaluate potential policies for the East San Gabriel Valley Mobility Action Plan, the team considered three main sources: plans and programs adopted by the Department of Regional Planning (responsible for long range planning among other duties), plans and programs adopted by Public Works (responsible for providing and maintaining transportation infrastructure), and the technical team's understanding of how mobility and transportation are evolving in Los Angeles County. These priorities are listed in the table below.

SOURCE	POLICY PRIORITIES	DEFINITION / EXAMPLE
DRP	Environmental Justice	Defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.
DRP	Sustainability	Broadly refers to a long-term approach to human activity that balances economic, social, and environmental needs.
DRP	Climate Change	The phenomenon of changing climate patterns and global temperature increases accelerated by increased greenhouse gas (GHG) emissions in particular, and the County's efforts to slow and counteract its impacts.
DRP / PW	Equity	An approach to decision making and the distribution of resources that is inclusive to individual and community needs, focused on alleviating past and present barriers to accessing resources needed to succeed and thrive.
PW	Accessibility	A measurement of where people can or cannot travel using various modes of travel, as well as how accommodating those places and modes of travel are to persons with disabilities.
PW	Connectivity	Relates to the ways in which travel modes connect or fail to connect to each other. May also be supported through use or deployment of technology.
PW	Safety	Relates to how dangerous a mode of travel or street corridor is to use for travel, with a focus on non-automotive travel. Primarily analyzed through the County's Vision Zero program and plan.
Consultant Team	Technology	Relates to ways in which technology can be used to address mobility needs or gaps.
Consultant Team	Land Use	The ways in which land is used have a major impact on travel need, and integrated transit and land use planning is coordinated between the teams

In addition to the policy priorities above, a number of other plans and policies from the County of Los Angeles and other relevant agencies were reviewed. These documents and their sources included:

- **County of Los Angeles**
    - General Plan and Mobility Element
    - Vision Zero Action Plan
    - OurCounty Sustainability Plan
    - Step-by-Step: Pedestrian Plan for Unincorporated Communities
- **Southern California Association of Governments (SCAG)**
    - Connect SoCal 2020
- **California Department of Transportation (Caltrans)**
    - California Transportation Plan
    - California Freight Mobility Plan
- **Los Angeles County Metropolitan Transportation Agency (Metro)**
    - Active Transportation Strategic Plan
    - Bicycle Mobility Plan
    - East San Gabriel Valley Active Transportation Plan

These plans and policies were reviewed to ensure that the recommendations for the East San Gabriel Valley are both broadly consistent with these documents and specific enough to the project study area that meaningful and relevant guidance is provided. Coordination of these plans also ensures that the recommendations to improve mobility will meet the guidelines of potential funding opportunities.

These priorities were used to formulate and evaluate the range of potential policies considered for the MAP. Section 8 of the MAP lists the policy recommendations for the ESGV area.

APPENDIX B
COMMUNITY ENGAGEMENT

B. COMMUNITY ENGAGEMENT

B.1 Strategy and Target Audiences

Public engagement played a pivotal role in understanding concerns and challenges faced by community members, business owners, visitors, and commuters in the ESGV. Residents and daily commuters of the area have a unique understanding of the physical and social limitations of the San Gabriel Valley, and clear mobility preferences and needs. These considerations helped adapt the strategies designed for the study to the local context, as communicated by the communities individually and collectively. They also informed the types of innovations and improvements recommended, so that only those that are both effective and acceptable to the community are carried forward.

The initial Public Engagement Plan detailed strategies and tools that were anticipated to be used to reach out to the various communities in the area. The study area itself is economically and ethnically diverse, but poor air quality and a lack of affordable transit options are widespread. The plan identified key stakeholders and populations to be engaged, with specific focus on vulnerable and historically-underrepresented groups. The plan detailed multiple phases of engagement that were to take place over the course of the study, their specific goals, intent, and expected outcomes.

With a diverse population with varying needs, it was imperative to understand these populations, and as such, multiple entities and groups of individuals were engaged across the development of the plan, sharing of plan outcomes and recommendations, and the structure of the final plan as a whole. The following compose the majority of stakeholders that were engaged as a part of the process:

Steering Committee / Technical Committees

The Agency Steering Committee, composed of representatives of local jurisdictions and public agencies either located within the project study area (such as the cities of Azusa, La Verne, Baldwin Park, San Dimas, Covina, Claremont, Diamond Bar, Glendora, and Pomona) or at the regional level (such as SCAG). The committee's membership was developed in consultation with DRP staff, and was crucial to understanding long-range planning efforts within the study area, relevant projects that may have an impact, and policies that need to be coordinated for the feasibility of recommendations. This audience's impact and engagement was high, given their own projects and programs that may coincide with the ESGV MAP, as well as their intimate understanding of their constituencies.

Stakeholders & Organizations

Community-based organizations, including environmental groups, transportation advocates, community advocates, and the like were critical audiences who were well informed and interested in specific issues that they represent and for which they advocate. These groups needed to be involved in regular communications, in meetings, and in some cases one-on-one, and were important channels for reaching hard to reach communities and populations. This audience's impact and engagement was high, given their intimate understanding of their own stakeholders.

Community Youth

Outreach to and engagement with young people was a crucial component of the engagement effort. Even in auto-oriented East San Gabriel Valley, young people show interest in non-automotive travel options. Auto- centricity has been disrupted by many intersecting issues such as its financial burden, its impact on the environment, and the rise of Mobility as a Service (MaaS) options. Young people of today will also become the commuters of tomorrow, and their unique perspective is traditionally under-represented in planning activities.

The project's learning academies, workshops, and other community events featured specific youth outreach activities. This audience's impact was high, but their engagement was low. This challenging engagement is exacerbated by limitations in direct contact through either schools and/or through families.

Community Members & Broader Public

Due to the regional character of the study, engagement activities needed to capture the input from the general public as much as possible. This included visitors and tourists heading to key activity centers, and other community members beyond the study area. This group became a core engagement opportunity as a result of attendance at pop-up event locations across the East San Gabriel Valley.

B.2 Challenges and Opportunities

Outreach in the East San Gabriel Valley requires a varied approach for successful engagement and connectivity to the communities served within the ESGV MAP project area. COVID-19 protocols, restrictions, and concerns limited traditional engagement activities. Additionally, community members may have become overwhelmed, and oftentimes burned out from digital methods of engagement. Despite these challenges, engagement results have yielded surprising numbers, which speaks to the need and success of the varied community engagement efforts. Some challenges still persisted, including lack of larger attendance at events, two-way discussions on social media, and access to school-aged children. As such, some engagement activities were one-direction only.

With the myriad mobility needs of families and school-aged children, the team prioritized outreach to these groups as an opportunity to plan for the future and develop the next generation of involved stakeholders. Initial goals were to include high school students in a process to develop awareness not only of the MAP effort, but also important mobility and urban planning efforts like tactical urbanism. Although repeated efforts to engage schools throughout the study area were unsuccessful, planned outreach through MAPlibs and social media "story" posts did move forward without the direct involvement of schools.

B.3 Overview of Activities

Digital Foyer

To facilitate community engagement, the MAP team utilized a "digital foyer," an online platform that acts a continuous, virtual meeting space. The foyer hosted informational documents and videos, online surveys, interactive maps, and links to more information about the County of Los Angeles Department of Regional Planning's work.

Social Media

There was an immense response to boosted social media postings as a result of in-person pop-ups, as well as four programmatic surveys. These boosted posts yielded significant engagement and reach—including greater than 92,000 individuals reached during the program surveys, Area Plan/MAP meeting posts, and pop-up notifications. This outreach included very pointed and direct project-related comments and feedback, as well as participation in and completion of surveys.

Key Engagement Statistics:

92,000
social media impressions

800
bus cards posted

8
MapLib art installations posted

8
pop-up events conducted

Online Surveys

The MAP team distributed seven online surveys to better understand community mobility needs and priorities. Survey topics included:

- "Gains and Pains": what works well now—and what doesn't-- in the ESGV.
- Mobility Priorities: to understand what is most important to area residents.
- Bicycling Survey
- Walking Survey
- Transit Survey
- Other Mobility Improvements Survey
- Mobility Recommendations: to gather feedback on the recommendations made in the Draft Plan.

MAPLibs

Based on children's "Mad Libs," MAPLibs are fun fill-in-the-blank games that gathered community members' stories of where they like to walk, bicycle, or roll in the ESGV. To further promote the project, the team also installed temporary stencils of the MAPLibs at key activity centers (such as parks) in the project study area. Residents could then scan a QR code to learn more about the project and what their neighbors wrote.

Bus Cards

In collaboration and coordination with Foothill Transit, the project team printed 800 11-inch by 26-inch posters, printed on cardstock, of artwork to be displayed on Foothill Transit buses. These posts were placed in interior bus locations to maximize visibility and assist in in publicizing the Mobility Action Plan process, outcomes, and upcoming events and opportunities for engagement. Artwork was provided to Foothill Transit on January 3, 2022, and ran on their bus fleet through June 2022.

Sign Installations

Pivoting and finding new, creative ways to get the word out about the MAP and the draft MAP availability, the concept below was proposed and approved by the project management team to be placed at high visibility locations that were relevant to the project. Eye-catching signs were developed and installed at nine locations:

- Along nine of the 12 identified focus corridors for complete and green streets, which have concept designs in the draft MAP.
- On utility poles/streetlights in front of or near popular commercial destinations (where people are likely walking and gathering).

Signs were in English and Spanish and provided:

- General information about the MAP
- Invitation to review the draft with QR link to the draft Plan
- Description of the specific corridor where the sign is placed

Presentations and Technical Meetings

The technical team and DRP staff delivered presentations and to key stakeholders and the general public over the course of the plan development process. These dates, the audiences, and the topics included:

- March 2021 – Steering Committee – Initial project kick-off and background
- June 2021 – Steering Committee – Summary of existing conditions analysis
- October 2021 – Steering Committee – Review of engagement activities and discussion of plan goals
- January 2021 – San Gabriel Valley Council of Governments (SGVCOG) Technical Advisory and Transportation Committee – Review of engagement activities and technical work
- January 2021 Planners Technical Advisory Committee
- April 2022 – General Public – Mobility Action Plan Workshop
- May 2022 – Steering Committee – Overview of the draft plan

B.4 Feedback and Recommendations

This final plan is responsive to and includes recommendations based on the feedback received during the community engagement process. Key themes and their recommendations include:

- **Safety** – Due to the high rates of drivers' speed, as well as a lack of sidewalks, bicycle lanes, or protected bicycle lanes, survey participants frequently expressed concerns for their safety while traveling.
  - Recommendation: Existing safety data was a major factor in the selection of corridors recommended for streetscape improvements in the plan.
- **Accessibility (ADA)** – A lack of sidewalks, curb ramps, and other features that would make it easier for all pedestrians to walk or roll to their destinations was the most common concern of respondents in the pedestrian survey. Respondents also identified ADA accessibility as critical to their use of the flexible microtransit or Personal Mobility on Demand services.
  - Recommendation: The technical team evaluated corridors throughout the service area with a focus on closing gaps in sidewalks and addressing a lack of accessibility.
- **Accessibility (Land Use/Transit Integration)** – Survey respondents and engagement participants frequently expressed a desire to be able to accomplish more of their daily tasks (such as shopping or visits to the grocery store, going to the gym, and accessing community amenities like parks and libraries) using transit or active transportation.
  - Recommendation: Flexible microtransit and Personal Mobility on Demand were recommended as options to pursue because they would be able to address gaps in existing fixed-route transit service that many not easily be remedied through adjustments to routing.
- **Comfort** – A common thread across the surveys administered was a desire by the community to have more comfortable infrastructure in their communities, such as more street trees that provide shade, or better protection from cars.
  - The plan identifies several corridors that are recommended for streetscape improvements that include additional greening and buffers between vehicles and pedestrians or cyclists.
- **Convenience and Flexibility** – When asked what would benefit people's ability to take transit, the most popular responses was more frequent service.
  - Recommendation: The flexible microtransit and Personal Mobility on Demand services recommended were selected for their ability to augment exiting transit service, either by closing gaps in the network, providing service in off-peak hours, or where increased service frequency may not be possible.
- **Information** – Fewer than a third of survey respondents were familiar with or had used either flexible microtransit or Personal Mobility on Demand.
  - Recommendation: Should deployment of these services be pursued, a thorough public engagement and education campaign will be needed, including how-to videos, in-person activities, and coupons for discounted or free rides for new customers.

APPENDIX C
EVALUATION CONCEPTS AND ASSUMPTIONS

C. EVALUATION CONCEPTS AND ASSUMPTIONS

Informed by the technical review, MAP goals and policies, feedback from the community, and evaluation of mobility options, the following sections provide transit service and active transportation infrastructure concepts, as well as more detailed steps for implementing recommendations offered in Chapter 5.

C.1 Concepts and Assumptions

C.1.1 Unincorporated Areas - Connected First/Last Mile Service

The purpose of providing connected first/last mile service is to improve connectivity to Foothill (and local service providers) frequent local network in proximity to unincorporated areas covered by less frequent local lines.

Personal Mobility on Demand (PMoD)

Service Design – Subsidized PMoD connections between key Foothill Transit bus stops and origins/destinations located in proximity.

Level of Service - Assumes three vehicles on weekdays; two vehicles on Saturdays; two vehicles on Sundays.

Ridership - Range estimate of 9,817 – 14,875; assuming 9,917 potential coverage hours, and customer demand ranging from 50% to 67% of available capacity. "Coverage hours" refer to the maximum number of potential revenue service hours that could be deployed if necessary, to meet demand for personal mobility service.

Costing - Net cost of service is calculated on assumed $5.00 per trip flat subsidy distributed through fare policy. Assumes that the customer pays an initial fare equivalent to a regular transit fare, followed by the subsidy, after which the customer is responsible for the cost of longer trips.

Example: Customer pays the first $2.00 of taxi/TNC market-based fare; sponsor(s) pay a flat $5.00 subsidy; customer pays any amount above a $7.00 one- way ride.[2]

[2] Based on prevailing TNC rates, a $7.00 trip would yield a 2.5 to 3 mile trip, an amount and trip distance suitable to accommodate the first/last mile requirement. The $2.00 customer fare is comparable to a regular transit fare, hence a $5.00 subsidy. These figures were used to populate the cost/ridership estimation tool, which is a working odel and may be amended to reflect alternate fare and/or subsidy levels.

BUSINESS FUNCTION	SAMPLE KPIS	REQUIRED DATA
Equity	▪ Trips delivered to low-income communities ▪ Increased access to destinations in communities ▪ Trips delivered to unbanked/underbanked communities ▪ Trip requests by mobile app vs. telephone requests through call-center	▪ Socio-economic and demography data ▪ Trip details
Customer Satisfaction	▪ Number of customer complaints ▪ Passenger wait time ▪ Average on-board time ▪ Average trip length ▪ Number of service denials ▪ Successful transfer connections (for feeder services) ▪ Reduced number of personal vehicle mileage	▪ Trip details; Origin-Destination ▪ Ridership ▪ Payments ▪ Vehicle travel time and schedule adherence data ▪ Missed connections
Finance	▪ Revenue trend ▪ Trends in cash and non-cash payments ▪ Cost/trip ▪ Subsidy/trip ▪ Cost/revenue hour ▪ Cost/revenue mile	▪ Cost and revenue data
Environmental	▪ GHG reduction ▪ Increased Mode share of electric vehicles	▪ Vehicle Miles Travelled (VMT) by modes delivering service

Flexible Microtransit

Service Design – One or two flexible routes anchored to a Foothill Transit park-ride lot, transit center or key transit hub, providing weekday peak and reverse travel connections between residences, employment locations, and other transit trip generators within a lower to medium density suburban area. Resources may be deployed to either supplement or replace Foothill Transit lower frequency conventional fixed route service.

Level of Service - Assumes one vehicle operating initially on weekdays only for a 10.5-hour service day. Initial service capacity of 8 customers per revenue service hour.

Ridership - Range estimate of 10,710 – 14,351; assuming 2,678 annual revenue service hours, and customer demand ranging from 50% to 67% of available capacity.

Costing[3] - Assumes total contract operating cost of $100 per service hour for 2,678 hours. Fare revenue ranging from $10,710 to $14,351, depending on customer demand. Net cost of service ranges from $257,040 to $253,399; assuming customer pays $1.00 average fare. Subsidy per trip range estimate $17.66 to $24.00 per passenger, depending on ridership.

A range estimate of the net cost of service for a single-zone service in a connected suburban/unincorporated area is $49,087 - $74,374; assuming the range ridership estimates indicated above, and a maximum $5.00 subsidy per one-way trip.

C.1.2 Active Transportation Infrastructure

To complement new and improved transit options and provide connectivity to transit services, infrastructure improvements can close the gaps in the bicycle and pedestrian network and provide additional mobility options to members of the community, especially those who may not have access to a vehicle. Multimodal considerations such as existing roadway widths, curbside infrastructure, vehicle speeds and volumes, and alignment with other plans, will determine what types of improvements should be implemented along each of the recommended corridors.

C.2 Service Performance Management

Table C.1 presents suggested key performance indicators (KPIs) to be used in the evaluation of On-Demand Flexible Microtransit and PMoD services. Evaluation may include both measuring the effectiveness and efficiencies of service delivery as well as to gauge customer acceptance of new mobility services.

Table C.1: Recommended Key Performance Indicators

BUSINESS FUNCTION	SAMPLE KPIS	REQUIRED DATA
Mobility/ Service O&M	▪ Riders per hour ▪ Ridership by service area/zones ▪ On-time performance ▪ Service reliability ▪ Number of booked and completed trips ▪ Number of no-shows and cancellations ▪ Vehicle revenue hours and miles ▪ Number of trips originating /terminating within a zone or predefined location ▪ Average vehicle miles without maintenance	▪ Trip details, Origin-Destination ▪ Ridership ▪ Payments and Payment Methods ▪ Vehicle travel time and schedule adherence data ▪ Vehicle maintenance data

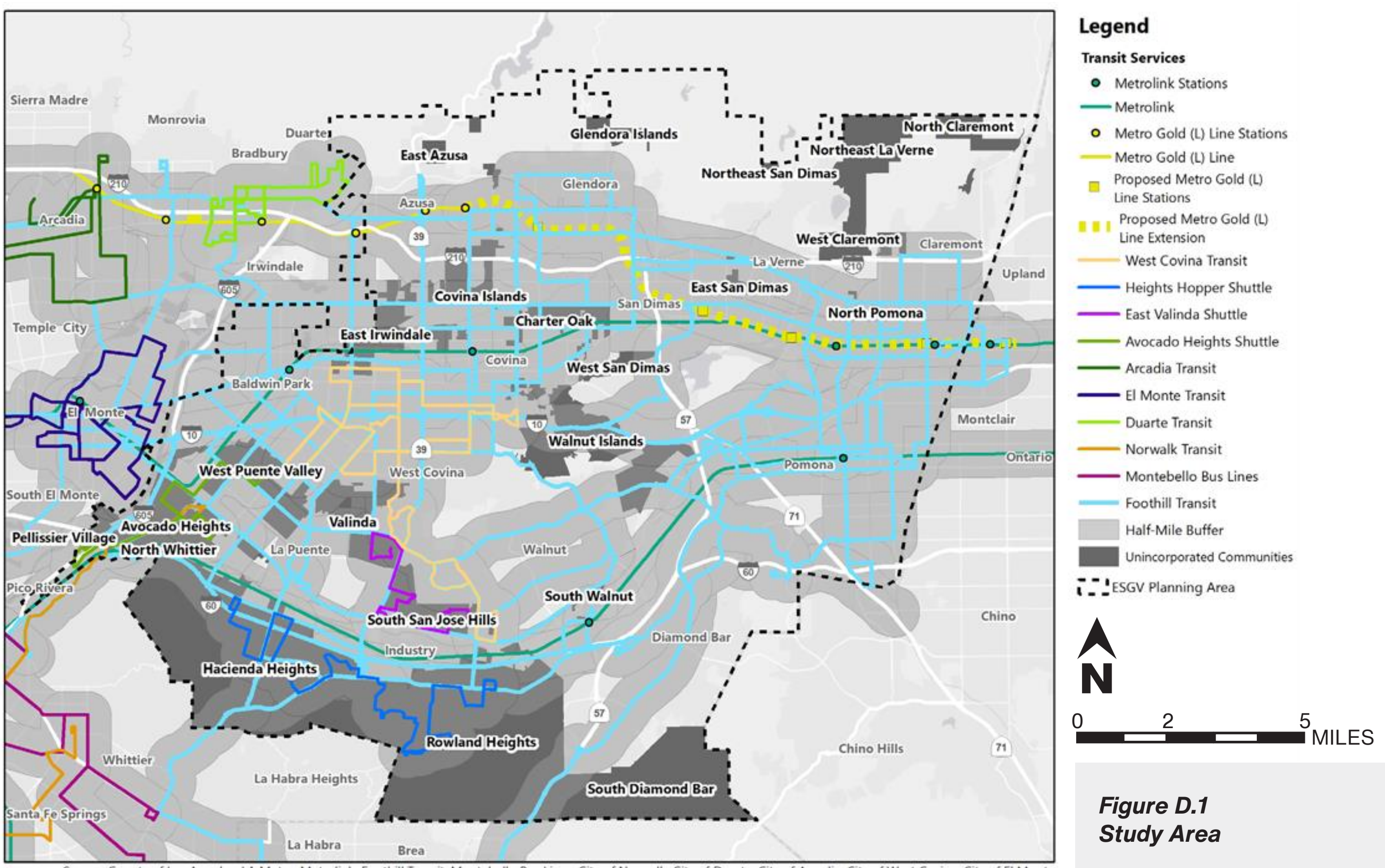
[3] Cost estimates/ranges are annualized figures, reflecting annual revenue hours.

APPENDIX D
COMMUNITY PROFILE

D. COMMUNITY PROFILE

D.1 Study Area

The MAP study area spans 210 square miles and is located east of I-605 Freeway, south of the Angeles National Forest and the San Gabriel Mountains, west of the Los Angeles County Line, and north of the Puente Hills. The major east-west highways running through the study area are I-210 in the north, I-10 in the center, and SR-60 to the south. Figure 3.1 presents the study area boundary, highlighting the locations of the unincorporated communities and cities within the ESGV.



Source: County of Los Angeles, LA Metro, Metrolink, Foothill Transit, Montebello Bus Lines, City of Norwalk, City of Duarte, City of Arcadia, City of West Covina, City of El Monte

Figure D.1
Study Area

D.2 Population/Employment

According to the Southern California Association of Government's (SCAG) 2020 Connect SoCal (RTP/SCS) growth forecast, the ESGV Planning Area has a population of about 1,057,000 residents, with moderately dense populated areas, likely due to its more suburban development pattern. Understanding population and employment distribution throughout the study area is important to determine potential locations of where people are traveling to and from.

Population Density

Population density is most concentrated in the western area of the region, where there are several unincorporated communities. Several unincorporated communities have high population densities as compared to adjacent cities in the ESGV. Others have very low population densities. Figure 3.2 illustrates the following:

1. Population is concentrated in the western portion of the study area near the I-10 and SR-39 corridors. This includes the unincorporated communities of La Puente, West Puente Valley, Valinda, East Irwindale, and Covina Islands, as well as the cities of Baldwin Park and La Puente.
2. Population is also concentrated in the eastern portion of the study area in and around the City of Pomona.

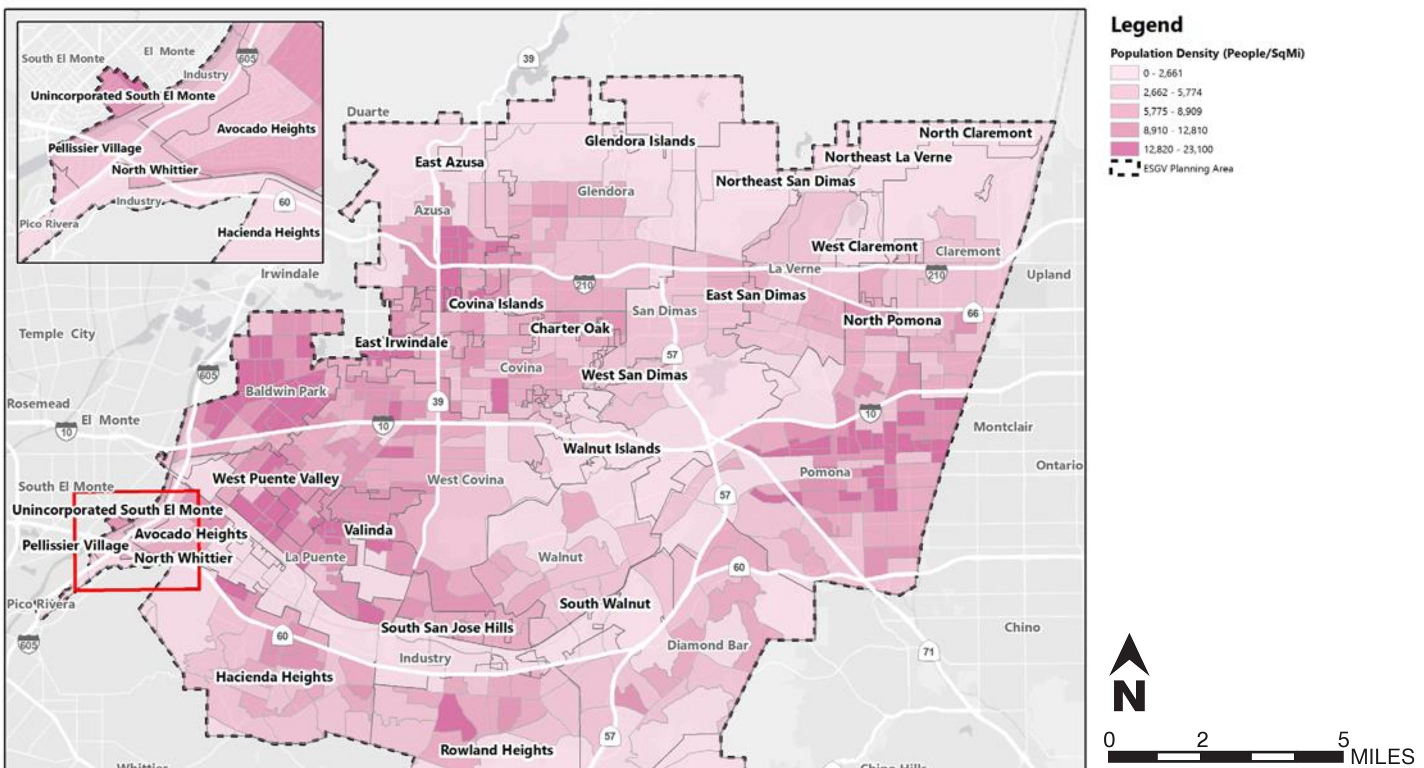


Figure D.2
Population Density

Employment Density

Employment density is concentrated in certain areas, particularly adjacent to major highways. As employment density does not always correlate with population density, residents may have to commute to work somewhere further than where they live. Across California, 37% of residents work in the city or place where they live. In the ESGVey, only 15% of residents work in the city or place where they live. These figures highlight that most ESGV residents commute longer distances to reach their place of employment. This condition has implications on travel time, travel costs, and access to different employment opportunities. Figure 3.3 indicates that:

1. Employment is concentrated along SR-60 and I-10, particularly in the cities of La Puente and Industry.
2. Other areas of high employment include communities in the cities of Covina, West Covina, La Verne, Claremont, and Pomona.

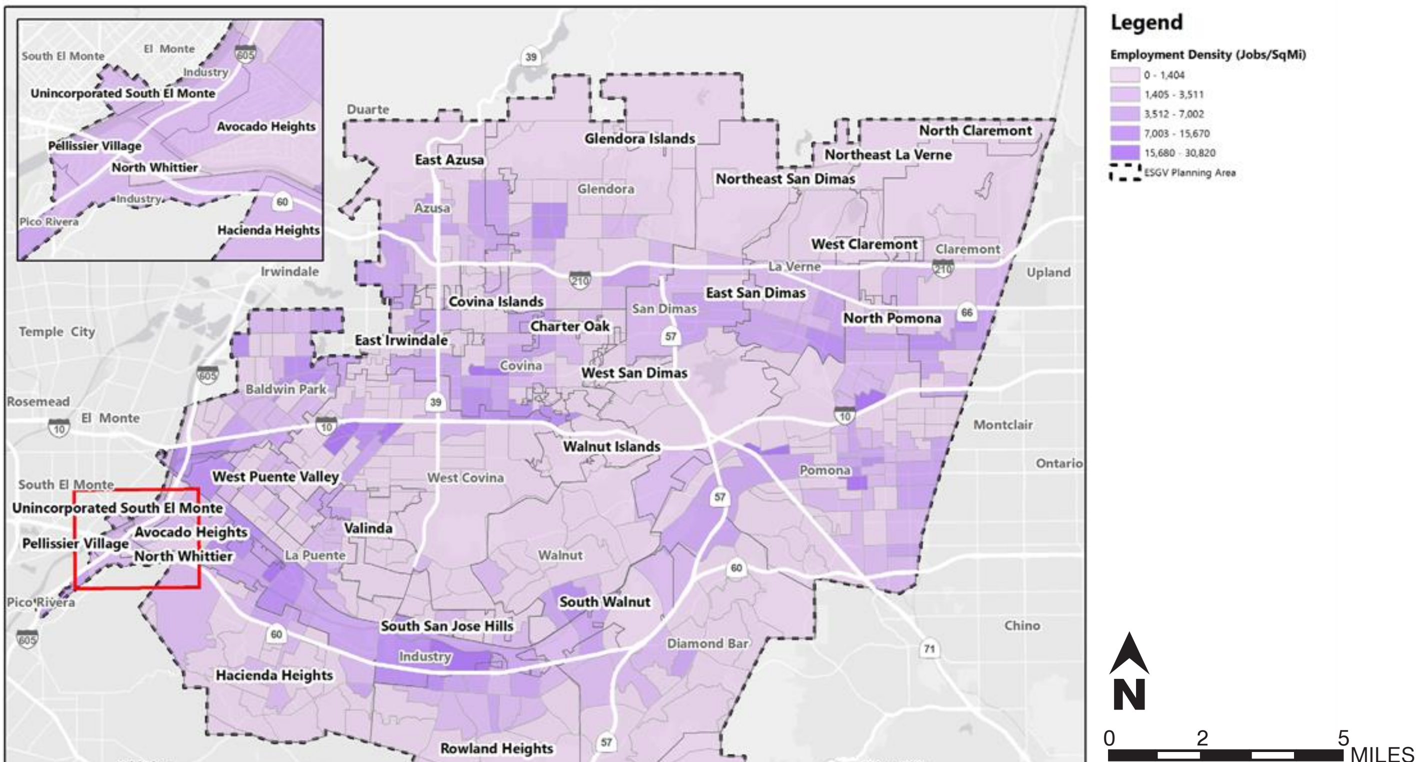


Figure D.3
Employment Population

Population Characteristics

Mobility needs vary for different groups of people. Demographic indicators can provide insight into who lives in the study area and their mobility needs and propensity to use certain modes of travel. The following figures illustrate these indicators across the study area:

Senior Population: Senior residents can have limited ability to travel by driving and may need alternative modes of travel. The transportation infrastructure in the ESGV is generally not supportive of seniors. Meeting the mobility needs of this demographic group would have co-benefits for other groups as well.

1. Senior residents make up as much as 60 percent of the total population in areas between Pomona and Walnut, beside the SR-57, and east of La Verne along Foothill Boulevard.
2. Typically, where there is a higher concentration of senior population, employment density tends to be sparse.

Youth Population: Youth and school-aged children (age 5-17) are particularly vulnerable travelers who may be less visible to motorists along the many car-centric streets in the ESGV. They need safe infrastructure when walking and biking, including safe intersections and crosswalks, especially near schools and parks.

1. Youth make up about a quarter of the population in some of the easternmost unincorporated areas of the ESGV, including Unincorporated South El Monte, West Puente Valley, Hacienda Heights, Valinda, and Covina Islands, as well as Northeast La Verne, North Claremont, and North Pomona.

People of Color: Residents of the ESGV are racially diverse. This include residents who have lived in Los Angeles County for multiple generations and some who are recent immigrants. According to the Census Bureau, in 2018, 34% of residents in the ESGV were foreign-born population, which is much higher than the national average of 13.8%. Asian residents make up more than half of the area's population, followed by White and Latino/Hispanic residents as the second and third most common race or ethnicity.

1. The percent of non-white population reaches over 50 percent in many areas, particularly in the central, and southern, and western areas of the study area that includes the City of Industry, Diamond Bar, Walnut, La Puente, and Azusa.
2. Areas with the highest concentrations (around 75 percent or higher up to 97 percent) of non-white population include the communities in and around the unincorporated communities of Rowland Heights and Hacienda Heights, and the cities of Walnut, West Covina, Baldwin Park, and Diamond Bar.

Low-Income Households: Low-income households (defined by SCAG as households with an annual income of less than $35,000) are more likely to use transit or other alternative forms of transportation, and need a safe and reliable network for mobility.

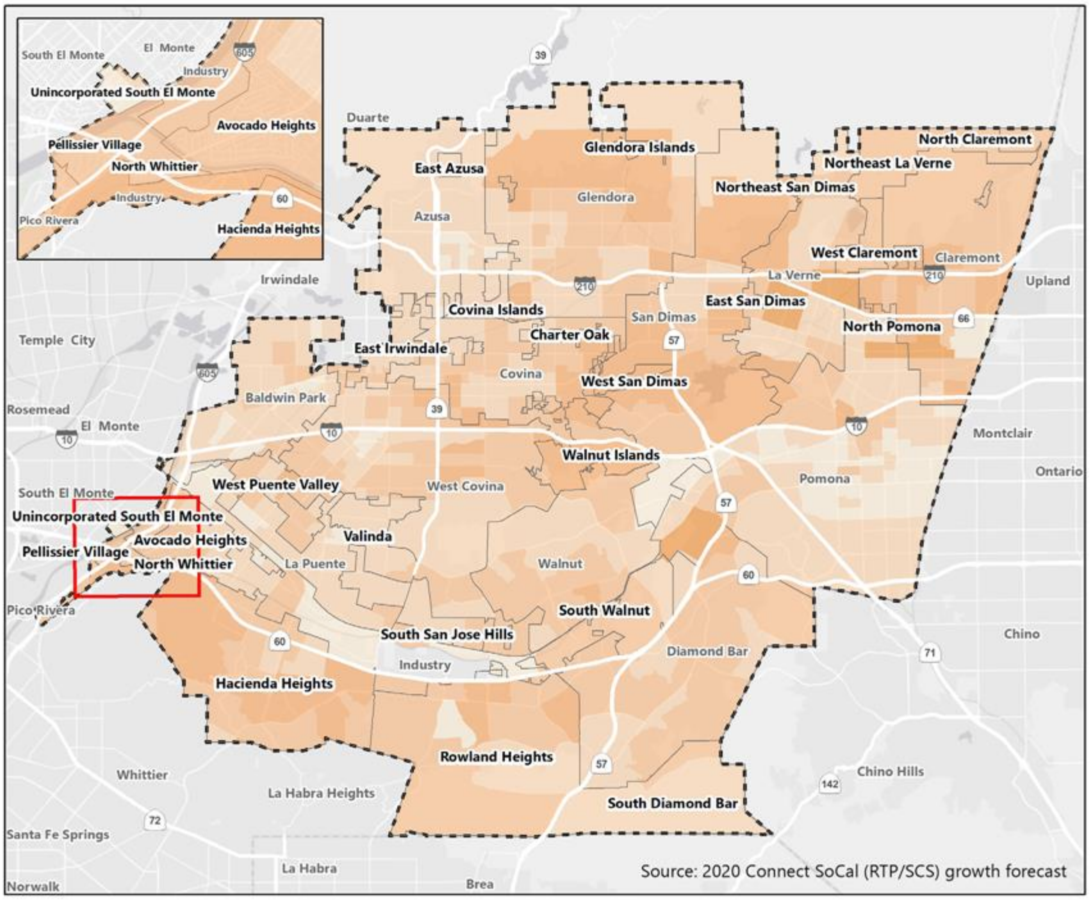
1. Areas with particularly high percentages (over 50 percent) of low-income households include the communities around the unincorporated communities of Walnut Islands and Rowland Heights, as well as the cities of Pomona, Baldwin Park, La Puente, and Azusa.

Educational Attainment: Those with higher levels of educational attainment tend to earn more than people with less education and are likely to live in communities that are less polluted and have access to the resources necessary for good health, such as health facilities, healthy grocery stores, green space, and high-quality schools. Those with lower levels of educational attainment may find it more challenging to access these healthy resources if they do not live in these same communities.

1. Broadly, the areas with the highest percentage of Bachelor's degree attainment include the communities in and around the cities of Glendora, La Verne, Claremont, Walnut, and Diamond Bar, as well as the unincorporated communities of Rowland Heights and Hacienda Heights.

Vehicle Ownership: Access to a personal vehicle in an auto-dependent area such as the ESGV influences a person's ease of access to job opportunities, healthy grocery stores, or other quality amenities for a healthy lifestyle.

1. As many as about 40 percent of all households do not own a vehicle in some areas in the ESGV, and therefore may rely on transit or active modes of transportation. These households are dispersed throughout the region, showcasing reliance on different travel modes throughout the region.



Legend

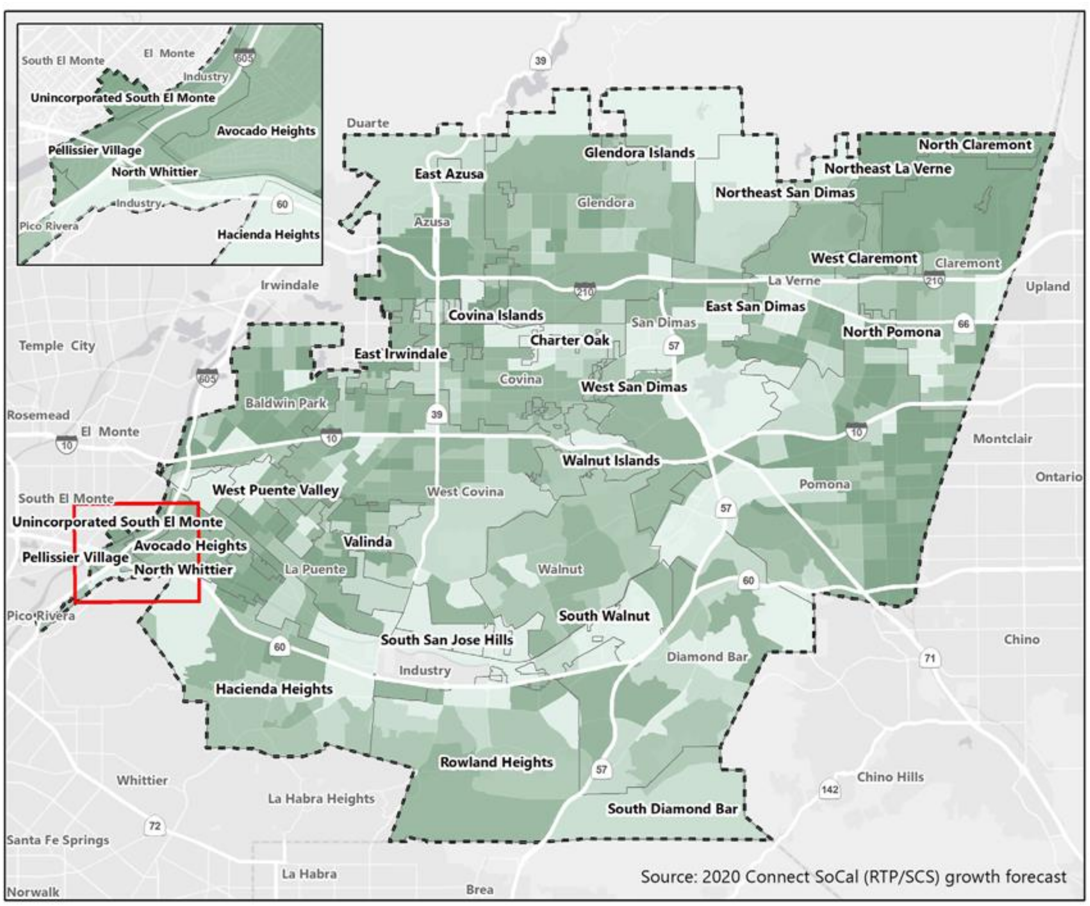
Percent Senior Population

- 0% - 9%
- 10% - 15%
- 16% - 22%
- 23% - 34%
- 35% - 60%
- ESGV Planning Area

N

0 2 5 MILES

Figure D.4
Senior Population



Legend

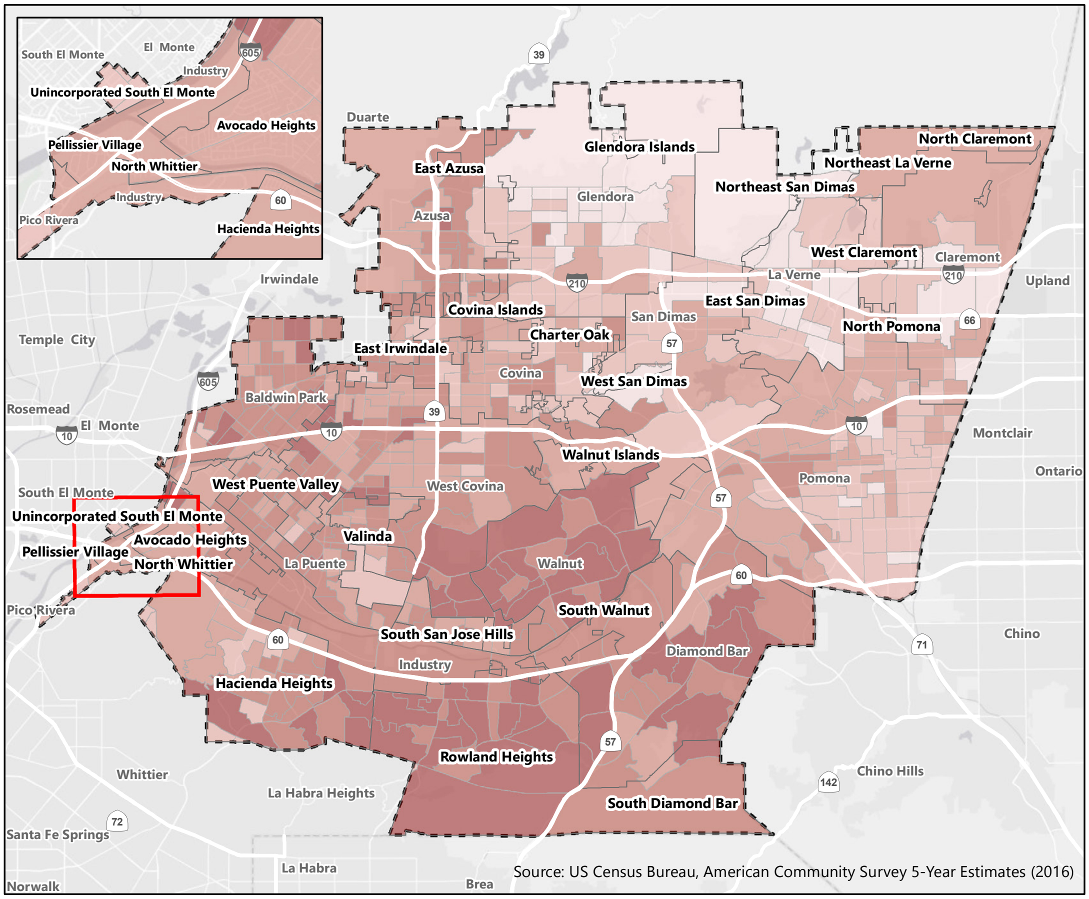
Percent Youth Population

- 0% - 5%
- 5% - 12%
- 13% - 16%
- 17% - 20%
- 21% - 27%
- ESGV Planning Area

N

0 2 5 MILES

Figure D.5
Youth Population

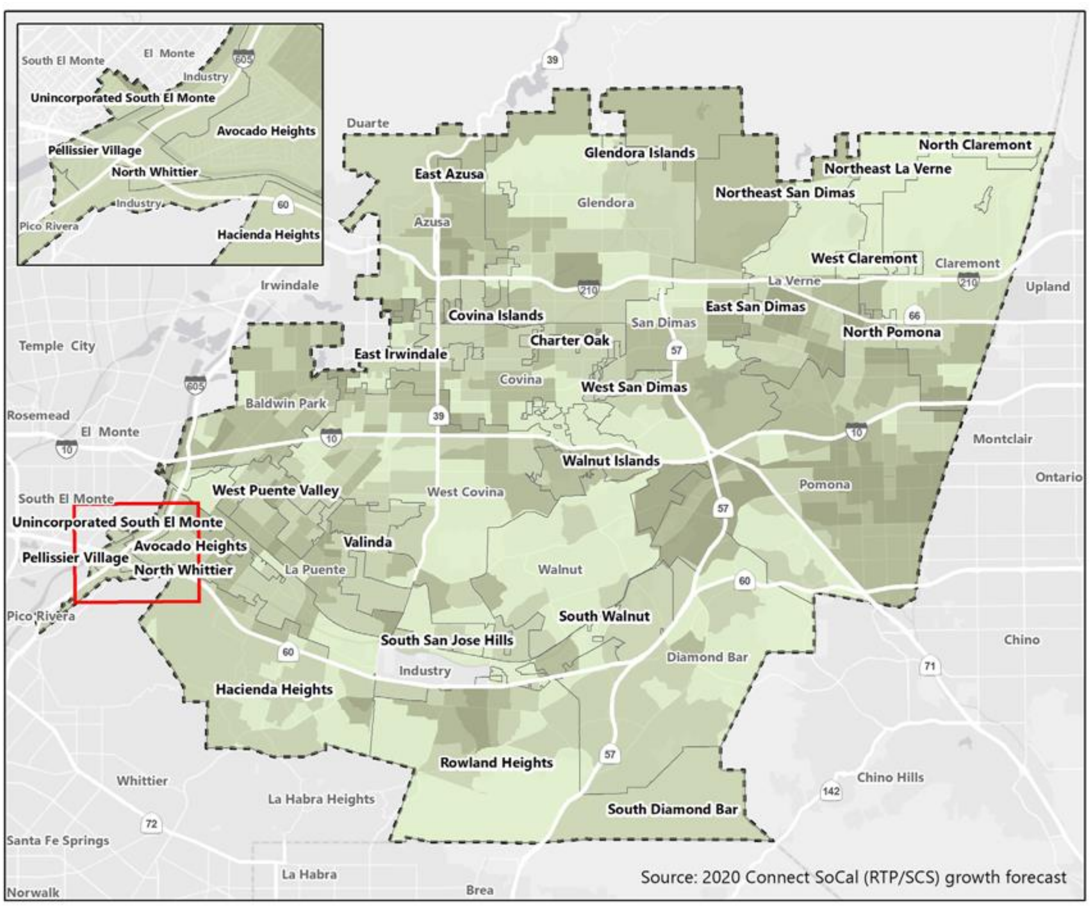


Legend

% Minority Population

- 5% - 25%
- 26% - 42%
- 43% - 57%
- 58% - 72%
- 73% - 97%
- ESGV Planning Area

Figure D.6
Minority Population



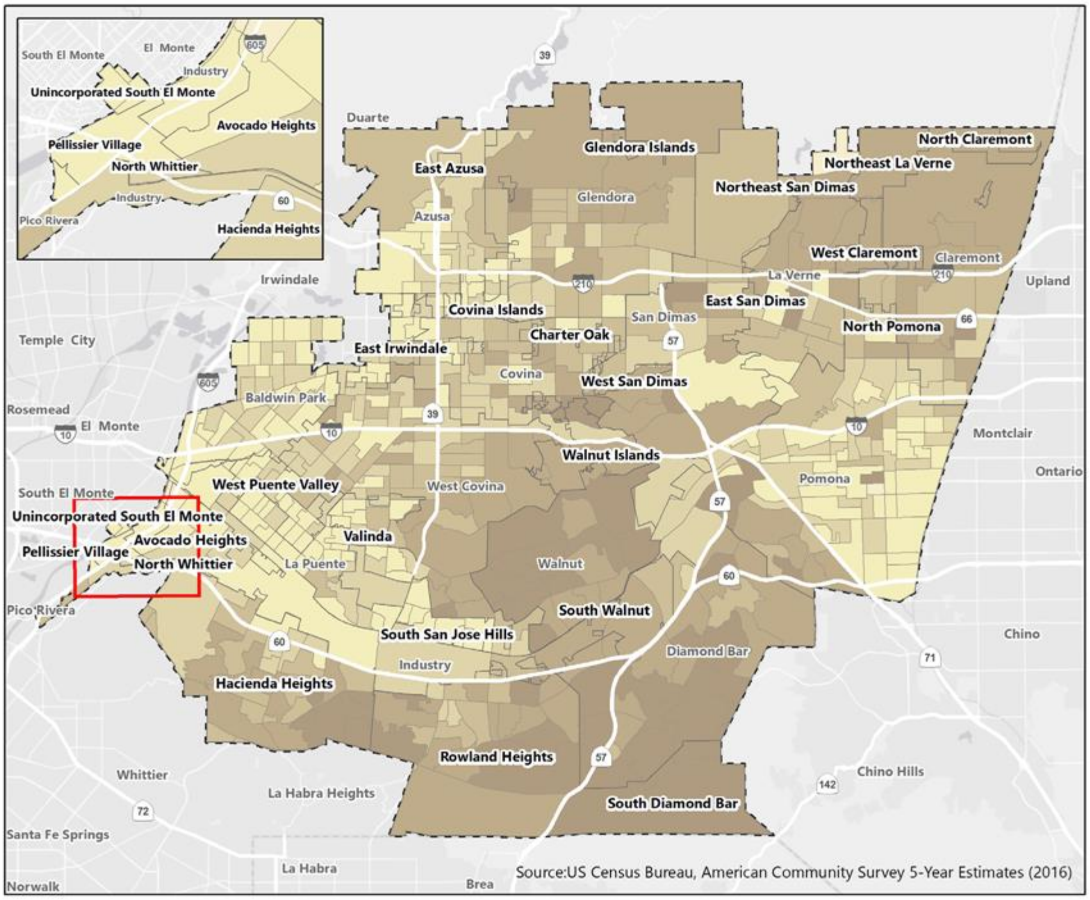
Legend

% Low Income Households

- 0% - 16%
- 17% - 28%
- 29% - 43%
- 44% - 100%
- ESGV Planning Area

Note:
Low income households have been identified by SCAG as households with less than $35,000 in annual income.

Figure D.7
Low-Income Population



Legend

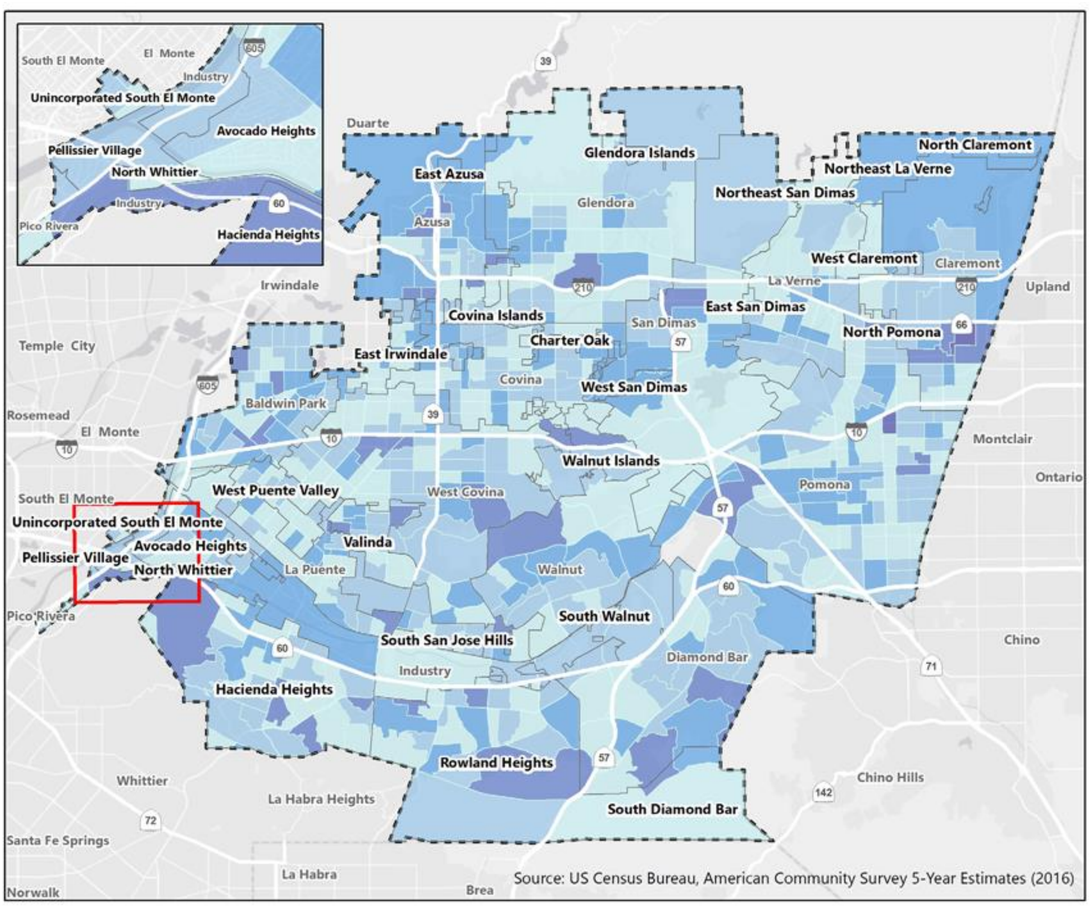
Percent Population with a Bachelors Degree

- 1% - 10%
- 11% - 17%
- 18% - 25%
- 26% - 34%
- 35% - 55%
- ESGV Planning Area

N

0 2 5 MILES

Figure D.8
Educational Attainment



Legend

% of Households with No Vehicle Available

- 0% - 2.2%
- 2.3% - 6.5%
- 6.6% - 11.7%
- 11.8% - 21.1%
- 21.2% - 43.3%
- ESGV Planning Area

N

0 2 5 MILES

Figure D.9
Low-Income Households

D.3 Disadvantaged Communities

Mobility strategies should include equitable consideration of the several communities in the study area with differing socioeconomic and environmental needs. Of the 224 census tracts in the study area, a total of 76 census tracts are designated as disadvantaged, according to CalEnviroScreen[1] scores. These census tracts are located in the unincorporated communities of West Puente Valley, Valinda, North Whittier, and Walnut Islands, as well as the cities of Baldwin Park, parts of West Covina and southern Azusa, La Puente, and Pomonaas shown in Figure 3.10:

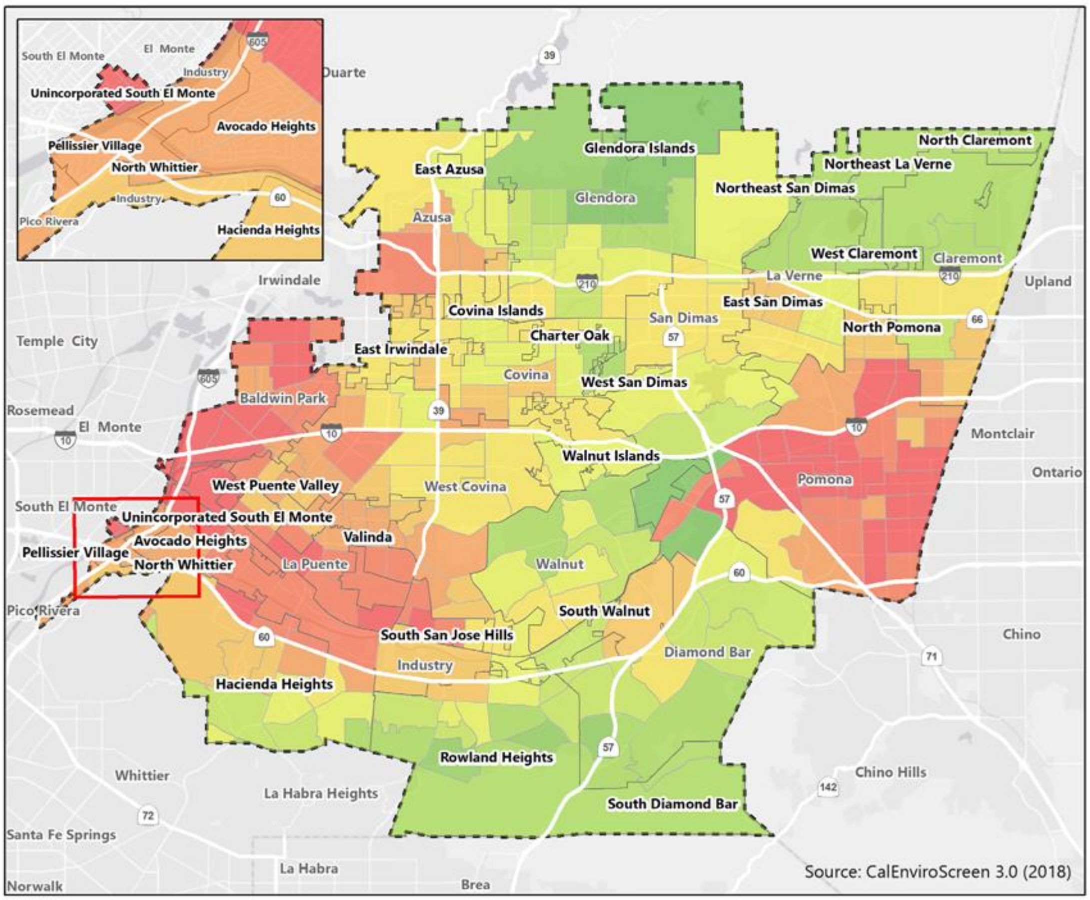
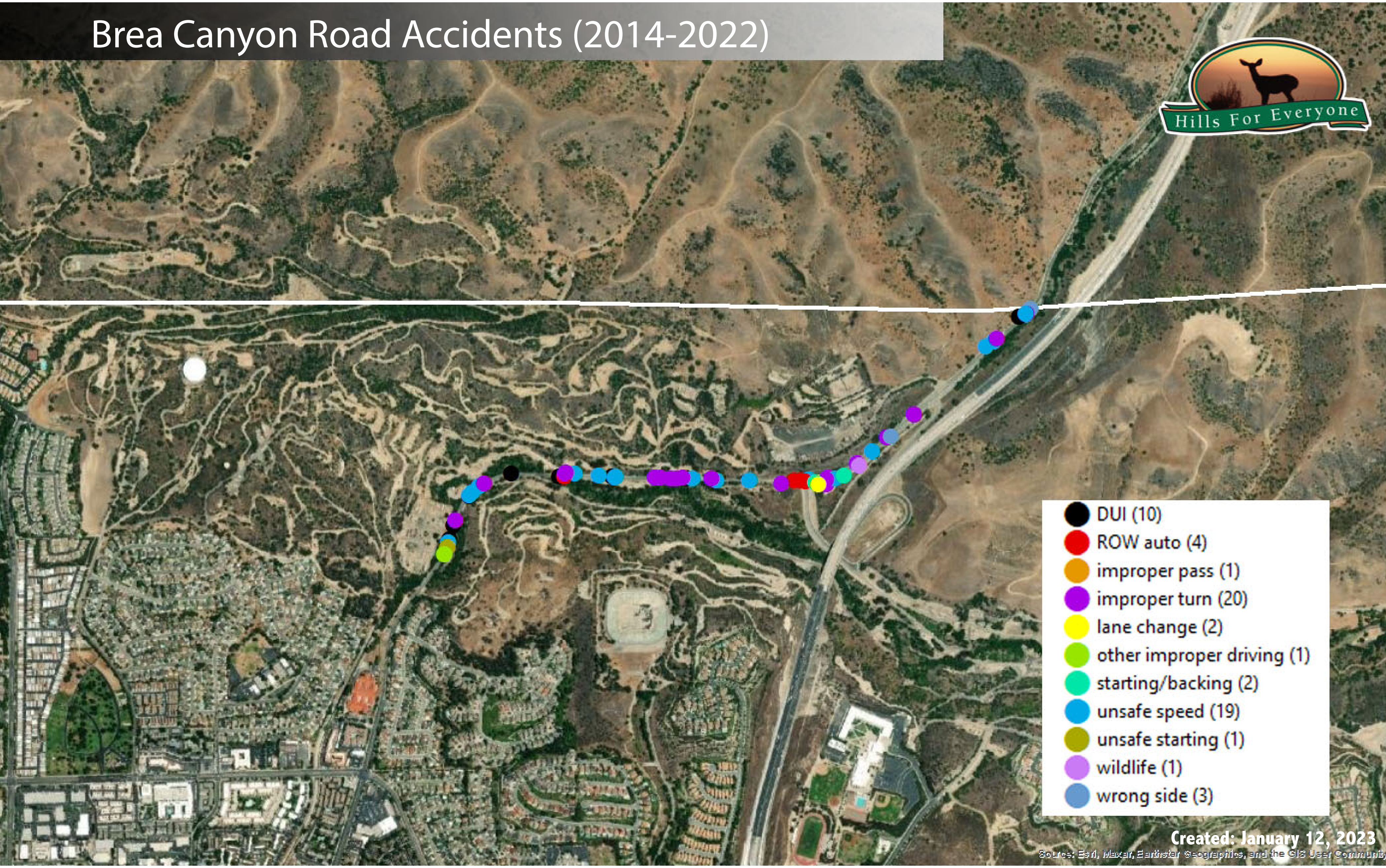


Figure D.10 Disadvantaged Communities

[1] The Office of Environmental Health Hazard Assessment's online tool, CalEnviroScreen 3.0, uses several indicators to determine a community's status as disadvantaged, pursuant to Senate Bill 535, which was passed in April 2017. The indicators re organized into four categories per census tract: 1) exposure indicators – indicators based on measurements of different types of pollution that people may come into contact with; 2) environmental effect indicators – indicators based on the locations of toxic chemicals in or near communities; 3) sensitive population indicators – indicators that measure the number of people in a community who may be more severely affected by pollution because of their health or age; 4) socioeconomic factor indicators – conditions that may increase people's stress or make healthy living difficult and cause them to be more sensitive to pollution's effects. Data for exposure and environmental indicators are sourced from a variety of statewide organizations, including the California Air Resources Board. Data for demographic-related indicators are sourced from the American Community Survey through the U.S. Census Bureau and the California Department of Public Health. Each census tract is then given an overall score based on these indicators.

Exhibit O



Brea Canyon Road Accidents (2014-2022)
Hills For Everyone
DUI (10)
ROW auto (4)
improper pass (1)
improper turn (20)
lane change (2)
other improper driving (1)
starting/backing (2)
unsafe speed (19)
unsafe starting (1)
wildlife (1)
wrong side (3)
Created: January 12, 2023
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Exhibit P

Brea Canyon Road Accident Statistics (Dec 2014-May 2022)

Data gathered by Hills For Everyone, December 2022

OBJECTID	Date	Accident Type	Severity	Source
1	20141218	improper turn	injury	CHP
6	20150430	DUI		CHP
7	20150518	improper turn		CHP
8	20150716	improper turn	injury	CHP
9	20150820	improper pass		CHP
13	20160501	DUI	injury	CHP
15	20170611	unsafe speed		CHP
16	20170827	improper turn	both	CHP
20	20180322	unsafe speed		CHP
22	20181214	wrong side		CHP
25	20190803	wrong side	injury	CHP
26	20190821	wrong side	injury	CHP
29	20191218	unsafe speed		CHP
30	20150130	ROW auto		CHP
31	20150607	ROW auto	injury	CHP
32	20180617	DUI	injury	CHP
33	20141220	DUI	injury	CHP
35	20150819	unsafe speed		CHP
37	20180906	DUI		CHP
41	20200216	DUI	injury	Brea PD
43	20200307	improper turn		Brea PD
44	20200310	unsafe speed		Brea PD
45	20200320	improper turn	fatal	Brea PD
46	20200413	DUI		Brea PD
47	20200713	unsafe speed	injury	Brea PD
48	20200722	lane change		Brea PD
53	20201004	improper turn		Brea PD
56	20201106	unsafe speed		Brea PD
57	20201125	unsafe speed		Brea PD
61	20210211	improper turn		Brea PD
62	20210224	improper turn	injury	Brea PD
63	20210320	unsafe speed	injury	Brea PD
64	20210505	improper turn	injury	Brea PD
66	20210710	improper turn	injury	Brea PD
67	20210810	unsafe speed		Brea PD
68	20210828	DUI		Brea PD
70	20211002	improper turn	injury	Brea PD
72	20211017	DUI	injury	Brea PD
73	20211023	unsafe speed	injury	Brea PD
79	20220115	improper turn	injury	Brea PD
81	20220204	unsafe speed		Brea PD
83	20220223	unsafe speed	injury	Brea PD
85	20220427	ROW auto		Brea PD

93	20220628	improper turn		Brea PD
94	20220707	DUI	injury	Brea PD
96	20220902	unsafe starting		Brea PD
97	20220906	unsafe speed		Brea PD
98	20200910	unsafe speed		Brea PD
100	20200713	unsafe speed	injury	Brea PD
102	20220223	unsafe speed		Brea PD
104	20220527	unsafe speed		Brea PD
0	20170514	improper turn	injury	Brea PD
0	20141214	improper turn		CHP
0	20150122	ROW auto		CHP
0	20141227	improper turn	injury	CHP
0	20150424	starting/backing		CHP
0	20150428	improper turn	injury	CHP
0	20150706	other improper driving		CHP
0	20170302	improper turn		CHP
0	20170412	starting/backing		CHP
0	20170714	improper turn	injury	CHP
0	20171201	unsafe speed	injury	CHP
0	20180302	lane change		CHP
0	20190226	wildlife	injury	CHP