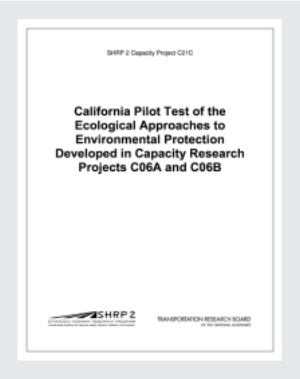


California Pilot Test of the Ecological Approaches to Environmental Protection Developed in Capacity Research Projects C06A and C06B

DETAILS

0 pages | 8.5 x 11 | PAPERBACK

ISBN 978-0-309-43397-6 | DOI 10.17226/22491

AUTHORS

Road Ecology Center & Department of Environmental Science and Policy, University of California

SHRP 2 Capacity Project C21C

California Pilot Test of the Ecological Approaches to Environmental Protection Developed in Capacity Research Projects C06A and C06B

SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
Accelerating solutions for highway safety, renewal, reliability, and capacity

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

SHRP 2 Capacity Project C21C

California Pilot Test of the Ecological Approaches to Environmental Protection Developed in Capacity Research Projects C06A and C06B

Road Ecology Center & Department of Environmental Science and Policy
University of California

TRANSPORTATION RESEARCH BOARD
Washington, D.C.
2013
www.TRB.org

ACKNOWLEDGMENT

This work was sponsored by the Federal Highway Administration in cooperation with the American Association of State Highway and Transportation Officials. It was conducted in the second Strategic Highway Research Program, which is administered by the Transportation Research Board of the National Academies.

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

Contents

Executive Summary

Like much of the US, California relies upon three scales of planning for transportation – project, corridor, and region. Each scale informs the others, leading to the development of state programming of projects, described in corridor and regional plans. Highway 37 in the San Francisco Bay Area is currently the subject of corridor planning by the California Department of Transportation, District 4 (Caltrans). The current C21 project "Highway 37 Stewardship Study" is the test-case for the California evaluation of C06 A&B (and other TRB) products. It will also inform the development of the corridor plan and model behaviors that Caltrans would like to include in future corridor plans. For example, the stakeholder process developed as the basis for the project could become *de rigeur* for Caltrans' future corridor planning. The project relies upon three inter-dependent processes: a stakeholder process to support scenarios descriptions and negotiated planning outcomes, a regional context description and assessment, and valuation/crediting approach to support scenarios comparison. Each of these project components links to a C06 A&B product (e.g., the regional ecological framework). They are also foundational pieces for the development of a stewardship-oriented corridor plan, the first of its kind in California.

The lessons learned from this process included issues specific to C06 and C01 tools, as well as larger-frame issues with combining transportation planning and environmental stewardship. For example, typically-long timeframes for planning and project delivery did not suit stakeholder expectations for getting started on obvious problems. Although the complete architecture of the Transportation for Communities (TCAPP) web site and the C06 reports were not useful to project participants, they may be useful libraries of important pieces of information. Team members felt that the contents of C01 and C06 should be available, but were not confident about their actual day-to-day use by transportation planners or other stakeholders, primarily because of the sheer amount of material. One important lesson from the potential application of C01 or C06 tools was that planning is best done in bite-sized pieces (e.g., focusing on a project study report), rather than the complete decade-long process from problem identification to programmed project. There are implications from this finding for how ecological capacity-building and training should occur: Through web sites, or through continuing "Academies"? Overall, the ecological framework provided a useful and understandable rubric for organizing information and thinking about decision-making.

Summary Findings from C06 Product Test

The integrated ecological framework in C06 suggests nine planning steps to improve the process of delivering transportation projects with early inclusion in planning of stakeholder interests and environmental information. Table ES.1 below summarizes how the team followed each of the first seven steps and the team's general findings from each.

Table ES.1. Steps of the Ecological Framework SHRP 2 C06

Step	Findings
Step 1: Build and Strengthen Collaborative Partnerships, Vision	The planning region boundary included the study highway and portions of five counties and several other state highways and interstates that share traffic with the highway. Stakeholders within this planning region were included within the stakeholder team and process. The team had difficulty representing all highway stakeholders and recommends that Step 1 encourages including the majority of affected party types.
Step 2: Characterize Resource Status. Integrate Conservation, Natural Resource, Watershed, and Species Recovery and State Wildlife Action Plans	The team used the stakeholder process to educate stakeholders about the content and availability of regional plans and data, but did not need to generate new information. The most significant data gaps are related to uncertainty around the predicted rate of sea level rise and the lack of accurate and detailed levee and berm topographic and location data. The conservation strategy for regional ecosystem processes and attributes was folded into the scenario development for the corridor, the corridor context description, and the regulatory-process foundation.
Step 3: Create Integrated Ecosystem Framework (Conservation Strategy +Transportation Plan)	The project team adopted the term "Corridor Context" instead of "Integrated Ecological Framework" to broaden the types of information and values the team included. The corridor context includes parallel recognition of community, transportation, environmental, and economic systems and values in decision-making about highways. Using these parallel categories for collecting and organizing information, in partnership with stakeholders and the community, and describing how well transportation plans support their values in these categories, reinforces the broad context in eventual project prioritization. To improve planning outcomes, the team recommends that more values are included in the Framework, such as local economy, community identity, environmental justice, climate adaptation, carbon budget, and possibly greenhouse gas emissions, and/or life cycle analysis.
Step 4: Assess Land Use and Transportation Effects on resource conservation objectives identified in the IEF	The team used the Road Effect Zone concept to capture potential effects of new projects on the environment. The team modeled traffic noise impacts as a specific case. Environmental regulatory agencies were also asked to consider different possible management scenarios for the corridor and speculate on the kinds of impacts that could occur, the permissibility of the scenarios and the mitigation that might be required under each scenario. Most regulatory staff stated that they had little ability to provide specific and formal input unless it is related to a regulatory action, such as a permit of environmental review. The team recommends that guidance be provided for how to assess transportation

	effects. The team further recommends that the liaison program be expanded to provide supported regulatory agency staff time to participate in the assessment phase of early planning, to improve connection between assessment and permits.
Step 5: Establish and Prioritize Ecological Actions	Based on their knowledge of environmental conditions, conservation objectives, and the connection between these and transportation infrastructure and plans, stakeholders and partners identified future scenarios for the corridor that supported these objectives. There did appear to be some agreement that raising the highway onto elevated causeway was environmentally-preferable, but many questions remained and key stakeholders were not present. In the absence of a clearly defined preferred alternative and specific recommendations from regulators, it is difficult to identify and establish mitigation priorities. Stewardship-conservation priorities may be more easily met in combined transportation and conservation planning.
Step 6: Develop Crediting Strategy	An overall valuation approach was used to frame credits, which captures a stewardship and community involvement ethos as well as mitigation activity. Two approaches were used to develop a "credits" system for positive action: 1) Choosing a valued path: Community preferences were quantified for specific possible future actions on the corridor, based on the actions' support for community values. 2) Developing credits within a path: Impacts on adjacent habitats and urban areas were quantified for each corridor scenario to support a unit impacted area approach to credits.
Step 7: Develop Programmatic Consultation, Biological Opinion, or Permit	The foundation for this step was laid with multiple meetings between transportation agency and regulatory agency staff. Because the process of early inclusion is atypical, it took a fair amount of persuasion to draw regulatory entities in. This could be improved by providing incentives to regulatory agencies and requirements for early regulatory involvement to transportation agencies receiving federal funds.

CHAPTER 1
Introduction

Corridor planning is an important geographic and time-scale intermediate step between regional and long-range planning and project delivery. The team chose this scale because it provides opportunities for including regional and local ecological, economic, transportation, and community information and needs early in transportation planning and project development.

In California, corridor plans form the basis for further study and development into pre-project initiation documents, the project initiation documents (PIDs) sponsored by either Caltrans or local agencies. The corridor plans and PIDs are used to develop the purpose and need for projects. A more thorough assessment of the facility development options, environmental mitigation needs, and stakeholder plans and needs in the corridor plan process can ensure that more comprehensive multimodal alternatives are developed in the early stages and that the necessary valuation is given to alternate modes and environmental enhancement. The purpose and need statement can benefit from a better understanding of the environmental and community needs that develop from the ecological approach and from bringing NEPA considerations and knowledge into the planning process. The PID purpose and need proceeds to the project development, design, and delivery stages in Caltrans. For the specific test case (Highway 37), this is key to designing and implementing a facility that considers the tidal marshes, preservation and recreation needs, as well as the safety needs of the public.

California and federal government agencies and private organizations have invested millions of dollars in restoring marshlands in the North San Francisco Bay (North Bay). These coastal marshlands are among the most endangered habitat types in the US and home to a diverse assemblage of plants and animals, including species listed under state and federal Endangered Species Acts (ESA). Highway 37 was built as a conduit between inland and East Bay areas (Richmond, Oakland, Berkeley, Solano County) and the North Bay communities and counties (Napa, Sonoma, Marin). It currently serves multiple transportation purposes: goods movement, inter-county commuting, and recreational travel (see Figure 2.1). It also passes through the marshes of the North Bay, separating the marshes from tidal influence and affecting natural flows and processes (Figure 4.1). Highway 37 is one of the lowest-elevation highways in the Bay Area and at its lowest elevation, the roadbed is currently just below sea level. As climate change results in sea level rise, this highway is likely to face erosion, more frequent flooding during storms, and gradual inundation by the sea.

Highway 37 bisects the city of Vallejo, which is struggling economically and has a large minority and low-income population. The highway provides access to other areas and effectively divides the community geographically. Besides suffering economically, a recent study (Shilling et al., 2010) has shown that Vallejo residents also have little access to parks compared to nearby wealthier communities. Highway 37 could provide a solution to this as it enters one of the largest potential recreation areas in the vicinity, North Bay marshlands.

These issues and the circulation requirements for the highway make it an ideal test case for an integrated ecological assessment framework and collaborative plan development among a wide range of stakeholder types.

Who: Partners

The project was led by UC Davis' Road Ecology Center, in partnership with Caltrans. UC Davis sub-contracted to partner organizations who are leaders in their respective urban and rural communities in planning, conservation, and stakeholder process.

- Caltrans, District 4
- UC Davis Road Ecology Center (http://roadecology.ucdavis.edu)
- Sonoma Ecology Center (www.sonomaecologycenter.org)
- Sonoma Land Trust (http://sonomalandtrust.org)
- Southern Sonoma County Resource Conservation District (http://sscrcd.org)
- Napa County Resource Conservation District (http://naparcd.org)

Who: Key Stakeholders

The partnership includes over 100 individuals and organizations that have joined us at one of 7 stakeholder meetings. Their effort and input helped shape this study and our understand of how using the C06 tools *in situ* results in transportation and ecological system stewardship. The stakeholder process has resulted in a cadre of committed individuals and organizations who attend stakeholder meetings and provide guidance and feedback for ways that regional concerns can be considered and addressed. Their input was critical to the development of the Regional Ecological Framework and description of plausible scenarios for the highway, which will become the foundation for crediting and agreements with regulators and others. In other words, the successful stakeholder process was a hallmark of the success the team had carrying out Step 1 of the C06 process and set the stage for an expanded version of COR-1, where the role of decision-maker is more broadly defined than in TCAPP.

CHAPTER 2
Step 1. Planning Region and Stakeholders

Build and Strengthen Collaborative Partnerships, Vision. *Build a vision of what is most needed for natural resources in the region and commit to integrate and utilize transportation and environmental regulatory processes to address these greatest conservation and restoration needs and goals*.

The team implemented this step by identifying and inviting a broad range of stakeholders to participate in a joint learning and visioning process. This included land-use, conservation, transportation, and other agencies and interests. The stakeholder process involved seven face-to-face meetings, a few conference calls, and a field trip. The process was used to define the planning region, conservation and transportation issues, and potential combined transportation and conservation solutions.

Step 1A. The Planning Region

The North San Francisco Bay region includes Marin, Sonoma, Napa, and Solano counties. Highway 37 traverses Sonoma County between Solano and Marin Counties, skirting Napa County on its southern boundary. It crosses the lower Napa River, Sonoma Creek, Petaluma River, and other small watersheds that feed into the North Bay. It traverses urban, agricultural, woodland, grassland, and wetland habitats, connecting Interstate 80 and State Highway 101.

The highway itself approximates a curve through the North Bay (red box, Figure 2.1). The study area is larger, roughly a rectangle (pink square, Figure 2.1) bounded on the west by the east edge of the city of Petaluma, on the north by the south edge of the city of Napa, on the east by the intersection of SR-12 and I-80, and on the south by the city of Albany. This area includes other highways potentially affected by sea level rise and decision-making about Highway 37. For example, planned or catastrophic reduction or elimination of traffic from the current right-of-way would displace traffic to State Highways 29, 12, and 121 to the north and Interstate 580 to the south.

Figure 2.1. Highway 37 (within red box insert) in the North San Francisco Bay planning region (pink box insert). The background image is from GoogleMaps.

One finding from the planning region definition was that it was possible to walk transportation and conservation-oriented people through the development of a scale that was useful for both types of activities. This planning region scale may be useful in future implementation of C06 and other Eco-Logical approaches because it should be possible to combine several corridors within the region into one over-arching planning process, even if each corridor is still covered by an individual planning report.

Step 1B. Stakeholder Involvement

Critical to the development of the corridor context, valuation approach, and foundation for agreements with regulatory agencies was the inclusion of stakeholders early in the process. Over 100 individuals and organizations participated in the stakeholder process. The team held seven stakeholder meetings, including the World Café workshop (see below). At successive meetings the team encouraged people to share their needs and desires for corridor planning, understanding of the issues facing the transportation corridors, ecological and community well-being issues that should be considered, and values for the corridor. This information sharing has been very important in getting and keeping transportation and environmental regulatory interests at the table.

Partners

The intent of this study was to provide opportunities for internal collaboration among DOT Offices and Divisions, as well as external collaboration between the DOT and local agencies and organizations. Explicit support was provided at the proposal stage through the initial stages of the project from several DOT Offices, including System Planning, Environmental, and Maintenance. Similarly, partner organizations included two Resource Conservation Districts (Napa County and Southern Sonoma County), a land trust (Sonoma Land Trust) and an environmental non-profit (Sonoma Ecology Center). This formal, structured partnering was intended to facilitate the working collaboration among the partner offices and agencies.

This partnership created a core group (hereafter called the "team") who collaborated to broadly consider the best ways to move forward on the effort.

Kickoff Methods

The core team decided that instead of hosting an official "kickoff" for a corridor that spans several counties and landscapes, it was more effective to host sequential "briefing" meetings that gathered data on participants' interests, and offered opportunities for stakeholders to learn about the effort and ask questions. The first three stakeholder meetings began with a substantive "briefing" theme to introduce new stakeholders to the study purpose and expected activities. At the conclusion of this C21 study, Caltrans has proposed to continue the stakeholder process to integrate findings from the C21 study process, foster increased communication among the stakeholders, and further develop potential corridor scenarios.

Collaboration Methods

Core Team Membership

This project used collaborative methods both through the project administration via a core team of agencies local organizations, and through the overall involvement of stakeholders that range from private landowners to federal regulators to tribal representatives. Core team membership includes the California Department of Transportation, the University of California, the Sonoma Ecology Center, the Sonoma Land Trust, the Southern Sonoma County Resource Conservation District, and the Napa County Resource Conservation District. The diverse constitution of the core team encouraged both broad outreach to stakeholders and also a range of views and experience in overseeing the project. That being said, the diversity did not extend to ethnic or community representation as the team were distinctly lacking in members of the communities of color that anchored the eastern end of the corridor. This seems to be a pervasive problem for many stakeholder planning processes and deserves special attention.

Meeting Location

To be responsive to differing travel distances, the core team decided to have the stakeholder meetings at varying locations along the Highway 37 corridor, thus encouraging greater

participation. The meetings were held in Novato (far west end of highway), Infineon Raceway (middle segment of highway), and Vallejo/Mare Island (far east end of highway).

Web Site

The core team determined that having a publicly-accessible web site was important in supporting stakeholder involvement and access to project-related resources. The University of California at Davis created a Highway 37 Corridor web site using open-source software: http://hwy37.ucdavis.edu. The web site is the sharing point for meeting materials, study reports, associated literature and reports, and the spatial and non-spatial datasets used in the study. UC Davis has committed to maintaining the web site until Caltrans or a consortium of agencies interested in Highway 37 can take it over.

Organizational Structure

The core team held monthly conference calls to consider project goals and structure. After the May 24, 2011 stakeholder briefing, the core team divided itself into three subgroups to more effectively address project goals outside of the monthly conference calls. The three subgroups were: Process, Development of a Regional Ecological Framework, and Development of a Crediting and Valuation Approach. The team‘s composition allowed it to seek feedback from transportation, conservation/environmental, and land-use institutions. Having this internal network connected to external networks was incredibly valuable in rapidly identifying potential future problems and fielding potential solutions.

Outreach/ evolution of involvement

Initially, the core team targeted key stakeholders in particular organizations to brief them on the project and invite their participation. The core team recognized that these people may not be the actual attendees, but that they would need to designate staff who could attend, thereby supporting the overall meeting series. Initial letters were sent to state and federal environmental regulators, local and regional transportation agencies, local and regional government representatives, and non-governmental organizations. The core team hosted an initial briefing on March 10, 2011 at the Schell-Vista Fire Station in Sonoma County, and 17 participants (including core team members) attended. Following this initial meeting, the core team broadened their contact list and on April 28, 2011, sent out a formal invitation letter to key stakeholders. This letter, sent from and signed by Caltrans Deputy District Director Lee Taubeneck, included the notes from the March meeting, a participant list, and an overall project briefing. Recipients were largely the same who received the previous, less formal invitation. Following the dispatch of this letter, core team members began personally contacting stakeholders to invite their attendance at subsequent meetings.

Thirty-five people (including core team members) participated in the May 2011 meeting at Mare Island, demonstrating that the personal follow-up calls to stakeholders were effective in building strong attendance. At this meeting, core team participants presented the overall

framework of the project and opened a discussion to further identify stakeholder interests and concerns. At this meeting, in addition to regulatory, transportation, and environmental interests, participants included tribal representatives and private landowners.

World Café ("Collaborative Partnerships" & "Prioritize Actions")

In order to find out more about what various organizations and stakeholders value about the highway corridor and associated community and natural values, the team engaged them in a café-style discussion. This approach was developed for just such an occasion and elicited value statements about possible future scenarios for the highway corridor. The expressed values were useful for developing the valuation and crediting approach. Association of values with different scenarios assists in developing possible ecological actions and overall stewardship of the corridor and related natural and human systems.

Step 1C. Statement of the Problem

Caltrans is exploring options for the future of Highway 37. This scenic roadway links travel to the East and West San Francisco Bay regions and the Napa/Sonoma Wine Country. Commuters, truckers, tourists, and many others travel on Highway 37, passing through cities, endangered species habitat, rare marshlands, and rich farmland. Flooding risks on the highway are increasing due to rising sea levels, and increased traffic continues to impact all who use this roadway, as well as the surrounding environment. Caltrans wants to work with others interested in the well-being of this corridor to create a plan and a vision that everyone can support. This vision must consider endangered species and their habitats; agriculture; increasing traffic; and sea level rise. It must also provide increased transportation choices and enhanced public access.

Highway 37 improvement options as part of corridor planning discussions have generally emphasized capacity expansion at key bottleneck locations. While not excluding other non-highway considerations, such considerations have not been the focus of mobility improvement discussions. The corridor is an important East-West highway connector in the Bay Area and its existing congestion is projected to increase over the next 25 years. Even though it is a secondary highway compared to the interstates and state highways it is parallel and networked with, it relieves pressure on these other routes. At the same time, it passes through very sensitive lands and is itself at risk of flooding in the future. Corridor planning for this highway informs the regional transportation planning process; the primary planning document for this process is the Regional Transportation Plan (RTP). Any major improvement project needs to be in the RTP to be considered for funding. Thus, the current corridor planning step is one of the earliest at which transportation demand, environmental constraints, and community preferences can be used to define strategies for improving transportation and stewardship of valued natural and human systems.

Making stewardship decisions for complex systems requires organizing similarly complex information about the systems. The Regional Ecological Framework from C06A provides a useful mechanism to organize information about natural systems to help inform

transportation planning. The framework is oriented toward spatial information about locations of species and habitats of concern, waterways, and other ecological attributes and processes that may be affected by transportation projects. The team has adapted and expanded the Framework concept to include more information about other aspects of the integrated human and natural systems in the study area. The C06 planning steps also provide a useful process for describing issues and using a stakeholder process to frame these issues in terms of combined transportation and environmental stewardship.

Special Issue: Sea Level Rise

Climate change brings with it sea level rise, which can impact natural and human communities in coastal areas. Because the study highway ranges from one or two meters above current sea level to slightly below sea level, the project rise of greater than 1 meter in the next 90 years poses a threat to the highway itself. The highway also acts as a levee between the rising Bay and thousands of acres of marshes that must be allowed to adapt to changing sea levels to survive. These marshes are both nationally important and habitat for endangered species, so the role of the highway in their adaptation must be considered in corridor planning.

Regionally, there is broad political and institutional acceptance of the possibility of rising sea levels requiring adaptive action in the near future. This was true in the stakeholder process where partner agencies and community members expressed concern that marsh adaptation be considered in new capacity planning. This resulted in broad support for a causeway option for the corridor, despite this being one of the more expensive possible constructed scenarios. This abandonment of the low-lying alignment was favored over armoring the existing footprint, which makes this an interesting case study for coastal areas in the US which are considering the same questions. It remains to be seen whether or not funding can be found to raise the alignment and thus reduce risk of the highway flooding and allowing the marshes to adapt to sea level rise.

> "Move highways and railroads that are barriers to marsh migration where there is otherwise space for marsh expansion/migration" (One Climate Change Adaptation Strategy Recommendation in EPA report, 2011 on SF Estuary. Page T-11)

CHAPTER 3
Step 2. Characterize regional plans and data

Develop an overall conservation/restoration strategy that integrates conservation/restoration priorities, data, and plans, with input from and adoption by all conservation and natural resource stakeholders identified in Step 1, addressing all species, all habitats, and all relevant environmental issues.

Highway 37 runs along the edge of San Pablo Bay (North San Francisco Bay Area) and the corridor is adjacent to wetlands, upland grasslands, oak woodlands, and riparian areas. It is recognized regionally and nationally as a unique and ecologically important landscape of natural beauty and ecological diversity. It is characterized by its lack of intensive development and, along with the South Bay, is recognized as the part of San Francisco Bay that offers the most opportunity for wetland restoration.

Historical Setting

The San Francisco Bay region, including San Pablo Bay, includes the most important estuary on the continental Pacific Coast for birds and a critical link in the Pacific Flyway. Historically, tidal marshes fringed San Pablo Bay and provided habitat for many species of fish, bird, and plants, many of which are now rare or extinct. Over 85 percent of the Bay's and over 82 percent of the North Bay's historic tidal wetlands were lost to land reclamation, with a dramatic reduction in the wildlife populations that depended on them. Many animal and plant species have become threatened or endangered as a result of this habitat loss.

Approximately 55,000 acres of tidal marsh existed in the North Bay before they were diked, drained and converted to agricultural lands. Today fewer than 10,000 acres remain. Restoration of historic wetlands and the preservation of existing open space are considered by local, state, and federal agencies as a critical step toward successfully implementing restoration and endangered species recovery efforts in the Bay-Delta and have been endorsed as a major goal by every government agency and organization interested in conservation and restoration of San Francisco Bay. For example, the *Baylands Ecosystem Habitat Goals Report* (1999) prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project, the San Francisco Bay Joint Venture *Implementation Strategy* (2001), and the Bay Area Open Space Council's *Conservation Lands Network Report* (2011) have developed specific goals to protect and restore Baylands and their watersheds in the North Bay.

Conservation and Restoration

San Francisco Bay's tidal marshes are valued, protected and restored in recognition of their ecosystem services, which include: high productivity and habitat provision supporting the food web leading to fish and wildlife; buffer against storm wave damage; shoreline stabilization; flood

water storage; water quality maintenance; biodiversity preservation; carbon storage and socio-economic benefits such as recreation. These services contribute to the Bay area economy and quality of life. Many state, federal and regional public agencies and nongovernmental organizations include among their objectives acquisition and restoration of wetlands along San Pablo Bay and many properties in the Region have significant restoration potential and therefore have been identified as high acquisition priorities. These agencies and organizations may acquire fee and/or easement interests in property either directly or through a grant to another conservation organization. The decision to convert agricultural land to seasonal or tidal wetlands is made on a case by case basis and based on economics, landowner goals, availability of acquisition and restoration funding, and the sustainability of agricultural operations in the corridor and in the region.

For years, scientists have recognized that restoration of the ecological vitality of the San Francisco Bay depends upon the restoration of many thousands of acres of tidal marshes around the Bay. The ecological benefits of conservation work in this region are widely acknowledged. Today, conservationists and scientists are also advocating for the restoration of tidal wetlands to provide an important natural buffer to anticipated sea level rise, which has important economic and conservation benefits.

In the last three decades, 30 wetland restoration projects have been constructed and 25 more are planned within Sonoma, Napa, and Marin counties. These alone total over 21,000 acres of restoration already completed or planned. There are potentially thousands of acres available in this area for restoration. Because many of the agricultural lands that were reclaimed from marshes remain largely undeveloped, the technical requirements for their restoration to tidal marsh are relatively straightforward: build a new flood protection levee and breach and grade down the existing levees that hold back the Bay. This process has been utilized during restoration of the Sonoma Baylands, Napa-Sonoma marshes, and other locations along San Pablo Bay where there were willing landowners and public agencies.

Selected key plans and policies for the Highway 37 corridor.

- San Francisco Bay Joint Venture: "Roadway planning should strongly consider the San Francisco Bay Joint Venture's partnership (27 member agencies and organizations) and federal executive order to meet its restoration objectives met through incentives and non-regulatory techniques."
- Focus: A Development and Conservation Strategy for San Francisco Bay, a partnership of ABAG, Metropolitan Transportation Commission, Bay Area Air Quality Management District, and BCDC.
- Baylands Ecosystem Habitat Goals Project. Published in 1999, the Baylands Goals are being updated to incorporate climate change and sea level rise.

- Change Hits Home: Adaptation Strategies for the San Francisco Bay Area, 2011. San Francisco Planning and Urban Research Association.
- Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on the shoreline. 2011. San Francisco Bay Conservation and Development Commission.

CHAPTER 4
Step 3. Development of Integrated Ecological Framework

Integrate the conservation and restoration strategy (data and plans) prepared in Step 2 with transportation and land use data and plans (LRTP, STIP, and TIP) to create the Integrated Ecosystem Framework (IEF).

The idea of the integrated ecological framework (C06A) is that it captures the environmental context of transportation infrastructure, in order to improve stewardship of ecosystems associated with transportation systems. By developing and populating the framework, parties involved in discussions of planning for specific facilities can start from the same knowledge base.

For this study a sub-group of the core team met and discussed development of the IEF. Ultimately the team devised a different name for the Framework. The project focused on corridor planning and had no obvious, direct intersection with existing land-use planning. Ideally the Framework as implemented in corridor planning should extend beyond ecological and transportation issues. After discussing concerns on connotations of "corridor" (not just used for transportation, but wildlife) and "regional" (Bay Area wide), the consensus was to name this framework the "Highway 37 Corridor Context". Other possible names discussed were "SR-37 Corridor Assessment Framework" and "Route 37 Context." The Highway 37 Corridor Context thus continues much of the intent of the IEF, while expanding its database and mission to include environmental, transportation, agricultural land-use, community, and economic considerations and information.

The purpose of the Corridor Context is to create a shared understanding of the context of Highway 37, with a common way of viewing information, to inform options and improve the ability to address stakeholder interests. The Corridor Context includes current conditions and likely or desired future conditions. In Caltrans terms, the Corridor Context serves as a "corridor assessment."

The types of content that are part of the Corridor Context include:

- Quantified/mapped traffic patterns and noise model products.
- Lists/maps of attributes that stakeholders value.
- Narratives for topics that can't be readily mapped; e.g. restoration history of wetlands or issue of appraised land value for agricultural formerly tidal lands. Trends in conditions that may be hard to map.
- Information that is better conveyed as graphs and diagrams.

Regional Objectives

The corridor cuts across the "Baylands" area of the San Francisco Bay, the predominant objective for which is large-scale restoration of tidal and other marshes in order to benefit native

species and ecological processes and, to a lesser extent, to buffer the effects of storms and sea level rise on coastal infrastructure. Caltrans objectives are to provide access to communities and other amenities via the corridor and to provide mobility and safety along the corridor, while minimizing impacts to environmental and community conditions adjacent to the corridor. These objectives overlap in the restoration and protection of natural landscapes in the region of the corridor.

It is not the job of the environmental agencies to protect the transportation function of the corridor. Nor is it the job of the transportation agencies to restore ecosystems, unless their degradation is linked to transportation infrastructure and traffic. However, there is general agreement in the North Bay that transportation agencies can play a stewardship role in the region by both avoiding new impacts and contributing to restoring existing and legacy impacts of the highway.

In the context of the corridor management plan, different scenarios for the corridor may quantifiably or relatively contribute more or less to each of the environmental and transportation objectives. A stewardship approach encourages selection of a scenario, or portfolio of approaches, that demonstrably minimizes, avoids, and potentially restores impacts, while providing a basic level of safe accessibility and mobility.

Description of Corridor Context

Several main types of information were included in the corridor context – 1) spatial data about the distribution and composition of natural and human communities and 2) narrative descriptions of the surroundings and issues facing the corridor. The spatial data and tabular traffic data were made available for download on the project web site: http://hwy37.ucdavis.edu.

Wetlands

Highway 37 is surrounded by salt-water, brackish, and fresh-water wetlands along approximately half of it its length. The highway cuts across the Bay-side of many wetlands that otherwise would be subject to tidal flows. Because these wetlands vary in elevation relative to the sea, certain wetland areas are maintained artificially in fresh-water or brackish conditions when they would otherwise be salt-water tidal marshes, or mudflats. The marshes are often adjacent to agricultural, urban, and other natural lands. Many are connected to nearby creeks, rivers, and the Bay through a network of artificial and natural sloughs and drains.

The Napa-Sonoma Marsh (Marsh) is a complex of tidal marshes, sloughs, rivers, and reclaimed marsh used as agricultural lands. It is located at the northern edge of San Pablo Bay and covers roughly 73 square miles (Madrone Associates 1977). This marsh has an area of 48,000 acres, of which 13,000 acres are abandoned salt evaporation ponds. The US government has designated 13,000 acres in the Marsh as the San Pablo Bay National Wildlife Refuge. The Marsh is fed by Sonoma Creek, Tolay Creek, and the Napa River. Most of the Marsh is only accessible by boat. Agricultural lands occupy almost half of the Marsh and are largely reclaimed

lands that support oats, hay and grains, and cattle and sheep. Salt production is the largest industrial use of the marsh, covering approximately 20% of the area.

The status of marshlands in the San Francisco Bay Delta Area has changed considerably. Around 1860, the Marsh was one of the most productive wetlands of the Pacific Coast, providing habitat for millions of birds. By the mid-1980s, the San Francisco Bay perimeter had lost over 91% of its wetlands. Approximately 85% of the original tidal marshes in the area have been lost due to creation of salt ponds, conversion to agricultural and industrial/urban use, and water diversion and management (Marshall & Dedrick 1994). Currently, the Marsh represents one of the few coastal marshland areas where restoration is feasible and is actively promoted by the California Coastal Conservancy, the California Department of Fish and Game, and the Point Reyes Bird Observatory.

The close interaction among hydrological regimes, soil characteristics, and vegetation is what governs the maintenance, functions, and services provided by tidal marshes. Currently and in the future, there could be two opposing threats: insufficient tidal flooding (due to restriction), or excessive tidal flooding (due to subsidence and sea level rise). Artificial infrastructure, including roads or berms, has an impact on marsh hydrological regime by causing inadequate provision of tidal flows (Boumans et al 2002). Constrained flows hinder ecosystem functions by disrupting the natural interactions among vegetation, soil, and hydrology. The lack of saltwater tidal exchange in restricted salt marshes has 1) promoted spread of invasive species that are less tolerant to salt water; 2) restricted nekton distribution, 3) promoted the oxidation of sediment organic matter leading to subsidence or loss of elevation, and 4) decoupled the natural sedimentation process in marshes for adaptation to sea level rise.

Ecosystem Functions and Services Provided by Napa-Sonoma Marsh

"The Economic Value of the World's Wetlands" provides a list of general functions and services provided by wetlands in Box 1 (Schuyt and Brander 2004). The different wetland types vary in function, contour, biota, tidal action, water quality, and in their respective contribution to the marine food chain. Wetland functions are the result of physical and biological processes and interactions. The main wetland functions that have global significance for the service they provide in tidal marshes are:

a. Biodiversity Support

The Marsh is a productive estuarine ecosystem providing habitat for a wide diversity of flora and fauna, including numerous rare endangered species and migratory species, many of which are attracted by the presence of water, high plant productivity, and other habitat qualities. Special status mammals and water birds include the salt marsh harvest mouse, the California clapper rail, and the black rail. Main endangered fish found are the Delta smelt, Sacramento splittail, steelhead trout, and Chinook salmon. Other aquatic animals include the endangered California freshwater shrimp, the Dungeness crab, and other benthic and planktonic invertebrates. Because of its bird diversity, the Marsh is one

of only seven marshes selected for intensive study by the Point Reyes Bird Observatory (based on a total of 50 discrete marshes similar to the San Francisco Bay).

b. Water Quality Improvement

Tidal wetlands improve degraded waters by recycling nutrients, processing chemical and organic wastes and capturing sediment loads; the cleansed water helps maintain aquatic organisms. These ecosystems undoubtedly provide water storage services and improved water quality in the Napa River and San Francisco Bay.

c. Disturbance Regulation and Protection

Marshes act like giant sponges, as they form a protective barrier for coastal urbanized areas, buffering buildings and transportation networks from wave impacts during storm surges. Marshes and floodplains are critical in mitigating flood damage, as they store large quantities of water, effectively reducing the height of flood peaks and the risk of flooding. Disturbance regulation saves high economic costs associated with flood damages in areas where wetlands are preserved and restored.

d. Carbon Regulation and Management

Thick layers of carbon-rich peat play a role in the global carbon cycle by binding poorly decomposed plant material into the substrate. The sequestration rate in wetlands is significant considering that carbon is buried in the sediment at rates up to 50 times higher than those observed on land, and these rates can be maintained for centuries or more.

e. Food-Web and Nursery Habitat Maintenance

The decomposed detritus from marsh vegetation contributes to the base of the food chain of estuarine and marine environments. The rich out-flowing of dissolved nutrients, organic debris, and invertebrate larvae, carried off by tidal currents, provide a food resource upon which many marine species rely, including commercially important fish. Anadromous fish such as shad, sturgeon, salmon, steel head trout, and striped bass use these areas year-round for feeding or during spring migration, and also use the area as a nursery ground during their juvenile stages (Madrone Associates 1977).

f. Recreation and Cultural Services

Public protected areas provide several recreation opportunities including fishing, bird watching, hunting, and environmental education. Waterfowl species recreation and hunting is well-known in marshlands around San Francisco Bay.

Each of these tidal marsh services will have an impact when loss of marsh acreage occurs. Because hydrologic conditions define wetlands, any alteration of water volume (increases, decreases, or timing of high and low waters) threatens the area and integrity of

wetlands (Zedler and Kercher 2005). And because the quality of the water further defines the type of wetland, increases in nutrient loadings (eutrophication) often threaten wetland integrity.

Due to the existence of several non-linearities in the quantification of ecosystem functions and services, the effect of development on specific services itself could show unexpected changes. For example, marsh drowning will result in an increase in un-vegetated intertidal habitat (i.e., mudflats), as will the inevitable erosion of low marsh habitat, especially along bay margins. This may or may not counteract expected mudflat losses within the open San Francisco Bay but should at least provide new foraging habitats for shorebirds, waterfowl, and other water-birds. Thus, although the loss of vegetated marsh would have negative consequences for marsh dependent species, there are likely to be benefits for other species and services associated with these species including recreation, fishing, and hunting. As a result, restoration and conservation planning in the face of sea-level rise (SLR) will necessarily involve an evaluation of ecological trade-offs, as is already the case for current restoration planning efforts.

Endangered Species

The wetlands, waterways, and grasslands surrounding the corridor are habitat for a wide variety of native fauna and flora, including several state- and federally-protected species (Figure 4.1). Protected species include: the Delta smelt, green sturgeon, Sacramento splittail, steelhead trout, Chinook salmon, California black rail, California clapper rail, and salt marsh harvest mouse. These species all raise permitting issues in conventional transportation planning and project delivery. One thing that is noteworthy is that environmental regulatory agencies described one future scenario for the corridor as “self-mitigating” when it came to endangered species – the causeway option.

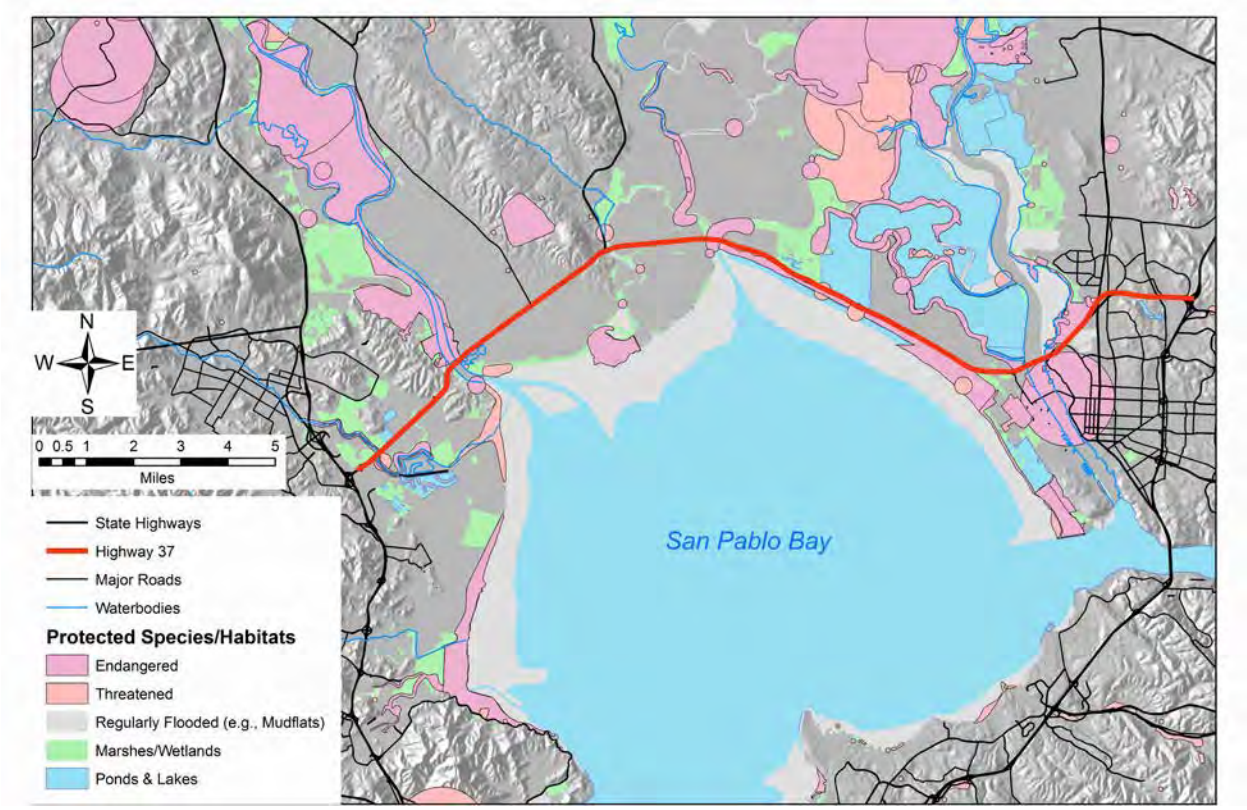


Figure 4.1. Protected species and habitats near highway 37.
Species and habitat spatial data from the California Natural Diversity Database.
These areas represent past occurrences, but not all, or current occurrences.

Land-Use

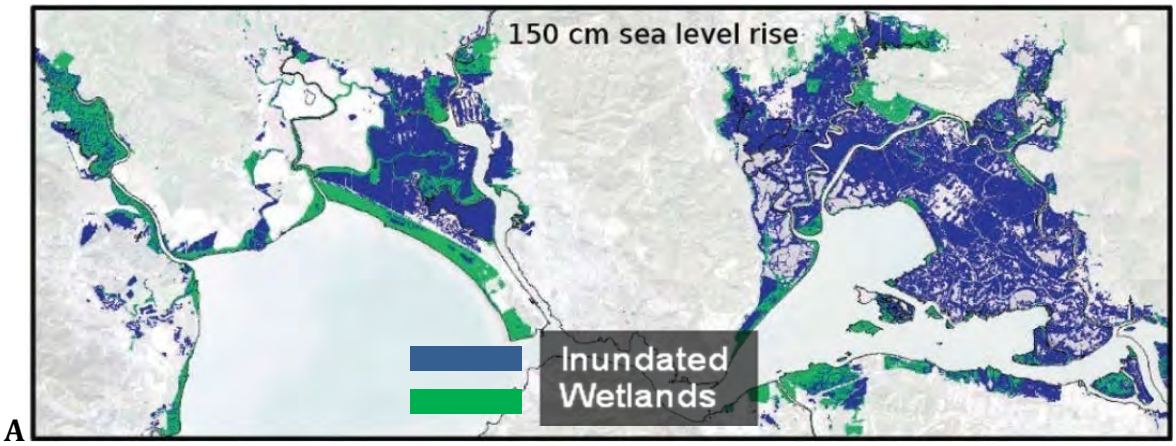
There are three main land-uses along the corridor, in descending order of extent: conservation/restoration, agriculture, and urban (commercial and residential). There are two main types of agriculture – growing hay and raising dairy-cows. In the larger North Bay region, there are other kinds of field crops, vineyards/wine-making, and orchards. Highway 37 probably contributes to the movement of agricultural goods within and out of the region. Either end of the corridor is anchored by small cities that are part of the larger urban area of the San Francisco Bay.

Changing land-use at the fringes of the Bay Area, primarily residential development, impacts the developed lands and surrounding areas, as well as areas such as along the Highway 37 corridor, which provide commuting pathways for exurban residents to urban jobs. Highway 37 is anchored at the west end by Marin County, which is one of the most expensive places to live in the US. Jobs-housing imbalances contribute to service and industrial workers driving from inland areas along Bay Area highways, including Highway 37, to jobs in Marin and Sonoma Counties (Hickey, 2011). Because new developments are slow to be approved (for legitimate environmental reasons) and house/apartment prices unlikely to become affordable, the imbalance

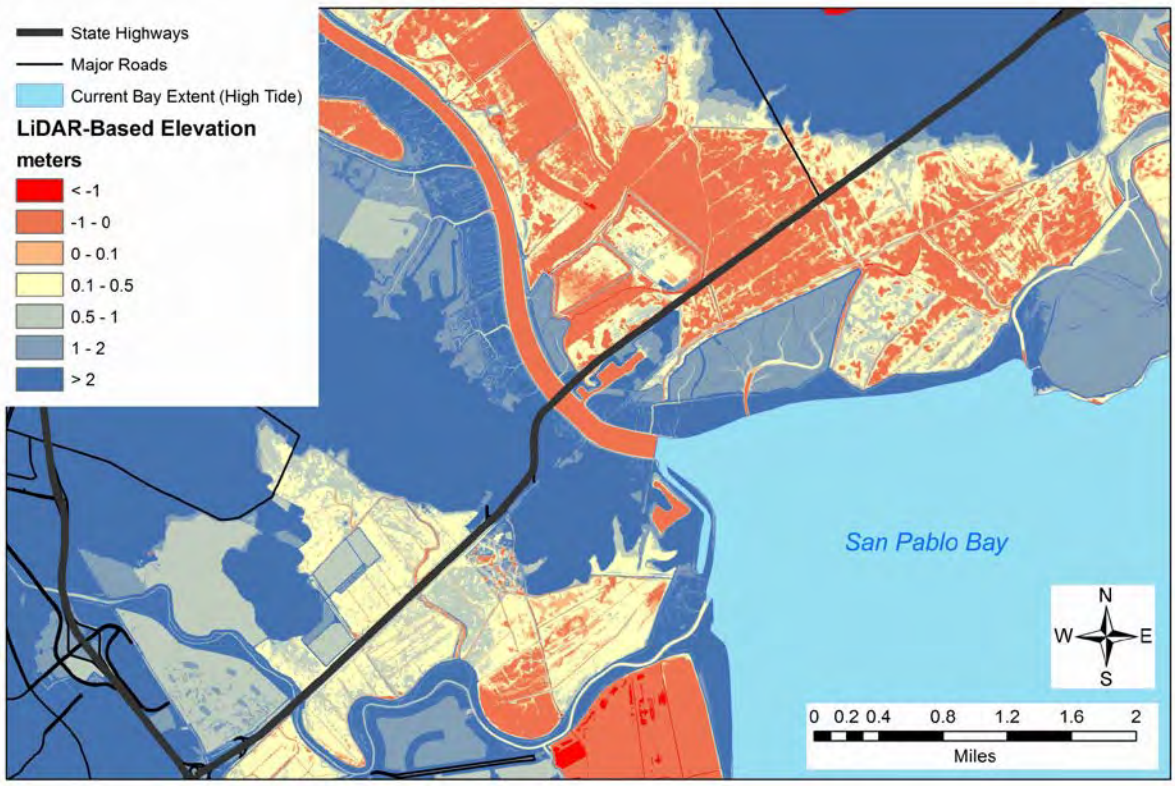
is likely to continue and worsen with regional population growth. Expanded capacity along Highway 37 is unlikely to make things better and may even exacerbate the situation if it becomes easier to commute from inland areas to Marin and Sonoma Counties.

Sea Level Rise

As a coastal highway, this corridor is under threat from sea level rise. It also poses a threat to the ability of nearby marshes to adapt to sea level rise. A state agency that is responsible for land-use and conservation planning in the Bay Area (the Bay Conservation and Development Commission, BCDC) recently developed a model of the inundation that could occur under likely climate change scenarios. This model shows much of the lowland North Bay wetlands and agriculture landscape under water, including most of the highway 37 corridor (Figure 4.2A). This "bathtub model" did not take into account the locations and elevations of berms and levees and therefore provides only an approximation of where sea level rise impacts might occur. However, when released it garnered a lot of negative and positive attention because of the risk that was apparent to various kinds of infrastructure and land-ownership. More recent, high-resolution elevation modeling by the US Geological Survey (Figure 4.2B) makes it obvious which segments of highway and areas of wetlands are most at risk from future sea level rise. The USGS is using these data to develop high-resolution, coastal sea level rise models.



A



B

Figure 4.2. Areas in the North San Francisco Bay potentially at risk from sea level rise. A. Model commissioned by the Bay Conservation and Development Commission, showing 150 cm rise by year 2100.
B. Areas adjacent to part of the highway below current sea level (<0 m elevation) and below future sea level at 2100 (<1-2 m elevation).

Transportation

Highway 37 constitutes a major regional east-west vehicular transportation corridor in the northern Bay Area, connecting the North Bay from US 101 in Marin County to Interstate-80 (I-80) in Solano County (Figure 4.3). Stretching west to east for approximately 22 miles, Highway 37 is anchored by Novato in Marin County and Vallejo in Solano County. Highway 37 runs along the northern shore of San Pablo Bay. It primarily serves commute and recreational traffic between Marin, Sonoma, and Solano Counties.

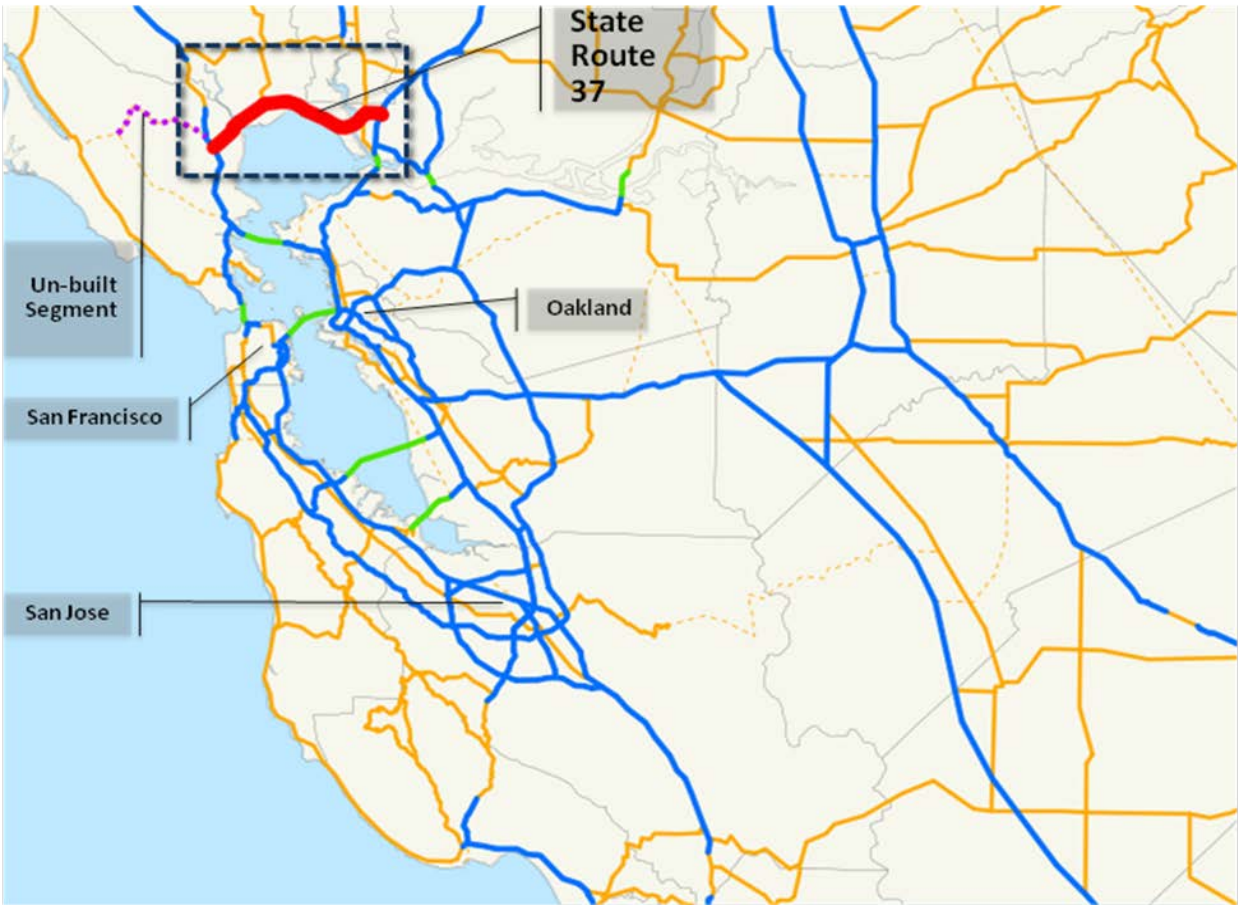


Figure 4.3. Position of the corridor in the Bay Area regional network of highways.

Traffic volumes are currently below capacity for the entire length of the corridor (Table 4.1). Without capacity enhancement, segments of the corridor are anticipated in 2035 to operate significantly above capacity. Increasing capacity is expected to alleviate congestion along segment B, which is the segment that runs without intersection through the marshes, between I-80 and State Highway 121.

Caltrans regularly collects traffic data along state highways. In addition, the agency and local agencies model projected future traffic volumes, based on current conditions, highway capacities, and changing land-use. Future traffic demand was modeled for the highways in the

study region. The Marin County Travel Demand Model was used for this exercise. Year 2035 forecasted volumes for Highway 37 were estimated for the existing facility configuration as well as a possible future four-lane freeway facility for the entire corridor length. In addition, a year 2035 model run was performed with existing Highway 37 removed from the model network west of Highway 29 (to simulate a realignment of Highway 37 along existing highway route alternatives because of rising sea level). For this scenario, year 2035 volumes were provided for key highway segments that provide an alternative to east-west travel on Highway 37.

Travel Demand Model Capabilities and Limitations

Results from a Travel Demand Model are for use in high-level planning analyses of long-term improvements, and do not represent comprehensive analysis of existing and future traffic conditions within a travel corridor. Travel demand models have specific analytical capabilities, such as the prediction of travel demand and general representation of traffic flow in a regional highway network. They use mathematical models to forecast future travel demand based on current conditions and future projections of household and employment characteristics. They are not designed to evaluate system management strategies, such as intelligent transportation systems (ITS) or specific operational improvements.

Average Annual Daily Traffic, Peak Hour Traffic and Volume-to-Capacity Ratios

Average Annual Daily Traffic (AADT) is a typical TDM performance measure showing the total number of vehicles that traverse a segment of highway for a year divided by 365 days. As a result it averages out seasonal variations in traffic volume, providing a general indicator of the volume of traffic accommodated by the highway segment. Another typical TDM performance measure is peak hour traffic, which shows the highest number of vehicles that traverse a highway segment during the single hour of highest peak traffic (usually noting if it is the AM or PM peak hour).

A vehicle-to-capacity (V/C) ratio compares the actual or projected number of peak hour vehicles shown to be travelling through the mainline highway lanes against the assumed full capacity of the same mainline highway segment. For example, a typical freeway lane is often assumed to accommodate 2,000 vehicles per hour per lane, so a 2-lane freeway would have a full capacity of 4,000 vehicles per hour. If that freeway had 3,150 vehicles per hour, it would be operating with a V/C ratio of 0.79. Any highway segment with a V/C ratio under 1.0 is assumed to operate under full capacity on a typical day. This does not necessarily mean there is no congestion or operational problems, just that the amount of travel demand is less than its theoretical capacity. While any V/C ratio over 1.0 is not physically possible, in a TDM output this simply represents a theoretical traffic demand beyond the full capacity of the highway segment.

Table 4.1. Traffic Volumes as Average Annual Daily Travel (AADT) for the Three Segments of the Highway Corridor

		2010	2035 (existing)	2035 (inc. capacity)
Segment Description	Segment	AADT	AADT	AADT
US-101 to SR121	Segment A	37,933	67,823	72,181
SR121 to Mare Island in Vallejo	Segment B	36,970	66,145	72,896
Mare Island to I-80	Segment C	92,382	114,932	119,366
(Exceeds peak volume/capacity ratio of 1)				

"2035 (existing)" refers to the highway with its existing capacity.
"2035 (inc. capacity)" refers to the highway with increased capacity in segment B (2 lanes to 4 lanes).
The orange highlight indicates traffic volumes that exceed capacity at peak times.

CHAPTER 5
Step 4. Assess Land Use and Transportation Effects on Resource Conservation Objectives Identified in the REF

The corridor provides commuting access between residential areas inland of the San Francisco Bay and service and commercial jobs in coastal Marin and Sonoma Counties. It also serves goods movement among agricultural, processing, and industrial facilities. Over the next 25 years, traffic on the highway (and other regional routes) is projected to increase by 30,000 AADT (between 30% and 80% increase), related to increased land development in the San Francisco Bay Area and adjacent areas. Expanding the capacity of the highway is projected to result in an additional 12% increase in traffic (Table 5.1), which may be related to the availability of an improved facility.

In the present study, the existing and projected traffic volumes were used to assess current and potential future effects on surrounding natural areas, as well as urban areas. The assessment was based on the "road effect zone", which is the area around a given roadway affected by the presence of the infrastructure and the traffic.

Road Effect Zone

Road/highway effects from the existence and use of infrastructure are pervasive throughout developed landscapes, but seldom measured, modeled, visualized, or used in planning and transportation decision-making. This means that the evaluation of potential transportation alternatives, potential impacts, and potential mitigation activities are not based on the actual distribution of effects from the transportation infrastructure.

The environmental impacts of roads and road networks vary in type and degree based on the physical properties of the roadway, the activities associated with the road, and the sensitivity of the local environment. The local environment affected by the road surface and traffic has been termed the "road effect zone" (Forman and Deblinger, 2000; Forman et al., 2002a). Although there is a rapidly growing literature on specific environmental impacts within this zone (stormwater runoff effects, biological invasions, noise, wildlife barriers), there have been few tests of the extent of the road effect zone, how various impacts are interrelated, and how these impacts could be minimized through pavement and roadside management activities, and how the zone could be used in transportation planning.

Road effects on aquatic ecosystems can consist of chemical inputs to waterways (Gjessing et al., 1984; Hoffman 1981; Bell and Ashenden 1997; Ziegler and Giambelluca 1997), alteration of aquatic community processes (Wilcox 1986; Maltby et al., 1995), impacts upon the physical characteristics (e.g., channelization) and processes of stream systems, and their ability to recover from land-use impacts (Meyers and Swanson 1995). Riparian roads can cause reduced riparian bird species richness and density (Rottenborn 1999) and overall species richness in wetlands (Findlay and Houlahan 1997). Roads can also affect terrestrial biodiversity directly

through loss of habitat and increased mortality, as well as indirectly by causing ecological changes in the "road-effect zone," hindering habitat connectivity, and fragmenting habitat patches (Jonsen and Fahrig 1997, Chapin et al., 1998, Rosenberg et al., 1999, Baker and Knight 2000). Road and land development can cause fragmentation with varying impacts (Yahner 1988, Theobald et al., 1997, Lidicker 1999). Fragmentation and disturbance impacts from roads may exacerbate threats of extinction from other factors through impacts on migration and habitat quality (Fahrig 2001). Not only do roads create artificial habitat edges, but they also pose a barrier to species dispersal and migration through aversion effects ("habitat alienation", e.g., Mac et al., 1996), direct mortality from traffic (Madsen 1996, Putman 1997, Rubin et al., 1998), and traffic noise-induced effects (Reijnen et al., 1997, Gill et al., 1996). The combination of edge and barrier can reduce the effective area for species that depend on intact habitat in the interior of patches.

Roads can affect people too. Traffic noise has been shown to be connected with increased incidence of hypertension and specific heart ailments (Lercher et al., 2011). This problem increases with age and is inversely related to education and income.

Table 5.1. Examples of Effects Distances from the Scientific Literature

Road Effect	Effect Distance (m)	Citation
Amphibian occupancy	1,000	Eigenbrod et al., 2009
Sensitive birds occupancy	1,200	Forman et al., 2002
Large mammals movement	600	Gagnon et a., 2007
Soil contamination	30	Backstrom et al., 2003
Wetlands processes	500	Findlayand Houlahan, 1996
Human health	400	Raaschou-Nielsen, 2011; Spira-Cohen et al., 2011

Note: These distances represent the furthest measurable distance of each effect in the cited study.

The "road effect zone" (Forman et al. 2002a) provides an efficient way to delineate, describe, and communicate about the interactions between roadways and natural systems and processes. This zone extends from the immediate road-side environment out to the extent of effects from individual roadways and road systems. Partial delineation and use of this zone concept has been used for tortoises (Boarman and Sazaki, 2006) and frogs (Lesbarreres et al., 2003). However, there is very little development of the zone concept in the literature, despite the fact that it is robust and measurable and that it would be very useful to guide road ecology research and transportation planning and management strategies.

As a proof of concept for modeling specific effects of transportation, the team focused on one of the more challenging components, accurately calculating the traffic noise envelopes around roads. Traffic noise effects occur at intermediate distances compared to near-road effects (e.g., weed-seed dispersal) and long-distance effects (e.g., NOx emissions impacts on regional

plant communities). The team used the noise model, System for the Prediction of Acoustic Detectability (SPreAD) version 2.0, developed at the Center for Landscape Analysis (UC Berkeley) by Sarah Reed, now at Colorado State University. The output of the model was a map of a part of the road effect zone and was used in discussions about road effects and ways to develop impact assessments and crediting strategies.

Modeling Noise Effects

The sound model, System for the Prediction of Acoustic Detectability (SPreAD), is an ArcGIS toolbox plug-in for modeling sound propagation from a single point source across the landscape. SPreAD was originally a spreadsheet routine developed by the U.S. Forest Service and the Environmental Protection Agency to study recreational noise in US National Parks and Forests. The Center for Landscape Analysis in San Francisco updated the model, converting the lookup tables to formulas. The model calculates noise propagation at a given frequency from a point-source, based on land-cover, topography, and climatic conditions. The road network totals 202 km and was broken into thirteen road segments, which were in turn further represented by points 250 m apart. Noise propagation from the points within each segment was analyzed, resulting in a raster representing noise intensities (in dBA). The team used current (2010) and projected (2035) average annual daily travel (AADT) traffic volumes and traffic composition (e.g., % heavy trucks) to calculate sound intensities (in dBA) at the highway. Traffic noise was estimated using the Federal Highway Administration's Traffic Noise Model, v2.5 (FHWA, 2004). Noise at the point of origin (highway), a digital elevation model (DEM), land cover (i.e., vegetation and developed areas), and climatic conditions were used to model sound propagation across the landscape.

The output of the sound model was a raster with a gradation of values from a peak at the roadway (greater than 80 dBA) to background noise (~35 dBA). Two cutoffs were used to understand potential impacts of traffic noise: greater than 40-50 dBA, for sensitive birds (Parris and Schneider, 2009; Dooling and Popper, 2007), and 50 dBA, for multiple effects on human health (reviewed in Lercher et al., 2011). The raster extent at 40 dBA was intersected with the California Vegetation map (CalVeg) to assess potential effects on sensitive wildlife living in different habitat types. The raster map extent at 50 dBA was intersected with the National Land Cover Dataset, urban areas, to approximate effects on human health. This type of intersection provides transportation planners and environmental regulatory agencies with a way of estimating the impacts of current and proposed transportation projects on species and habitats of management concern.

Traffic noise can affect both natural and human system well-being. Estimating traffic noise impacts on highways in a region with varying traffic intensities provides a mechanism for both calculating total transportation impacts, as well as understanding trade-offs inherent in developing different transportation corridors. In the North San Francisco Bay region, traffic noise impacts vary considerably among highways with different traffic volumes and in different natural settings and communities (Figure 5.1B). These varying impacts are critical to understand

if regional highway-specific and cumulative impacts are to be understood and used in transportation planning.

Noise Effects Findings

There are various ways that noise effects can be accounted for to inform credits, valuation, and decision-making. The easiest and crudest is in terms of habitat area affected. This doesn't necessarily measure harmful outcomes, so much as provide an estimate of impact in land-units, which are a familiar currency in transportation and land-use decision-making. The impacts to wildlife and people can be derived from the area-affected, if there is knowledge about how many individuals, or what species, live in the affected area.

Traffic noise can affect sensitive birds down to a sound intensity of 40 dBA. This is about the noise level of a suburban neighborhood, which is still higher than the noise level in a quiet grassland or forest (~20 - 25 dBA). Noise affects most wildlife, birds, and humans at levels above 50 dBA, with more severe effects as the noise level goes up toward 100 dBA, levels which can cause physiological harm. The team estimated the habitat-area affected by traffic noise from Highway 37 and from the regional highways (Figure 5.1), under different improvement/expansion scenarios (Table 5.2). These scenarios are described in "Step 5" below and in Appendix A. Scenarios B & C involve expanding the highway to four lanes upon a raised footprint (B), or a causeway (C), for which traffic is expected to increase. Scenario D involves removing the majority of the current alignment and co-aligning the highway with Interstate 80 to the south. Under current conditions, greater than 14,000 people may be affected by traffic noise (greater than 50 dBA) from highway 37 (Figure 5.2, Table 5.2). This number goes up to greater than 23,000 by 2035, due to traffic increases. Removing the stretch of Highway 37 that goes across the marshes reduces the traffic through the neighboring urban area and thus the number of people affected by noise (7,800).

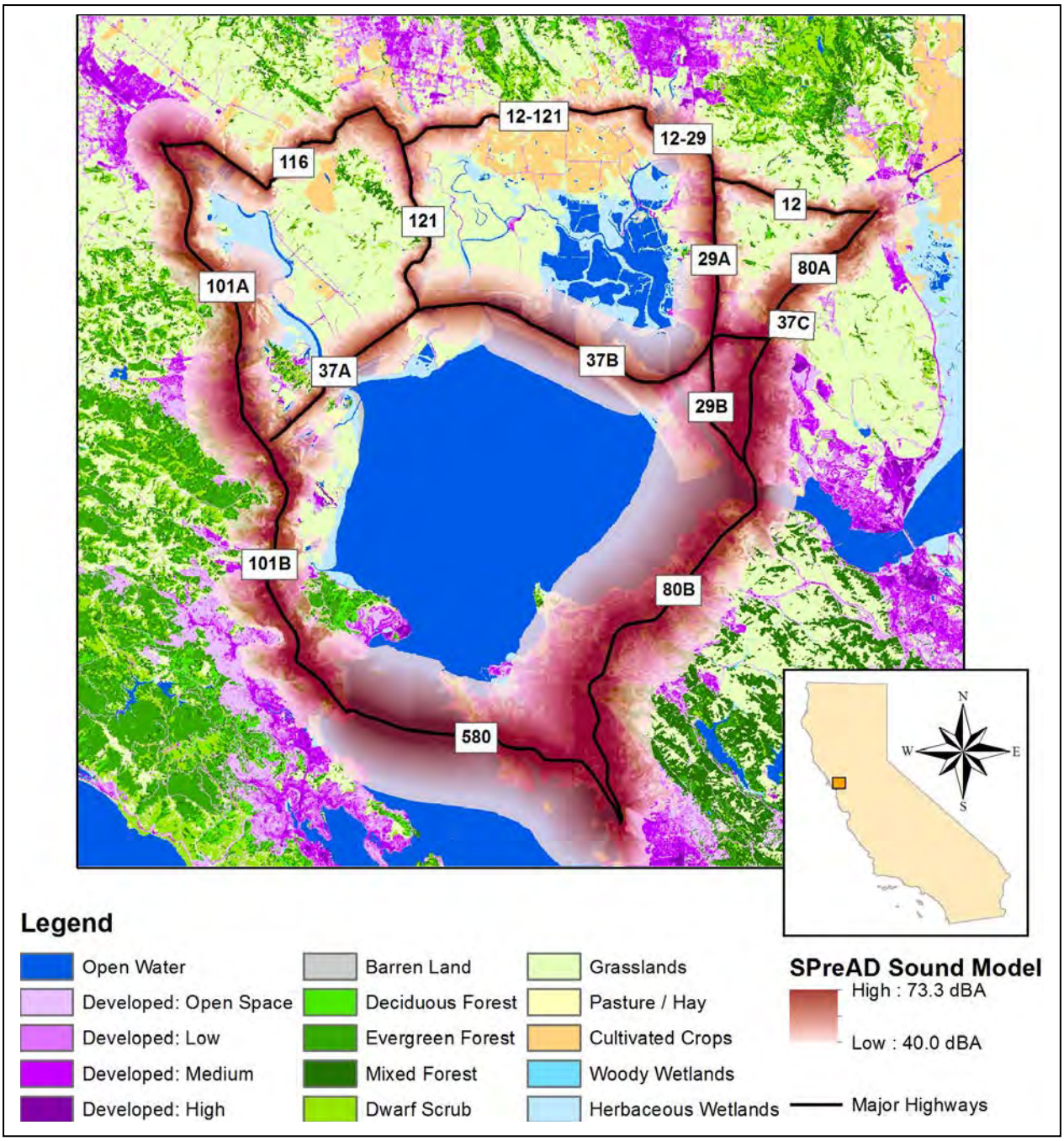


Figure 5.1. Noise impacts from traffic on planning region highways. Traffic noise dissipation was estimated using the model SPreAD. Land-cover is represented using the National Land Cover Dataset.

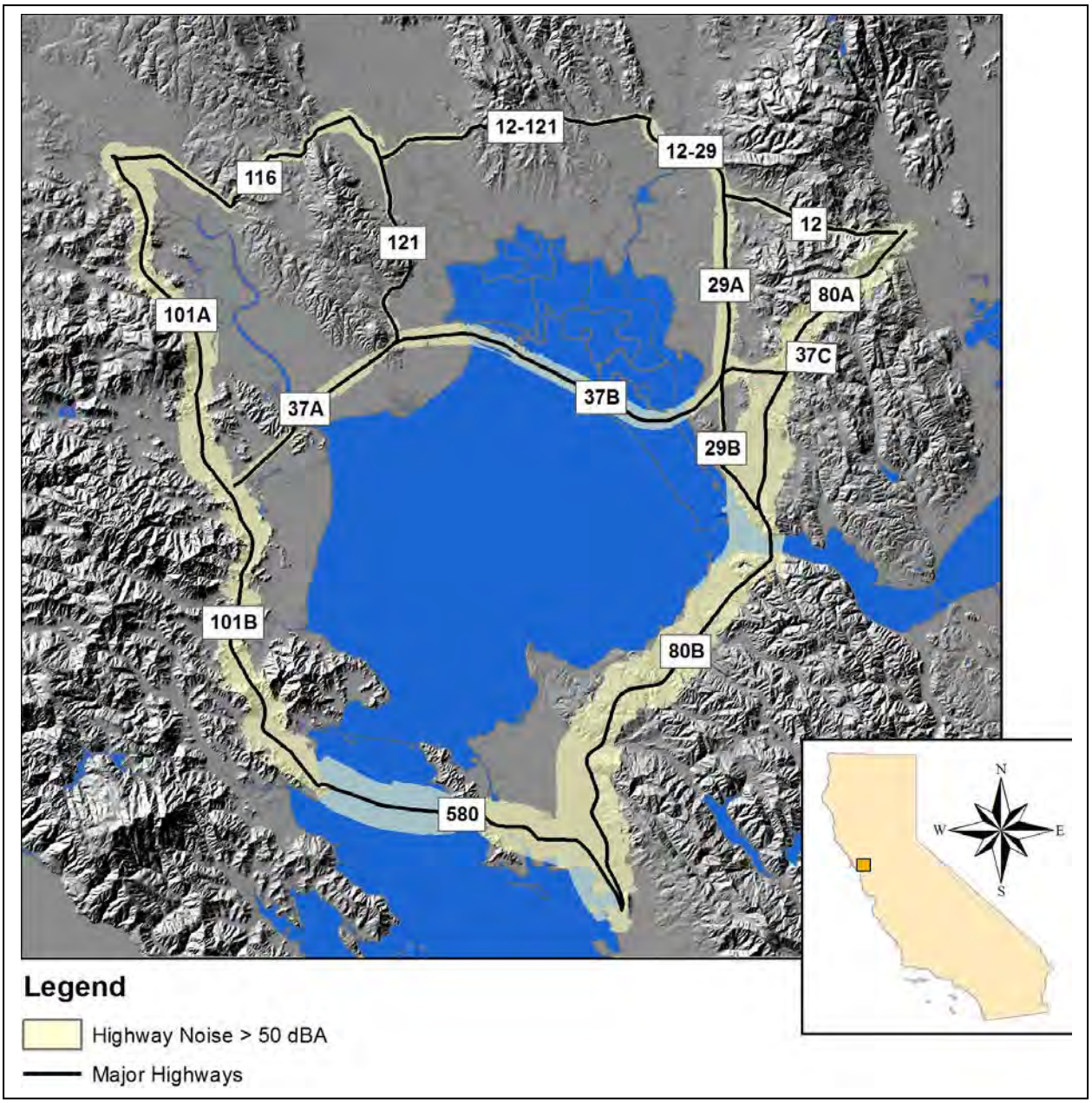


Figure 5.2. Traffic noise impact area for sound intensities >50 dBA.

Table 5.2. Traffic Noise Affected Areas Under Different Timeframes and Improvement Scenarios

Habitat Type	2010 Affected Area Ha (≥40 dBA)	2010 Affected Area Ha (≥50 dBA)	2035, Scenarios B & C Affected Area Ha (≥40 dBA)	2035, Scenarios B & C Affected Area Ha (≥50 dBA)	2035, Scenario D Affected Area Ha (≥40 dBA)	2035, Scenario D Affected Area Ha (≥50 dBA)
Open Water	2,038	415	2,590	701	140	13
Annual Grass	1,502	165	2,509	307	205	15
Coastal Oak Woodland	189	23	313	37	0	0
Urban (# of people affected)	1,994	575 (14,375)	2,852	947 (23,675)	1,306	312 (7,800)
Saline Marshes	1,491	573	1,923	799	125	13
Freshwater Marshes	752	278	869	407	10	4
Blue Oak Woodland	49	9	71	14	11	7
Cropland/ Pasture	2,223	610	2,668	988	0	0
Total	**8,244**	**2,073**	**10,943**	**3,253**	**491**	**52**

Note: Area is in hectares (Ha). The number of people affected in urban areas was calculated by taking the average population density in the area (25/Ha) and multiplying by the affected area in Ha.

As noted above, traffic noise contributes to hypertension and specific heart conditions (Lercher et al., 2011). One way to think about noise impacts is in terms of economic cost of induced health effects. Without knowing the actual number of affected people in the traffic noise zone, an estimate can be made of number of people and annual costs of traffic noise-induced hypertension. Hypertension costs on average $1,598/year medical costs (Trogdon, 2007) + $300/year employee-productivity loss (Goetzel, 2004) = $1,898/year. Approximately one out of three adult Americans have diagnosable and treatable hypertension (CDC,

www.cdc.gov/bloodpressure/facts.htm). Using the estimate of noise affected population near Highway 37, one type of health cost associated with noise can be calculated:

2010 (Current condition)	14,375 people X $1,898/year-person X 1/3 = $9,085,489/year
2035 (Scenarios B & C)	23,675 X $1,898/year-person X 1/3 = $14,963,405/year
2035 (Scenario D)	7,800 X $1,898/year-person X 1/3 = $4,929,865/year

Traffic noise is not the only cause of hypertension. Similarly, these are not the only costs that could occur from noise effects on health, or noise-annoyance. They are also not the only impacts that could have costs associated with them. For example, noise effects on habitat quality and occupancy would change the "value" of habitat adjacent to highways, to wildlife and to people.

CHAPTER 6
Step 5. Establish and Prioritize Ecological Actions

Caltrans is currently developing a Corridor Management Plan for State Highway 37. This plan will be informed by this study and stakeholder process. The approach the team took for this step was to combine the idea of transportation system modification with ecological protection and improvements to create an overall portfolio of stewardship actions. To make this more concrete in terms of the highway, future scenarios were created that reflected the discussion within the project team and with stakeholders. These scenarios provided a more grounded discussion of impacts and benefits to different constituencies, environmental impacts and permits, cost and feasibility, and potential corresponding ecological and mitigation actions. The scenarios were presented several times after development and feedback, including in the survey sent out to stakeholders and communities near the highway. It was important to note that the Plan does not yet have formally-described alternatives.

Five Possible Futures for the Corridor

During discussion within Caltrans and among stakeholders in this study, five high-level scenarios have arisen as possible futures for Highway 37. These five are intended to provide alternative scenarios suitable for future transportation needs and also recognize the sensitivity of the environment in the area surrounding this transportation corridor. In developing the scenarios, consideration was given to multi-modal travel, impacts to tidal and brackish marsh habitat in San Pablo Bay, adjacent land-uses, traffic flows, climate change-induced sea level rise, and what constitutes “sustainable transportation”. Appendix A contains additional detail about activities, impacts, and benefits associated with each scenario.

a. “No Highway Expansion”: Caltrans would continue to manage the corridor with maintenance and repair activities and minor operational improvements (but no significant change in the footprint or capacity). This scenario has the least new permitting and regulatory requirements. Although regulatory agencies saw this scenario as having few new impacts, they recognized that existing impacts would continue and impacts from repairs were likely to increase over time.

b. “Expanded Footprint”: The height and width of the corridor through the marshes would double and the corridor would be expanded to four lanes to address current and projected future traffic. This was originally the default choice of Caltrans for expanding the highway – by both reducing impacts from sea level rise and flooding and increasing capacity. Through the study, Caltrans staff have recognized that other scenarios should be explored. Regulatory agencies expressed the opinion during meetings that this was the scenario least-likely to receive the necessary environmental permits because of its high-

level of continued and new impacts.

c. "Napa-Sonoma Causeway": The corridor (two or four lanes) would be elevated onto a causeway across the tidal marshes (option 1) or across the San Pablo Bay (option 2) between Vallejo and Novato. Despite the expense that is likely to construct this option, it has remained the main focus of discussion among all stakeholders, including transportation and conservation organizations. Existing and new impacts would be reduced compared to scenario (b) and possibly (a). Some regulators described the project as self-mitigating, while others recognized that the elevated roadway would still project traffic noise into sensitive habitats.

d. "Strategic Co-alignment": The corridor would be re-aligned away from marshes and wetlands between Vallejo and Novato, with I-80 and 580 to the south, or with Highways 29 and 12/121/116 to the north. This novel approach would require de-construction of the existing road-bed and combination of the numbered highway (37) with another regional highway. Improvements to this alternate combined route may need to be made. Regulators regarded this scenario as having the least impact, with agencies expressing concern over displaced impacts to other highways.

e. "San Pablo Bay Tunnel": The corridor would be routed through a tunnel at the shortest feasible distance between the Vallejo and Novato areas. This scenario was suggested by a Caltrans environmental scientist because of its technological feasibility and relatively low environmental impact. However, this may be the highest cost scenario and is generally regarded by stakeholders as infeasible from that point of view. Regulators had trouble discussing this scenario because of perceived infeasibility but described it as having very-low post-construction impact.

These scenarios describe fairly exclusive and different possible futures. However, it is possible that various components of these scenarios could be combined to better address key issues identified by stakeholders during this study (such as multi-modal travel, sea level rise, agriculture, re-establishment of tidal flow, ecosystem, and habitat restoration and protection).

Transportation-Associated Stewardship and Mitigation

The project team saw many options for corridor projects that provide ground-breaking environmental benefits. Maximizing environmental benefits will require planning discussions with local organizations, since partner organizations are already working on these issues and locations.

From an environmental review perspective, the project should be evaluated based on the net improvement it provides in environmental values. The project may have substantial short-

term negative impacts, but for all scenarios, the long-term environmental benefits, if any, should be considered, and in some cases those long-term benefits may far outweigh any short term impacts.

Some possible specific actions to pursue are listed here:

- Floodplain and Bayland enhancement, and wildlife habitat connectivity, as part of watershed-wide multi-benefit projects. Numerous parties in all affected counties are in the process of designing multi-benefit water projects for funding by the Department of Water Resources through the Bay Area Integrated Regional Water Management Plan.
- Spend mitigation money on actions consistent with the objectives put forth by the San Francisco Bay Joint Venture, Baylands Ecosystem Habitat Goals, Conservation Lands Network, FOCUS, and other consensus plans for the region. These are primarily related to marshlands acquisition and restoration.
- Repair fish passage barriers, including those created by Caltrans' own infrastructure. Plant along streams or for other bird or animal habitat.
- Fund fish and wildlife monitoring projects. The streams crossing under Highway 37, in general, support several protected species of fish, yet it has been impossible to find grant funding to determine their diversity or numbers.
- Conduct habitat enhancement on agricultural properties. For example, install bird boxes for a variety of species or implement riparian restoration projects.
- The north Baylands are unique in the Bay region, and provide Bay-wide benefits. It may be possible to enhance mitigation resources for the North Bay by using mitigation money from projects around the Bay.

To be considered stewardship actions, as defined here, these actions may receive resources from Caltrans, but not for mitigation of proposed projects. Even without any infrastructure projects, the existing highway footprint has un-mitigated impacts on wildlife and natural processes, which will be exacerbated with sea level rise. Improving travel may involve supporting multi-modal travel, rather than highway expansion. Improving environmental conditions in the corridor may involve moving/re-aligning the highway away from the marshes, or otherwise allowing the Bay and marshes to re-connect.

Mitigation for proposed expansion or repair of the highway could involve the proposed ecological actions above, or "self-mitigating" construction actions, like re-aligning the highway, raising it onto a causeway, or replacing the footprint with a tunnel under the Bay. Minimizing and avoiding impacts should be the first mitigation actions considered, and for certain future scenarios for this corridor may be all that is needed. Compensatory mitigation is considered the last-resort by environmental regulatory agencies, but is often the primary consideration of transportation and other infrastructure agencies. For this corridor, compensatory actions could be based on the impact assessment in the next step.

CHAPTER 7
Step 6. Description of Credit and Valuation Approach

The crediting system described by C06 Step 6 is intended to provide a consistent approach to measuring impacts and using a formal equivalent to impacts (e.g., acres) as an exchange unit in a crediting system. The crediting system then forms one basis for negotiations over mitigation requirements and tradeoffs between ecological and transportation functions. The team's implementation of this concept was based on two approaches:

1. The first involved statement of values and corridor scenario preferences, elicited using formal surveying of stakeholder-advisors and community members, as well as documentation of value statements made at stakeholder meetings (particularly the October World Café meeting in Vallejo). This approach does not allow calculation of "credits" per se, but it does provide a broad view of socially-preferable directions and rankings of possible alternatives for the corridor.

2. The second approach involved a method developed by the Road Ecology Center and Sustainable Transportation Center at UC Davis, under contract with Caltrans. It was refined during this study in collaboration with a visiting scholar from the French Ministry of Transportation (Appendix B). The approach is based on twin pillars of accurately measuring impacts of transportation on ecological and human systems and using stakeholder and community preferences as one way to value attributes of the overall system and prioritize among possible choices or scenarios. Impacts of transportation were estimated using the "road effect zone" approach, which is a geographically-explicit expression of road effects for a given roadway and landscape. The output of the impacts assessment is measured in area units, providing an exchange currency for transportation planning.

Approach 1: Stakeholder Valuation of Corridor Context and Plan Alternatives

The stakeholder process for the project was extensive and included many interested parties. This process used stakeholder meetings and a "World Café" style workshop to both discover important values on the corridor and to identify those values which are irreplaceable in any planned scenario. However, it did not include the broader community, so the process was augmented using a standardized survey made available to interested community members.

Stakeholder Advisory Process

Values for existing uses and objectives for the corridor and associated ecosystems and communities were compared among the future scenarios. In the first step, World Café stakeholder participants applied their values to different transportation, wetlands, open space,

and management attributes (A). In addition, changes in indicators for these attributes are quantified for each scenario, to facilitate scenario comparison (B).

Café participants were asked to compare their values for each of 4 types of concern (and specific concerns): Transportation systems (congestion, regional system impacts, safety), Wetlands (wetland habitat, wildlife, sea level rise adaptation), Open Space (open space, agriculture, recreation), and Management (decision reversibility, cost). The votes for each type of concern were summed to give an estimate of how much stakeholders valued the different ways of viewing the corridor. Despite the fact that only 1 environmentalist was present among the 58 participant stakeholders, the dominant concern was for wetlands as habitat for wildlife and for the capacity of the tidal marshes to adapt to sea level rise.

The value of this finding is primarily in developing weights for the valuation approach. One way to calculate weights would be to compare the relative values for each type of concern in the "high" category (Figure 7.1). This calculation results in the following: Wetlands, 45; Transportation, 28; Management, 15; and Open Space/Ag, 12. Another approach is to multiply the number of votes in each category by the value (from 1 to 5), then sum the weighted votes within each type of concern. This calculation results in the following: Wetlands, 30; Transportation, 26; Management, 23; and Open Space/Ag, 22. With either approach, the relative ranking among types of concern stays the same, but the differences are smoothed out by taking into account lower value categories.

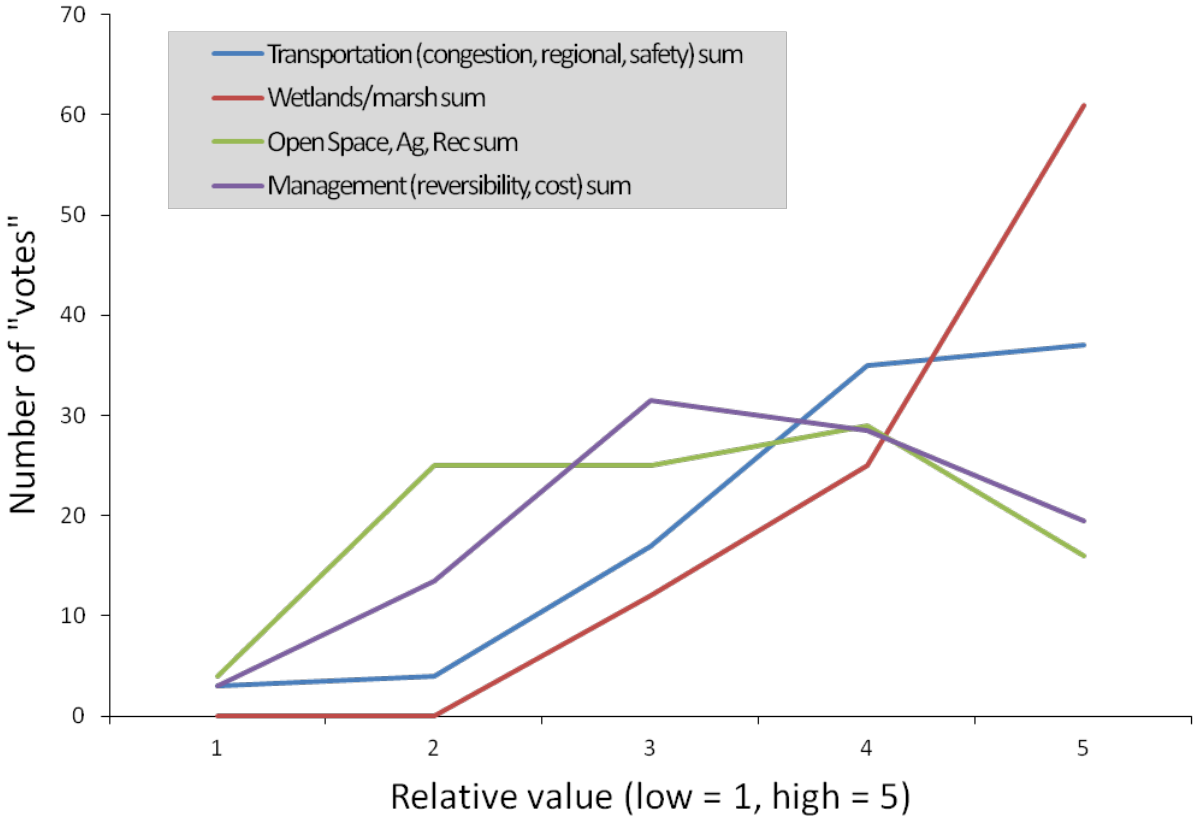


Figure 7.1. Relative value among types of concern along the corridor.

Community Activity, Values, and Preference Survey

The purpose of conducting a community survey was to reach the greatest possible diversity of people who will be affected by changes to Highway 37 (within the budget of the project). Despite advertising the stakeholder meetings through partner channels, only a small group of people who would be impacted by changes to Highway 37 was aware that a planning process was under way. Additionally, the meetings were held during normal business hours and in different locations due to the large land area that Highway 37 spans. Therefore, even those that were aware of the meetings may not have been able to attend them. The community survey was able to reach an additional set of stakeholders whose views are significant to this corridor plan and who may have otherwise been overlooked.

Community members living near the corridor were randomly selected and sent a postcard during February, 2012, asking them to complete a web-based survey describing their activities and preferences for the corridor (n = 529 completed surveys). The preferences questions began with getting them to describe their feelings about traffic conditions, environment, rural character, and highway management. Then participants were asked their opinions about specific future scenarios for the highway and how well they felt these scenarios supported different possible

values for the corridor context. Stakeholder process participants were also invited to take the survey (n = 49 completed surveys).

Survey Details

The community survey contained 47 questions divided into the following question groups: "Your Travel and Experience with Highway 37", "Your Vision for Highway 37's Future", and "Proposed Changes to Highway 37 and General Comments".

The community survey was anonymous. Only the respondent's ZIP code was collected so that data analysis by city would be possible. The first section, "Your Travel and Experience with Highway 37", included general questions about travel behavior and the respondent's awareness of sea level rise and local wetland health. Questions were also asked about the respondent's willingness to take public transit as an alternative to driving on Highway 37.

The second question group was designed to capture how each respondent values individual components of a potential corridor plan. Survey respondents were asked to rate the importance of each item below on a five-point scale.

- Rural Character
  - Preservation of open space and views
  - Support for regional agriculture
  - Public access to the water and wetlands for recreation and education
- Transportation
  - Traffic congestion relief
  - Minimal impact (during construction) to the existing transportation system
  - Safety, emergency access, and maintenance vehicle access
  - Providing public transportation options
  - Providing a bicycle/pedestrian path (or bike lanes)
  - Minimal or no impact to the natural environment
- Environment
  - Protection of wildlife and their habitat
  - Restoring the Bay marshes and the natural processes related to them
  - Wetland health and adjustment to sea-level rise
  - Restoring tidal action now blocked by the highway structure
  - Providing safer animal migration
- Highway Planning and Management
  - A travel option that can easily be changed if needed
  - Minimal financial cost
  - Provides access to work, recreational, and other destinations

Respondents were also asked to rank the criteria listed above for overall importance, by selecting the top five planning components that were most valuable to them.

The third set of questions used the same criteria as listed above, but asked each respondent to consider each planning criteria again as it relates to one of the five possible scenarios for the future of Highway 37. Respondents rated each scenario's ability to support each planning criteria on a five-point scale.

The scenarios are as follows:

a. **No Highway Expansion** - Manage the corridor with maintenance and repair activities and minor operational improvements (no significant change in the footprint or capacity).
b. **Expanded Footprint** - Height and width of the corridor through the marshes would double and the corridor would be expanded to four lanes to address current and projected future traffic volumes.
c. **Napa-Sonoma Causeway** - Option 1: over existing footprint at areas of low elevation; Option 2: across San Pablo Bay between Novato & Vallejo.
d. **Strategic Re-alignment** - Corridor would be re-aligned away from marshes and wetlands between Vallejo and Novato, with I-80 and 580 to the south, or with Highways 29 and 12/121/116 to the north.
e. **San Pablo Bay Tunnel** - Corridor would be routed through a tunnel at the shortest feasible distance between the Vallejo area and the Novato area

In the last section, respondents were asked to rank the five corridor scenarios overall, as well as their willingness to pay a toll to assist with the expense of any changes to Highway 37. General comments were also welcomed.

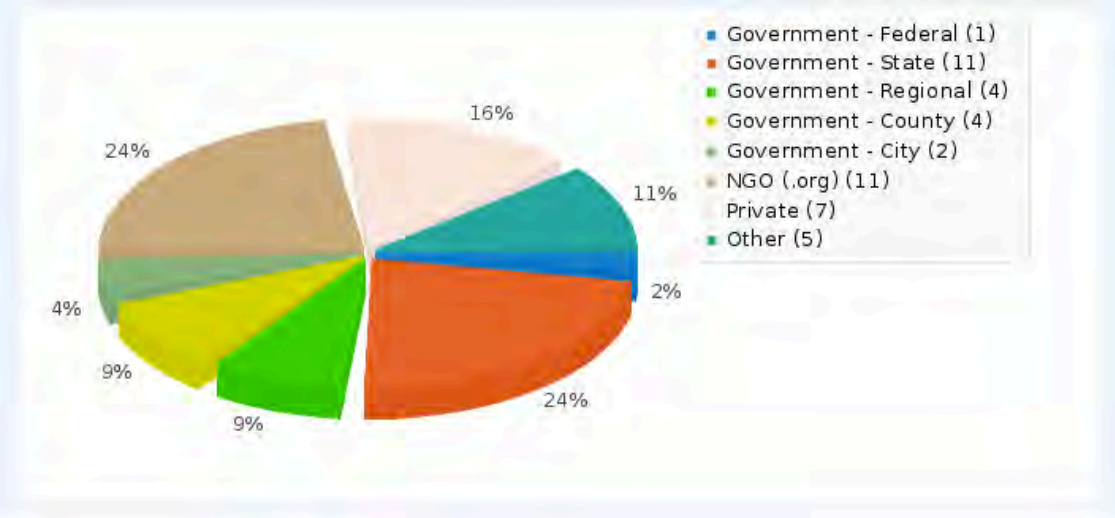
Survey Results

The results of the survey provided a way to both gauge broad community and stakeholder-advisor support for different values that could come into play along the corridor, as well as how different constructed highway alternatives might serve different needs.

STAKEHOLDER PROCESS REPRESENTATION

Institutions and Interests: A stakeholder process is often considered to be a proxy system for including broad social values and inputs in planning. The stakeholder process included a slice of these values, as represented by institutional interests that participated in the process. Figure 7.2 shows the organizational and sectoral representation of stakeholder process participants who completed the survey. Approximately half of respondents represent a government agency of some kind (Figure 7.2A), but many different types of interests are represented (Figure 7.2B).

A



B

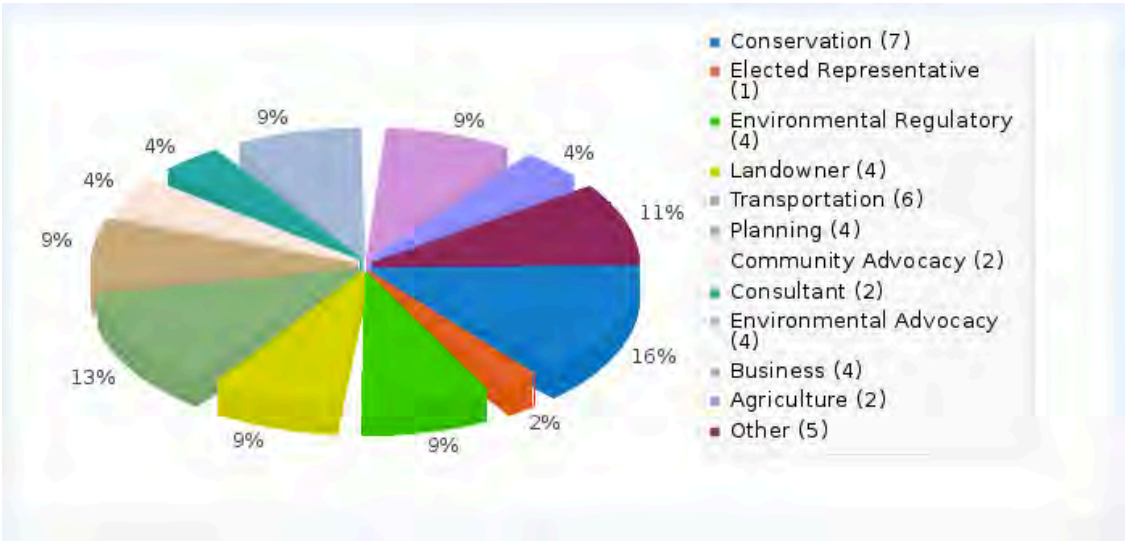
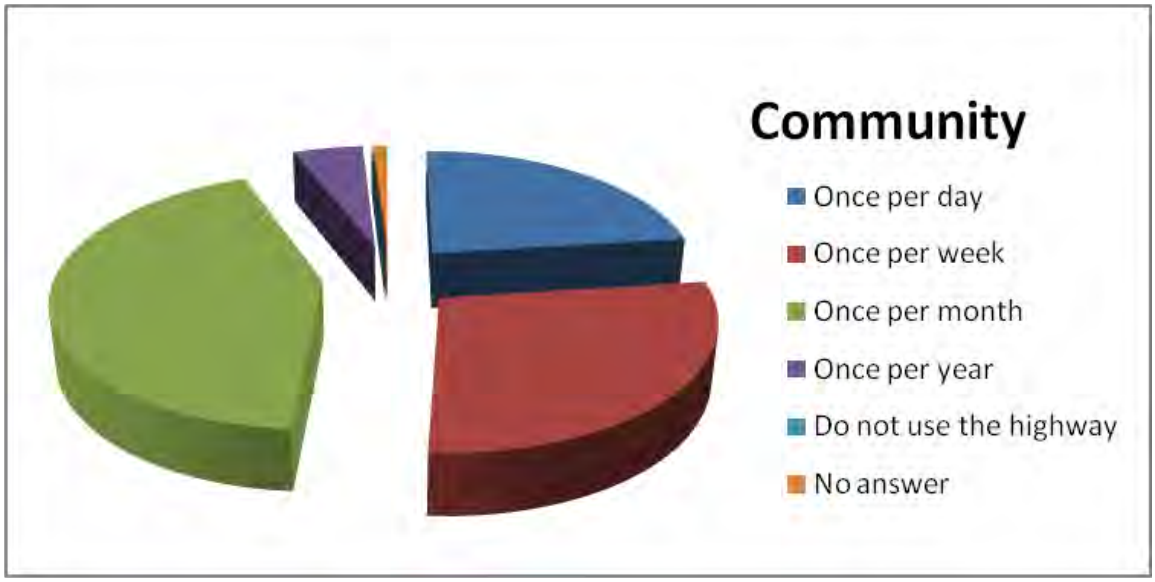


Figure 7.2. Institutional and sector representation of stakeholder respondents.

Travel Behavior: One way to compare the stakeholder process participants with the community at large is based on their responses to the survey. Survey respondents were queried about their travel use of Highway 37. Their use of the highway was slightly different – 50% of community members used the highway once per week or more often, compared to 30% of stakeholders (Figure 7.3).

A



B

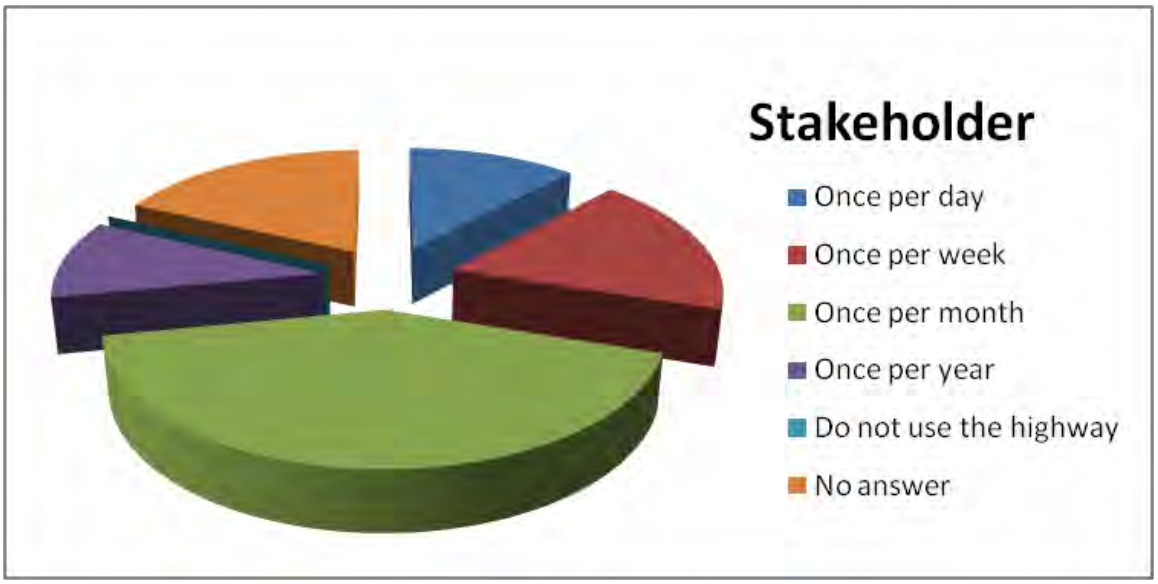


Figure 7.3. Frequency that A) community members and B) stakeholder process participants drive on Highway 37.

Sea Level Rise and Wetlands: Another way to compare community members and participants in the stakeholder process is based upon their knowledge and familiarity with sea level rise and wetlands. Both of these concepts played a large role in discussions about future scenarios for the highway. In general, stakeholders had greater familiarity/knowledge of sea level rise and wetlands than respondents to the community survey (Table 7.1).

Table 7.1. Familiarity of Stakeholder Process Participants and Community Members with Sea Level Rise from Climate Change and Wetlands

Sea Level Rise (SLR)	**Stakeholder**	**Community**
Don't believe SLR is occurring	0%	10%
Unfamiliar	6%	20%
Somewhat familiar	24%	43%
Very familiar	54%	22%
I'm an expert	0%	1%
Wetlands and Their Role		
Unfamiliar	0%	9%
Somewhat familiar	21%	53%
Very familiar	46%	33%
I'm an expert	16%	2%

STAKEHOLDER AND COMMUNITY VALUES AND CHOICES

Respondents to the survey were asked about the components of the corridor context that they valued (Table 7.2). These values were then used to refine their selection of transportation scenarios, insofar as the scenarios supported their values.

Table 7.2. Percentage of Respondents Who Find the Listed Values or Planning Criteria "Somewhat Important" or "Very Important"

	"Stakeholder"	**"Community"**
Rural Character		
Preservation of open space and views	90%	82%
Support for regional agriculture	85%	79%
Public access to the water and wetlands for recreation and education	81%	73%
Transportation		
Traffic congestion relief	76%	92%
Minimal impact [during construction] to the existing transportation system	59%	79%
Safety, emergency access and maintenance vehicle access	86%	90%

Providing public transportation options	72%	62%
Providing a bicycle/pedestrian path (or bike lanes)	68%	47%
Minimal or no impact to the natural environment	91%	73%
Environment		
Protection of wildlife and their habitat	90%	82%
Restoring the Bay marshes and the natural processes related to them	90%	69%
Wetland health and adjustment to sea-level rise	88%	69%
Restoring tidal action now blocked by the highway structure	79%	50%
Providing safer animal migration	86%	63%
Highway Planning and Management		
A travel option that can easily be changed if needed	53%	75%
Minimal financial cost	50%	70%
Provides access to work, recreational, and other destinations	92%	93%

The results in the table show that traffic congestion, safety concerns, and access are the most valued criteria for community members. Open space and wildlife protection are also highly valued, but less so than the transportation concerns. The results are slightly different for institutional participants in the stakeholder process, as they appear to value the environmental criteria more, which is consistent with the findings from the World Café.

Asking community respondents to rank the planning criteria relative to each other offers slightly different results. Traffic congestion was the overwhelming concern, ranked first by 40%. Wetlands health (14%) and wildlife protection (11%) came in a distant second and third place.

VALUES AND FUTURE SCENARIOS

The role of values for the corridor context in selecting future scenarios can be presented in two ways, both representing the same idea of how much each future scenario supports each main value area. The first way (Figure 7.4A) is to look at how each scenario contributes to each value area (Rural Character, Transportation, Environment, and Planning and Management). The second way (Figure 7.4B) is to look at the overall contribution of each scenario to all value areas simultaneously. Respondents ranked each scenario for its support of different values and these ranks were coded as follows: does not support = 0, somewhat supportive = 1, supports = 2. The weighted-average support "score" was calculated for each scenario-value combination (e.g., environment and scenario B).

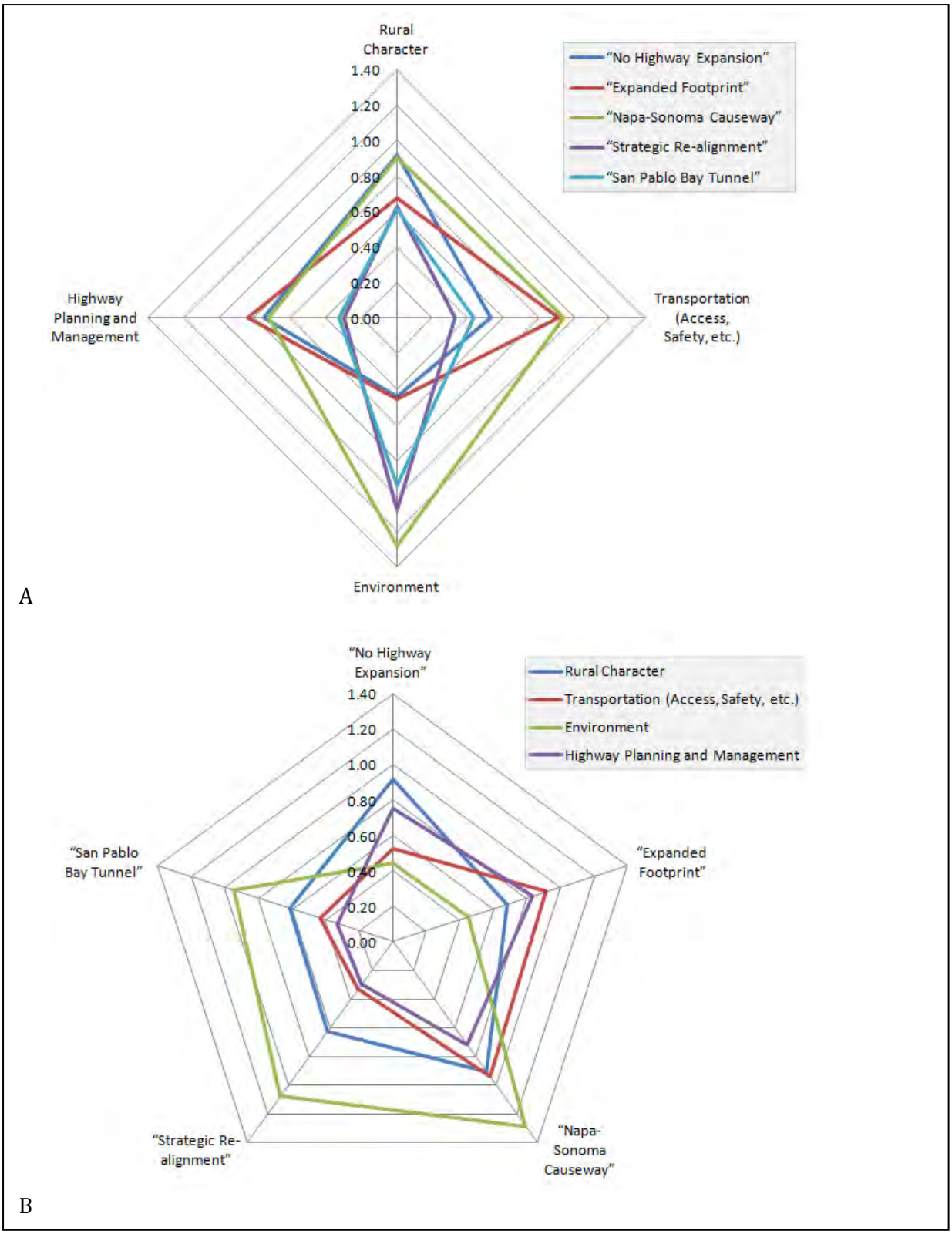


Figure 7.4. Support from each future scenario for different values.
(A) Contribution of each value to each scenario.
(B) Contribution of each scenario to each value.

The causeway (C) and no highway expansion (A) were most supportive of rural character, scenarios A,B, and C were all moderately supportive of planning and management, B and C were seen as most supportive of transportation needs/desires, and C, D, and E were seen as most supportive of the environment (Figure 7.4A). Seen in a slightly different way, the causeway, scenario C, was most supportive of environmental needs, relative to other values; the expanded footprint, scenario B, was most supportive of transportation needs, relative to other values. When these two scenarios are looked at side by side, both are seen to support transportation needs, but there is a clear perceived difference between their support for environmental needs. According to the community and stakeholder survey respondents, the scenario that supports the most planning criteria is the Napa-Sonoma Causeway.

Although estimated relative cost was not shared during the surveying process, it's probably safe to assume that most people will realize that the tunnel (E) and causeway (C) are likely to be the most expensive and no expansion (A), or removing the highway footprint (D) are likely to be the least expensive (Table 7.3). The scenarios that may be the least feasible (D and E) were ranked lowest. The most feasible expansion option with the least environmental impact (the causeway, C) was the highest ranking, despite its likely high price tag. When asked if they would be willing to pay a toll to assist with the expense of any change to Highway 37, nearly equal numbers of community respondents said yes and no. 46% of stakeholders are willing to pay a toll to see improvements made to the Highway 37 corridor.

Table 7.3. The Project Team Estimated Relative Cost for Each Scenario, Shown Here as Relative Ranks, for the Sake of Comparison.

Scenario	"Stakeholder"	"Community"	Relative Cost*
A) **No Highway Expansion** – third most favored	8%	17%	4
B) **Expanded Footprint** – second most favored	20%	29%	3
C) **Napa-Sonoma Causeway** – most favored	66%	45%	2
D) **Strategic Co-alignment** – least favored	4%	4%	5 (lowest)
E) **San Pablo Bay Tunnel** – fourth most favored	0%	5%	1 (highest)

* "Cost" is a relative estimate for each scenario and does not reflect actual cost.

Approach 2: Measuring Impacts ("Assess Transportation Effects")

The team used the "Road Effect Zone" model to measure the effects of the highway corridor and associated highways in the region. One type of effect is excess noise from traffic. The team modeled traffic noise for all highways in the region that provide similar access and mobility as

Highway 37. The team used traffic projections for 2035 to anticipate traffic noise impacts in order to improve valuation of the noise impact for future highway capacity scenarios. Traffic noise impacts wildlife and people, though at different sound intensities and frequencies. In addition, a high-level assessment of expected traffic impacts was conducted using a County-level Travel Demand Model. A more detailed traffic simulation model is needed to advance this element of traffic impacts in the study area.

Valuation

The proposed valuation approach is a combination of weighted values among concerns and quantification of the concerns among alternative scenarios (Appendix B). By combining what stakeholders value with quantification of impacted benefits (e.g., wetland function) among alternative futures for the corridor should improve the social/political acceptability of the decision outcome, as well as the potential environmental-stewardship benefits.

CHAPTER 8
Step 7. Develop Programmatic Consultation, Biological Opinion or Permit

Develop Memoranda of Understanding (MOUs), agreements, programmatic 404 permits, or ESA Section 7 consultations for transportation projects in a way that documents the goals and priorities identified in Steps 5 & 6 and the parameters for achieving these goals.

The team's approach to this step was to bring environmental regulators into an informal consultation process much earlier than is typical. This was in order to anticipate any conflicts that could arise early in planning, rather than at the later project-environmental review stage. The primary finding from this exercise was that environmental regulators and transportation agency staff were able to find common grounds for discussions, though sometimes it was a struggle because of the lack of a specific project to discuss. In addition, US Fish and Wildlife Service staff that were funded by the liaison program (FHWA) were told by their liaison coordinator at Caltrans that they could not bill time spent on this project to the liaison contract. This created difficulties as they were the staff that would eventually review and permit any projects in the corridor. Ultimately, every regional, state, and federal agency that would have a permitting role in the corridor participated in at least one meeting to discuss regulatory and permitting issues on the corridor.

Highway 37 traverses one of the largest wetlands complexes on the West Coast and is likely to face high regulatory hurdles for almost any transportation projects. Transportation agency staff have said that this has contributed to a lack of desire to pursue expansion of the highway, despite its growing congestion and linkage role in the larger highway network. Pursuant to state and federal regulatory laws, Caltrans would need to prepare various technical studies and environmental reports for any future transportation improvement on Highway 37. The following sections describe the inclusion of regulatory agencies in the early phases of Step 7 and permitting issues for the corridor that would be the basis for further progress on this Step.

Reaction/Involvement/Integration of Regulatory Agencies to Application of Ecological Methods

The team approached the involvement of regulatory agencies in the study by first interviewing them, then holding a joint meeting where they could discuss potential regulatory and permitting issues associated with potential actions along the corridor. The team used a basic template of questions for each interview. In several cases, the team spoke to more than one staff person from each agency.

The team worked first with environmental permitting staff at Caltrans to develop and review a list of contacts for the agencies. As a result, the final list of contacted and interviewed agencies was: a) Federal -- U.S. Army Corps of Engineers (ACOE), U.S. Environmental

Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), and U.S. Fish and Wildlife Service (USFWS); and b) State -- San Francisco Bay Conservation and Development Commission (BCDC), California Department of Fish and Game (CDFG), and San Francisco Regional Water Quality Control Board (RWQCB).

Early Participation

Most permitting agencies are not used to a process of early engagement with infrastructure agencies to improve planning and decision-making. Generally, the responses to the query regarding early participation in corridor planning fell along a continuum ranging from great interest in early involvement to little interest until a strategy was defined. NOAA and USFWS were enthusiastic about being involved in the development process. EPA was interested, and still learning about the project. CDFG was also interested in early involvement, and their regular attendance at the meetings confirmed this. USFWS and NOAA both expressed their support for any efforts to discuss projects earlier, noting this had not been the norm, and they welcomed the opportunity to work on potential ideas at the formative stages. The RWQCB has a strong preference toward certain strategies (causeway, strategic realignment of highway), but noted their real interest is how any idea affects water quality - roadway runoff in particular. BCDC expressed a desire to be “circumspect” in their participation, and did not want to help frame a project they would be permitting. While they have been more involved in other projects, BCDC staff felt the magnitude of this effort warranted that strategies come from county boards of supervisors, local communities, and others more directly affected by the results. ACOE noted a strong preference to wait until there was a specific plan in place, along with identified impacted acres, before it would be worthwhile to offer their opinion.

One-on-One Meetings

Most of the agencies noted that it was not necessary to meet separately prior to the World Café, since this meeting was “the first bite of the apple.” Once there were some ideas on the table, most staff said that would be the better time to consider direct meetings. USFWS said they would welcome early, direct conversations any time about how to work together better. Their staff has a strong interest in seeing some up-front studies that will help Caltrans have more information now for implementing measures later for the project, particularly as they relate to wildlife connectivity. Despite the federally-funded liaison program, USFWS noted that for some time, there has been increasing tension between Caltrans and USFWS, and it would be extremely helpful to identify policy measures now that could provide some context for various transportation-related conservation efforts rather than addressing each issue through a separate biological opinion later. USFWS staff who are Caltrans liaisons assigned only to Caltrans projects, though willing to participate in stakeholder meetings, had no Expenditure Authorization (EA) to which they are allowed to bill their time for this project. One of the Caltrans Chiefs noted that not having an EA makes it more difficult to assign his own staff to participate. Having

some mechanism to support staff, both at regulatory agencies and within Caltrans, is essential in supporting earlier communication and participation for transportation projects.

Attendance at an Early December Stakeholder Meeting Focused on Regulators

Without exception, all contacted agencies participated in a stakeholder meeting in early December to discuss the strategic ideas that emerge from the World Café in October. ACOE noted that the more detailed the proposal, the more ACOE could commit to time for comments. ACOE noted that even if adding details would mean meeting a month later, it might be worthwhile to wait and discuss a more refined proposal. Other agencies seemed comfortable commenting on draft strategies in general, and did not emphasize specificity understanding their comments would be general as well.

USFWS noted that one benefit of a stakeholder meeting with regulatory issues as the focus is that stakeholders can better understand how much Caltrans actually does to mitigate impacts to wetlands and other areas adjacent to Highway 37 (Figure 8.1). This person noted that there is a perception that all projects are bad for the environment, when in fact Caltrans is under strict requirements to take measures to mitigate impacts. Such a public meeting may help with the overall understanding that Caltrans does in fact do many good things in association with a project. CDFG noted that having all the regulatory staff in the room at the same time with the permit applicants is ideal because it avoids inter- and intra-agency confusion about impacts and allows for potential collective mitigation strategies among agencies.

Figure 8.1. State Highway 37 traversing wetlands and fresh/brackish impoundments.

Regulatory and Permitting Issues

Environmental Review

If future projects on Highway 37 include federal dollars, environmental studies and permits must be prepared in compliance with both the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Federal Highway Administration's (FHWA) responsibility for environmental review, consultation, and any other action required in accordance with NEPA and other applicable federal laws for this project will be carried out by Caltrans under its assignment of FHWA responsibilities pursuant to 23 USC 327.

Section 4(f)

The Department of Transportation Act (DOT Act) of 1966 included a special provision - Section 4(f) - which stipulates that the FHWA and other DOT agencies cannot approve the use of land from publicly-owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless there is no feasible and prudent alternative to the use of the land; or the action includes all possible planning to minimize harm to the property resulting from use.

Section 4(f) consideration would most likely be part of the environmental documentation for one or more of the alternative scenarios discussed for the corridor due to the presence of

parks and protected lands in the vicinity of Highway 37. The San Pablo Bay National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service, is also located in Sonoma and Solano counties. Recently, approximately 3,300 acres of the former Skaggs Island Naval facility were transferred from the U.S. Navy to the U.S. Fish and Wildlife Service to be included in the San Pablo Bay National Wildlife Refuge. In Marin County, Highway 37 sits adjacent to the Petaluma Marsh Wildlife Area. This land is managed by the California Department of Fish and Game. In Sonoma County, Highway 37 is located adjacent to the Napa-Sonoma Marshes Wildlife Area which is also managed by the California Department of Fish and Game. The areas noted above are also designated in the San Francisco Bay Plan as wildlife refuge priority use areas. Caltrans would be responsible for determining whether 4(f) is triggered and preparing the appropriate level of documentation.

Regulatory Approvals

Obtaining regulatory approvals can take anywhere from 3 to 12 months, or longer depending on the complexity of the project and the type and number of resources affected. As a federal and state lead agency, permit applications for capital improvement projects are typically prepared and submitted by the Caltrans District 4 Office of Biological Sciences and Permits. Permits are prepared based on information from consultation with state and federal resource agencies, species experts, literature searches, plant and wildlife surveys, wetland delineations, and impact analyses. The District biologist serves as the key liaison with resource and regulatory agency staff regarding the impacts to environmental resources. Agencies providing permits for this corridor could request information on the following items as they relate to proposed improvements:

- Wetland delineations,
- Species surveys,
- Habitat assessments,
- Cultural resource assessments,
- Hydrological studies,
- Plans that include existing culverts and engineering drawings of new water crossings which must be assessed for fish passage barriers (pursuant to Senate Bill 857),
- Staging and access areas,
- Construction equipment and methodology,
- Bay fill,
- Public access,
- Dredging,
- Excavation,
- Maintenance,
- Avoidance and minimization efforts,

- Best management practices (BMPs),and
- Compensatory mitigation.

During the Caltrans Project Approval and Environmental Document (PA&ED) phase and prior to the Ready to List (RTL) phase, permits would be negotiated and secured from state and federal resource and regulatory agencies (Table 8.1). These permits are required for the Plans, Specifications, and Estimate (PS&E) bid package to ensure that potential contractors are aware of any permit conditions that may restrict the manner, methods, or timing of construction activities that could affect their bid offer. Caltrans ensures that permit conditions are “buildable and biddable” and are reasonable and appropriate given the type and extent of potential effects to natural resources.

Table 8.1. Agencies and Corresponding Permits Required for Actions Along the Highway 37 Corridor

Agency	Permit Required	Type of Permit	Statutory Authority	Permitting Issue
BCDC	Yes	Major Permit	McAteer-Petris Act	All alternatives may have bay fill and impacts to wetlands and public access.
CDFG	Yes	1602, 2080.1, 2081(b), 3053	DFG Code, CEQA/CESA, Native Plant Protection Act	Threatened/Endangered species are present along SR 37 and SR 12. All alternatives may have lakebed/stream/river alterations.
RWQCB	Yes	401/402	Clean Water Act, Porter-Cologne Act	The Department must obtain a state certification that all discharges comply with provisions of the CWA.
CSLC	Yes	Lease may be required.	Common Law Public Trust	The State Lands Commission has jurisdiction over all ungranted tidelands and submerged lands.
USCG	Yes	Bridge Permit	FESA (Section 9), Rivers and Harbors Act, General Bridge Act	There are navigable waters located within the vicinity of SR 37 and SR 12.
USACE	Yes	404, Individual	Clean Water Act, Rivers and Harbors Act	All alternatives may require dredging and may have impacts to wetlands.
USFWS	Yes	B.O	FESA (Section 7)	All alternatives will have impacts to threatened and endangered species, ground disturbance, noise disturbance, changes in water quality and quantity, air quality, and lighting.
NOAA	Yes	B.O	FESA (Section 7), Marine Mammal Protection Act, Magnussen-Stecenson Act	Threatened/Endangered species are present along SR 37 and SR 12. Some alternatives require pile driving and dredge disposal. All alternatives may affect fish passage. Some alternatives may affect marine mammals.
CDOT	Yes	4(f)	Department of Transportation Act	All alternatives will have impacts to public park lands and wildlife refuges.

There were several interesting outcomes of the stakeholder process that included regulatory agencies:

1. The causeway scenario (C) was described as “self-mitigating” by one regulatory agency because, although it would have traffic noise and construction-related impacts, the benefits realized from elevating the roadway above the marshes were significant enough to out-weigh these impacts.

2. Non-regulatory stakeholders felt that regulatory agency participation in early discussions and planning for the corridor was critical to eventual successes on the corridor. This was because of the obvious benefits of getting regulatory input early in choosing among potential competing ideas for future scenarios for the corridor. There was little patience or understanding among stakeholders for why this approach wasn't already the case.

CHAPTER 9
C06 and C01 Tools Assessment

Most project team members reported difficulty with taking advantage of the SHRP 2 materials available either as reports from C06, or on the TCAPP web site. However, at the same time, all project team members thought the overall C06 process, as implemented, was both an excellent way to get stakeholders and partner agencies involved in transportation planning and a suitable way of framing ecological, transportation, and community data and interests. The overall finding was that the web (TCAPP) and report (C06) materials themselves may have limited utility, but that they describe an important way of conducting transportation business.

This finding has important implementation implications. Rather than assuming that just passively making materials available on the web will be effective in transforming transportation planning, it may be more effective to actively engage DOT personnel in learning processes. This could occur as "Academies" sponsored by FHWA where invited DOT staff participate in workshops on applying C06 and other SHRP 2 products. Alternatively, trainers could travel among state DOTs, or regional get-togethers of DOT staff, and provide training using C06 materials.

Partner Feedback on C06 and TCAPP Tools

Below are specific comments on the first five C06 steps. Project partners did not use the TCAPP or C06 tools as an everyday guide to the planning process. In part, this is because transportation planning jargon is still unfamiliar to many with a role in transportation planning. For example, the differences between corridor planning, visioning, programming, long range transportation planning—all the types of processes that might occur before detailed construction planning—are not clear to all concerned parties. Transportation partners also did not make frequent use of these tools as intended or requested. Partners reported that C06 provided some useful approaches and tools that were easy to understand and that provided important advances in planning. After repeated requests and inquiries from the project lead, no partner reported success or interest in using TCAPP, including after the winter, 2012 revision. This was reported as being because of the relative opacity of the site for most planner-users. Although the information could be found, the lack of apparent connection between the information and the day-to-day planning and project delivery needs of state and local transportation agency staff reduced the motivation to do anything with TCAPP beyond politely experimenting with the site because of TRB's interest that the project partners do so. The good news is that most people involved in this C21 project found ways to include the important concepts in C01 and C06 in their planning and assessment process. This cultural change may be more effective than expecting people to adopt new processes wholesale.

C06 Steps

Step 1: Build and Strengthen Collaborative Partnerships, Vision. *Build a vision of what is most needed for natural resources in the region and commit to integrate and utilize transportation and environmental regulatory processes to address these greatest conservation and restoration needs and goals*.

Prior to the C21 project, there was no engagement of partner organizations in developing transportation or environmental alternatives for the corridor. Over the last year, the project has contributed to stakeholders voicing their visions of what the future could hold for the corridor. The majority of partners and stakeholders believe that the current condition and habitat value of the marshes is a critical filter through which to view the highway and potential capacity projects associated with the corridor. At the same time, there is a distinct time-frame disconnect between people's expectations for change along the highway and the rate at which projects are likely to proceed through conventional corridor-regional-project pathways. For example, most stakeholders are concerned that the ability of the surrounding marshes and the highway itself to survive sea level rise would be jeopardized by planning that took longer than the next 10 years. In contrast, transportation agency partners consider a 25-year horizon to be adequate and have stated that this corridor is well back in line for funded enhancement compared to other network highways.

Step 2: Characterize Resource Status. Integrate Conservation, Natural Resource, Watershed, and Species Recovery and State Wildlife Action Plans. *Develop an overall conservation/restoration strategy that integrates conservation/restoration priorities, data, and plans, with input from and adoption by all conservation and natural resource stakeholders identified in Step 1, addressing all species, all habitats, and all relevant environmental issues.*

The corridor location, at the edge of San Francisco Bay, an estuary of national significance, benefits from a wealth of credible, detailed plans for conservation and recovery of species, habitats, and ecosystem functions in the corridor vicinity. These plans include clear goals and prioritized action steps to achieve those goals. The plans and associated data are readily available. There are also detailed regional and county-level plans for increasing recreational access to the Baylands, although the scope of these plans appears to vary greatly depending on the funding environment that existed when they were most recently approved. The team used this C21 process to educate stakeholders about the content and availability of plans and data, but did not need to generate new information. The most significant data gaps are related to uncertainty around the predicted rate of sea level rise and the lack of accurate and detailed levee and berm topographic and location data. Recently-available LIDAR data may be helpful in identifying areas of vulnerability to sea level rise. The team found an additional data gap in the area of plans for sustaining local agriculture, for sustaining local economies, or for meeting the needs of the

corridor's low-income users. (If these plans exist the team is not aware of them.) While the stakeholder process included good representation from the local agricultural community, it did not capture other users, such as low-income and commuter populations. It was beyond the budget of the project and the expertise of the project team to locate or produce such plans or reach out to the under-represented communities, though this was an important missing component of the stakeholder process. The conservation strategy for regional ecosystem processes and attributes was folded into the scenario development for the corridor, the corridor context description, and the regulatory-process foundation. In the case of the last, Caltrans staff developed a report describing the various environmental issues that would require permitting under the different future corridor scenarios.

Step 3: Create Regional Ecosystem Framework (Conservation Strategy + Transportation Plan) *Integrate the conservation and restoration strategy (data and plans) prepared in Step 2 with transportation and land use data and plans (LRTP, STIP, and TIP) to create the Regional Ecosystem Framework (REF).*

The project team adopted the term "Corridor Context" instead of "Regional Ecological Framework" to broaden the types of information and values the team included. The corridor context includes parallel recognition of community, transportation, environmental, and economic systems and values in decision-making about highways. Using these parallel categories for collecting and organizing information, then seeking feedback from stakeholders and the community about how well transportation plans support their values in these categories, reinforces the broad context in eventual project prioritization. The team echoes stakeholder/regulatory engagement in saying that the C06 steps focus too narrowly on traditional approaches to recognizing and protecting environmental values in transportation planning. The team recommends that planning outcomes will be better if more values are included such as ecosystem stewardship (not just mitigation), local economy, community identity, environmental justice, climate adaptation, carbon budget, and possibly greenhouse gas emissions, and life cycle analysis. Some of these important values are difficult to map. For Highway 37, for example, the issue of sustaining agriculture in the North Bay has emerged as a critical issue for stakeholders, but this issue falls outside the C06 framework. The TCAPP Decision Guide is more complete in this respect.

Step 4: Assess Land Use and Transportation Effects on resource conservation objectives identified in the REF. *Identify preferred alternatives that meet both transportation and conservation goals by analyzing transportation and/or other land use scenarios in relation to resource conservation objectives and priorities utilizing the REF developed in Step 3 and models of priority resources*.

The team has spent a great deal of time on this step, working over many options with an array of stakeholders. Based on their knowledge of environmental conditions, conservation objectives, and the connection between these and transportation infrastructure and plans, stakeholders and partners identified future scenarios for the corridor that supported these objectives. In addition, environmental regulatory agencies were asked explicitly to consider different possible management scenarios for the corridor and speculate on the permissibility of the scenarios and the mitigation that might be required under each scenario. This conversation was very important for transportation partners to witness at this stage because responding to this feedback is more likely to result in development of planned projects that provide the stewardship benefits sought under one interpretation of the Eco-Logical rubric. It may be wise to include the development of draft scenarios earlier in the decision-making process than is currently prescribed by either C06 or TCAPP. For this project, some stakeholders had a hard time focusing solely on values and goals, in the absence of tangible scenarios for the highway. Discussions on values and goals were too abstract, and came to a halt in a short time, whereas discussions that included possible scenarios were vigorous and creative. It was relatively easy to draw out values and goals from the discussions about scenarios. It was difficult for the regulatory stakeholders to provide more than speculative comments on various scenarios because of the lack of detailed information about the impacts on resources and the long planning time frame. Most regulatory staff stated that they had little ability to provide specific and formal input unless it is related to a regulatory action, such as a permit of environmental review. While the discussions were useful and generated comments (reflected in the meeting summaries) the team did not solicit or receive detailed comments on various alternatives or mitigation strategies.

Step 5: Establish and Prioritize Ecological Actions *Establish mitigation and conservation priorities and rank action opportunities using assessment results from Steps 3 and 4.*

After 6 to 9 months of explicit discussion of particular strategies and future scenarios for the corridor, there did appear to be some consensus that raising the highway onto an elevated causeway was environmentally-preferable, but many questions remained and some key stakeholders were not present. In the absence of a clearly defined preferred alternative and specific recommendations from regulators, it is difficult to identify and establish mitigation priorities. What the team does know is that the conservation and restoration strategy for the corridor is well articulated in regional plans and these plans are being implemented by local, state, and federal organizations. It seems likely that these plans can serve as the blueprint for understanding transportation project impacts on wetlands and potentially how those impacts could be mitigated (avoided or reduced). There will be additional project impacts on agricultural lands and these were not addressed in much detail during the process.

Step 6: Develop Crediting Strategy. *Develop a consistent strategy and metrics to measure ecological impacts, restoration benefits, and long-term performance, with goal of having analyses throughout the life of the project be in the same units*.

Two approaches were used to address this step: 1) measuring stakeholder and community values and preferences, and 2) measuring transportation system impacts. Caltrans had previously contracted with UC Davis, Road Ecology Center, to develop a valuation protocol to use in project, corridor, and regional planning. This approach was adapted in collaboration with a visiting scholar from the French Ministry of Transportation (Appendix B). This approach was used as the basis for using measures of ecological impacts. This step was partially completed, primarily because of challenges associated with bringing partners and stakeholders into what can be a conceptually and technically challenging topic. Most partners and stakeholders understood the value of stating values and preferences, as well as the importance of measuring impacts. How that information should be used to inform decision-making about transportation and ecological actions remained opaque because of the lack of a planning or statutory vehicle for doing so.

Step 7: Develop Programmatic Consultation, Biological Opinion, or Permit. *Develop Memoranda of Understanding (MOUs), agreements, programmatic 404 permits, or ESA Section 7 consultations for transportation projects in a way that documents the goals and priorities identified in Steps 5 and 6 and the parameters for achieving these goals.*

The primary progress that was made in this step was formalizing the inclusion of regulatory agencies with an eventual permitting role early in corridor planning. Typically, this does not occur (at least in California), with regulatory involvement only taking place once projects have been described and programmed. A foundation was developed for what is likely to be at least a decade of discussion about how capacity or modal improvements could be made on this corridor, while improving, or at least not harming, the nearby environment.

TCAPP Steps

This section contains feedback and comments from the project on the decision-making guidance provided by the Corridor Planning portion of the Decision Guide for TCAPP (Transportation for Communities—Advancing Projects through Partnership). The guidance describes nine key decisions, numbered COR-1 through COR-9.

In general, TCAPP lists only public agencies as “partners.” In the team’s process, however, non-agency entities such as non-governmental organizations and local agencies such as Resource Conservation Districts have represented natural system issues more consistently than most agencies have. These entities have attended all stakeholder meetings, and have been the main communicator of environmental issues, values, and datasets to Caltrans. However, these entities were only able to take this role because the SHRP 2 grant paid for their time to participate. It appears that if these entities were not consistently at the table, important land use

issues might not have seen the light of day, such as the issue of supporting and sustaining local agricultural livelihoods, or the flood-protection role of privately-maintained levees. It also appears that, because normally Caltrans consults only with the regulatory side of natural resource agencies, not the conservation side, without the non-agency participants, Caltrans might not have seen the magnitude of the opportunities for ecological restoration that improvement of the corridor provides.

COR-1. Approve Scope of Corridor Planning Process

We did not pursue a formal approval of scope. From the beginning, the entire length of the Highway 37 corridor was the focus. In addition, networked routes were also included in the scope of the study, because they are connected through traffic flows and could experience increased traffic if Highway 37 was abandoned or flooded. We spent time identifying relevant datasets and information sources associated with any actions on the corridor.

COR-2. Approve Problem Statements and Opportunities

Much feedback on planning and infrastructural deficiencies and opportunities arose from the team's stakeholder meetings. Caltrans provided traffic data that highlighted transportation deficiencies, and Sonoma Land Trust and Southern Sonoma County RCD took the lead on describing the deficiencies in terms of marsh restoration and agricultural operations, respectively. Opportunities were represented primarily by existing large-scale restoration plans described in previous sections of this memo.

COR-3. Approve Goals for the Corridor

This project focused on eliciting values, not goals, and they seem similar enough for the project's purposes. We obtained a great deal of input on goals and values, from the public, business community, NGOs, RCDs, and to a lesser degree from local transportation agencies. The World Café format worked well for eliciting goals and values. For example, it became clear that Napa and Sonoma Counties are firmly committed to preventing increasing capacity or traffic on the alternative routes 12/121/116. Similarly, most agency/stakeholders identified marsh restoration and adaptation to sea level rise as critical conservation goals, which was reflected in the community survey.

Part of the TCAPP guidance is that natural resource agencies' role is to "Provide input on the most important environmental needs in the planning area and where partners may be able to work together to make a difference across multiple resources of concern." However, it often appeared opportunities needed to comply with a valid regulatory interpretation to be seen as feasible. This orientation was apparent both within the resource agencies and within Caltrans.

COR-4. Reach Consensus on Scope of Environmental Review and Analysis

We did not carry out this step.

COR-5. Approve Evaluation Criteria, Methods, and Measures

There was no formal adoption of criteria, methods, or measures, primarily because most transportation partners saw this as an early stage in a corridor planning process, in contrast to conservation concerns, which were looking for shorter-term action.

COR-6. Approve Range of Solution Sets

We found that describing a range of possible future scenarios for the highway was necessary, to get stakeholders to engage mentally in such a long-term planning process. Therefore, early in the project, simultaneously with COR-3, we began publicly discussing five scenarios, at least one of which is quite unlikely (i.e., tunnel). It was easier for people to identify their goals and values when considering specific scenarios than when considering the corridor as it already exists. See below for more detail on the scenarios, which also appear elsewhere in this report.

COR-7. Adopt Preferred Solution Set

This step has not been taken formally by Caltrans, but the project team did see consensus emerge on a preferred construction scenario – a causeway across the marshes. This consensus construction scenario is not yet enshrined in Caltrans planning, and there is no assurance that the agreement among stakeholders will survive the next planning or fundraising phases.

The results of this C21 study's stakeholder discussion on scenarios will be included in an updated TCR for Highway 37. The TCR serves as early documentation of Caltrans' long-term corridor vision, an early step in informing the regional transportation planning process.

References

Backstrom, M., U. Nilsson, K. Hakansson, B. Allard, and S. Karlsson. 2003. Speciation of heavy metals in road runoff and roadside total deposition. Water, Air, and Soil Pollution, 147: 343-366.

Baker, W. L., and R. L. Knight. 2000. Roads and forest fragmentation in the Southern Rocky Mountains. Pages 97–122 *in* R. L. Knight, F. W. Smith, S. W. Bruskirk, W. H. Romme, and W.I. Baker. Eds, forest fragmentation in the Southern Rocky Mountains. University of Colorado Press, Boulder, Colorado.

Bell, S., and T. W. Ashenden. 1997. Spatial and temporal variation in nitrogen dioxide pollution adjacent to rural roads. *Water Air and Soil Pollution* 95(1–4):87–98.

Boarman, William I., and Marc Sazaki. 2006. A highway's road-effect zone for desert tortoises (Gopherus agassizii). Journal of Arid Environments 65:94-101..

Boumans, R. M., D. M. Burdick, and M. Dionne. 2002. Modeling habitat change inn salt marshes after tidal restoration. Restoration Ecology 10 (3): 543-555.

Chapin, T. G., D. J. Harrison, and D. D. Katnik. 1998. Influence of landscape pattern on habitat use by American marten in an industrial forest. *Conservation Biology* 12(6):1327–1337.

Dooling, R.J. and A.N. Popper. 2007. The effects of highway noise on birds. Report prepared for Caltrans, contract #43A0139.

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. www.ecologyandsociety.org/vol14/iss1/art24/

Fahrig, L. 2001. How much habitat is enough?. *Biological Conservation* 100:65–74.
Federal Highway Administration (FHWA) 2004. FHWA Traffic Noise Model version 2.5 look-up tables user's guide. Prepared for FHWA by John A. Volpe National Transportation Systems Center. FHWA-HEP-05-008.

Findlay, C.S. and J. Houlahan. 1996. Anthropogenic correlates of species richness in Southeastern Ontario wetlands. Conservation Biology, 11(4): 1000-1009.

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. 2002a. Road Ecology: Science and Solutions. Island Press. Washington, D.C. 424 pp.

Forman, R. T. T., Reineking, B., and Hersperger, A. M. (2002b). Road traffic and nearby grassland bird patterns in a suburbanizing landscape. Environmental Management, 29, 782-800.

Gagnon, J.W., T.C. Theimer, N.L. Dodd, S. Boe, and R.E. Schweinburg. 2007. Traffic volume alters elk distribution and highway crossings in Arizona. Journal of Wildlife Management, 71(7):2318–2323. AND Storlie 2006

Gill, J. A., W. J. Sutherland, and A. R. Watkinson. 1996. A method to quantify the effects of human disturbance on animal populations. *Journal of Applied Ecology* 33(4):786–792.

Gjessing, E., E. Lygren, L. Berglind, T. Gulbrandsen, and R. Skanne. 1984. Effect of highway runoff on lake

Hickey, R. 2011. Driving home economic recovery. Report for the Non-Profit Housing Association of Northern California.

Hoffman, R. W., C. R. Goldman, S. Paulson, and G. R. Winters. 1981. Aquatic impacts of deicing salts in the central Sierra Nevada Mountains, California. *Water Resources Bulletin* 17:280–285.

Jonsen, I. D., and L. Fahrig. 1997. Response of generalist and specialist insect herbivores to landscape spatial structure. *Landscape Ecology* 12:185–197.

Lercher, P., D. Botteldooren, U. Widmann, U. Uhrner, and E. Kammeringer. 2011. Cardiovascular effects of environmental noise; Research in Austria. Noise and Health, 13 (52): 234-250.

Lesbarreres, D., A. Pagano, and T. Lode. 2003. Inbreeding and road effect zone in a Ranidae: the case of Agile frog, Rana dalmatina Bonaparte, 1840. C.R. Biologies, 326: S68-S72.

Lidicker Jr, W. Z. 1999. Responses of mammals to habitat edges: an overview. *Landscape Ecology* 14:333–343.

Mac, R. D., J. S. Waller, T. L. Manley, L. J. Lyon, and H. Zuuring. 1996. Relationships among grizzly bears, roads and habitat in the Swan Mountains, Montana. *Journal of Applied Ecology* 33(6):1395–1404.

Madrone Associates Environmental Consultants. 1977. Natural Resources of Napa Marsh. Assisted by: James Michaels, Wildlife Biologist Region 3, Department of Fish and Game Under Contract to: California Department of Fish and Game.

Madsen, A. B. 1996. Otter *Lutra lutra* mortality in relation to traffic, and experience with newly established fauna passages at existing road bridges. *Lutra* 39(2):76–88.

Maltby, L., A. B. A. Boxall, D. M. Farrow, P. Calow, and C. I. Betton. 1995. The effects of motorway runoff on freshwater ecosystems. 2. Identifying major toxicants. E*nvironmental Toxicology and Chemistry* 14:1093–1101.

Marshall, J.T. and K.G. Dedrick. 1994. Endemic Song Sparrow and Yellowthroats of San Francisco Bay. Pp316-327 in N.K. Johnson & J. Jehl (eds.), A Century of Avifaunal Change in Western North America. Studies in Avian Biology 15.

Meyers, T. J., and S. Swanson. 1995. Impact of deferred rotation grazing on stream characteristics in central Nevada: a case study. *North American Journal of Fisheries Management* 15(2):428–439.

Parris, K.M. and A. Schneider. 2009. Impacts of traffic noise and traffic volumes on birds of roadside habitats. Ecology and Society, 14(1): 29 [online] URL: www.ecologyandsociety.org/vol14/iss1/art29/

Putman, R. J. 1997. Deer and road traffic accidents: options for management. *Journal of Environmental Management* 51(1):43–57.

Raaschou-Nielsen, O., Z.J. Andersen, M. Hvidberg, S.S. Jensen, M. Ketzel, M. Sorensen, J. Hansen, S. Loft, K. Overvad, A. Tjonneland. 2011. Air pollution from traffic and cancer incidence: a Danish cohort study. Environmental Health, 10:67 doi:10.1186/1476-069X-10-67.

Reijnen, R., R. Foppen, and G. Veenbaas. 1997. Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors. *Biodiversity and Conservation* 6(4):567–581.

Rosenberg, K. V., J. D. Lowe, and A. A. Dhondt. 1999. Effects of forest fragmentation on breeding tanagers: a continental perspective. *Conservation Biology* 13(3):568–583.

Rottenborn, S. C. 1999. Predicting the impacts of urbanization on riparian bird communities. *Biological Conservation* 88(3):289–299.

Rubin, E. S., W. M. Boyce, M. C. Jorgensen, S. G. Torres, C. L. Hayes, C. S. O'Brien, and D. A. Jessup. 1998. Distribution and abundance of bighorn sheep in the Peninsular Ranges, California. *Wildlife Society Bulletin* 26(3):539–551.

Schuyt K, Brander L. 2004. The Economic Value of the World's Wetlands. World Wildlife Fund, Gland/Amsterdam, Neth. 32 pp

Shilling, F.M. C. Cornwall, F. Knapczyk, R. Zlomke, D. DiPietro, J. Sharp, R. Adams, J. Hemmert, L. Komoroske, D. Waetjen, A. Hollander, E. Aalto, and K. Keightley. 2010. Application and findings of the North Bay-Delta transect watershed assessment framework. Final Report to California Department of Water Resources. 322 pages.

Spira-Cohen, A., L.C. Chen, M. Kendall, R. Lall, and G.D. Thurston. 2011. Person exposures to traffic-related air pollution and acute respiratory health among Bronx schoolchildren with asthma. Environmental Health Perspectives, 119 (4): 559-565.

Theobald, D. M., J. R. Miller, and N. T. Hobbs. 1997. Estimating the cumulative effects of development on wildlife habitat. *Landscape and Urban Planning* 39(1):25–36.

Wilcox, D. A. 1986. The effects of deicing salts on vegetation in Pinhook Bog, Indiana. *Canadian Journal of Botany* 64:865–874.

Yahner, R. H. 1988. Changes in wildlife communities near edges. *Conservation Biology* 2(4):333–339

Zedler JB, Kercher S. 2005. Wetland resources: status, trends, ecosystem services, and restorability. Annual Review of Environmental Resources 30: 39.

Ziegler, A. D., and T. W. Giambelluca. 1997. Importance of rural roads as source areas of runoff in mountainous areas of northern Thailand. *Journal of Hydrology* 196(1-4):204–229.

APPENDIX A
Description of Highway 37 Future Scenarios

SR 37 SCENARIO	Relative Cost *	Construction-Related Activity	Traffic Operations Impacts	Regional Transportation Impacts	Community Impacts	Environmental Impacts
A) No Highway Expansion *Manage the corridor with maintenance and repair activities and minor operational improvements (no significant change in the footprint or capacity)*	$$	• Maintenance issues / landscape control • More emergency response / repairs from flood events and eventual sea level rise	• Existing congestion queues worsen at bottlenecks (121 and Mare Island) from increased demand • More frequent road closures from floods/emergency repair • Some congestion relief at 121 if operational improvements made at this intersection independent of any broader 37 corridor improvements	Maintenance of existing rates of change in congestion, periodic flooding-based displacement of traffic to 80/580 (majority) and 12/116	Feeling that infrastructure is falling apart and being swallowed by bay. Continued impact to Vallejo and Novato from traffic noise and emissions.	Very large missed opportunity for restoration. Continued impacts to marsh and other habitats. Inhibition of hydraulic connectivity of marshes to Bay; failure to adapt to sea-level rise.
B) Expanded Footprint *height and width of the corridor through the marshes would double and the corridor would be expanded to 4 lanes to address current and projected future traffic volumes*	$$$	• Construction staging areas; may bring construction materials by barge or by existing roadway. Need at least 50' on each side for construction access. • Dredging for fill material • Dig out mud, build up embankment with rock and fill material • Discharge prevention activities from construction area • No temporary alignment needed; put traffic on one side of road	• Congestion relief at 121 and Mare Island with upgrade to 4 lanes between those points; assumes operational improvements at connections. • Local road access retained, assumes upgrades to local road connections.	Temporary drop in congestion (10 years) on highway, then continued increase, potential attraction of 80/580 and 12/116 traffic and thus increase in traffic on 37	Increased impact to Vallejo and Novato from traffic noise and emissions (minor).	Makes marsh restoration more difficult and expensive in future. Increased impacts to marsh and other habitats. Inhibition of hydraulic connectivity of marshes to Bay.

		while building the other side.				
C) Napa-Sonoma Causeway *Option 1 - over existing footprint at areas of low elevation Option 2 - across San Pablo Bay btw Novato & Vallejo*	$$$$	• Construction staging areas; may bring construction materials by barge or by existing roadway. Need at least 50' on each side for construction access. • Build tressle; causeway built along existing alignment • Piledriving of main supports and falsework piles • Removal of old alignment segments • Discharge prevention activities from construction area	• Option 1 – Congestion relief at 121 and Mare Island with upgrade to 4 lanes between those points; assumes operational improvements at connections. • Local road access retained, assumes upgrades to local road connections. • Option 2 – Access to 121 and Lakeville broken; local access to SR 37 disrupted • Congestion relief at 121 and Mare Island with upgrade to 4 lanes between those points; assumes operational improvements at connections.	Temporary drop in congestion (10 years) on highway, then continued increase, potential attraction of 80/580 and 12/116 traffic and thus increase in traffic on 37	Unknown positive impact of improved habitat quality, such as ecotourism. Increased impact to Vallejo and Novato from traffic noise and emissions.	Allows bay water back into former baylands and restoration of large natural areas; which creates buffer against sea level rise and storm surge. Improves opportunities for and effectiveness of marsh restoration.
D) Strategic Re-alignment *corridor would be re-aligned away from marshes & wetlands between Vallejo*	$/$$	• Cooperative agreement and legislation possibly needed to coordinate relinquishment of old alignment • Removal of old alignment segments	• Increased traffic on alternative routes could result in demand for traffic relief projects along those routes • Local decision to keep portions of existing roadway intact for local uses	Increase in traffic displaced to 80/580 (major) and 12/116 (minor), then continued increase	Potentially degrades rural character of communities on 12/121/116 due to increased traffic (noise, emissions). Potential economic	Allows bay water back into former baylands and restoration of large natural areas; which creates buffer against sea level

and Novato, with I-80 and 580 to the south, or with Highways 29 and 12/121/116 to the north					harm to commuters from increased travel time and to certain local businesses without through traffic on former SR 37. Unknown positive impact of improved habitat quality, such as ecotourism. Reduced noise and emission impacts to Vallejo and Novato.	rise and storm surge. Improves opportunities for and effectiveness of marsh restoration.
E) San Pablo Bay Tunnel *corridor would be routed through a tunnel at the shortest feasible distance between the Vallejo area and the Novato area*	$$$$$	• Construction staging areas; may bring construction materials by barge or by existing roadway. Need at least 50' on each side for construction access. • Bay fill/soil removal • Dam needed to keep water out of above-ground construction activities. Dig tunnel alignment from above, then cover it up and restore after construction. • Removal of old alignment segments	• Congestion relief at Mare Island with upgrade to 4 lanes at that point • Access to 121 and Lakeville broken; local access to SR 37 disrupted	Temporary drop in congestion (10 years) on highway, then continued increase, potential attraction of 80/580 and 12/116 traffic and thus increase in traffic on 37	Unknown positive impact of improved habitat quality, such as ecotourism. Reduced noise and emission impacts to Vallejo and Novato.	After construction, allows bay water back into former baylands and restoration of large natural areas, which creates buffer against sea level rise and storm surge. During construction, inhibition of hydraulic connectivity of marshes to Bay.

* Relative Cost is on scale of $ to $$$$$; cost is relative to other scenarios and is meant to include ongoing operation & maintenance cost.

Scenario D (Strategic Realignment) is undefined in terms of necessary improvements.

APPENDIX B
Credit and Valuation Approach

Summary

Describing credits for different transportation and ecological actions was an intent of C06 and the C21 test of C06. No specific methods were described in C06, so we limited our investigations to conceptual discussions of crediting and valuation with transportation and other stakeholders. This introductory and conceptual approach is appropriate at this point because the field of valuation and economic valuation of environmental attributes (including benefit/cost analysis) is relatively new in transportation planning and decision-making.

The approach described here formed the basis for presentations and discussions with transportation and other stakeholders in this C21 project. It also formed the basis for how two valuation approaches were conducted: 1) preference surveys to quantitatively describe stakeholder value systems and 2) impacts analysis conducted with impacted-area as the currency of valuation.

Because there were no specific projects defined in this study, there was no credits system developed or tested. However, we felt that the concepts were sufficiently well-introduced and supported by both Caltrans' previous research into valuation and guidance from TRB/FHWA that it is possible that corridor management could adopt this form of decision-support in the future.

What Are Credits?

In order to plan for infrastructure development in complex social-ecological systems, it may be necessary to create devices that draw equivalencies among non-like objects. Credits are one type of device that use units of measure that are native to part of the system (e.g., Ha of land), or derived from financial calculations (e.g., $-equivalents), or that are normalized on a preference scale of some kind (usually from least to most preferred). In the current study, credits are units of value whereby dissimilar attributes of the Highway 37 Corridor Context can be compared in planning, impacts analysis, programming, and mitigation budgeting.

Credits in this study are proposed as scores on a scale from 0 to 100 given to alternatives for five themes: Transportation, Environment, Cost, Community, and Reversibility. Each theme is accompanied by indicators of impact within each theme, which allows the development of stewardship-oriented scenarios, as well as evaluation of the actual impacts that accompany each scenario. The normalization of impacts to a 0 to 100 credit scale can serve as an intermediate step for subsequent conversion to fiscal equivalents for system attributes for which fiscal equivalents are known. Because these equivalents are approximate at best, the unit-less credit scale permits valuation without the inexactness of monetizing benefits and dis-benefits (including costs) of various project choices. For the environmental theme for this corridor, the nearby tidal and freshwater wetlands provide both constraints and opportunities for stewardship

planning. Because of the unique potential for wetland restoration in the State Route (SR) 37 Corridor Context, there may be few possibilities for mitigation bank strategies or payment of ecosystem services. However, even if mitigation banking might not be appropriate in this corridor, if wetlands around SR 37 are restored, these activities could confer credit benefits to other project areas.

What is Valuation? Choice of the Valuation Method

Two Valuation Methods Considered: Crediting Strategy and Monetary Valuation

In its application to pilot test the tools from C06A and B, UC Davis proposed to use two approaches for the sixth step, develop crediting strategy. The first approach is to use one of the products of the C06B project: a credit system, as one accounting system for ecological, economic, and equity effects of decisions. To be functional in this system, the accounting or credit system would provide a way to both indicate relative or absolute effects or impact and to measure potential performance of credits, usually in the context of mitigation. In our case, this valuation will be based on a value given by normalization and aggregation of indicators on a defined scale (0 to 100, for instance). An alternative framework based on Caltrans' existing valuation approach for impacts, developed in collaboration with the UC Davis Road Ecology Center and Sustainable Transportation Center is also proposed, and this method is based on monetary values to evaluate impacts. The aim with the combined approach is to contribute to a more complete accounting of environmental, economic, and equity impacts of transportation early in decision-making, including describing a crediting strategy. We describe in the next sections how each of these two methods works. However, for our study, we will use only the valuation approach based on a crediting strategy, for reasons developed below.

Use of Monetary Values for SR37

The use of monetary value gives a common scale for the valuation of impacts. Such dollar values for some impacts (emissions, for instance) are already used for Cost Benefit Analysis (CBA) by Caltrans, more precisely in life-cycle benefit/cost analysis. Such analysis is performed using a model called Cal-B/C[1] and impacts such as accidents or vehicles emissions are monetized in this type of analysis. But others impacts such as noise or water pollution should be monetized as well. Many wetland functions, for instance, result in goods and services that are not traded in markets and therefore remain un-priced. It is then necessary to value these goods or services using a non-market valuation technique. For SR 37, monetization of wetlands would be a key step and we will discuss its implementation as an example of how we could give a dollar value to impacts for our project. The first step for monetary valuation is to understand what characteristics of the wetland can be valued, so we will first summarize the functioning, uses,

[1]www.dot.ca.gov/hq/tpp/offices/ote/LCBC_Analysis_Model.html

and values of wetlands. Then we will present valuation methods and why they cannot be implemented in our project.

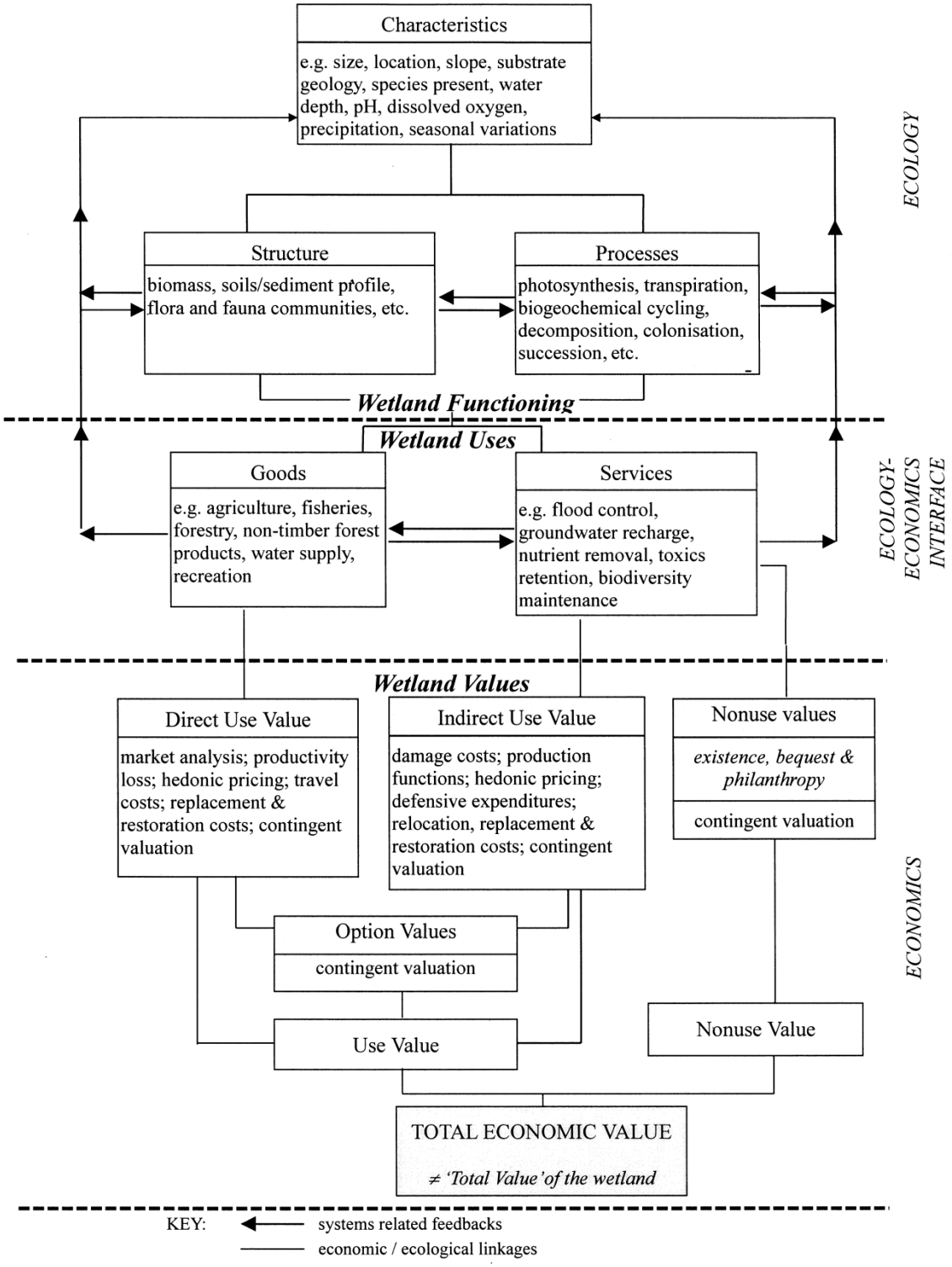
Monetization Process for Wetlands

FUNCTIONING, USES, AND VALUES OF WETLANDS

The functioning of the wetland comes from different ecological processes (e.g., photosynthesis), characteristics (e.g., water depth), and structure (e.g., fauna and flora). Then, wetland uses result from the functioning of the wetland (Figure B.1). Wetlands uses contain both wetlands services (e.g., flood control) and goods (e.g., fisheries). It is at this stage that connection is made between ecology and economy since wetland uses can be monetized because links can be made between wetland uses and human activity. Yet monetization of wetland uses is not direct and it depends on what type of use is considered. In addition, decision-making regarding wetlands does not have to rely upon monetization as the only way to include wetlands' value in decision-making.

- Goods provided by wetlands have a direct use value, so they can be monetarized with market analysis, contingent analysis, and mitigation costs
- Indirect use value can be found for some wetlands services. For instance, flood control can be monetarized by the costs of maintenance of levees. Contingent analysis or hedonic prices can also be used to monetize these services.
- Some services, like knowing that the wetland exists, don't have a use value. Therefore, contingent valuation must be used for these services.

Main economic valuation techniques are described in the next section.



Source: Turner et al. 2000.

Figure B.1. Connections among wetland functions, uses, and values.

Valuation Methods

Three valuations methods that we could use to value wetlands are revealed and stated preference methods, contingent analysis, or benefit transfers.

REVEALED AND STATED PREFERENCE APPROACHES

The two main types of valuation for non-market goods (wetland services, in our case) are the revealed preference methods and the stated preference methods. Revealed preference approaches depend on a connection between the non-market good of interest (for instance, noise) and a market good (for instance, housing). The method uses data revealed by behavior related to actual decisions (for instance, changes in prices of housing). The major problem of this method is that it is based on existing conditions and so the possibilities of alternatives are limited. In contrast, stated preference techniques are based on hypothetical situations and surveys that are used to determine people's willingness to pay for a situation.

Contrary to revealed preference methods, stated preference methods can be used for environmental goods like a wetland where we have both use and non-use values.

THE CONTINGENT VALUATION METHOD

Contingent valuation method is a stated preference method and it is usually used to estimate the value of an environmental change scenario. The method implies the use of a survey which begins with a statement describing the change in environmental goods or services. Then it asks individuals to reveal how much they are willing to pay for the change. For example, we could ask people how much they are willing to pay to restore wetlands surrounding Highway 37. In theory this method can be used to estimate values for environmental resources and ecosystem services, including those supporting both use and non-use values, which is what we need to get a valuation of wetlands. However, respondents must understand the nature of what is being valued as well as be able to know how they would be willing to trade off between changes in the environmental attribute and their income. This is a major difficulty for the contingent valuation method which can vary a lot between places and respondents. It especially depends on people's income. Another issue with contingent valuation is that this method is time- and resource-consuming, since it is based on surveys. In our case, the time limit does not allow for a contingent valuation of wetlands.

BENEFIT TRANSFERS FOR WETLANDS

Benefit transfer is defined as the transfer of existing estimates of non-market values to a new study which is different from the study for which the values were originally estimated. It is a secondary approach for valuation. This method is often used mainly because it saves time and resources. Usually, benefit transfer is best suited for tasks where the need for accuracy is low and it is generally considered a "second best" valuation method because benefit transfers involve reusing existing data, and a benefit transfer does not provide an error bound for the value in the new application after the transfer.

Since contingent valuation method would be time and resource consuming, benefit transfers were considered for our study. However, "A recent review by Heimlich et al. (1998) lists 33 studies over the last 26 years with per acre values ranging from US$0.06 to US$22050. Even within the same study looking at a single ecosystem function, Batie S.S., and Wilson (1978) find values per acre that differ by two orders of magnitude from one site to another."(Woodward et al., 2001). This study shows that variability comes from the methodology used for the evaluation and insists that in-site studies should still be used, knowing the potential biases of valuation methods. Therefore, it is less desirable to use benefits transfer to estimate wetland's value and we will only use the valuation method based on credits proposed in C06B.

Crediting Strategy in C06B Approach

Although C06 proposed a list of steps to be followed (Table B.1), the choice of the methodology was broad because these steps were not detailed and they can be seen as a list of what the evaluation should include rather than a precise guideline. Therefore it leaves a lot of possibilities as to how the evaluation will be conducted.

Table B.1. Purpose and Implementation of Step 6 from C06B Project (TRB, 2011).

Step 6: Develop Crediting Strategy
Purpose: Develop a consistent strategy and metrics to measure ecological impacts, restoration benefits, and long term performance – with the goal of having the analyses throughout the life of the project be in the same language. *Implementation Steps*: **6a. Diagnose the measurement need.** Examine the ecological setting (including regulated resources and frameworks, non-regulated resources, and ecosystem services); examine the regulatory and social setting, and identify additional opportunities. **6b. Evaluate ecosystem and landscape needs and context to identify measurement options.** **6c. Select or develop units and rules for crediting** (e.g., rules for field measurement of ecological functions, approved mitigation/conservation banking, outcome-based performance standards using credit system)**.** **6d. Test applicability of units and rules in local conditions.**

6e. Evaluate local market opportunities for ecosystem services.

6f. Negotiate regulatory assurance

The crediting strategy can be seen as a multi-criteria analysis, as we can see in our implementation of Step 6 to SR 37 study described below.

Choice of the Crediting Strategy Approach

If we use a valuation approach, we look at economic values of environmental impacts and we have to use contingent valuation for different types of values, which demands time and resources. The difference with a crediting strategy (multi-criteria analysis) is that the crediting strategy uses indicators from the wetland structure and characteristics and not only its uses. This approach can be linked to strong sustainability as opposed to the valuation approach which is closer to weak sustainability: when we use economic valuation, we do not take the irreversibility factor into account. Giving an economic value to a wetland might also mean that the benefits from this wetland are the same as benefits from another ecosystem, which we can buy through mitigation banking. But what is not considered here is the irreversibility of the damage caused to the wetland and factors like the uniqueness of the considered wetland. Therefore, economic value as it is used here only considers part of the total value of the wetland.

Definitions (Joumard et al. 2010):

Weak sustainability : "According to the weak approach of sustainable development, the natural capital is a component of the total capital composed by all the productive goods, so-called productive capital, the human capital and the stock of knowledge and know-how of the people, so-called social capital, and the resources and natural goods, renewable or not, so-called natural capital. These different types of capital are supposed measurable and equivalent. The annuities due to the use of the natural capital by the present generation can be reinvested in the form of a reproducible economic capital, to be transmitted to the future generations. […] In these conditions, the sustainable development of an economic sector is not limited by an ecological constraint."

Strong sustainability: "The second variant of sustainable development is the strong approach, which claims the irreducible character of the natural capital. It means that the sustainable development should comply with the ecological constraints due to the preservation of the quantity and the quality of the natural capital, i.e. the nature."

Also, the aim of our study is to help decision making by stakeholders through a better knowledge of impacts, and indicators might be a better approach as they are more transparent and can be easily understood, unlike economic valuation. Economic valuation is made through methods like contingent valuation and then uses concepts such as discounting which are not as easy to understand as a range of indicators. Thus, it might be easier for stakeholders to discuss a rather simple evaluation in which they can discuss different objectives described by indicators and weights of indicators. This would help decision making more than an economic valuation because stakeholders can easily discuss every point and by that process get a better understanding of potential impacts and concerns.

Relationship to C06 Approaches

The general methodology chosen for this study is described below. We divided it into the substeps developed by C06 team and adapted to our project (Figure B.2).

Substeps

For each substep, we will give a summary of C06B recommendations and describe how we will implement them in the SR 37 study.

Step 6a: Diagnose the measurement need: examining the ecological setting, the regulatory and social setting, identifying additional opportunities.

C06B RECOMMENDATIONS

This first substep is targeted at diagnosing the resource measurement needs. It is divided into three parts. The first part is the ecological setting: examining natural environment and resources in the area. The second part is the regulatory and social setting, which can be examined through a historical review of stakeholder's experiences and a forward-looking review that evaluates potential regulations or social expectations from projects. The third part, additional opportunities, can be evaluated by examining ongoing efforts and conservation programs.

APPLICATION FOR THE SR 37 STUDY

The draft Caltrans Corridor Plan for SR 37 was used as a basis for this step as it already provided a description of the corridor including its transportation characteristics (current and forecasted), environmental constraints, and previous and potential future projects. The regulatory setting is already described in the Corridor plan.

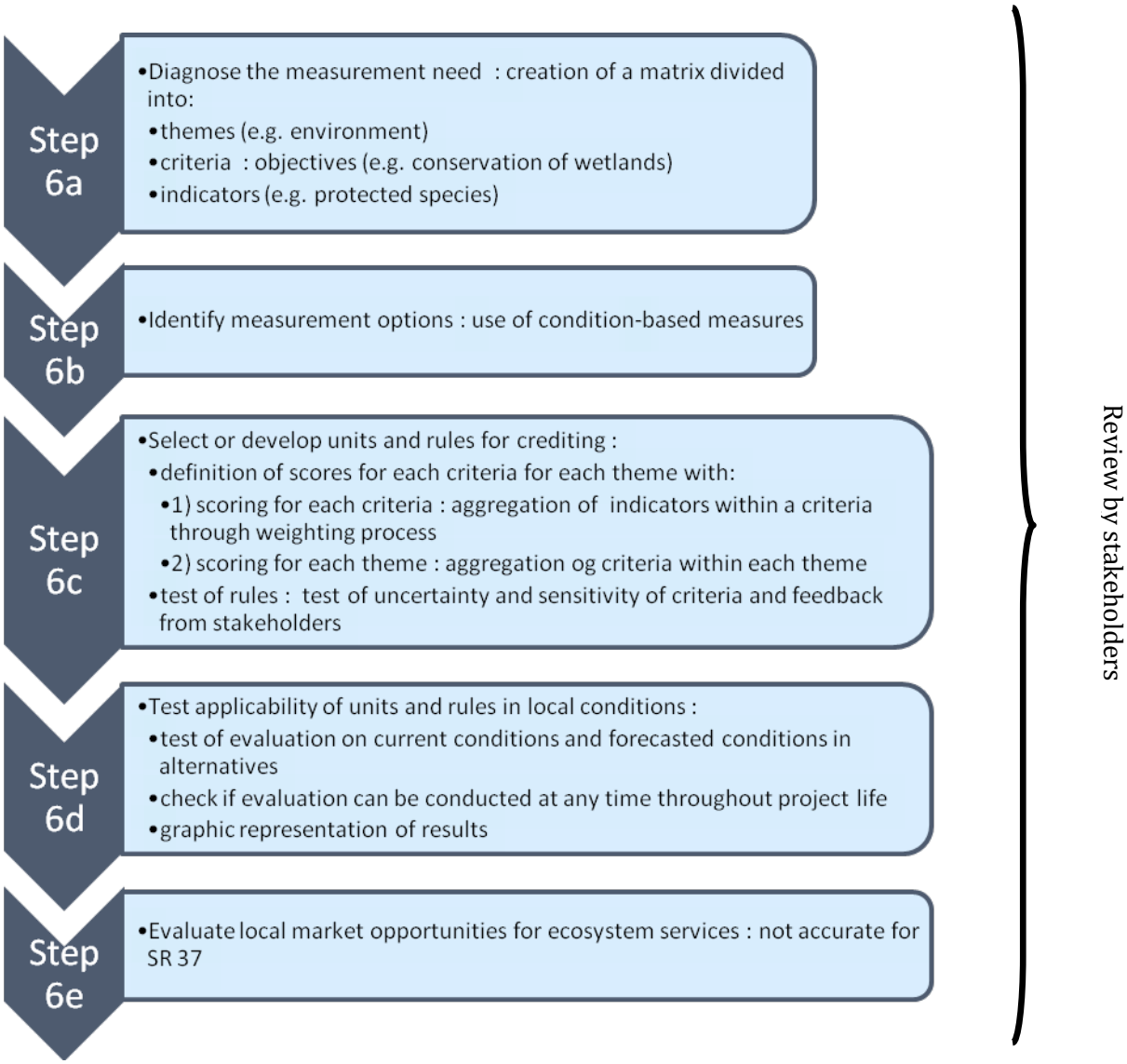


Figure B.2. Application of C06B framework for Step 6 to SR 37 study.

In order to get a global image of ecological and social setting, we developed a matrix divided into themes, objectives (or criteria), and indicators (Figure B.3).

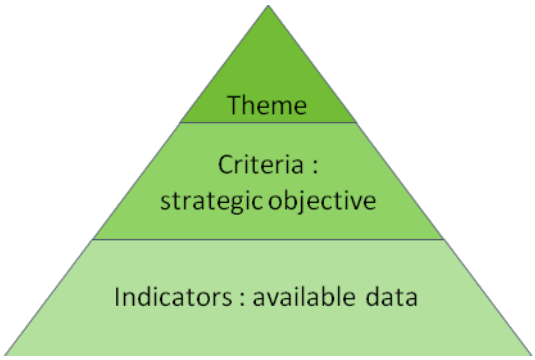


Figure B.3. Hierarchy of themes, criteria, and indicators.

Definition of Themes and Objectives

The matrix was first organized into different themes and objectives listed by TCAPP: environment, transportation, cost, economy, and community. It was then adapted to the SR 37 study. Other themes and objectives were added to match the SR37 study, like objectives concerning wetlands. Objectives will be used as criteria for each theme. For this step, meetings and feedback from stakeholders can help with getting to know different impacts that were not previously listed, as agricultural impacts linked to sea level rise and wetland restoration. Also, this matrix can be compared to and, if needed, completed by the lists of impacts listed in Caltrans' existing valuation approach for environmental impacts developed in collaboration with UC Davis Road Ecology Center and Sustainable Transportation Center.

Definition of Indicators for Each Criterion

With help from the TCAPP website and depending on available data, each criterion (impact/measure listed) will then be linked to one or several indicators that can be provided for which data can be provided. TCAPP web tool also includes lists of existing studies for several indicators. That can eventually be carefully transferred to SR 37 study if we have a lack of data and if a transfer is consistent with both the existing study and SR 37 characteristics.

Step 6b: Identify measurement options.

This step mainly aims at defining units for managing the resources.

C06B RECOMMENDATIONS

In this section, various existing measures used in environmental management settings are presented: condition-based measurements, model-based measurements, and function-based measurements.

Condition-Based Measurements

Condition based measurements focus on quantifying changes in the status of the regulated resource. For instance, species of concern would be measured through population surveys. These systems also include pollutant load measurements, which are normally defined by quantifying specific amounts of criteria pollutants added or removed from the system. Condition-based examples include water quality measurements, and indices of biological integrity. Two forms of condition-based measures are indices of environmental quality and observation-based systems.

Model-Based Measurements

This type of measures relies on data to estimate species or ecosystem response and on a set of rules and conditions that are expected to result in an environmental outcome. Model-based systems are similar to condition-based measurements systems, but are usually employed for planning purposes because they focus not only on sample-based data but also on the elements of the ecosystem that can be affected by human action.

Function-Based Measurements

These measures focus on habitats, structures, and processes as the basis for measuring the environment. Function-based systems are not species-specific, and are used when rare or unique resources need measures, but are not easily measured with one species. Model-based measurements can start to combine elements of a function-based measure and a condition-based system where the model relies on habitat or field data to estimate habitat use and densities. To truly get at a measurement for use in transportation projects, the results need to tie the natural impacts back to specific actions at a site. This is needed for the full suite of mitigation decisions: avoidance, minimization, and compensation. These concerns need to guide the selection or development of a measure.

APPLICATION FOR THE SR 37 STUDY

Given the sensitivity of resources, SHRP C06 research recommends that functional measures are used in the study. This approach should provide “a common unit of measurement for biological, chemical, and physical processes”. The dollar could have been this common unit, as recommended by Caltrans’ existing valuation approach for environmental impacts developed in collaboration with UC Davis Road Ecology Center and Sustainable Transportation Center. The reasons why we won’t use this approach were explained earlier.

Using models of wetland condition and processes could be an appropriate basis for valuation in the SR 37 study. Caltrans provides forecasts for transportation data as well as ecological models on impacts, such as noise. But a major challenge for the ecological impact concerns wetlands, and wetlands are a very complicated ecological system. Not all of its functioning is well understood, especially when hydrology is concerned. Therefore, it remains difficult to conduct model-based measures for wetlands because it is difficult to find out exactly how indicators of wetlands well-being will react to alternatives. Therefore, we will use

condition-based measures in our study: for instance, species of concern would be measured through population surveys.

Step 6c: Select or develop units and rules for crediting.

C06B RECOMMENDATIONS

In this section, C06B provides recommendations to develop a custom measurement system for multi-resource crediting: define the spatial unit, develop a conceptual diagram, generate attributes (criteria) and scores, check attributes, and check that measures can work at any point of time. All rules developed during this process must be agreed upon.

APPLICATION FOR THE SR 37 STUDY

The method proposed here and summarized in Figure B.4 is rather simple and transparent. These qualities were needed here because they will help the discussion between stakeholders who can discuss every indicator.

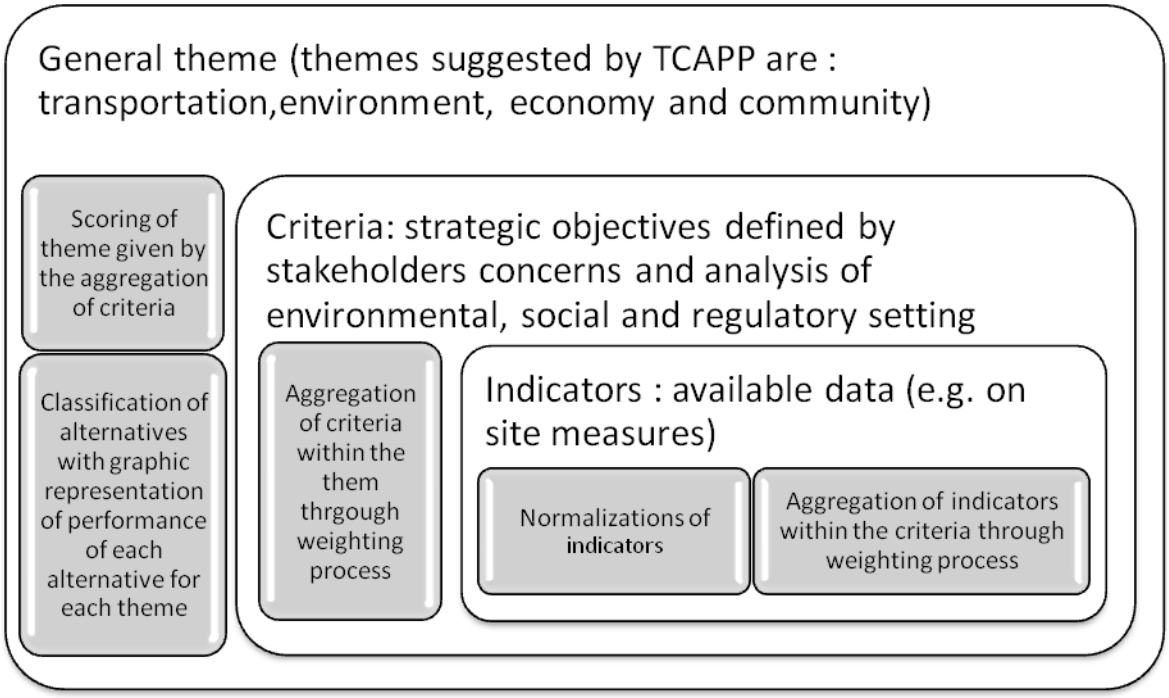


Figure B.4. Implementation of Step 6c.

In the matrix of impacts constructed earlier, each theme will be equally-weighted. Each criterion inside each theme will then be weighted. A conceptual diagram was developed with the matrix of impacts and can eventually be used to help with the choice of weights or to show how weights are distributed, following C06 recommendations. The issue with these diagrams that we

have is that some impacts like water quality appear at different points of the diagram (for instance, as a consequence of runoff water or as a consequence of vehicles emissions). Therefore, weighting cannot be based on the conceptual diagram because we would have too much double counting, but it will help stakeholders to have a more comprehensive understanding of the system.

Each criterion will then get a score depending on the performance of the alternative considered for this criterion through a normalization process of its indicators explained later. When we have the scores, we can calculate a score for each theme. No global score will be given for each alternative because the idea of the evaluation is to help dialogue among stakeholders and between Caltrans and regulators. Thus, the most important part of this work is to give stakeholders the best possible knowledge of potential impacts of different alternatives in order for them to make the best decision. That's why it may be more important to discuss different weighting options and aggregation options than to have a final score. The final result of the evaluation study should give a good idea of both positive and negative impacts of alternatives, which should ultimately help stakeholders weight their own concerns regarding the other stakeholders' concerns and then hopefully come to an agreement on the alternatives.

One issue about this approach is that weights of themes and criteria are decided before the valuation and therefore the results of the valuation depend on how each theme was previously weighted. However, different weight options can be used in order to represent different approaches or points of view on the project.

The normalization process and the weighting will be reviewed for uncertainty and sensitivity. Uncertainty tests look how the uncertainty of an indicator can spread and affect the global evaluation and sensitivity tests focuses on how much a single indicator affects the evaluation. Sensitivity tests for these two parts of the evaluation will be made to check the consistency of the indicators. Then, stakeholders should review the results to agree on results and values used in normalization and weighting.

The selections of criteria and indicators will be discussed with stakeholders as well as how each weight and determination of benefits and dis-benefits during the evaluation process could be useful as this can be a basis to determine credits. Finally, ways to deal with the benefits and dis-benefits will be developed.

Step 6d: Test applicability of units and rules in local conditions.

C06B RECOMMENDATIONS

The application is recommended in three steps: determine baseline condition using on-site data, generate alternative scenarios, and evaluate future conditions.

APPLICATION FOR THE SR 37 STUDY

A current and future condition evaluation is generated for each alternative considered. This means that a precise definition of the alternatives should be produced at this point or earlier by

stakeholders. Defining alternatives earlier could be useful because it can help determine objectives and needed data.

Step 6e: Evaluate local market opportunities for ecosystem services.

C06B RECOMMENDATIONS

Market opportunities include existing conservation/mitigation banking systems or payment for ecosystem service (PES). PES programs are negotiated contracts with landowners to maintain a certain level of environmental performance to maintain or enhance ecosystem services. Examples of PES can be found in Forest Trends and Ecosystem Marketplace, 2008.

Developing ecosystem metrics and tracking project impacts using those measures can make it easier to access any operating regional ecosystem markets. If ecosystem markets are available and if metrics were developed from previous step, then the ecosystem measurement system should be well-suited to use within the ecosystem market.

Ecosystem markets present various benefits for departments of transportation:

- First, they remove the risk of uncertainty of the project linked to the needed approval by environmental agencies. Projects are often slowed or stopped by deficient environmental analysis like the Environmental Impact Report (EIR) required by federal and state laws: National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), or Clean Water Act, for instance.
- Second, ecosystem markets include a transfer of liability: the liability for the restoration or conservation success is placed on the banker and not on the department of transportation.
- Third, this system produces a better alignment of mission since instead of road constructors, restoration professionals build mitigation sites.
- Fourth, ecosystem markets can produce improved ecosystem outcomes because bankers can have more comprehensive and meaningful projects to address ecosystem priorities.

But although PES systems have great potential power for ecosystem preservation, according to Redford and Adams, seven major criticisms can be listed (Redford and Adams, 2009), including the risk that economic arguments about services valued by humans will overwrite and outweigh noneconomic justifications for conservation and the concern that there is no clear way to track the performance of the system. Therefore, ecosystem markets must be only one of several tools aiming at preserving ecosystems.

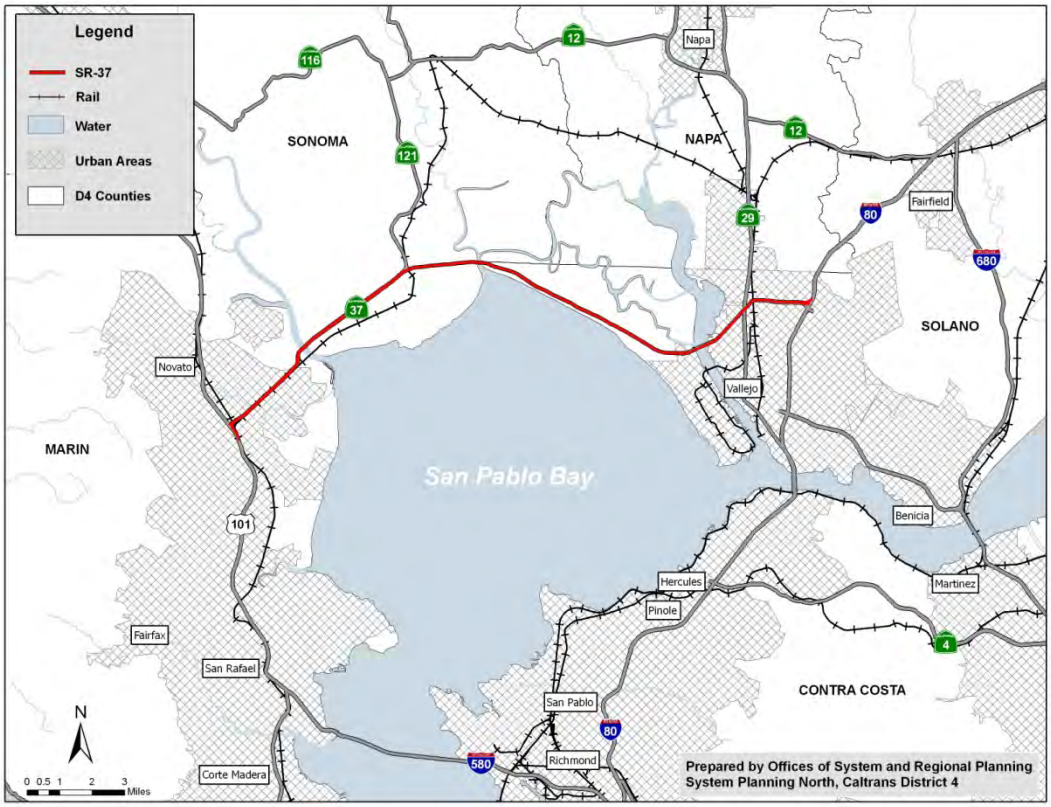
APPLICATION FOR THE SR 37 STUDY

The unique potential for wetland restoration in the SR 37 setting might not make bank strategies or PES sufficient mitigation strategies in this case. Indeed, in the geographic setting of SR 37 there is a low housing density and development (cf. urban areas in Figure B.5). This makes this

place a unique opportunity of wetland restoration for the Bay Area and this nationally-important estuary.

Therefore, since the ecosystem is unique, banking systems or PES might not be a satisfying approach for this project because they imply that mitigation or restoration projects can be equivalent to the impacts, which is not the case for unique systems. Indeed, widening Highway 37 would have irreversible impacts that cannot be compensated by another wetland project because no other wetland project has the same potential benefits in the Bay Area.

However, if mitigation banking might not be sufficient for this project, if the removal alternative or the causeway alternative is considered, these wetlands could become a mitigation bank themselves and receive money from crediting strategies from other projects. It would also be a way to pay for the extensive wetland restoration.



Source: Caltrans draft Corridor Plan, 2010.

Figure B.5. Geographical setting of Highway 37.

Stakeholders Role in the Evaluation Process

Stakeholders are supposed to participate at every step of the evaluation. The crediting strategy described here is designed to get a maximum involvement of stakeholders. Discussion about objectives will help identifying and discussing concerns; discussion about criteria will help sharing data; and discussion about weighting will help getting a shared agreement on priorities.

The construction of alternatives will also necessitate the involvement of stakeholders, because of the various issues that have to be addressed. Stakeholders at this point will help in constructing better alternatives because they can share their own expertise that other stakeholders may not have. Construction of alternatives is an important step and it will also lead to better knowledge of concerns and potential impacts. Therefore, this step can help in defining objectives and criteria and thus it should take place early in the process.

The evaluation should help in understanding the benefits and impacts associated with each alternative scenario for the highway. Benefits and impacts can be used to optimize alternatives, where optimization limits imapcts and maximizes benefits.

Implementation of the Method

Choice of Themes and Objectives

Themes and objectives are the two levels under which the project will be evaluated. Therefore, this choice is a very important step. The question here is: what do we want to measure? Stakeholders have various goals. For instance, Caltrans wants to reduce congestion, Sonoma Land Trust wants to restore wetlands, the Bay Trail wants bikes paths, US Fish and Wildlife Service want to preserve biodiversity and protect listed species, and land-owners want levees to protect their land from flooding. Themes and objectives must reflect all these different intents in order to inform agreements. TCAPP proposes a list of themes and objectives on its web tool. It can be used as a basis and adapted to SR 37 after feedbacks from stakeholders.

Themes for SR 37 could be Transportation, Environment, Cost, Community, and Reversibility:

- Transportation could include objectives like reducing congestion and delays, reducing the risk of injury-causing accidents, and improving accessibility.
- Environment could include wetland conservation, tidal wetland adaptation to sea level rise, air and water quality, preservation of habitat and biodiversity, and noise pollution.
- Cost could include infrastructure and mitigation costs, cost effectiveness and economic impact, and avoidance of future catastrophic costs from sea level rise.
- Community could include objectives like land preservation, historic preservation, equitable distribution of transportation costs and benefits, access to recreation, community cohesion, and public health.
- Reversibility would measure the “possibility of re-orienting, or cancelling the project once finished, according to future choices” (Joumard et al. 2010).

Criteria for the Choice of Indicators

Quality of basic data affects the quality of the overall evaluation. Several dimensions, listed in OECD Handbook (Nardo et al. 2005), need to be considered while selecting data:

- ***Relevance***
  The relevance of data is a qualitative assessment of the value contributed by these data. Value is characterized by the degree to which statistics meet current and potential needs of the users.

- ***Accuracy***
  The accuracy of data is the degree to which they correctly estimate or describe the quantities or characteristics that they are designed to measure. Accuracy is usually measured in terms of the error, or the potential significance of error.

- ***Timeliness***
  The timeliness of data products reflects the length of time between their availability and what they describe. The punctuality of data is also important: it depends upon the existence of a publication schedule and reflects the degree to which data are released in accordance with it.

- ***Accessibility***
  The accessibility of data products reflects how readily the data can be located and accessed. It implies, for instance, distribution channels, pricing policy, affordability, copyright, and suitability of the form in which the data are available.

- ***Interpretability***
  The interpretability of data products reflects the clarity with which the user may understand and analyze the data. It reflects how well the indicator varies with what it represents and how it is influenced by uncertainties. It should move in an analogue fashion to the phenomenon.

The choice of basic data mainly depends on its availability in the area of concern and the quality of the overall evaluation depends on the coherence between indicators and not only on the quality of each single indicator. However, these criteria will be used as guidance when a choice between indicators can be made.

Double Counting

The problem if the evaluation is based on objectives is the potential double counting because the same criteria can be used to assess different objectives. For instance, water quality can be an indicator for the preservation of wetland or wildlife, but it can also be used for the objective of human health. But even though evaluation based on objectives can lead to double counting, it

might be more important to see how far each objective is reached with different alternatives than how many times an indicator was used.

Also we can consider that double counting is useful to some extent because if a resource is a valid indicator for different objectives, then maybe it should be counted twice because it serves two different objectives.

Normalization of Indicators

Once we have our criteria and indicators, the next step is to normalize them to a common value scale. Several normalization processes are described.

Choice of the Type of Normalization

Different methods exist for normalization, although none of them is totally satisfying. Table B.2 below summarizes the main methods and their advantages and disadvantages.

Table B.2. Comparison of Methods for Normalization

Method	
Advantages	**Disadvantages**
Empirical normalization Min max method gives the 0 value (Min) to the most unfavorable observed value and 1 or 10 (Max) to the best recorded value. All intermediary values are calculated based on the formula: Y = X – Min/(Max – Min).	
Simple and efficient to compare alternatives with an initial state.	Variability of Min and Max values that depend on observed values, new observation outside the previous limits will lead to new normalization. Extreme values/or outliers could distort the transformed indicator.
Axiological normalization Close to the empirical approach with *min* and *max* limits. The limits are not statistically identified, being chosen based on the undesirable situation, which receives the "0" value, and on the ideal situation, which can or cannot correspond to a strategic objective and which receives the value "1". Alternatives to min and max here are : • **Distance to a reference method** that takes the ratios of the indicator to a value of mean reference for this indicator: $Y=X/X_{expected}$	

- **Indicators above or below the mean**: this transformation considers the indicators which are above and below an arbitrarily defined threshold, *p*, around the mean $X_{expected}$:

$$Y = \begin{cases} 1 \; if \; \dfrac{X}{X_{expected}} > (1+p) \\ 0 \; if \; (1-p) < \dfrac{X}{X_{expected}} < (1+p) \\ -1 \; if \; \dfrac{X}{X_{expected}} < (1-p) \end{cases}$$

Simple and efficient to compare alternatives. Reduced impact of extreme values.	Might be less realistic than the empirical approach because limits depend on objectives, not on observations.
Mathematical normalization Transformation of data by means of a mathematic function in order for the values to range between an upper and a lower limit.	
	Lack of transparence for the user and possible change of initial distribution of values.
Statistical normalization All values are expressed in standard deviation, so that the variables average is equal to zero.	
Does not depend on min and max values determined by strategic objectives or statistics.	Does not depend on min and max values determined by strategic objectives or statistics.

Since the aim of the study is to get stakeholders involved in a more comprehensive process, transparency is important. Therefore, an axiological or empirical normalization would be better here because stakeholders can easily understand and discuss indicators since they understand the normalization process. An empirical normalization is preferred for our study because we aim at having few alternatives (three to five), and therefore an axiological normalization could distort the reality of the impacts of each alternative by comparing them on a reduced scale.

Positive versus Negative Count of Impacts

Another question here is to choose how we want the indicator to be read: more is better or less is better? The appreciation by stakeholders might be different for some indicators. For instance, congestion can seen as a “less is better” indicator because drivers earn time when the road is less congested and this is counted as positive impact with a positive value of time which derived from the observation that people are willing to pay to save time. However, we can look at congestion from another point of view: congestion might be an indicator for which more is better because if the road is congested people might want to avoid congestion by using other modes or by car sharing, if these alternatives are available. Or they might also want to live closer to their work, which would limit urban sprawl. In that case loss of time consequent to a transportation project can be seen as a positive impact from a transportation and accessibility point of view. Therefore, the direction of each indicator (more is better or less is better) must be derived from the objectives.

Aggregation of indicators and criteria

Choice of the Aggregation Method

Aggregation is the process through which several indicators are summarized into a single index. The questions related to aggregation are: Do all indicators have the same weight? If not, how should weights be determined? What mathematical function will we use to aggregate indicators? In our study, a simple and transparent method is preferred since it is necessary to get stakeholder’s involvement. Therefore we will calculate the mean of aggregated indicators.

Choice of the Weighting Method

Weighting methods have various advantages and disadvantages (Table B.3). The weighting method that seems the most accurate for our study is the budget allocation method, because of its transparency and easiness to implement. This method could include some stakeholders as experts. The idea is to ask stakeholders how they would weigh the criteria in their field: transportation criteria should be weighted by transportation stakeholders, environmental criteria by environmental agencies, and then average weight could be used as weights. However, we cannot to have too much difference between weights for the same criteria, so the given weights might need to be transformed in order to get an arbitrarily-defined standard deviation. If a standard deviation is too high it might be an indicator that the criteria is not accurate, in which case the criteria can be changed..

Table B.3. Advantages and Disadvantages of Some Weighting Methods

Weighting method	
Advantages	**Disadvantages**
Hierarchical Weighted Total (aggregation on tree) When criteria can be organized in a tree, weights are attributed to each single indicator and to all combinations of indicators belonging to the same node, at all different levels of the aggregation tree.	
• Simple to use and transparent.	• Difficulty in constructing the tree. • The creation of a tree is not always possible.
Public Opinion Similar to budget allocation, people are asked to express their degree of concern (*e.g.* great or small) about issues, as measured by indicators.	
• Allows all stakeholders to express their preference and creates a consensus for policy action.	• Implies the measurement of "concern" (see discussion on the Budget Allocation). • Could produce inconsistencies when dealing with a high number of indicators (see discussion on the Budget Allocation).
Budget Allocation Experts on a given criteria are asked to allocate a "budget" of 100 points to the indicator set, based on their experience and subjective judgment of the relative importance of the respective indicators. Weights are calculated as average budgets.	
• Weighting is based on expert opinion and not on technical manipulations. •Transparent, relatively straightforward nature and short duration. • Expert opinion can increase the legitimacy of the evaluation.	• Weighting reliability : Weights could reflect specific local conditions (e.g., in environmental problems), so expert weighting may not be transferable from one area to another • Allocating a certain budget over a too large number of indicators may produce inconsistencies (for a number of indicators higher than 10). • Weighting may not measure the importance of each individual indicator but rather the urgency or need for political intervention for the individual indicator concerned.

Analytic Hierarchy Process Pairwise comparisons of indicators are made and then the relative weights of the individual criteria are calculated using an eigenvector.	
• Can be used both for qualitative and quantitative data. • Weighting is based on expert opinion and not on technical manipulations. • Expert opinion is likely to increase the legitimacy of the composite and to create a forum of discussion in which to form a consensus for policy action.	• Requires a high number of pairwise comparisons and thus can be computationally costly. • Results depend on the set of evaluators chosen, therefore not reproducible.
Conjoint Analysis Surveys are conducted asking for an evaluation (a preference) of a set of alternative scenarios. A scenario might be a given set of values for the individual indicators. The preference is then decomposed by relating the single components (the known values of individual indicators of that scenario) to the evaluation.	
• Weights represent trade-offs across indicators. • Takes into account the socio-political context and the values of respondents.	• Time and resource consuming. • Depends on the sample of respondents chosen and on how questions are framed. • Could produce inconsistencies when dealing with a high number of alternatives (see previous discussion on the Budget Allocation). • Requires a large sample of respondents and each respondent may be required to express a large number of preferences. • Estimation process is rather complex

Sensitivity and uncertainty tests

Several subjective choices have to be made during the evaluation process including:

- Choice of indicators,
- Definition of criteria,
- Choice of aggregation process, and
- Choice of weighting model.

We cannot suppress the subjective factor of our evaluation and the message given by the final evaluation results is determined by these choices. The uncertainty test aims to quantify the overall uncertainty in themes rankings as a result of the uncertainties in the model input. The aim of sensitivity analysis is to assess the evaluation impacts associated with the subjective choices taken. Sensitivity analysis studies how the variation in the outcome can be caused, qualitatively or quantitatively, by different sources of variation in the indicators. Sensitivity analysis and uncertainty analysis are thus closely related. Using both uncertainty and sensitivity analysis can help:

- To assess the robustness of the final ranking,
- To increase its transparency,
- To identify which themes or objectives are favored or weakened under certain choices, and
- To help frame a debate around the index.

These tests also help to identify benefits and dis-benefits in the evaluation process: if we change one weight, how does that affect each stakeholder?

Graphic Representation of Evaluation Outcomes

Alternatives are evaluated under several themes, which are themselves divided into several objectives, and these objectives are evaluated through a range of indicators (cf. Figure B.4: Implementation of Step 6c). Therefore, we can disaggregate the evaluation into three levels. The outcomes of our study should be the two main levels:

- Evaluation of alternatives' general performance related to each theme (Figure B.6), and
- Evaluation of performance of alternatives for the objectives within the theme (Figure B.7).

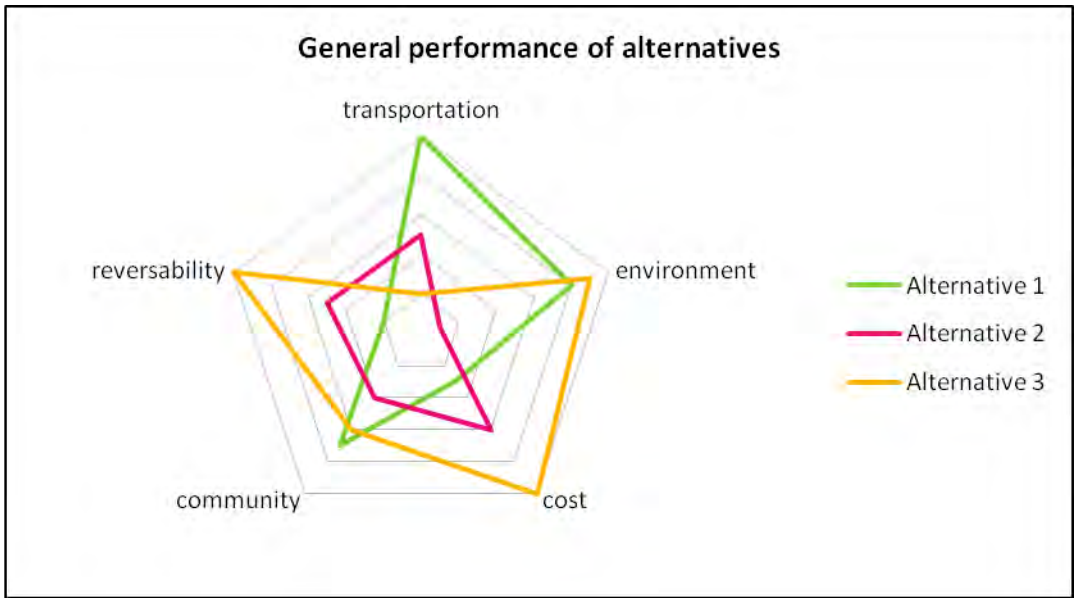


Figure B.6. Example of spider diagram for themes.

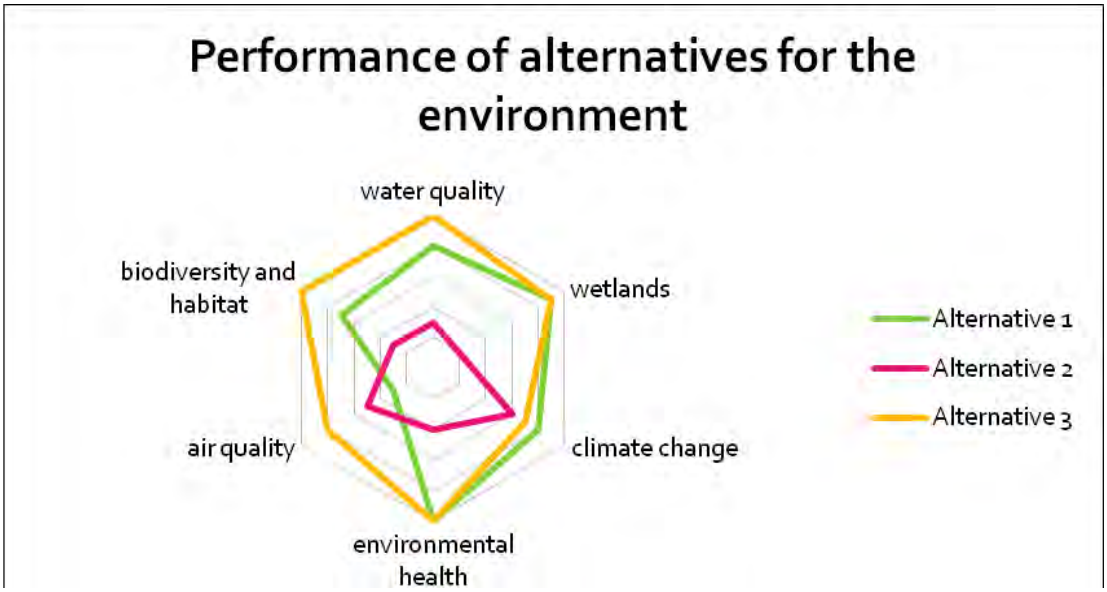


Figure B.7. Example of spider diagram for environmental objectives.

The combination of these two levels will give a good sense of how each alternative is performing and it will also make it easier to discern benefits and dis-benefits. The use of spider diagrams like these is clear and it permits one to see how different alternatives are performing on multiple criteria and clearly distinguish strong and weak points of each alternative.

Comparison of Alternatives

As shown in figures B.6 and B.7, we can compare alternatives with a spider diagram. Within the framework of sustainable development, the most circular alternative will be preferred as it shows equilibrium among criteria. A weak point of spider diagrams is that a change in the order of criteria can affect the perception of the performance. In order to mitigate this weakness, a number of criteria shown on the diagram must remain small (less than eight) and a matrix summarizing the evaluation will be presented in addition to spider diagrams.

At this point of the evaluation process, an identification of benefits and dis-benefits in each alternative could be made by identifying each stakeholder with his/her objectives. However, this might also not be useful in the decision process as some stakeholders will be characterized as beneficiaries which might lead to opposition to them by non-beneficiaries. In the crediting strategy proposed by C06B however, designation of who benefits and does not is useful as this can be a basis to determine credits and then develop negotiation among relative beneficiaries.

References

San Francisco Bay Conservation and Development Commission (BCDC), Draft Staff Report. Living With A Rising Bay: Vulnerability And Adaptation In San Francisco Bay And On the Shoreline, 2009. 175 pages.

Boulanger P.-M., Les indicateurs de développement durable : un défi scientifique, un enjeu démocratique. Les séminaires de l'Iddri,2004, n°12, Paris, avril 2004, p. 24.

Carraro C. , F, Ciampalini, C. Cruciani, S. Giove, E. Lanzi, Aggregation and Projection of Sustainability Indicators: a New Approach, Paper prepared for the OECD 3rd World Forum, 27-30 October 2009, Busan, Korea.

Department for Communities and Local Government: London. Multi-criteria analysis: a manual. 2009. 168 pages.

Forest Trends and Ecosystem Marketplace. Payments for Ecosystem Services: Market Profiles. PROFOR. 2008. 35 pages.

Groot, S. D. Environmental functions as a unifying concept for ecology and economics. Environmentalist, 1987. 7(2):105-109

Joumard R. and Gudmundsson H. (eds), Indicators of environmental sustainability in transport: an interdisciplinary approach to methods, INRETS report, Recherches R282, Bron, France, 2010. 422 p

Joumard R., Mancebo Quintana, S., Arapis, G., Zacharz, T., Chains of causalities of environmental impacts. Seminar COST 356 EST ‘‘Towards the definition of a measurable environmentally sustainable transport’’, 20 February 2008, Oslo, Norway. Proceedings, Institute of Transport Economics/TOI ed., Oslo, 2008, pp.9–21 (http://cost356.inrets.fr).

Joumard, Nicolas. Transport project assessment methodology within the framework of sustainable development. Ecological indicators, 2010, Volume 10, pages 136–142

Kerry Turner, Jeroen C. J. M. van den Bergh, et al., Ecological-economic analysis of wetlands: scientific integration for management and policy, Ecological Economics, 2000, Volume 35, Issue 1, October 2000, Pages 7-23

Lee, J.F.J., M. Springborn, S.L. Handy, J.F. Quinn and F.M. Shilling. Approach for economic valuation of environmental conditions ad impacts. Prepared for Caltrans. 2010. 124 pages

Mogridge, M. J. H., The self-defeating nature of road capacity policy. 1997. Transport Policy, Vol. 4, No. I, pp. 5-23

Nardo M., Saisana M., Saltelli A., Tarantola S., Hoffman A. and Giovannini E., Handbook on constructing composite indicators: methodology and users guide, 2005, OECD-JRC joint publication, OECD Statistics Working Paper, STD/DOC(2005)3, JT00188147, 108 p.

Navrud, S., and G. J. Pruckner. Environmental Valuation - to Use or Not to Use? A Comparative Study of the United States and Europe. Environmental and Resource Economics, 1997, 10:1-26.

NRC (National Research Council). Valuing Ecosystem Service. Washington, D.C.: The National Academies Press. 2005.

Redford, K. H. and W. M. Adams., Payment for ecosystem services and the challenge of saving nature. Conservation Biology, 2009. 23(4):785-787.

Singh, R. K., Murty, H. R., Gupta, S. K., & Dikshit, A. K. An overview of sustainability assessment methodologies. Ecological Indicators,2009, volume 9, pages 189-212.

Transportation Research Board, PROJECT C06(B): Development of an Ecological Assessment Process and Credits System for Enhancements to Highway Capacity, 2010, 88 pages

Transportation Research Board, Integration of Conservation, PROJECT C06(A): Highway Planning, and Environmental Permitting Using an Outcome-Based Ecosystem Approach, 2011, 189 pages

Woodward, Yong-Suhk Wui, The economic value of wetland services: a meta-analysis, Ecological Economics, 2001. Volume 37, Issue 2, May 2001, Pages 257-270