INTERDISCIPLINARY TEAM APPROACH TO MITIGATING ADVERSE ENVIRONMENTAL IMPACTS OF HIGHWAY CONSTRUCTION

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To assess the effectiveness of the interdisciplinary team approach in highway planning and project development in California, the author, by using the case study method, examines the interrelationships and interworkings of engineering and nonengineering skills in addressing problems associated with the impact of highway construction on the sensitive natural environment within the jurisdiction of the Coastal Zone Conservation Commission. As a result of this analysis, the author concludes that agency organizations should provide for an in-house core of expertise and use outside consultants only when highly specialized expertise is needed. Also, the organization must be flexible so that the concept can be applied easily at all stages of the highway planning and project development process. Of importance to the successful operation of the interdisciplinary team approach is the attitude of top management. It must be responsive to issues raised by all disciplines and must consider the contributions of all disciplines equally and fairly. Through the implementation of the California Action Plan, California has committed itself to the effective application of the interdisciplinary team approach.

•PEOPLE, in their efforts to build a better society, have had an enormous impact on the environment. Until a few years ago, their activities rarely were challenged. Today, however, we are witnessing a rise in the surge of public concern over all governmental and private activities, particularly those that can disrupt and degrade the environment. Highway development seems to receive the brunt of this criticism. Highways are the most often seen and used public works, and, thus, are a handy target.

The difficulties being encountered by transportation departments probably will continue. Who is at fault is not important. Transportation departments must consider the problems and try to solve them. Their planning efforts must reflect the present public mood. The public's environmental concerns must be addressed early in the planning process. In meeting this challenge, transportation departments must use a full complement of disciplines to ensure that not only engineering aspects are considered but also that social, economic, and other environmental concerns are addressed properly. The consensus within the transportation community seems to be that the interdisciplinary team concept is the approach that will best satisfy public concerns. How California applies the concept is the theme of this paper.

Public pressure and criticism have brought about federal and state legislation that directs transportation programs. Legislation and regulation have provided the impetus for proper consideration of all environmental factors in the planning process and in day-to-day activities. The National Environmental Policy Act of 1969 (NEPA) provided a statement of environmental policy, a statutory foundation to which administrators could refer for guidance in making decisions when environmental values conflict with other values. And the legislation went further than stating policy. It provided an action-forcing procedure in Section 102(A), which states that all agencies of the federal government shall

> Utilize a systematic interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and decision-making which may have an impact on man's environment.

California enacted the California Environmental Quality Act in 1970, which directed the state to "Develop and maintain a high-quality environment, now and in the future, and take all action necessary to protect, rehabilitate, and enhance the environmental quality of the state." This statement, "take all action necessary," implies that California should use the systematic interdisciplinary approach to conform to federal legislation.

Introducing the systematic interdisciplinary team concept into transportation planning and design has provided impetus for a broad approach to environmental concerns. It ensures that full consideration will be given to all environmental factors encountered in highway planning.

The desirability of a systematic interdisciplinary team approach generally is accepted, but the means of obtaining such an approach are not widely agreed on. The problems in achieving an effective systematic interdisciplinary approach are numerous and difficult. Using a specific case study, I would like to discuss how the California Department of Transportation approaches this problem.

Recognizing the importance of the interdisciplinary team, the Federal Highway Administration in March 1973, convened a panel of experts to discuss the subject. They determined that this approach is

> A process through which pertinent expertise is utilized in an integrated manner in the planning of projects. This insures that inputs on, or aspects of the environment are adequately considered, assessed, and incorporated, and that responsible evaluations and decisions are made.

This pertains to planning of projects. Other cases involve projects for which routes already have been determined (pipeline projects) and are well beyond the planning stage. This paper will discuss an example of this.

ORGANIZATION

Before NEPA was enacted, California recognized that environmental problems would become a dominant aspect of highway planning and development. At the same time, the importance of the systematic interdisciplinary team approach to addressing these concerns was realized. As early as August 1969, Community and Environmental Factors Units were established within the Division of Highways. The units are interdisciplinary; that is, they provide a core of disciplines that can address all aspects of the environment. The general disciplines include law, psychology, business administration, environmental planning, and urban transportation planning. The special disciplines include ecology, archaeology, sociology, economics, engineering, and geology. The units also are flexible so that talents can be applied not only in the early planning states but also on a project-by-project basis. This flexibility is necessary because much of the department's work has already passed the planning stage. The organization of disciplines is shown in Figure 1.

The case study to be discussed in this paper arose as a result of a highway project that was to go through an environmentally sensitive coastal zone. The department consulted with the Coastal Zone Conservation Commission. (This commission came into being after route location on this project had been determined and construction was to begin. This accounts for the fact that alternate route selection and the no-build alternate were not factors in the team's deliberations.) The department determined that it would prepare a special report before construction that would include a study

of the impact of the project on the sand dunes, wildlife, and vegetation. In addition, the department agreed to look at possible route and design changes (within existing rights-of-way), construction techniques, and other forms of mitigation that would reduce the impact of the project on the marshes and vernal pools and associated wildlife.

The study area, shown in Figure 2, lies within 1,000 yd (900 m) of the Pacific Ocean between the north boundary of Fort Ord and 0.5 mile (0.8 km) north of Cardoza Avenue near Marina, California, in Monterey County. The project has progressed well into the planning and design process. The environmental concerns basically involved 3 distinct problems, each of which required unique and specific expertise for its solution.

STUDY PROCESS

The unique environmental problems required that the department provide, in addition to engineering, environmental design arts, and planning expertise, the expert knowledge of a biologist, geologist, soil stabilization expert, ecologist, sedimentologist, and soil conservationist. The team was made up of a design engineer, a coastal sedimentologist, a wildlife biologist, a landscape architect, an ecologist, an engineering geologist, and a project engineer. Of the 7 members all but 2 were in-house personnel. The team met first to determine the environmental problems posed by the highway project and the best study approach to arrive at feasible solutions. Field investigations allowed the members to discuss their ideas and to further define the problems. Together they developed a formal approach to the conduct of the studies, a study outline, and sequential deadlines necessary to meet schedules so that the team leader could determine whether objectives were being met and keep the study on schedule.

When the study outline was developed and deadlines were established, the team members addressed problems in their own areas of expertise and consulted with each other to ensure that their individual inputs would result in an integrated final study.

PROBLEM AREAS AND MITIGATION

As the team progressed through its study process, it was able to identify specific environmental problems and alternate measures necessary to mitigate these problems. The development of the mitigation measures made obvious the nature of the interdisciplinary team approach. In this phase, all those involved worked closely together, exchanged information, and educated each other to arrive at measures that were acceptable and feasible for each discipline and the effort as a whole. For example, the sedimentologist suggested a process of highway grade changes for dune stabilization. In his discussions with the geologist and the engineer, he found that his measures were not feasible and that other solutions might be possible.

Sand Dunes

Problem

The southerly portion of the highway right-of-way cuts through large coastal dunes partially covered with coastal sage scrub vegetation. The scrub vegetation had succeeded in stabilizing the dunes to a considerable degree until the 1950s when off-road vehicles (ORVs) began cutting the numerous trails that characterize the surface today (Figure 3). As these trails were cut, the winds began moving the exposed sand, which caused the numerous denuded channels and drifts that characterize the present surface. The demise of the horseshoe-shaped (parabolic) dunes affected by the project is well advanced at present (Figure 4).

The dunes provide open space for outdoor recreation (destructive and nondestructive)

Figure 1. Environmental branch organization.

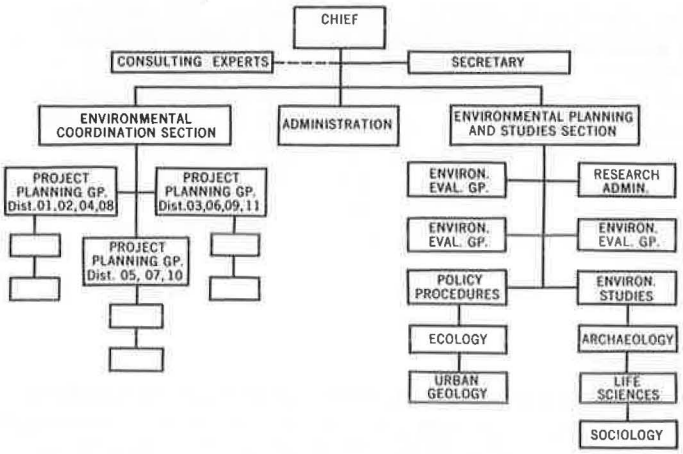
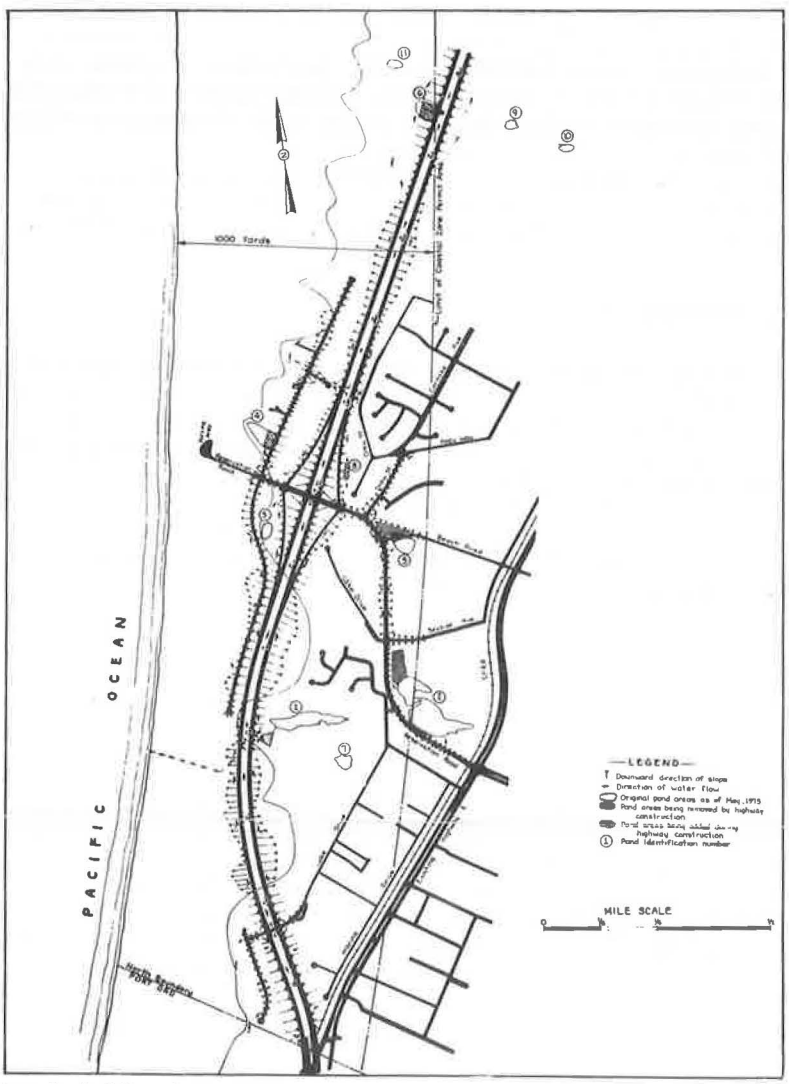


Figure 2. Study area.



Note: 1 yd = 0.9 m. 1 mile = 1.6 km.

Figure 3. Off-road vehicle impact on sand dunes.

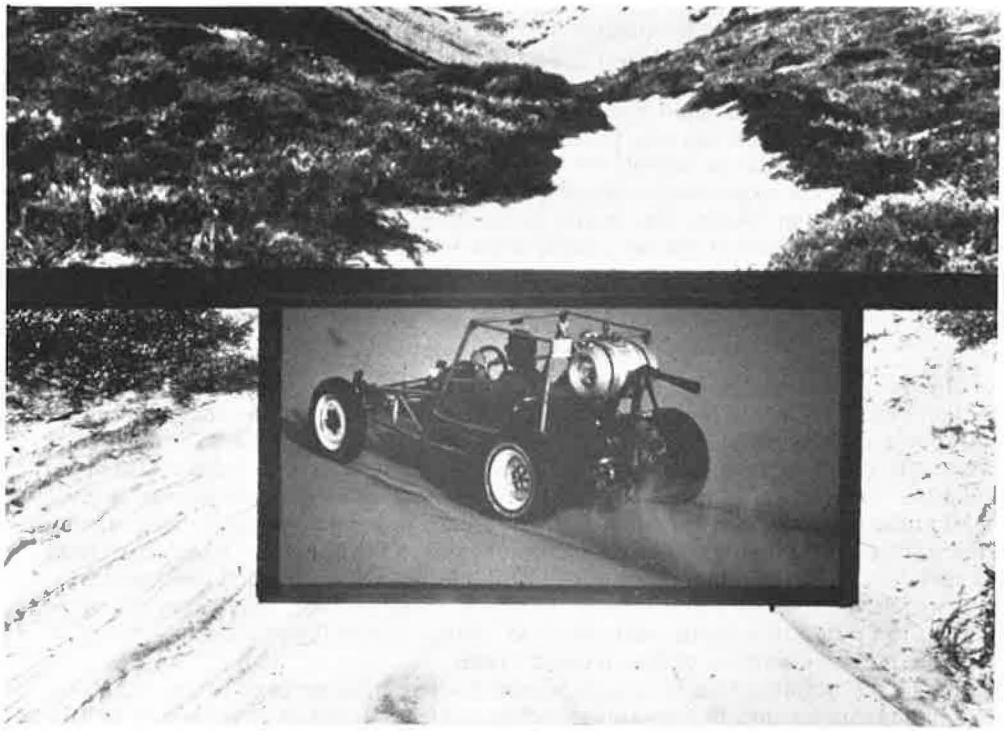


Figure 4. Demise of sand dunes.

and wildlife habitat for numerous wildlife species. The plants providing habitat for these animals vary considerably (Figure 5). Some of the most prominent are salt bush, coyote bush, bush lupin, and sand verbena. Most of them are native to the area; there is a scattering of introduced species. Ice plant is present in widely scattered patches, and the various species are prominent in the present coastal ecosystem. Because of the existing disturbed conditions in the dunes, the team determined that the highway project was not expected to result in a significant loss of vegetation and wildlife habitat. Only a short-term loss would be involved, and then revegetation would take hold. The highway would not be a significant barrier to wildlife.

Mitigation

After full investigation and group meetings, the team determined that the most critical problem associated with this highway project was the stabilization of dune sand on cut and fill slopes and throughout the right-of-way. Associated with this was the need for an aesthetically pleasing landscape that would enhance the environment for travelers and residents. To solve this problem, the team devised an innovative plan to minimize impact and enhance environmental quality. This plan involved spreading a layer of soil-stabilizing compound on disturbed slopes and covering it with special fiber, fertilizer, and seed mix in various combinations. The soil-stabilizing compound used was hydromulch, which consists of 2 emulsions: One is a vinyl acetate, vinyl acrylic, or acrylic base; the other is a lignin sulfonic acid base. These techniques are being used on a considerable portion of the project area.

As a temporary stabilization measure before the establishment of native plants, the department transplanted European beach grass and erected drift fences in critical areas where the wind force is concentrated. These are limited to areas where wind conditions are severe enough to warrant tree planting and will give trees protection. The grass will be replaced through natural plant succession. Drift fences will be removed when stabilized conditions indicate that they are no longer needed. These are the only areas where fertilizer will be used. The fertilizer will be the slow-release type to ensure against excessive nutrient addition to aquatic ecosystems.

The reestablishment of native plants (Figure 6) in the shortest possible time is the key to achieving a stable and attractive environment in the right-of-way. Reliance on native species not only will improve the possibilities for successful erosion control but also will provide wildlife habitat suited to the needs of the native fauna. Trees, in particular, are an important mitigating factor because the coastal strip, at present, contains few trees, and the scattered small groves planted in the right-of-way will serve as nesting and roosting sites for birds and will provide a source of additional feed for birds and other animals. In addition, the team suggested increased planting of trees and shrubs during the highway planting project after road construction to further improve stabilization, aesthetics, and wildlife habitat.

Mitigation measures have improved the aesthetics of the dune area (Figure 7). Where the highway cuts through the dunes, it will be hidden considerably from the inhabited area on the east and totally from the beach area. Although this largely destroys the classical form of 3 of these dunes, it is not a great environmental loss because the dunes over which the freeway will pass are not a rare physiographical feature and they already had been substantially altered. The right-of-way will be changed from a modified and unstable dune landscape to a freeway form containing rounded cuts and fills covered with vegetation. The freeway will be a double-paved surface visible to few people other than highway travelers. The landscape after the highway is built will be more stable than it is at present if ORV activity is eliminated and continuous maintenance of facilities, soils, and vegetation is accomplished.

Figure 5. Plant habitat of sand dunes.

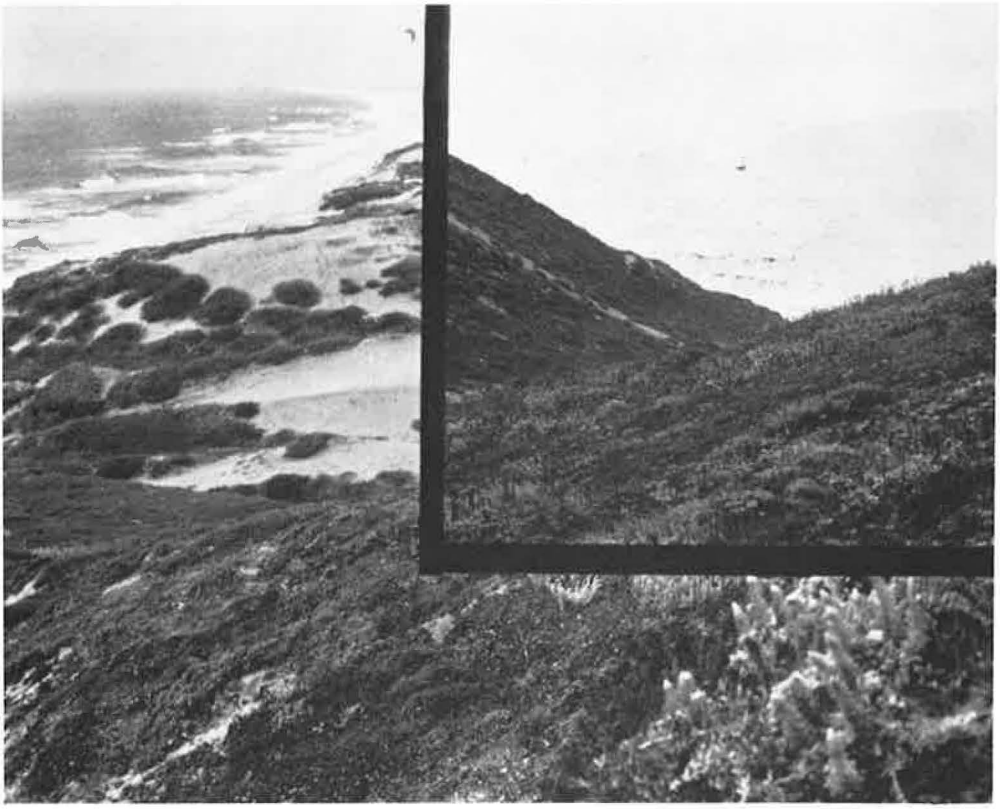


Figure 6. Native plants of sand dunes.

Figure 7. Improved aesthetics of sand dunes.

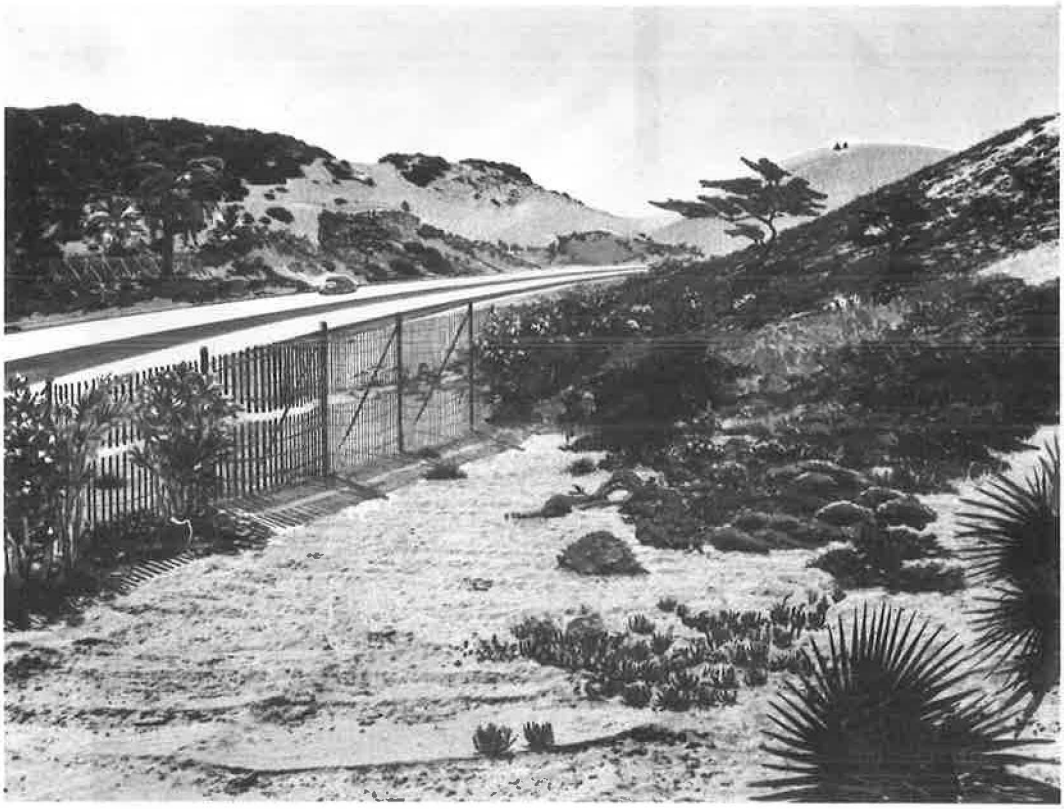


Figure 8. Vernal pool in study area.

Vernal Ponds and Marshes

Problem

The involved vernal, or seasonal, ponds and drainage ponds, which are similar but fresher, have been damaged to some degree by human misuse (Figure 8). Natural processes are very slowly filling in these low spots. However, ORVs, horseback riding, sand extraction, and subdivision activity have been accelerating this process. Some wildlife continue to use the ponds to varying degrees primarily on a seasonal basis.

The marsh vegetation consists of concentric rings determined by water preference and salt tolerance where disturbance is minimal. The form and surface area of the 6 ponds affected by the project will be altered to a certain degree. The vegetation pattern should reestablish itself through natural processes. Vertebrate and invertebrate wildlife will continue to make use of these habitats. Whether they will do so in greater or lesser numbers cannot be determined with certainty.

Vibration of freeway traffic will cause some compaction of sand under the highway. Compaction could cause a minor reduction in subterranean drainage flow, which could cause a slightly higher water table on the east side when there is a great deal of precipitation.

Mitigation

These ponds will be altered considerably through surface area change caused by the highway project. To mitigate this impact, we planned the modifications in such a way that no net loss of surface water area would result from the project (Table 1). Within the highway right-of-way, the small areas of marsh vegetation on the periphery of these pools will be maintained in the natural form developed through the readjustment process. Outside the right-of-way, local land use controls will be needed to ensure preservation of the remaining natural qualities associated with this vegetation. No measurable loss of wildlife habitat is anticipated. The ponds may still be used by schools, nature groups, and others for nature study. The highway project, after completion, will be especially suited to those who wish to learn about the effects of human activities on natural plant and animal communities. Interested parties can compare these disturbed environments with protected natural areas with similar ecosystems to learn more about the impact of the highway and to test mitigation hypotheses. The California Department of Transportation will follow up on these studies.

Table 1. Modification of vernal pools.

Pond Number	Total Area[a] (acres)	Area Taken (acres)	Area Replaced (acres)
1	2.8	0.1	–
2	5.0	0.2	1.1
3	1.1	0.3	0.8
4	1.4	0.6	–
5	0.5	–	–
6	1.0	0.8	–
7	0.7	–	–
8	0.0	–	0.2
9	0.4	–	–
10	0.4	–	–
11	0.4	–	–
Total	13.7	2.0	2.1

Note: 1 acre = 0.4 hm²

[a]Area based on water level as of May 7, 1973.

Private Development and Recreation in Coastal Zone

Problem

Local land use plans for this area include a mix of urban uses including residential and industrial uses on both sides of the proposed freeway. Proposals on open-space zoning in the dune and beach area community park development indicate that retaining open space between freeway and ocean is possible. The recent enactment of the Coastal Zone Conservation Act of 1972 and the completion of the Tri-County Coastline Study of 1972 further emphasize this possibility. Land use will depend on local, state, and federal regulations.

Improved access in the dune land area on the

newly constructed roadways will allow increased land development. Other socioeconomic factors will affect this, however. Intensive development of the steeply sloped dunes can be attained only through grading and will result in destruction of natural land forms and biota. Such development may increase the amount of blowing sand, which might result in serious problems for highway maintenance and for other developments. And if the dune area is not developed, ORVs will accelerate erosion of the dunes.

Mitigation

State highways can increase the opportunity for land use control by local agencies. In this case, the freeway could be used as a divider between open coastal space and urbanization on the landward side. It would limit access to the dunes and beach area between Fort Ord and Beach Road to the 2 frontage roads constructed as part of the project. This gives landowners and public officials an opportunity to halt present destructive land uses. As final land use determinations are being made for this area, frontage road use can be carefully controlled by fences and gates.

CONSIDERATION OF ALTERNATIVES

The systematic interdisciplinary team approach must consider all workable alternatives to ensure that all environmental factors are fully considered. In this case study, the team considered the possibility of mitigating adverse impact through location and configuration changes in the right-of-way. The consensus was that significant mitigation could not be achieved because such action would create additional problems involving availability of additional land, legal constraints, costs, and design changes. The team recommended rounding or contouring of slopes in several areas to reduce highway impact on ponds, vegetation, and the natural form of the dune topography. Consideration was given to various grade changes, and a comparative analysis was made between the adopted grade and an alternative that would average 20 ft (61.1 m) higher through the dunes. The team determined that it would provide some benefits in reduced wind erosion and capture of incoming sand. However, it had several disadvantages. Because roadway and slope alterations would be more conspicuous, they would require an additional 1 million yd (0.9 million m) of borrow material, which would have additional environmental impact at the borrow site.

CONCLUSIONS

The team effort produced the results for which it was designed—the development of mitigation measures acceptable to all concerned. In addition, some valuable lessons were learned that will provide guidance in achieving better results in the future.

Team Management and Leadership

This case study showed that the selection of a team manager is important to the efficient and successful operation of the team. The team leader should be a generalist who has the ability to recognize what the problems will be, pull together the expertise needed to address these problems, understand the people on the team, and manage their efforts effectively.

Team Use

It is generally agreed that the systematic interdisciplinary approach must be used at all stages of the highway planning process. However, in California, much present and

future work will be pipeline projects. New projects will be limited. Therefore, although it is most important that the interdisciplinary team approach be used early in the planning process, there must be enough flexibility in the system to allow the team approach to be applied at any stage in the planning process. The case study was a good example of the application of the team approach to a specific problem that arose late in the planning process.

Organization

It was apparent from the case study that organizations within highway departments that address environmental concerns must be flexible. Most departments cannot afford the luxury of the full staff necessary to address all the environmental problems that might arise. The California Department of Transportation uses a core of interdisciplinary experts that are retained in-house and bring in outside expertise to address specific problems as required. This approach appears to be effective. The level of effort must be determined on a project-by-project basis. And this will, to a large extent, determine the size and the makeup of the team.

Top Management Attitudes

The action plan being developed by the various states requires that top management be responsive to the issues and contributions of all disciplines. Top management must ensure that people are employed who can recognize what disciplines are required for full-time staff and what disciplines are required only for particular projects or only for various planning stages of projects. Top highway management also must be committed to the interdisciplinary team approach and must develop team leadership to ensure that this commitment prevails throughout the organization.

Consultant Activity

From the results of this case study, one can conclude that outside expertise plays an important role in the structuring and the operation of the interdisciplinary team approach. It is important that, when consultants are used, in-house expertise be used to oversee, coordinate, and evaluate their activities.