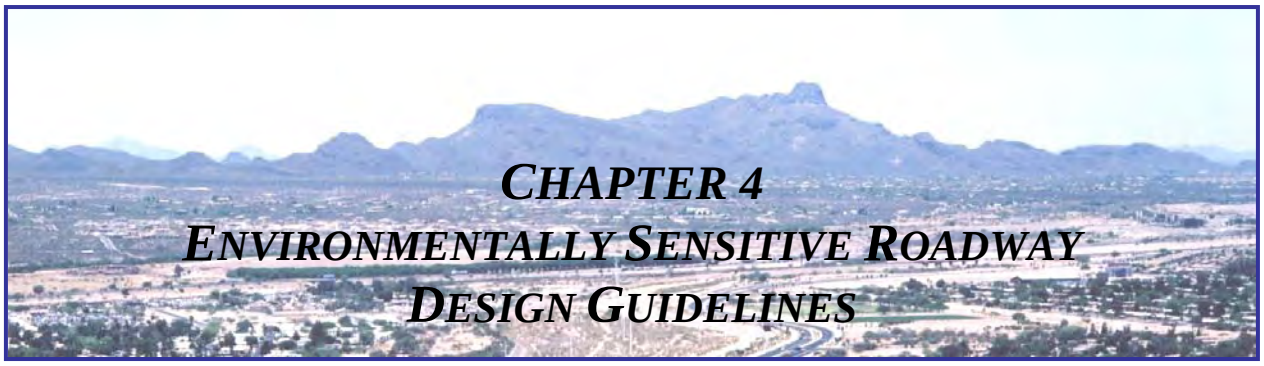


CHAPTER 4
ENVIRONMENTALLY SENSITIVE ROADWAY DESIGN GUIDELINES

4.1 INTRODUCTION

The Environmentally Sensitive Roadway Design Panel (the Panel) developed general recommendations for roadway improvement projects within environmentally sensitive areas in July 2001. The Panel was formed in response to community concerns about potential conflict between preserving environmentally sensitive areas, transportation design and construction practices, and the ongoing need for infrastructure improvements. The Panel's initial goal was to develop special design guidelines that would bridge the gap between community concerns and the County's design of new or improved roadways in environmentally sensitive areas.

The Panel re-convened in 2002 to expand upon its initial recommendations. The 2002 Panel consisted of experts from multiple disciplines. Members included roadway engineers, wildlife biologists, cultural resources experts, and a landscape architect. The resulting guidelines, presented in this chapter, provide roadway design specifications that will minimize impacts to our region's resources. The approach defined in this chapter is intended to provide roadway design teams with environmental information early in the design effort. This information should allow design teams to adjust specific design elements to better account for biological, cultural, and historic resources in the roadway corridor. Additionally, the chapter provides some mitigation tools necessary to conduct transportation projects in environmentally sensitive lands. For example, greater flexibility in the range of acceptable design values for specific roadway features is identified for ESR design. This document is not, however, an exhaustive resource of mitigation ideas. Further information on how to treat or mitigate potential effects of roadway projects can be obtained from pertinent websites that are cited in this chapter and listed in Appendix 4-A.

4.2 ENVIRONMENTALLY SENSITIVE LANDS AND ROADWAY DESIGNATION

Environmentally Sensitive Lands (ESL) are those areas that are unique and ecologically or culturally sensitive. The public has made known its interest in and the importance of these areas. In Pima County, ESL are determined by certain Sonoran Desert Conservation Plan (SDCP) Conservation Lands System categories and/or the designation of a Scenic and/or Historic Route. ESL may exhibit several characteristics, such as the presence of habitat for special status species (e.g., endangered species), vegetation communities that are growing in scarcity (e.g., cottonwood-willow riparian plant community), cultural resources (e.g., historic buildings), and designated scenic routes. A transportation project within ESL is defined as an ESR and should be designed and constructed to minimize disturbances to the area resources. Specifically, an ESR is a roadway that meets any of the following criteria:

- Location within or crossing any of the areas on the SDCP Conservation Lands System Map, which are identified as:
  - Biological Core
  - Multi-Use or Recovery Area
  - Important Riparian Area
  - Agriculture within Recovery Area
  - Existing Development
  - Scientific Research Area
- Location within or crossing a High or Moderate Archaeological Sensitivity Zone or a Priority Cultural Resource
- Identified as a Historic Roadway or Route
- Identified as a Scenic Route

The information referenced in criteria A and B above, with the exception of Priority Cultural Resources, is found on the Pima County Website (see Appendix 4-B). Scenic Routes are identified on the *Pima County Major Streets and Scenic Routes Plan* (see Appendix 4-A).

Examples of the website maps used to determine ESR criteria are presented in Appendix 4-C. From the SDCP Conservation Lands System Map, the example project area, shown in red, clearly involves three ESR criteria: (1) High Archaeological Sensitivity Zone, (2) Multiple Use or Recovery Area, and (3) Important Riparian Area. The *Pima County Major Streets and Scenic Routes Plan* indicates that the project area also meets the ESR criteria of being a designated Major Scenic Route. The Historic Roadways or Routes data layers will be developed in the future and posted on the web. Map data on Priority Cultural Resources is restricted. The Pima County Cultural Resources Office should be contacted to determine if a roadway project meets the ESR criteria of being located within or crossing a Priority Cultural Resource or is a known historic roadway or route. To access site-specific information on the Pima County website, "zoom in" to a scale of 1:128,000.

4.3 ENVIRONMENTAL RESOURCE ASSESSMENT AND MITIGATION PROCESS

Once it is determined that a project will contain roadways that meet the ESR criteria, there are a number of steps that the responsible party must take. These steps are related to the following three design elements, which are discussed in Sections 4.4, 4.5, and 4.6 respectively.

- Biological Resource Preservation and/or Enhancement
- Cultural or Historic Resource Preservation and/or Enhancement
- Visual and Aesthetic Resource Preservation and/or Enhancement

A process has been developed for each of these resource design elements. The process begins with the discovery/identification of the individual resources within each element, which produces initial inventories for each resource element. The next stage of the process is an inventory analysis in which the Design Team assesses the potential impacts of the project on each of the resources and then identifies potential treatment options. Design elements used to create these treatment options may include:

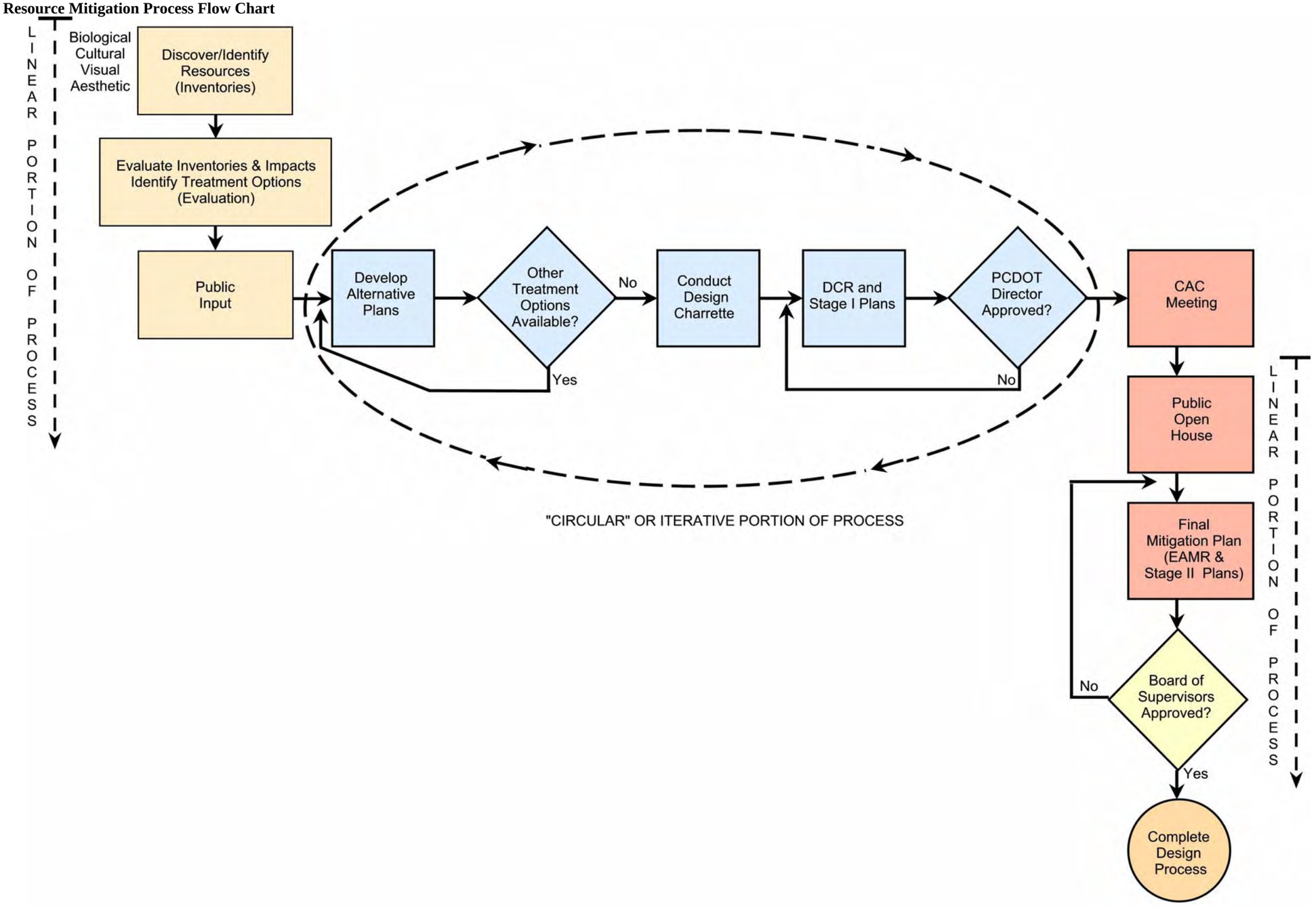
- Art
- Lighting
- Bicycle facility
- Noise wall or other abatement
- Bridge structural elements
- Pavement type/surface
- Construction phasing/sequencing
- Signage
- Cultural inventory/treatment
- Utility locations
- Drainage and culvert design
- Viewsheds
- Equestrian facilities
- Vegetation preservation/management
- Landscape Improvements
- Wildlife crossings

Sufficient information has now been gathered to allow the Design Team to solicit public input and initial reaction to the inventories and to the array of possible treatments/mitigation measures. The public input may take several forms, including CAC meetings, public open houses, or other outreach techniques as deemed appropriate.

Up to this point in the process, the Design Team has been operating in a linear mode, with resource studies being conducted separately from each other. The process now enters the stage in which the individual assessments are combined and various holistic solutions coalesce. This is a dynamic stage, with feedback loops that promote an "iterative" or "circular" process. The stage begins with the Design Team performing a functional analysis based on the treatments/mitigation measures that were previously examined by the public. Next, in a design charrette (i.e., an intensive workshop), the Design Team analyzes the opportunities and constraints of the project. The objective is to discuss major design issues that impact the environment and to formalize design solutions. The outcome of the charrette is a conceptual design that incorporates the most effective resource preservation and enhancement treatments. This conceptual design is then incorporated into the Design Concept Report (DCR), which documents the planning process (see Chapter 3, Section 3.17). The DCR is submitted to Pima County for review and comment.

With the completion of the DCR, the design concept is presented to the public for review and comment. Again, the public involvement may take several forms, including CAC meetings, public open houses, or other public outreach techniques as appropriate. The public involvement is a precursor to finalization of the mitigation portion of the EAMR (see Chapter 3, Section 3.18) and the approval of the Pima County Board of Supervisors. Board approval triggers the completion of the construction documents through the standard roadway development procedures of Pima County's *Community Participation and Mitigation Ordinance* (see Chapter 1, Appendix 1-A). Figure 4-1 summarizes the Environmental Resource Mitigation Process.

Figure 4-1
Environmental Resource Mitigation Process Flow Chart



4.4 BIOLOGICAL RESOURCE PROCESS

This section describes steps to identify biological resources and evaluate the impacts of proposed roadway projects. In addition to determining the presence/absence of special status species and their habitat, this process also measures vegetation so that appropriate re-vegetation of the site can be undertaken. For ESR projects, vegetation measurement shall be conducted by a qualified biologist/botanist or registered landscape architect and will consist of following two procedures: (1) Tree Caliper Measurement and (2) the Releve Method. Appendix 4-D provides a detailed description of vegetation measurement, while Appendix 4-E and Appendix 4-F provide information regarding appropriate plant species and landscaping guidelines, respectively. Since ESRs are located in ESL, it is imperative that the post-project environment duplicate the pre-project environment to the greatest extent possible.

In addition, all projects must address and comply with all Pima County environmental ordinances (e.g., Riparian, Buffer Overlay), with the exception of the Pima County Native Plant Preservation Ordinance (NPPO). **The NPPO protects only certain species, and does not serve to recreate complete plant assemblages; therefore, the Pima County NPPO does not apply to ESR projects.**

Steps in the Process

Following are the key steps in the Biological Resource Process. Key terms are defined at the end of this section.

Step 1: Discover/Identify Existing Resources

Step 1 consists of researching background information and conducting site visits and surveys as appropriate.

Background Information[1]

- Contact the USFWS through its website (see Appendix 4-B) and the AGFD by letter/future website to request information on special status species in the project area.
- Determine whether the project area lies within or in close proximity to any SDCP Conservation Land System designations for the project area, including Critical Landscape Linkages. For this purpose, the project area is defined as 1/4 mile from the project right-of-way.
- Determine distance of project to or inclusion within SDCP Priority Conservation Areas and or Modeled Potential Habitat for any of the SDCP Priority Vulnerable Species.
- Determine if the project area is within (or contains portions of) riparian areas inventoried as part of the SDCP Riparian Study (termed Harris Riparian on MapGuide).

[1] The Pima County MapGuide web page (see Appendix 4-A) can be used to access the information needed for Step 1: B, C, D, and E. To access detailed information such as the Conservation Land System, "zoom in" to a scale of 1:128,000.

- Determine if the project area is within a designated Preserve Area.
- Determine if the project area is within (or contains portions of) riparian areas classified as Title 16 Floodplain and Erosion Hazard Management Watercourses as determined by Pima County Code (see Appendix 4-B for relevant website).

Conduct Site Visit and Various Surveys

- Conduct site visit to determine if habitat for any special status species exists.
- Conduct species-specific surveys for federally protected Threatened and Endangered Species as warranted based on habitat outcome.
- Inventory plants using the two methodologies outlined in Appendix 4-D to measure the vegetation. Do not use the Pima County NPPO measurement techniques. In some instances, the project area (or portions thereof) may have been previously graded or disturbed. If this is the case, vegetation in an adjacent undisturbed area will serve as a representative. To measure adjacent vegetation use the sampling method described in Appendix 4-D.
- Document presence of any special elements (e.g., springs, caves).
- Coordinate with Pima County staff to determine if there are any concerns including those of non-special status species. Coordination may include meetings with USFWS and AGFD.
- Determine location for specific biological linkages, if any.

Step 2: Evaluate Effects

- Evaluate effects (impacts) to SDCP Riparian areas, if any.
- Evaluate effects (impacts) to habitat of any special status species (from USFWS and AGFD responses).
- Evaluate effects (impacts) to special status species (from USFWS response and AGFD response) known to be present on the project site.
- Conduct any additional surveys and site visits as needed or directed.
- Determine if the project meets the development density for the specific SDCP Conservation Land System Classification designation.
- Evaluate effects (impacts) to non-special status species and biological linkages based on outcome of meeting with Pima County staff.

Step 3: Identify Potential Conservation Measures/Treatment Options
(with assistance from USFWS and AGFD)

- Determine if SDCP Riparian areas, Title 16 Watercourses, and special status species habitat can be avoided to minimize effects to special status species.
- Determine appropriate mitigation measures (e.g., conservation easements, re-vegetation, road crossing design, off-site compensation) for project area based on special status species presence. Additional site visits may be needed.

- Submit assessment to appropriate agencies for concurrence.
- Monitor project to assure mitigation measures have been accomplished.

Key Definitions

Special Status Species: Defined as federally protected threatened and endangered species, Sonoran Desert Priority Vulnerable Species, plant species protected by the Arizona Native Plant Law, Bureau of Land Management/U.S. Forest Service Sensitive Species, and species identified by AGFD as Wildlife Species of Special Concern.

Priority Conservation Area: An area that supports essential (core) habitat for Priority Vulnerable Species (see below) based on expert knowledge. There are four levels of conservation areas. Definitions of each level can be found in the Biological Information on MapGuide, For Use By Public Works Staff, July 2002.

Modeled Potential Habitat: The County mapped environmental characteristics (e.g., riparian areas, elevation, soil composition) and known species locations using GIS. These maps were compared to known habitat requirements for each of the Pima County vulnerable species to determine the potential distribution of that habitat across Pima County. On the website, a High-Medium-Low color scale is used to depict the distribution of potential habitat.

Priority Vulnerable Species: These consist of 55 species of concern within Pima County that are proposed for protection under the Conservation Lands System.

4.5 CULTURAL RESOURCES PROCESS

The effect of construction on cultural resources must be considered as a part of roadway planning and design. Cultural resources are those places and things that have been created by the people who have lived, over many centuries, in what is today Pima County. These resources include: archaeological resources, historic resources, historic roads, and traditional cultural places. Cultural resources collectively represent Pima County's prehistory and history over many thousands of years, providing tangible links to our heritage. These resources are fragile, finite, irreplaceable, and non-renewable, and have scientific, educational, recreational, aesthetic, and spiritual values.

Pima County has determined that protecting cultural resources is in the public interest. Consequently, these resources must be considered during project planning and design. To facilitate planning and design, this section defines cultural resources, explains how their value is determined, describes the cultural resource review process, and examines treatment options that can be used to mitigate effects should cultural resources be impacted by a proposed Pima County roadway project.

Key Terms

Here, the term *cultural resource* is used to refer broadly to four kinds of phenomena: (1) archaeological resources, (2) historic resources, (3) historic roads, and (4) traditional cultural places. Following established Pima County protocol (Pima County, August 2000), cultural resources are defined below.

Figure 4-2: *A 2500-year old house floor found on the flood plain of the Santa Cruz River is an archaeological resource.*

Archaeological resources are any material remains of past human life or activities that are preserved in their original setting and are important to understanding prehistory or history. These sites or districts may include occupation sites; work areas; farming sites; burials/other funerary remains; artifacts; campsites; hearths; rock art; intaglios; trails; battle sites; religious or ceremonial sites, caves and rock shelters; architectural/other remains of structures of all kinds, including pit houses, pueblo rooms, adobe or rock foundations; and other domestic features, usually dating from prehistoric or aboriginal periods, or from historic periods at least 50 years old, for which only archaeological vestiges remain. This definition has been broadly applied to include prehistoric and historic sites of all time periods, functions, and spatial distributions, extending from the earliest human occupation some 12,000 years ago to the 20th century.

Historic resources are sites, districts, structures, objects, or other evidences of human activities that represent facets of the history of the nation, state, or locality. Also included are places where significant historical or unusual events occurred even if no evidence of the event remains, and places associated with persons significant in our history that have gained importance in the last 50 years.

Historic resources include a wide variety of sites, buildings, structures, and objects, including residences, commercial establishments, engineered features such as roads and bridges, schools, churches, military forts, cemeteries, parks, streetscapes, and properties that are listed on the National Register of Historic Places either individually or as groups of properties defined as districts.

Figure 4-3: *A 19th century Queen Anne revival style house in Tucson is a historic resource.*

Historic roads, while technically a subset of historic resources, are of particular relevance and importance to roadway design and construction. Consequently, a historic road is considered here as a discrete resource type. Historic roads have contributed to our culture in a meaningful way through design, experience, or association. This quality may be based on aesthetic, engineering, or cultural significance. Roads with aesthetic qualities are generally designed to enhance traveler experience by passing through parks or scenic landscapes. Roads with significant engineering qualities exhibit functional characteristics where design and technology are combined to facilitate efficient transportation. Historic roads may also be important as corridors or routes across the landscape that were used during broadly defined periods of exploration, migration, and settlement. In some cases, the original surfaces of historic roads may no longer exist.

Figure 4-4: *The bridge over Cienega Creek, built in 1921 is a historic road feature.*

Traditional cultural places are important because of their association with a living community's cultural practices or beliefs that are: (a) rooted in community history and (b) important in maintaining the continuing cultural identity of the community. The cultural significance of a traditional cultural place is derived from the role the property plays in historically rooted beliefs, customs, and practices of a community. Cultural resources that meet this definition are typically, but not exclusively, identified as significant to Native American communities. Examples include places where traditional plants used in ceremony are gathered, natural landscape features associated with an event or figure important in creation myths, or springs revered because of life giving water.

Figure 4-5: *The Santa Rita shrine on Arivaca Road is a place of traditional cultural value.*

National Register of Historic Places

The National Register of Historic Places is the nation's honor roll of places considered important to the American public on the national, regional and/or local level. The Register was created as part of the National Historic Preservation Act of 1966, and is maintained by the National Park

Service (NPS). NPS developed criteria to assess the eligibility of cultural resources for listing in the Register. Pima County applies these criteria to all public works projects when cultural resources may be affected. Only cultural resources that are listed or are eligible for listing in the National Register are considered for further treatments/mitigation. The criteria are defined in the U.S. Department of the Interior Regulations 36 CFR Part 60. To be eligible, a cultural resource must be 50 or more years old and meet at least one of the criteria listed below.

"The quality of significance in American history, architecture, archaeology, engineering and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

a. that are associated with events that have made a significant contribution to broad patterns of history; or
b. that are associated with the lives of persons significant in our past; or
c. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
d. that have yielded, or have the potential to yield, information important in prehistory or history."

National Register determinations are made during a review process that is specifically designed to assess and treat impacts to cultural resources during public works projects.

Steps in the Process

To determine whether a proposed road project must follow the ESR review process because of the presence of cultural resources, the map of archaeological sensitivity zones should be consulted. This map is presented on the Pima County website (see Appendix 4-B). Projects located within the high or medium sensitivity zone will be treated as ESRs, and subject to the guidelines presented below. Additionally, specific cultural resources may be affected for which further information is needed. The Pima County Cultural Resources Office should be contacted with a letter and vicinity map that detail the nature and location of the project. The staff will determine whether the project could potentially affect priority cultural resources – that is places that have been determined by Pima County to be of extraordinary importance to the history and culture of the County. Road projects that will affect these priority sites will be required to follow the review process outlined below.

The review process that Pima County follows for assessing and treating the effects of public works projects on cultural resources mirrors the federal process as detailed in federal regulations at 36 CFR 800. Table 4-1, presented at the end of this section, outlines the process steps.

Step One: Identify and Assess Cultural Resources

The first step involves collecting data on cultural resources within the project area as defined by the Pima County Department of Transportation. A professional archaeological consultant, along

with a registered architect if warranted, conducts background research to determine whether or not the project area has previously been surveyed to current standards. This researched information should include: what cultural resources are known within the project area, who did the work, when it was done, how it was done, and what was found. Often, additional information is needed and the archaeologist conducts a field survey of the project area. The results of the background research and survey are documented in a report, which is reviewed by the staff of the Pima County Cultural Resources Office. If no cultural resources will be affected by the proposed project, the process ends and the cultural resource requirements for the project have been met.

If cultural resources are located within the project area, they are assessed based on the National Register criteria discussed previously. The staff of the Pima County Cultural Resource Office consults with the SHPO in Phoenix by sending the SHPO a copy of the survey report to make a National Register determination. In some cases, other parties such as state and federal agencies are consulted if they have regulatory involvement in the project. To assess National Register eligibility, on occasion additional information may be needed that requires subsurface testing to characterize the nature of archaeological deposits. The findings are documented in a report and sent to the consulting parties as needed. Once National Register determinations have been completed for all the cultural resources that may be affected, the project then goes to the next step in the review process.

Step Two: Evaluate Effects to National Register Eligible Cultural Resources

The second step entails the professional architectural consultant and/or registered architect evaluating the potential effects of the proposed project on those qualities that make the cultural resources located in the project area eligible for listing in the National Register. If the effects will be adverse, then treatment options for either avoiding effects or mitigating those effects are formulated, and a plan is prepared by a professional archaeologist or architect as applicable. Examples of various treatment options are provided in Table 4-2 and further discussed in Section 4.7. These options may include avoiding cultural resources through project redesign, or preserving them in place using physical barriers to ensure their protection. Rehabilitation and reuse are also treatment options where cultural resources are incorporated into the design of the project. Another option is to relocate the resource, if practical, to another location. Lastly, treatment can consist of data recovery to record and analyze information that would otherwise be lost through construction. Which treatment option is selected will depend on the types of cultural resources that will be affected and what can most practically be achieved given limitations of time and money.

Treatment options will be further refined as a result of the design charrette (see first page of Section 4.3) during which potential impacts are evaluated with the road Design Team. Once the project design is selected, the preferred treatment option is detailed in the mitigation plan, which is submitted to the SHPO and other consulting parties for their review and comment. The mitigation plan is then revised as needed to reach agreement on the best course of action to be taken.

Step Three: Implement Mitigation Plan

The last step in the review process involves implementing the mitigation plan to either avoid the National Register eligible cultural resources or conduct a program to mitigate adverse effects to those resources. This will require coordinating the work with the construction phasing discussed in Section 4.4. As a matter of convention, once any required mitigation fieldwork is completed, then, upon approval by staff of the Pima County Cultural Resource Office, construction may begin in the project area while laboratory research, analysis, artifact curation and report preparation is ongoing. When the report is complete, the SHPO is consulted one last time to ensure that the end result of the mitigation plan is acceptable, although by this time road construction may already be underway or even finished. Copies of a final report are sent to all relevant parties.

Conclusion

Pima County recognizes the importance of considering the effects of its actions on cultural resources and has determined as a matter of policy that steps should be taken to avoid or lessen these effects. Public works projects have been subject to this policy since 1983 and the cultural resources review process has been consistently included in Pima County roadway projects since 1989.

Avoidance of cultural resources or preservation in place is always the preferred means of mitigating potential effects of road construction. Cultural resources are finite in number and so each one that is lost is another that will not be available for future generations. Typically, the cultural resource review process is engaged during the environmental assessment phase of project planning, and the survey is conducted once plans have been developed. However, opportunities for avoidance and preservation in place are often limited because not enough is known about cultural resources before design begins. The ESR procedures described in this chapter incorporate more cultural resource information earlier in the planning process, encouraging a collaborative approach between project designers and cultural resource professionals to achieve preservation more often.

For more information about historic preservation related topics, consult the applicable websites listed in Appendix 4-B.

Table 4-1
Cultural Resources Review Process

Identify/Assess Resources			**Evaluation of Effects**	**Mitigation of Effects**
Resource Types	*Inventory/ Testing*	*National Register Criteria*	*Treatment Options/Planning*	*Mitigation Plan*
- Archaeological - Historic - Historic Roads - Traditional Cultural Places	- Background Research - Informant Interview - Field Survey - Field Testing	- Apply NR Criteria a. Historic Events b. Historic People c. Type, Period, Method, etc. d. Information Potential	- Avoidance - Preserve/Protect - Rehab/Reuse - Relocate - Mitigate/Record	- Implement Plan - Complete Field Work - Proceed with Road Project
	Report Prepared		Mitigation Plan Prepared	Mitigation Report Prepared
	Internal Review	External Review	Internal/External Review	Internal/External Review
		Consult w/SHPO and other parties as needed	Consult w/SHPO and other parties as needed	Consult w/SHPO and other parties as needed

Table 4-2
Examples of Treatment Options by Cultural Resource Type

Archaeological Resources: Sites, Objects, Districts/Complexes	**Historic Resources: Buildings, Structures, Objects, Districts, Landscapes**
Treatment Options - **Avoidance** Redesign Realign - **Preserve/Protect** Intentional Burial Physical Barriers Covenants/Easements Donation - **Data Recovery** Testing/Excavation Mapping, photography, records research Informant Interview	Treatment Options - **Avoidance** Redesign Realign - **Preserve/Protect** Covenants/Easements Donation - **Restore/Reuse/Retrofit** Restore to original condition. Incorporate historic elements into new design - **Relocate** Move from harms way - **Record/research** Drawings, photography, records research Informant Interview
Historic Roads: Aesthetic, Engineered, Cultural	**Traditional Cultural Places: Shrines, Burials, Rock Art, Gathering Places, Natural Features, Springs/Drainages, Landscapes**
Treatment Options - **Avoidance** Redesign Realign - **Adaptive Reuse** Incorporate historic elements into new design Retain historic setting - **Record/Research** Drawings, photography, records research Informant interview - **Public Information/Education** Signage, information kiosks, popular publications, lectures	Treatment Options - **Avoidance** Redesign Realign - **Preserve/Protect** Intentional Burial or reburial - **Restore/Reuse** Repair Provide new access to - **Relocate** Move away from harm - **Record/Research** Map, photograph (if appropriate), research Informant interview - **Ceremonial Treatment** On site ceremony/ritual

4.6 VISUAL AND AESTHETIC RESOURCE PROCESS

This section provides an overview discussion of the process to: (1) identify visual and aesthetic resources, (2) analyze and evaluate the visual impacts associated with different types of roadway projects, and (3) develop treatments/mitigation measures to address impacts to important visual resources and to maintain and/or enhance the aesthetic character of the roadway corridor.

Key References

The following documents may be reviewed in conjunction with the process outlined in this section and shown in Figure 4-6. The Visual and Aesthetic Resource Evaluation Process for ESR design projects is based on a combination of the principles presented in seven documents on visual analysis included in Appendix 4-A.

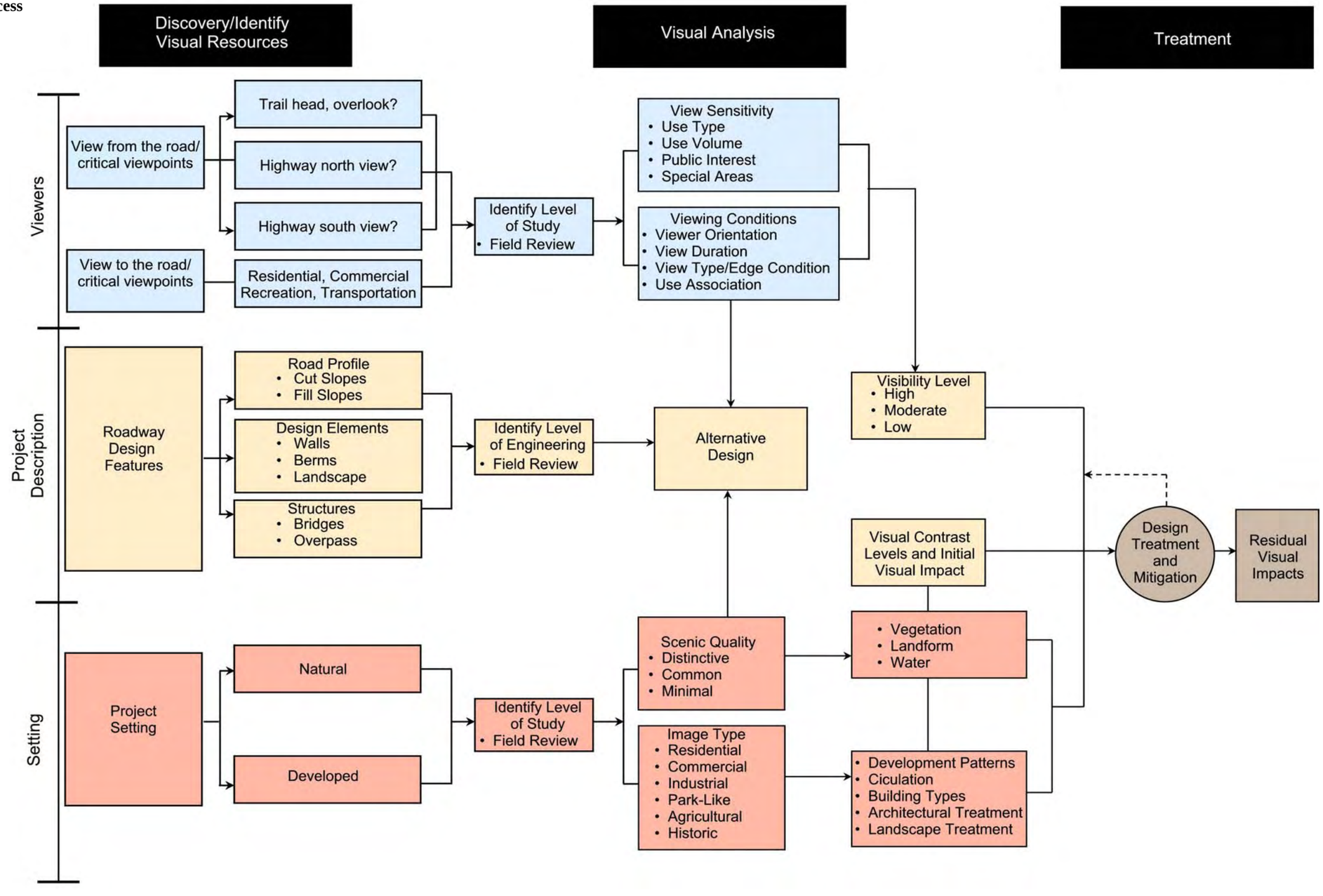
Highlighted below are steps for characterizing visual resources within a project area, evaluating the effects of the project on those resources, and developing and prioritizing treatments/mitigation measures to mitigate the project effects. These steps are intended as guidelines for the integration of aesthetic considerations into the planning and design of roadway projects. Appendix 4-G provides a more detailed discussion of the specific techniques that may be used to conduct this process.

Steps in the Process

Step 1: Discovery/Identification of Visual Resources

The first step in the Visual and Aesthetic Resource Evaluation includes a field review to identify and inventory the visual elements associated with (1) viewers from and to the roadway area, (2) the setting of the project, and (3) elements of the project that will result in a change to the setting.

Figure 4-6
Environmentally Sensitive Roadway Design
Visual Resource Study Process



The intent of this step is to initially characterize the visual resources, to identify those elements of the project that may affect those resources, and to determine the potential level of visual analysis and treatment required for the project. Also during this step, any specific visual practices and standards of agencies that have jurisdiction in the project area should be identified.

Viewers

From the Roadway – Include roadway users (vehicle occupants and in some cases bicyclists) as well as special viewpoints associated with the roadway (trailheads, scenic overlooks, rest areas etc.). It is important to note that when identifying highway viewers, both directions of traffic should be considered in the evaluation. In situations where sidewalks or trails are a part of the project, views from these facilities should be considered.

To the Roadway – Include adjacent property users, including those involved in residential, commercial, industrial, and recreational uses.

Setting

Landscape settings of proposed roadway projects may be natural or developed. Natural settings are those that consist of elements including landform, vegetation, and water and that demonstrate little if any human modifications or disturbance. (Natural settings may include ranching and grazing lands.) Developed settings include those areas in which residential, commercial, industrial, recreational, or agricultural (e.g., cotton fields, orchards) uses have been established.

Project Description

In order to evaluate the effects of a proposed roadway project on the viewers and the setting, it is important that project design features (including potential treatments/mitigation measures) be well defined. In some cases, the project description may entail the development of a new road, requiring the removal of vegetation within an entire corridor area and the modification of landform through grading (cut and fill slopes). Other projects may include only the widening of an existing roadway, resulting in selective vegetation clearing and the use of retaining walls. Finally, some projects may only involve the addition of small project features to address very localized issues (e.g., barriers, landscaping, guardrails, lighting, signage).

Step 2: Conduct Visual Analysis

The visual analysis begins with identifying initial visual impacts, which are based on the effects that the proposed project will have on the views from and to the roadway and contrasted with the existing views from and to the roadway. The level of this analysis should be determined at the conclusion of Step 1, including a confirmation of specific tasks and the level of detail required for the analysis. Following is an overview of the tasks that may be required for the visual analysis. A detailed description of these tasks, with examples, is provided in Appendix 4-F.

Viewers

The analysis of viewers includes (1) the sensitivity of users with views from and to the project, and (2) the viewing conditions, or variables, associated with those views. Collectively, this information may be used to determine overall visibility levels (i.e., high, moderate, or low) associated with the different types of viewers that may have views from, or to the roadway.

Sensitivity of Viewers – Viewer sensitivity levels are the measure of viewer concern for change in scenic quality or the image of a particular setting in which a roadway is being developed, modified, or improved. Criteria for the identification of viewer sensitivity include user type, user volume, public interest (national, state, or local), and association with special areas or unique viewer expectations (e.g., scenic highways, special recreational areas, or historic areas).

Viewing Conditions – Viewing conditions are defined by a set of viewer variables that assist in characterizing views from and to the roadway project from sensitive view locations, and include the following:

- *Viewer Orientation:* including parallel versus perpendicular views from the road
- *Duration of View:* including consideration for roadway speed limit
- *View Distance:* near foreground to background
- *Visibility/Edge Condition:* open, filtered, or screened
- *Viewer Use Association:* viewer expectations and special designation areas
- *Silhouette:* contrast of element with sky
- *Magnitude:* size of element

Visibility Level Synthesis – Using these criteria, a synthesis of overall visibility levels may be assigned to segments of the road characterizing views from and to the roadway area, as well as from specific viewing locations associated with the roadway (as necessary).

Setting

Analysis of the project setting includes the characterization of similar patterns of landform, vegetation, land use, and unique features. Description of these factors permits an evaluation of the potential effect of the proposed roadway design project in conjunction with scenic quality (natural setting), or visual image types (developed settings).

Natural Setting – Natural landscapes or settings may be characterized based on similar patterns of the following elements:

- Landform
- Color
- Vegetation
- Scarcity

- Water
- Cultural Modifications (including ranching and grazing)

These elements are combined to determine the overall scenic quality of the natural setting. In general, those areas with greatest diversity exhibit the highest level of scenic quality, while areas with little or no variety are considered less visually appealing.

Developed Settings – The visual image of developed settings (counterpart to scenic quality in a natural setting) is based on types of use and development patterns that are defined by visual character, land use patterns, and viewer orientation. The visual character is concerned with the composition of design elements including form, line, color, and texture. These elements influence the visual dominance, and focus within each setting. In general, these patterns may be classified into five image types: residential, commercial, park-like, industrial, and open/agricultural images.

Visual Contrast

As warranted, the visual contrast analysis is a systematic process that is used to analyze the potential visual impacts of the proposed roadway improvement and associated activities. The degree to which the roadway project affects the visual and aesthetic quality of a natural or developed setting depends on the contrast created between the project and the existing setting. The contrast can be measured by comparing the design features associated with the project description with the major features in the existing setting (natural or developed). The basic design elements of form, line, color, and texture are used to make this comparison and to describe the visual contrast created by the project in a natural setting, while the effects to image type are used to define contrast in developed areas. Using this information, the impacts may be summarized to discuss the modification to the natural setting or visual image type of an area and the effects to views from and to the roadway.

This analysis process provides a means for determining the visual impacts and for identifying the measures and treatments to mitigate these impacts. It is important that potential mitigation measures be identified early in the process since their identification will assist in project design and the development of specific alternatives.

Step 3: Identify Optional Treatment

The purpose of this step of the visual resource and aesthetics evaluation process is to identify potential treatment options that may be utilized to enhance viewing conditions and/or address the impacts to viewers and the project setting as previously defined. This step focuses specifically on the selection of relevant design elements or treatments as earlier described, the evaluation of how these solutions address visual and aesthetic opportunities and impacts, and how treatments/mitigation measures should be prioritized for implementation. Examples of design treatments/mitigation measures, and how these measures may be applied to different types of roadway projects are presented in Section 4.7.

4.7 MITIGATION TOOLS

Mitigation of environmental impacts can take many forms. Depending upon perspective, certain mitigation measures may be more desirable than others. Within the context of this ESR design guide, it is important to define the range of possible mitigation measures that may be available to designers, and to help them choose the most appropriate ones for implementation. The following sections represent a toolbox to assist designers with the process of identifying, assessing and selecting treatment options and roadway design techniques that best satisfy the environmental preservation and enhancement goals of each project.

Environmentally Sensitive Roadway Design Guidelines

Many sources currently exist for design of roadway facilities, ranging from local to national. The primary references for Pima County projects are listed below. These publications provide guidance to designers, offering a full scope of acceptable and safe design criteria.

- Chapters 2 and 3 of this manual
- American Association of Transportation Officials, *Policy on Geometric Design of Highways and Streets,* 2001. *(AASHTO Policy 2001)*
- AASHTO, *Roadside Design Guide*, 2002 (*AASHTO Guide 2002*)
- AASHTO, 1996, and revisions 1997 - 1999, *Standard Specifications for Highway Bridges*

There are a number of key roadway elements that impact ESR designs. These elements range from design speed (impacting the driver's ability to see and avoid wildlife on the roadway) to lane widths (impacting overall roadway width and resultant resource disturbance) to drainage design (facilitating wildlife crossings and enhancing riparian habitats). The potential variation within each of these elements can have minimal to devastating impacts on environmental resources. For example, a four-lane arterial road can range in width from 96 feet to 70 feet. Over a one-mile project length, that 26-foot difference could mean the preservation of over three acres of environmentally sensitive land. Other design elements can also have major impacts.

Guidelines follow for minimizing impacts on ESR projects. These guidelines are broken down into Roadway Elements and Construction Phasing.

<u>Roadway Elements</u>

The list below provides suggested limits for key elements of the ESR design. In all cases, the final approval of the use of these design criteria is the responsibility of the County Project Manager and the County Department of Transportation Engineering Manager.

- *Design Speed/Posted Speed:* ESR design speed should be 30 to 50 miles per hour, with the posted speed 5 mph less that the design speed.
- *Lane Width:* ESR lane widths can be the minimum widths shown in Chapter 2, Table 2-1.

- *Shoulder Width:* ESR paved shoulder width is 6 to 9 feet, with 6 feet as the standard width. The designer has a range of acceptable values to narrow the road width, widen the shoulder, or to allow for a wider median while maintaining a given total width.
- *Bridge Width:* ESR bridge geometrics follow current RDM and AASHTO guidelines.
- *Bridge Structural Capacity:* ESR bridge structure follows AASHTO guidelines.
- *Superelevation Rate (horizontal alignment):* Maximum rates are 0.08 and 0.06 for rural and urban/suburban roads, respectively, for design speeds of 45 mph and above. For design speeds of 40 mph and below, apply the simplified curve formula, $e + f = V^2 / 15R$, as described on pages 192-198 of *AASHTO 2001 Policy*. The designer can use these higher rates to reduce the radius of the horizontal curve.
- *Vertical Alignment:* See *AASHTO 2001*. The designer needs to consider the specific conditions (biological, cultural, historical) along the ESR corridor and may lengthen the vertical curve if warranted. Shortening of vertical curves should be done only through the Pima County design exception process.
- *Grade:* Maximum grade of 10% is allowed in mountainous areas, 5% in rolling terrain. The designer can use steeper grades to reduce cuts and fills.
- *Stopping Sight Distance:* See *AASHTO 2001*.
- *Cross Slope:* 2% for through lanes and shoulders.
- *Number of Through Lanes:* Maximum of 4-lanes (2 per direction).
- *Vertical Clearance:* See *AASHTO 2001*.
- *Horizontal Clearance:* For ESR design speeds between 30 mph and 45 mph, the horizontal clearance (from face of curb to obstruction) is 2.0 feet minimum for curb sections. For sections with no curb, the minimum clearance is 10 feet (measured from through travel lane to obstruction). For an ESR design speed of 50 mph along an uncurbed roadway, the designer should use the clear zone distance from the *AASHTO Roadside Design Guide*. When the roadway has curbs, an ESR design speed of 50 mph requires a 2.0-foot minimum horizontal clearance.
- *Median Width:* For ESR projects, the required horizontal clearance to obstructions in medians corresponds to item M., above. Width of median can vary from 20 to 40 feet. At signalized intersections, a maximum width of 30 feet should be used. Note that a tree having an expected mature diameter greater than 4 inches is considered an obstruction, while lesser vegetation or landscape may not be an obstruction.
- *Alternative Modes:* Bus pullouts and pedestrian sidewalks all must be assessed for impacts, and width reduction (or elimination) may be necessary depending on the resources being impacted. ESR roadways will include bicycle lanes with a 6-foot standard width, but in constrained circumstances this width may be reduced by 1 foot.
- *Drainage:* See Pima County *Roadway Design Manual*. The designer may wish to call for larger than required drainage culverts to allow for wildlife crossings. Additionally, the designer may choose to allow flows more frequent than the 100-year event ($Q<Q_{100}$) to flow across the road if circumstances warrant this type of treatment.

- *Noise:* Noise walls are considered appropriate only when shown to enhance biological or cultural/historical resources or to mitigate negative impacts on these resources. The ESR designer is encouraged to use "barrier" mitigation wherever possible, including rubberized asphalt pavements.
- *Right-of-Way:* ESR corridors (150 to 300 feet) may be planned for wider-than-normal public rights-of-way to enhance or to mitigate impacts of the road design.

Construction Phasing

Historically, roadway contractors have had a great deal of flexibility in scheduling construction activities. Once a project has been awarded, the site becomes the contractor's responsibility – essentially his/her property – for the duration of the contract. As a general rule, the first activity to commence is site clearing and grubbing and the relocation of affected utilities that are in the way. This particular activity can have immediate and negative effects on natural and cultural resources. These impacts may continue for the entire duration of the project, creating unexpected and irreversible environmental impacts. Other construction activities also affect natural and cultural resources.

Wildlife travel patterns, important seasonality issues (such as breeding), and significant features should be identified during the design phase of the project. Construction specifications and sequencing of work need to address these issues. For most ESR projects, it is advisable for the designer to develop construction-sequencing plans as a part of the contract documents. This will help ensure that the construction team properly implements the environmental goals of the project, and that the contractor is afforded a workable project while creating/maintaining corridors or habitat.

Biological Resource Conservation Treatments/mitigation Options

Biological resources (e.g., riparian areas, special status species habitat) of ESR projects within ESL should be preserved. The project area should be evaluated to determine if SDCP Riparian areas, Title 16 Watercourses, and special status species habitat are avoidable. If avoidance is not possible, there are several option for treatments/mitigation measures. These include, but are not limited to:

- Conservation Easements
- Revegetation
- Wildlife Road Crossing Design
- Off-site Compensation

All mitigation plans, especially those concerning special status species, should be developed in conjunction with Pima County, AGFD, and USFWS. Projects should include a monitoring component to ensure that treatments/mitigation measures have been accomplished. The options for treatments/mitigation measures are presented in more detail below.

Conservation Easements

A conservation easement is a legal agreement voluntarily entered into by a property owner and a qualified conservation organization such as a land trust or government agency. The easement contains permanent restrictions on the use or development of land in order to protect its conservation values. Easement restrictions vary greatly between agencies/organizations.

Revegetation

Revegetation of all ESR areas shall be done with the appropriate plant species, including seed mix plants. Every effort should be made to revegetate with plant species that were removed and/or are commonly found in the project environment, matching density, relative location patterns (e.g., small cactus under shrubs), slope, and soil preferences whenever possible. A list of plants native to Pima County is presented in Appendix 4-E. These plants should be used in all ESR areas. Certain plant species shall not be used under any circumstances (see also Appendix 4-E). All transplant vegetation and seed mixes are to be planted and irrigated correctly. Planting and irrigation guidelines are presented in Appendix 4-F. Trees with anticipated mature diameter of 4 inches or greater should not be located in medians or within clear zones. Vegetation should not be located at intersection corners or in medians that would restrict driver visibility to oncoming or crossing vehicles.

Wildlife Road Crossing Design

Land bridges, herp walls, lighted crossings, and bridges that span rather than cut drainages are all features that could be incorporated into Pima County transportation plans. In northwestern Arizona, the Federal Highway Administration (FHWA) is planning to construct a land bridge near Lake Havasu to allow bighorn sheep to cross Interstate 40. A Florida land bridge serves dual purposes: the edges are vegetated with native species with a sand base for animal passage, and the center is designed for pedestrian and equestrian use.

Figure 4-7: *Example of a large wildlife crossing.*

Wildlife walls and fences funnel animals to designated crossings. Sound walls are an effective barrier to wildlife and can serve as wildlife walls as well. However, 10-foot sound/noise walls are not the ideal addition to the landscape, and their use for ESR design is discouraged. Shorter walls can be just as effective for wildlife. A wall 3-4 feet high will allow birds to fly over while encouraging other wildlife species to use designated crossings.

Figure 4-8: *Herp wall along a roadway.*

Herp walls are designed specifically to funnel lizards, snakes, small turtles and amphibians into designated crossings (Figure 4-8). Herp walls are smooth, short walls placed along the edge of the road that have a top lip that prevents reptiles and amphibians from crawling onto the road.

Lighting is another very important and often overlooked component of effective wildlife crossing design. Lizards and snakes prefer bright, warm habitats to cool, dark tunnels, therefore culverts intended for wildlife are not always conducive to the habitat requirements of reptiles. Additionally, deer will not enter a dark tunnel with an exit that is perceived to be very small (perceived exit size is dependent on size and length of crossing structure) or that may conceal predators. Incorporating light into these structures encourages more animals to use them. Grates can be placed in the road or medians to allow natural sunlight into the crossing, or solar lights can be placed in the interior. (See University of Arizona pedestrian underpasses as an example of solar lighting in a tunnel.)

Crossings designed for one species may not serve other species. For example, design of roads in pygmy-owl habitat incorporate native vegetation to the edge of the road to allow adequate crossings. However, vegetation should be kept away from the edge of the road to discourage other animals from crossing in areas other than designated crossings. It is important to identify the target species or group of animals so that appropriate designs are chosen.

In some instances, bridges that completely span a drainage are more effective than traditional box culvert design (Figure 4-9). Larger mammals (e.g., deer, bear) are more likely to use a wide-open crossing rather than a closed box culvert. Such crossings also preserve riparian habitat by spanning entire floodplains, rather than only floodways with associated destruction of adjacent overbank areas that contain considerable amounts of riparian habitat.

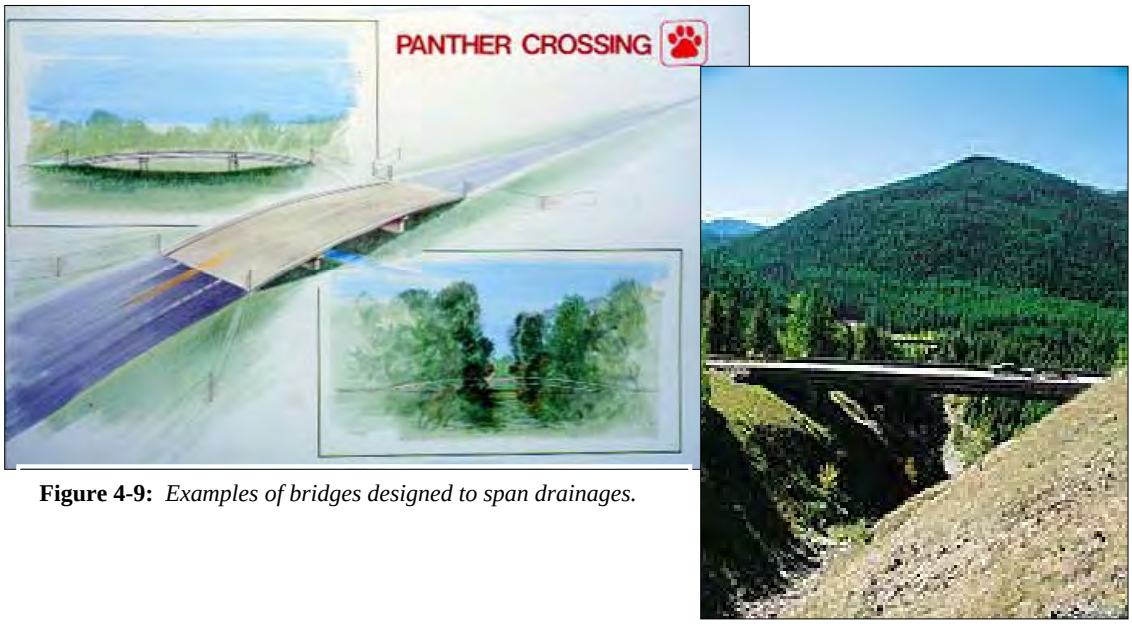


Figure 4-9: *Examples of bridges designed to span drainages.*

An important aspect of designing a wildlife crossing is determining the most effective placement for wildlife use. Corridor studies using landscape topography, wildlife ecology, computer modeling, and radio-telemetry techniques are all valuable resources for determining appropriate crossing locations. These studies should be conducted during the "Discover/Identify Existing Resources" stage of the Biological Resource Process. (See Section 4.4 of this document.)

The following is a list of tools for creating wildlife crossings. It is not exhaustive since each species may require unique design features tailored to their needs.

- Install speed humps, speed tables, traffic circles, or other "traffic calming" elements to slow traffic
- Set lower speed limits
- Provide wildlife friendly lighting to discourage wildlife from foraging near the road (i.e., avoid bright lights that attract insects, thereby attracting insectivores)
- Widen clear zones to deter wildlife from the edge of road
- Install wildlife crossing signs to inform motorists
- Install large lighted culverts for large mammal crossings
- Install small lighted culverts for smaller wildlife
- Install herp walls to encourage reptiles and amphibians to use appropriate culverts
- Install grates in medians to allow natural sunlight into culverts
- Use solar lighting to illuminate dark culverts
- Plant native vegetation in medians and other landscape/re-vegetated areas
- Span drainage floodways when feasible
- Create land bridges
- Conduct a wildlife corridor study to determine best placement of wildlife crossings
- Create "escape cover" around wildlife crossings by using dense native vegetation
- Eliminate "escape cover" (i.e., vegetation) near hazardous areas to deter wildlife from crossing road
- Use fencing in conjunction with plant material to guide wildlife to appropriate crossings

Additional sources of information on wildlife crossings are provided in Appendix 4-C of this document.

Off-Site Compensation

Off-site Compensation also is referred to as a *conservation bank.* Like a financial bank, a conservation bank is a place that contains important resources, in this case natural resources. The conservation bank protects these resources just like a bank protects money. When a project is planned that will impact endangered species or other natural resources, such as wetlands,

credits in a conservation bank can be purchased. The bank owner then uses the money to protect the resources in the bank.

Traditionally, project developers have been asked to preserve a portion of the area they are developing. Often this is a good policy. However, sometimes it may be better for endangered species to have larger areas protected in banks. It also is more efficient and cost effective to manage a bank instead of small, isolated properties.

The term "mitigation bank" is sometimes used to refer to conservation banks. This is appropriate in the case of non-Federal projects and projects that require U.S. Army Corps of Engineers wetlands permits. Federal law allows non-Federal property owners, such as private landowners, corporations, tribes, or state or local governments, to *mitigate*, i.e., compensate for, impacts to the environment.

Appendix 4-B includes an address for a USFWS website that contains more information on conservation banks.

Cultural Resources Treatment Options

As discussed in Section 4.5 the cultural resource review process consists of three steps: (1) identification and assessment, (2) evaluation, and (3) treatment. Treatment is the stage in the process in which the characteristics that make a cultural resource important are protected, or the effects of project related disturbance to those characteristics are mitigated prior to construction. The measures used to accomplish treatment range from complete avoidance of cultural resources to research and recording prior to their destruction through construction.

When cultural resources are identified within a proposed road right-of-way, the manner in which potential effects can be treated will vary depending on a host of factors including, but not limited to, the resource type and the characteristics that make it important, its location within the proposed right-of-way, whether it is possible or even desirable to avoid the resource, limitations of time and money, and public awareness of and sentiment regarding the resource. For this reason, engineers and designers are advised to consult with the Pima County Cultural Resources Manager during the planning and design stages of ESR projects. By law, state and federal agencies may also need to be consulted before a consensus can be reached on the proper treatment for a cultural resource that may be affected by road construction.

Typically, if archaeological sites cannot be avoided, a data recovery program is developed identifying a set of research questions and methods that guide field and laboratory work. The objective is to collect the information content of the site before it is lost to construction and to add new information to a body of knowledge of how people lived in the past. Buildings, structures, and other engineered features, such as roads and bridges, are typically recorded in the field and through archival research to capture the history of their design, construction, and use over time. This work is usually done in reference to broad themes in American history on the national, state, and local levels to provide meaningful context to the research. On occasion, cultural resources valued by traditional communities, such as Native American communities, may be affected by a proposed road project. In these instances, experts in applied anthropology

use a combination of fieldwork, oral interview and archival research to recover information about these resources and to work with the communities to conduct appropriate means of treating effects. Treatment can be time consuming and expensive, requiring careful planning so that the work can be done well in advance of construction but after enough of the planning has been done to identify potential effects on the ground.

To provide a sense of the kinds of treatment that may be employed in road construction projects, Tables 4-3 through 4-6 contain typical treatment options for each resource type and corresponding design recommendations for how to achieve treatment. Each table lists the treatment options from top to bottom in a range from the most beneficial to cultural resources to the least beneficial. Avoidance and preservation in place is always the preferred treatment option. This means that impacts to cultural resources are deliberately avoided and preservation measures are adopted to ensure protection. It is important to note that treatment often involves a combination of treatment options to mitigate the effects of construction on cultural resources. Tables 3 through 6 are not intended to be comprehensive or exhaustive. Each ESR project that may affect cultural resources will involve unique circumstances, so alternative treatment options may be possible with different design implications.

Table 4-3
Archaeological Resources: Sites, Objects, Districts/Complexes

Treatment Options	Design Recommendations
- **Avoidance** Redesign Realign	- Include a buffer zone of 50 feet minimum between the edge of the construction zone and the edge of the archaeological resource to ensure avoidance.
- **Preserve/Protect** Intentional Burial Physical Barriers Covenants/Easements Donation	- Add 12-24 inches of topsoil to "cap" the resource by intentional burial. Archaeological testing must be conducted prior to capping. - Fencing, earthen berms, or other permanent barriers can be used to ensure avoidance in conjunction with a buffer zone. - Covenants and easements are legal instruments to ensure avoidance. Same design implications as avoidance. - Donation can occur as a part of avoidance strategy where preservation responsibility is assumed by a third party. Same design implications as avoidance.
- **Data Recovery** Testing/Excavation Mapping, photography, records research Informant Interview	- Data recovery collects information through scientific investigation in accordance with the Secretary of the Interior's Standards and Guidelines. No design implications.

Table 4-4
Historic Resources: Buildings, Structures, Objects, Districts, Landscapes

Treatment Options	Design Recommendations
- **Avoidance** Redesign Realign	- Include a buffer zone of 50 feet minimum between the edge of the construction zone and the edge of the historic resources to ensure avoidance.
- **Preserve/Protect** Covenants/Easements Donation	- Design to minimize road vibrations that may affect nearby historic resources. Do not add visual elements, such as lighting or signage, that may detract from historic character. Use landscaping and/or public art to enhance historic feeling and association. - Covenants and easements are legal instruments to ensure avoidance. Same design implications as avoidance. - Donation can occur as part of an avoidance strategy where preservation responsibility is assumed by a third party. Same design implications as avoidance.
- **Restore/Reuse/Retrofit** Restore to original condition Incorporate historic elements into new design	- Requires modifying a historic resource in accordance with the Secretary of the Interior's Standards and Guidelines. Design implications are situational and may be significant.
- **Relocate** Move from harm	- Removal of historic resource from project area as an alternative to demolition. Requires design input for site of relocation.
- **Record/Research** Drawings, photography, records research Informant Interview	- Recover information in accordance with the Secretary of the Interior's Standards and Guidelines. Consult with knowledgeable individuals prior to demolition. No design implications.

Table 4-5
Historic Roads: Aesthetic, Engineered, Cultural

Treatment Options	Design Recommendations
- **Avoidance** Redesign Realign	- Include a buffer zone of 50 feet minimum between the edge of the construction zone and the edge of the resources to ensure avoidance.
- **Adaptive Reuse** Incorporate historic elements into new design Retain historic setting Mitigate road noise	- Reduce traffic speeds. Retain historic elevations, lane widths, shoulders and road curvature. Do not add new sidewalks, curbs or lighting. Use landscaping to preserve rural feeling and association where appropriate. Use rubberized asphalt to dampen road noise.
- **Record/Research** Drawings, photography, records research Informant interview	- Recover information in accordance with the Secretary of the Interior's Standards and Guidelines. No design implications.
- **Information/Education** Signage, information kiosks, popular publications, lectures	- Place information kiosks/signage in highly visible areas with roadside turnoffs to provide public access. Use in conjunction with recordation and research.

Table 4-6
Traditional Cultural Places:
Shrines, Burials, Rock Art, Gathering Places, Natural Features, Springs/Drainages, Landscapes

Treatment Options	Design Recommendations
- **Avoidance** Redesign Realign	- Wide buffers are recommended. Distances established through negotiations with traditional community. Design implications are situational and may be significant.
- **Preserve/Protect** Intentional burial or reburial	- Human graves are to be treated in accordance with state law and the wishes of lineal descendants or those culturally affiliated. This may require removal and reburial outside of the project area prior to construction. No direct design implication.
- **Restore/Reuse** Repair Provide new access to resource	- Restore for reuse, and/or provide new access to resource. Design implications are situational and require negotiations with traditional community.
- **Relocate** Move from harm	- Relocate to outside of the project right-of-way. Project design implication may be minimal.
- **Record/Research** Map, photograph (if appropriate), research Informant interview	- Recover information in accordance with the Secretary of the Interior's Standards and Guidelines. Consult with knowledgeable individuals prior to disturbance. No direct design implications.
- **Ceremonial Treatment** On site ceremony/ritual	- Possible outgrowth of above. On site ritual treatment required before resource disturbance. No design implications.

Visual and Aesthetic Resource Treatments/mitigation Options

As described in Section 4.6, the purpose of this step of the Visual and Aesthetic Resource Evaluation Process is to identify and prioritize potential design treatments/mitigation measures that may be used to maintain or enhance views in ESL in which roadway projects are proposed. This step focuses specifically on the selection of relevant design elements, treatments, or mitigation measures and the evaluation of how these solutions address visual and aesthetic impacts and opportunities. As part of this step, the areas identified for visual mitigation may be prioritized to meet visual goals, as well as other environmental and design goals for the project. Depending on the specific project, monitoring the implementation of the selected treatments/mitigation measures may be required during and following construction.

Following are a listing of sample types of treatments/ mitigation measures. This list is followed by three case examples illustrating how these measures can effectively address visual and aesthetic concerns.

Sample Treatments/Mitigation Measures

As described in Section 4.7 and illustrated in Figure 4-6, the development of treatments/ mitigation measures is the "circular" portion of the visual resource analysis process, which focuses on the identification of alternative plans. These alternative plans, which include design treatments/mitigation measures, are evaluated based on: (1) their effects to the visibility level of

views about which people care and (2) their ability to reduce the contrast of proposed roadway design features within natural or developed settings and to enhance the overall aesthetic of the roadway corridor.

Visibility Levels

Measures that are typically used to address visibility concerns are related to either the "screening" of undesirable views, or the "opening" of views to areas of high scenic quality or to areas that are aesthetically pleasing (e.g., developed setting). Techniques for screening include, but are not limited to, the use of vegetation, landform (e.g., berming), or structural elements (e.g., walls, fences, planters). In general, the opening of views is accomplished most often through selective clearing, or the removal of vegetation, and/or through the elimination or modification of roadside elements and structures (e.g., billboards). In making the determination regarding either the screening or opening of views, viewer orientation and duration of views are especially critical, along with the character or setting of the area being viewed.

Setting

The key to identifying appropriate treatments and measures to mitigate impacts to the setting is to determine the contrast between the proposed roadway project (including specific design elements) and the natural and/or developed character of the project area. In those areas where the contrast is pronounced, using elements that repeat the general form, line, color, and/or texture of the surrounding area will help to reduce that contrast, resulting in a project that better blends with its setting. This applies to all of the following examples.

Vegetative Treatments – The addition of new landscaping enhancements to existing landscaping and re-vegetation or reclamation practices should be consistent with the existing or planned setting of an area.

Landform Treatments – Minimizing the amount of cut and/or fill slopes (alignment) and the use of berms, slope laybacks, and rock sculpting can be effective measures to reduce the contrast of roadway features (especially in a natural setting). When using retaining walls, consideration for the size, form, color, and texture of materials is important.

Structural and Design Treatments – The addition of structures, including walls, bridges, and overpasses (vehicular and pedestrian), as well as detailed design elements including lighting, signage, and pavement types/surfaces should (where possible) not detract from the scenic quality of a natural area and should act as unifying elements in developed settings. In selective cases, however, these elements may be created to serve as public art also and, therefore, be intended to attract attention.

Case Examples

Following are examples of alternative design treatments/mitigation measures that may be developed for different types of roadway projects.

Case 1: Development of a New Road

Project requires the location of a small portion of new roadway, resulting in the removal of vegetation within an entire corridor area and modification of landform through grading (i.e., cut and fill slopes), including the modification of drainages. The results of the visual analysis may indicate moderate to high visual impacts to both the setting and the viewers' viewing experience, especially if the impacts are within a natural area with distinctive scenic quality elements and a high level of viewer sensitivity and visibility both from and to the new section of road.

Analysis may also show that construction of the new roadway could result in strong contrast to landform based on cut and fill requirements and on the removal of vegetation within the corridor area. Design treatments/mitigation measures that could assist in reducing contrast and enhancing the aesthetic character of the corridor may include, but are not limited to:

- Color treated retaining walls to addresses form and color contrast associated with significant landform modifications.
- Selective clearing, re-vegetation and reclamation, and landscaping to reduce form, line, color and texture contrast associated with removal of vegetation within the entire corridor. Focus of revegetation and reclamation may be concentrated in the drainage areas since those areas tend to be of higher scenic quality.
- Use of small bridges to address the contrast associated with grading and some vegetation removal. This option could, however, simply end up adding structures in an otherwise natural setting. The introduction of bridges, therefore, should be carefully considered.
- Landform modification through berming, slope modification, and rock sculpting.

Case 2: Widening of an Existing Roadway

Project requires addition of another lane, resulting in modest vegetation clearing, but no significant additional landform modification (e.g., grading). The vegetation clearing could either enhance or detract from views from and to the road depending upon the location of the clearing. Key to this evaluation is the type and volume of users in the area, and the scenic quality or developed image of the setting. If the setting is natural, then the quality of the setting should be identified as distinctive, common, or minimal. If the setting is developed, the widening could affect the current image of the area based on the image type or open up views to undesirable areas. Design treatments/mitigation measures that could assist in enhancing views could include, but are not limited to:

- Selective clearing, transplanting, and or replacement of vegetation in a manner that complements views from the road (e.g., opens up views to distinctive natural features or maintains screened views to industrial areas).
- Selection of vegetation types that are complementary to the surrounding area.
- Selective use of berming, fencing, or walls to screen views as appropriate.

Case 3: Roadway Improvement Resulting in the Addition of Pedestrian Access and Signage

Project requires signage and traffic control, resulting in possible placement of elements/features that could impair the visual quality of the setting. Treatments/mitigation measures that could help reduce visual clutter and impaired views include design features, such as signage, lighting, paving, and use of berms, that are compatible with the forms, colors, and textures of the surrounding image types, whether residential, park-like, or commercial.

4-8 POST-CONSTRUCTION ASSESSMENT

At the post-construction stage of the ESR design process, project impacts on environmental resources have been identified, treatment options considered, mitigation plans developed, and construction completed. As the operations phase of the roadway commences, the community has the opportunity to observe the effectiveness of its investment in the environmental mitigation effort. A number of the treatments/mitigation measures presented in this chapter, as well as many of the treatments/mitigation measures that will be created as a result of implementing the ESR process, will have limited documentation of long-term effectiveness. To ensure that the implemented preservation and enhancement plans are accomplishing their stated goals, it is imperative that follow-up studies of these projects be conducted.

If the purpose of post-construction assessment is to ensure the effectiveness of mitigation efforts, the first step is to clearly define the goals. Goals will be developed through the process outlined in previous sections of this guide, particularly Section 4.3. Environmental goals of a given project should be clearly communicated to all stakeholders as the project proceeds from planning to design to construction and eventually to operation. Some of the goals will be short-term, intended to preserve resources through the disruption created by construction. Others will be longer-term, such as pygmy owl corridor enhancement, and will need long-term follow-up monitoring to assess effectiveness.

The Design Team has the primary responsibility of developing assessment programs for ESR projects, even though the team will not typically be engaged by Pima County post-construction. The design of monitoring programs should be scientifically valid, with adequate frequency of measurements, and should be consistently applied to as many projects as possible to build a significant base of assessment data as quickly as possible. These assessment programs should be designed to be carried out by Pima County's existing operations and resource management personnel, so that the cost of collecting follow-up data does not adversely affect the ability to implement the programs.

Once the feedback information has begun to flow through to Pima County, a structure is needed to receive and analyze that information. A standing staff committee, with appropriate consultant support, should be formed and tasked with managing this important monitoring of data. On a regular basis, the committee should review the information that has been gathered and assess the success of the mitigation plans that were initially created for the individual projects under review. The committee should, when possible, contact the original authors of the project's environmental goals and follow-up programs to receive their input. Finally, evaluating the effectiveness of the mitigation plans and implementing suitable actions should close the feedback loop. Possible actions could include further treatments/mitigation measures, abandonment of efforts, direction to ongoing Design Team, and modification of monitoring schemes.

APPENDIX 4-A
Chapter 4 References

Note: These documents are revised periodically; therefore users should double check that they have the specific version of the document specified in this chapter, or, if the reference is undated, that they have the most recent version.

- American Association of State Highway and Transportation Officials. 2001. *A Policy on Geometric Design of Highways and Streets*.
- ———. 2002. *Roadside Design Guide*.
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APPENDIX 4-B
Websites

1. Arizona Department of Transportation cultural resource program with additional links: http://www.dot.state.az.us/ABOUT/envplan/cultural.html#environmental

2. Arizona State Historic Preservation Office and its programs: http://www.pr.state.az.us/partnerships/shpo/shpo.html

3. Arizona State Museum: http://www.statemuseum.arizona.edu

4. Pima County:

   Website MapGuide for information on Biological Core, Multi-Use or Recovery Area, Important Riparian Area, Agriculture within Recovery Area, Existing Development, Scientific Research Area, and Archaeological Sensitivity Zone: http://www.dot.co.pima.az.us/gis/maps/mapguide/mgmap.cfm?path=/cmo/sdcpmaps/sdcp.mwf

   Pima County Major Street and Scenic Routes Plan

   http://www.dot.co.pima.az.us/gis/maps/majscenic/MSSRc02_01.pdf

   Title 16 Floodplain and Erosion Hazard Management Watercourses
   http://www.dot.co.pima.az.us/flood/riparian

5. National Register of Historic Places, maintained by the National Park Service, including properties listed in Pima County: http://www.cr.nps.gov/nr/

6. Southern Arizona Division of the State Historical Society: http://www.arizonahistoricalsociety.org/

7. U. S. Fish and Wildlife Service:
   Special Status Species: http://arizonaes.fws.gov
   Conservation Banks: http://sacramento.fws.gov/es/cons_bank.htm

8. Wildlife Crossing Information
   Proceedings of the International Conference on Ecology and Transportation 2001: http://itre.ncsu.edu/cte/ICOET/ICOET2001.html

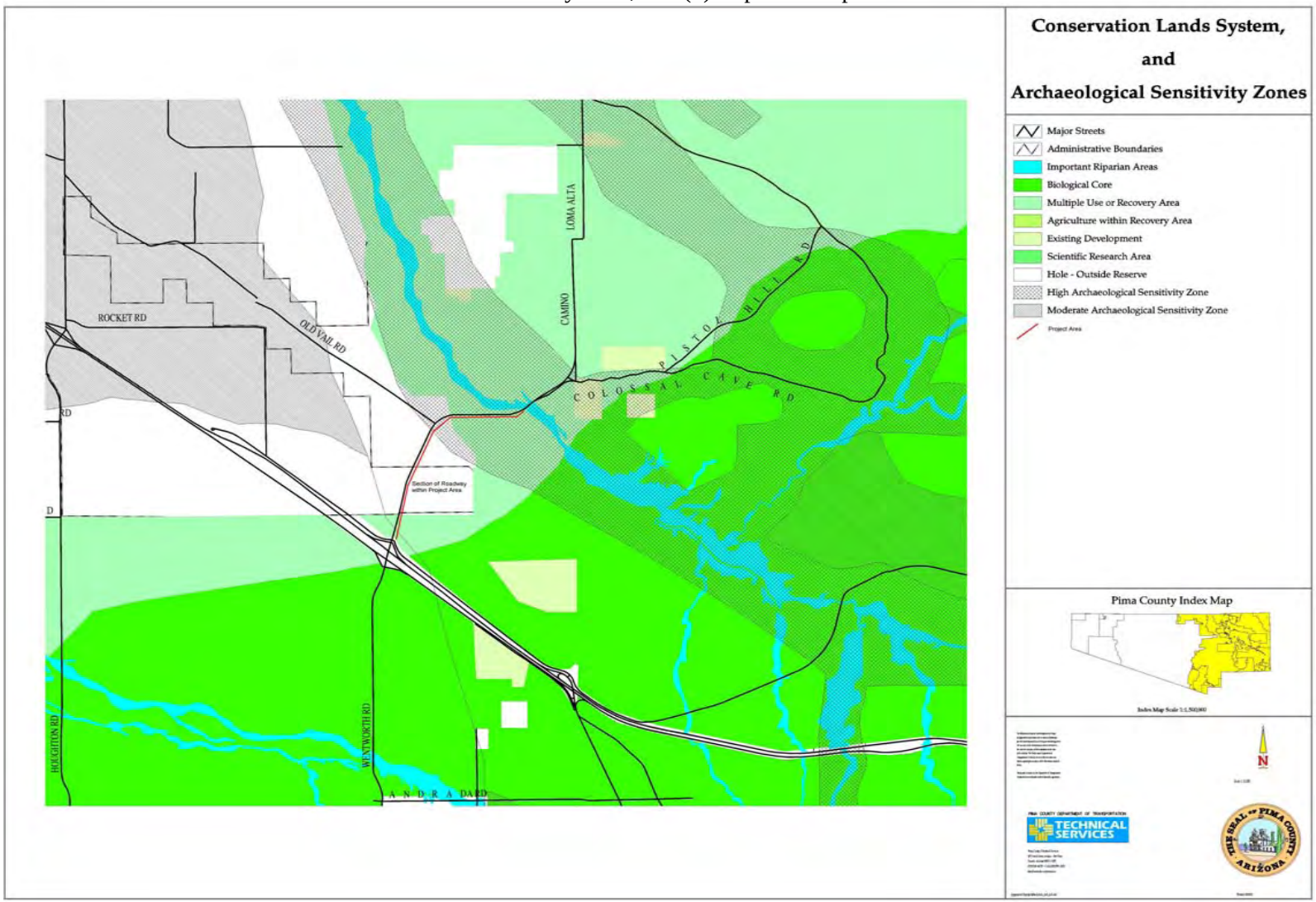
   The Humane Society: http://www.hsus.org/ace/13409

   The Defenders of Wildlife; Habitat and Highways Campaign: http://www.defenders.org/habitat/highways/

   Federal Highway Administration; Critter Crossings
   http://www.fhwa.dot.gov/environment/wildlifecrossings/

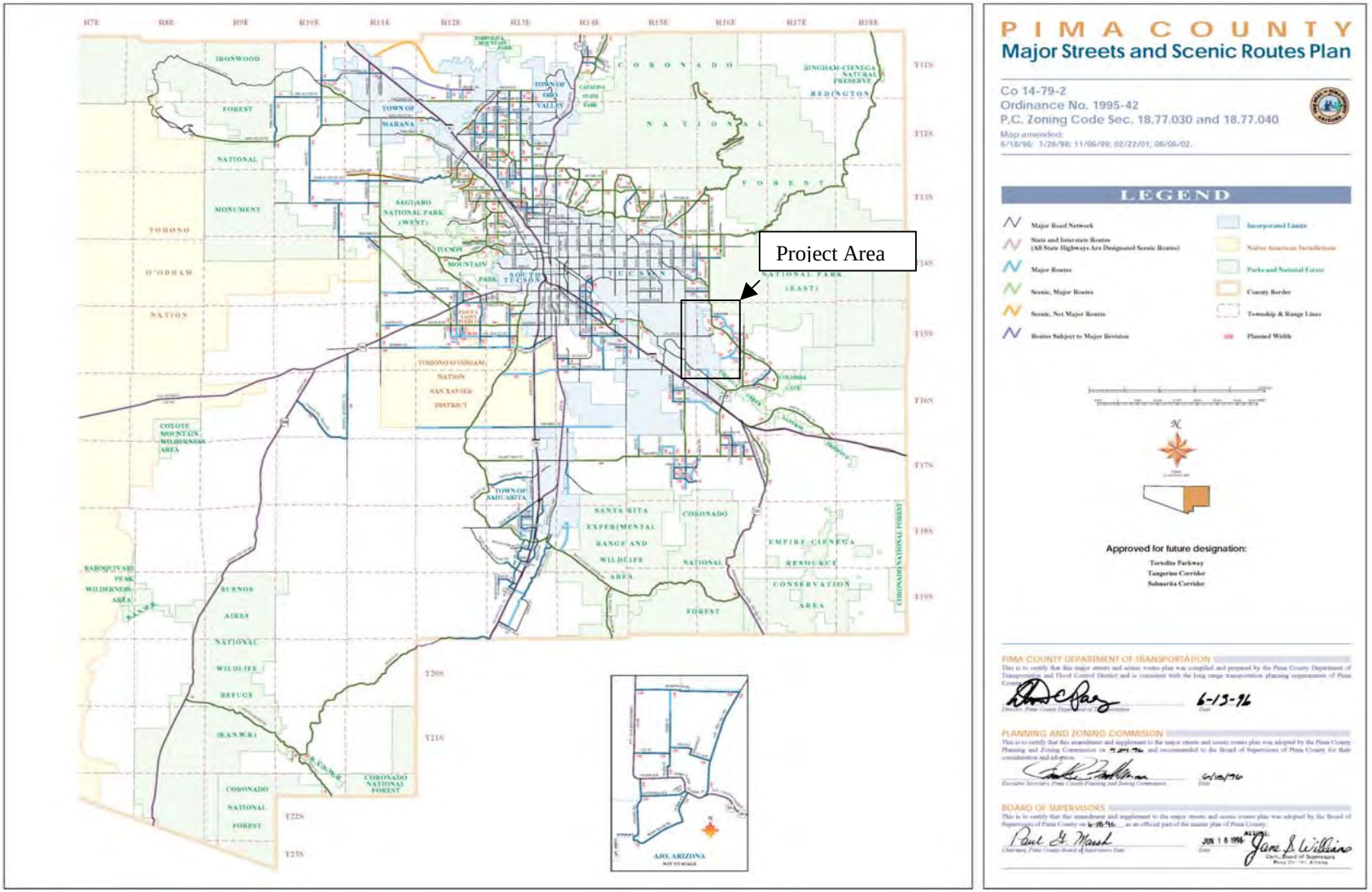
APPENDIX 4-C
Sample ESR Project Maps

Map 1: The example project area, shown in red, clearly involves three ESR criteria: (1) High Archaeological Sensitivity Zone, (2) Multiple Use or Recovery Area, and (3) Important Riparian Area.



APPENDIX 4-C, continued

Map 2: The Pima County Major Streets and Scenic Routes Plan indicates that the project area also meets the ESR criteria of being a designated Major Scenic Route.



APPENDIX 4-D
Vegetation Measurement

As part of the biological resource identification process, the vegetation of the project area should be accurately characterized so that appropriate re-vegetation can occur upon completion. The goal is to recreate the entire pre-project vegetation community as closely as possible. The current Pima County Native Plant Preservation Ordinance (NPPO) will not accomplish this because not all plants on a site are protected by the NPPO. Also, in some instances the area has been degraded prior to the start of the project, leaving no vegetation framework to adequately determine how to re-vegetate the area. The following methods utilize species diversity and density measures to accomplish the goal of vegetation re-creation.

Species diversity requires the identification of all species present in the project area. ***Density*** refers to the actual number of plants per a given area.

Steps in Measurement Process

Measuring vegetation is a two-step process as described below.

Step 1: Inventory of Protected Plant Species

Complete an inventory of all saguaros and Pima County protected tree species. Saguaros and protected trees should be assess for viability and transplantability as well as documenting size and location (in a manner similar to the Native Plant Preservation inventory requirements.) The diameter of all protected trees (including non-viable individuals) is measured with a forestry caliper (at 24 inches from the ground), and all trees greater than or equal to 3 inches are to be inventoried. For trees that have multiple stems at the point of caliper measure, the largest 3 stems are measured, and the individual is included in the inventory if the sum is greater than 3 inches. The diameter measurements are totaled for each protected species.

Mitigation of trees shall be based upon total caliper inch for each species and the existing densities as determined by the Releve Method or other approved methods (see Step 2 below). Mitigation for each species shall be calculated by multiplying 125% of the sum caliper inch by the percentage of the site that is disturbed outside of the development envelope. Replanting density must match pre-project conditions as closely as possible. The final caliper inch value is to be distributed into appropriately sized trees. For example, if the pre-project site contained ten (10) mesquite trees, all over 10 inches in diameter, it is not appropriate to replant using a larger number of smaller trees to attain the appropriate caliper inch value.

Example

- 100 caliper inch of palo verde
- 10-acre site where 25% remains disturbed outside of the development envelope, i.e., 2.5 acres of plantable area remains

Result: 100 cal inch x 25% x 125% = 31.25 cal inches that must be replaced in the 2.5 acres

Mitigation of saguaros will be 1:1. Preserve in place as many saguaros and other cactus as possible. Only those saguaros 10 feet high and under that are assessed as being viable and transplantable should be considered for salvaging. Replacement saguaros shall be in the 4 to 6 foot range. Special consideration shall be given to individual specimen species.

The Releve Method will be used to determine the seed mix, and assist the landscape designer in determining the appropriate number of other cactus and non-protected tree and shrub species that will be appropriate in the landscaping in the various vegetation entities.

Cactus not required for the revegetation should be offered to neighbors or non-profit succulent or plant organizations. Permits will be required from the Arizona Department of Agriculture for transplanting cactus protected by the Arizona Native Plant Law.

Step 2: Determine Seed Mix and Re-Planting Densities

The **Releve Method** is a widely recognized technique that vegetation ecologists use to sample an area for such variables as species diversity, cover, density, and abundance (Bonham 1989). This technique uses circular plots (releves) to obtain the information necessary to assess a vegetation community to develop appropriate re-seeding and re-vegetation parameters. The method will be employed to produce two types of information that will be used for two purposes: (1) to determine a seed mix and (2) to determine the re-planting density of Pima County protected cactus and shrub species.

This method should be applied in the spring and fall to most accurately measure the annual/ephemeral flora. If the area to be re-seeded is degraded prior to the project, this method should be applied to a nearby site with undisturbed vegetation and similar topography. Density measurements will be used to determine appropriate numbers for the re-planting of all Pima County protected cactus and shrub species.

It is crucial that the personnel conducting this method are highly skilled in plant identification, including ephemeral/annual species.

Following are the steps in the Releve Method, as modified for application to transportation construction projects:

a. **Entitation.** Once the project area is defined, field personnel visually assess how many *vegetation entities* (discrete assemblages of species) are represented. If the area is relatively homogenous, with the same assemblage of species represented throughout, then there is only one (1) entity to be sampled. In many instances, however, there will be two (2) or more discrete species assemblages. In the Sonoran Desert, a common example is an upland community with a wash running though it. The wash may contain an assemblage of species distinct from the surrounding uplands.

b. **Establishment of Plots.** Each entity will be sampled with random circular plots (releves). The appropriate number and size of these plots will depend upon the size and diversity of the project area. The larger and/or more diverse an entity is, the more and/or larger plots are

required to accurately sample the area. In a typical Arizona Uplands community in Pima County, a general rule of thumb would be a minimum of four (4) 20-foot radius plots per acre for small projects. A project area should have a minimum of five (5) plots, regardless of size.

The locations of plots must be established *randomly*. The investigator should not *choose* where to establish plots (for example, in a location convenient to the desired outcome). Instead, locations must be chosen in an unbiased fashion. Here are several approaches to accomplishing this task:

- Entities can be defined on a topographic map of the project area in the field, and then transferred to a mapping program such as Arc View. A common feature of mapping software is a random-point generator. The investigator can ask the program to randomly distribute a given number of points onto the map, and obtain Global Positioning System coordinates for those points. It is then possible to navigate to those exact coordinates in the field to set up the releves.
- Releves can be located across a project area in a systematic way by applying a grid overlay. Releves can then be located at regular intervals (for example, every 500 meters). An advantage of this method is the ability to easily add more points if necessary by adding to the grid.

c. **Data Collection.** Once at a random plot location, the center of the plot and plot boundaries are temporarily defined with flagging. Every species of plant is identified and individuals of the species are counted, including ephemeral/annual species. Unknown plants are collected and brought to the University of Arizona Herbarium or to a qualified botanist for positive identification.

Field personnel also record species present in the area that are not captured by the releves. These plants are listed in parentheses. If the releves are not capturing species that appear to be dominant in the landscape, then additional and/or larger releves are required.

Applying the Releve Method to ESR Projects

Using the Releve Method to Determine Replanting Densities

Once the releves have been completed, a master list of all species with density values is produced *for each entity sampled*. For each entity, density values are individually averaged for all species. The average values are used to determine the appropriate replanting densities per acre for tree, shrub and cactus species. Some of these values may not be used in the final landscaping plan because the Tree Caliper Measurement Method and saguaro replanting requirements will be used to determine replanting densities for species that were inventories The species list should be evaluated to exclude invasive.

See Table 1 for an example.

Using the Releve Method to Determine Seed Mix Composition

The master list is evaluated to exclude invasive or non-native species. Next, each species is evaluated for availability of seed; if there is no seed source available, then those species are omitted from consideration in the seed mix. In many cases, a particular species will be recorded as present in the area, but absent from the actual releve (indicated by parentheses). These plants are considered for inclusion in the seed mix at low levels.

The density values for all species to be included in the seed mix are totaled. In addition, most cactus species (except saguaro) are excluded because the seeds are not commercially available and live plants will be included in the replanting. The mean for each species is then divided by the total number of plants to arrive at a seed mix percentage value. These values are then adjusted for availability and size through consultation with seed experts. These values will be the basis for the finalized seed mix. It may become necessary to adjust the PLS/acre or species composition because of changes in seed availability. Table 1 is a spreadsheet that presents hypothetical releve data, including all plant species present, density values, and conversion to seed mix percentages.

In order for this process to be effective, it is imperative to contract seed suppliers ***as early as possible in order to ensure availability, especially because many of the species included are not generally collected because of lack of demand.***

Table 1. Hypothetical Releve Analysis. In this example, all large shrubs, trees, subshrubs, forbs, and grasses have been included in the seed mix (except for the invasive grass species *Pennisetum ciliare*). Re-planting densities were calculated for cactus species.

	Density (plants per 20 ft releve, 0.028 acre)					**Average (per 20 ft releve, 0.028 acre)**	% of seed mix	**Average (per 20 ft releve, 0.028 acre)**	re-planting density (per acre)
	Releve 1	**Releve 2**	**Releve 3**	**Releve 4**	**Releve 5**				
Large Shrubs and Trees									
Acacia constricta	1	0	3	1	3	**1.6**	**1.5**		
Fouquieria splendens	3	0	2	0	1	**1.2**	**1**		
Larrea tridentata	6	2	4	3	5	**4**	**3.6**		
Parkinsonia microphylla	0	0	2	4	0	**1.2**	**1**		
Prosopis velutina	0	1	2	1	0	**0.8**	**0.8**		
Cacti									
Carnegiea gigantea	0	2	0	1	0			**0.6**	**21.4**
Echinocereus fasciculatus	3	2	0	6	1			**2.4**	**85.7**
Ferocactus wislizeni	0	1	2	1	1			**1**	**35.7**
Mammillaria grahamii	4	5	8	0	5			**4.4**	**157**
Opuntia engelmanii	1	2	1	0	1			**1**	**35.7**
Opuntia versicolor	0	1	1	0	0			**0.4**	**14.2**
Subshrubs, Forbs, and Grasses									
Abutilon incanum	0	1	4	0	3	**1.6**	**1.5**		
Ambrosia deltoidea	23	15	19	24	4	**17**	**15.5**		
Bouteloua aristidoides	4	6	9	5	1	**5**	**4.5**		
Encelia farinosa	9	17	2	8	6	**8.4**	**7.6**		
Erioneuron pulchellum	55	42	30	24	10	**32.2**	**29.3**		
Lesquerella gordonii	0	11	4	8	0	**4.6**	**4.1**		
Muhlenbergia porteri	5	1	7	4	0	**3.4**	**3**		
Pennisetum ciliare	1	0	0	1	3	**0**			
Psilostrophe cooperi	2	4	6	4	0	**3.2**	**3**		
Senna covesii	1	6	4	9	0	**4**	**3.6**		
Zinnia acerosa	16	22	16	30	24	**21.6**	**20**		
					total	**109.8**	**100%**		

APPENDIX 4-E
Pima County Approved Plant Species for Environmentally Sensitive Roadways

Trees		Minimum Size
Arizona (Velvet) Ash	*Fraxinus velutina*	15 gal.
Arizona Sycamore	*Platanus wrightii*	15 gal.
Arizona Walnut	*Juglans major*	15 gal.
Arizona White Oak	*Quercus arizonica*	24" box
Blue Palo Verde	*P. florida*	15 gal.
Desert (Sweet) Acacia	*Acacia smallii*	15 gal.
Desert Willow	*Chilopsis linearis*	15 gal.
Foothill Palo Verde	*Parkinsonia microphylla*	24" box
Fremont Cottonwood	*Populus fremontii*	15 gal.
Goodding Willow	*Salix gooddingii*	15 gal.
Ironwood	*Olneya tesota*	24" box
Mesquite	*Prosopis velutina*	15 gal.
Mexican Blue Oak	*Quercus oblongifolia*	24" box
Mexican Elder	*Sambucus mexicana*	15 gal.
Net Leaf Hackberry	*Celtis reticulata*	15 gal.
Texas Mulberry	*Morus microphylla*	15 gal.
Western Soapberry	*Sapindus saponaria*	15 gal.

Shrubs and Subshrubs		Minimum Size
All Scale	*Atriplex polycarpa*	5 gal.
Arizona Rosewood	*Vauquelinia californica*	15 gal.
California Buckwheat	*Eriogonum fasciculatum*	1 gal.
Catclaw Acacia	*Acacia greggii*	5 gal.
Creosote Bush	*Larrea tridentata*	5 gal.
Desert Fern	*Lysiloma microphylla*	15 gal
Desert Hackberry	*Celtis pallida*	5 gal.
Desert Senna	*Senna covesii*	1 gal.
Fairy Duster	*Calliandra eriophylla*	5 gal.
Four-wing Saltbush	*Atriplex canescens*	5 gal.
Indigo-bush	*Dalea greggii*	5 gal.
Long-leaved Joint Fir	*Ephedra trifurca*	5 gal.
Mimosa	*Mimosa dysocarpa*	5 gal.
New Mexico Locust	*Robinia neomexicana*	5 gal.
Red Barberry	*Berberis haematocarpa*	5 gal.
Shrub Live Oak	*Quercus turbinella*	15 gal.
Wait-a-minute Bush	*Mimosa biuncifera*	5 gal.
Whitethorn Acacia	*Acacia constricta*	5 gal.

Shrubs and Subshrubs - *continued*		**Minimum Size**
Brittlebush	*Encelia farinosa*	5 gal.
California Buck-thorn	*Rhamnus californica*	5 gal.
Chuperosa	*Beloperone californica*	5 gal.
Desert Honeysuckle	*Anisacanthus thurberi*	5 gal.
Desert Lavender	*Hyptis emoryi*	1 gal.
Desert Olive	*Forestiera neomexicana*	5 gal.
Desert Zinnia	*Zinnia acerosa*	1 gal.
Golden Eye	*Viguiera deltoidea*	1 gal.
Gray-thorn, Gray-leaved Abrojo	*Zizyphus obtusifolia*	5 gal.
Hop Bush	*Dodonea viscosa*	5 gal.
Jojoba	*Simmondsia chinensis*	5 gal.
Limber Bush	*Jatropha cardiophylla*	1 gal.
Mexican Manzanita	*Arctostaphylos pungens*	5 gal.
Ocotillo	*Fouquieria splendens*	8 cane
Paper Flower	*Psilostrophe cooperi*	1 gal.
Rayless Encelia	*Encelia frutescens*	5 gal.
Rock Sage	*Salvia pinguifolia*	5 gal.
Seep Willow	*Baccharis glutinosa*	5 gal.
Silk Tassel	*Garrya wrightii*	5 gal.
Squaw Bush	*Rhus trilobata*	5 gal.
Squaw Bush	*Condalia warnockii*	5 gal.
Sugar Sumac	*Rhus ovata*	5 gal.
Triangle-leaf Bursage	*Ambrosia deltoidea*	1 gal.
Trumpet Flower	*Tecoma stans*	5 gal.
Turpentine Bush	*Ericameria laricifolia*	1 gal.
White bursage	*Ambrosia dumosa*	1 gal.
White-stemmed Milkweed	*Asclepias albicans*	5 gal.
Cacti and Other Succulents		
Banana Yucca	*Yucca baccata*	5 gal.
Barrel Cactus	*Ferocactus wislizenii*	6”
Barrel Cactus	*Ferocactus covillei*	6”
Bigelow Nolina	*Nolina bigelovii*	5 gal.
Buckhorn Cholla	*Opuntia acanthocarpa*	2’
Cane Cholla	*Opuntia spinosior*	2’
Chain-fruit Cholla	*Opuntia fulgida*	2’
Desert Night-blooming Cactus	*Peniocereus greggii*	5 gal.
Desert Spoon	*Dasylirion wheeleri*	5 gal.
Engelmann Prickly Pear	*Opuntia engelmannii*	5 pad
Golden-flowered Agave	*Agave chrysantha*	5 gal.

Cacti and Other Succulents - *continued*		**Minimum Size**
Hedgehog Cactus	*Echinocereus engelmannii*	1 gal.
Hedgehog Cactus	*Echinocereus fasciculatus*	1 gal.
Palmer Agave	*Agave palmeri*	5 gal.
Pincushion Cactus	*Mammillaria microcarpa*	1 gal.
Purple Prickly Pear	*Opuntia violacea*	5 pad
Saguaro	*Carnegiea gigantea*	4’
Soaptree Yucca	*Yucca elata*	5 gal.
Staghorn Cholla	*Opuntia versicolor*	2’
Teddy Bear Cactus	*Opuntia bigelovii*	2’

Herbs		**Lbs./Acre**
Adonis Blazing Star	*Mentzelia multiflora*	1
American Carrot	*Daucus pusillus*	1
Arizona Lupine	*Lupinus arizonicus*	1
Bluedicks	*Dichelostemma pulchellum*	1
Desert Lupine	*Lupinus sparsiflorus*	1
Desert Mallow	*Sphaeralcea ambigua*	1
Desert Mariposa	*Calochortus kennedyi*	1
Eriastrum	*Eriastrum diffusum*	1
Four O’ Clock	*Mirabilis bigelovii*	1
Gordon Bladderpod	*Lesquerella gordoni*	1
Indian Root	*Aristolochia watsoni*	1
Lance-leaved Ditaxis	*Ditaxis lanceolata*	1
Large Yellow Evening Primrose	*Oenothera primiveris*	1
Larkspur	*Delphinium scaposum*	1
Lizard Tail	*Gaura parviflora*	1
Long-capsuled Primrose	*Camissonia chamaeneroides*	1
Mexican Gold Poppy	*Eschscholtzia mexicana*	1
Orange Caltrop	*Kallstroemia grandiflora*	1
Prickly Poppy	*Argemone* sp.	1
Rock Gilia	*Gilia scopulorum*	1
Sand Verbena	*Abronia* sp.	1
Small-flowered Blazing Star	*Mentzelia albicaulis*	1
Spiderling	*Boerhaavia* sp.	1
Trailing Four O’ Clock	*Allionia incarnata*	1
Twist Flower	*Streptanthus arizonicus*	1
Virgin’s Bower	*Clematis drummondii*	1
White Desert Primrose	*Oenothera caespitosa*	1
White Prairie Clover	*Petalostemum candidum*	1

Herbs - *continued*		**Lbs./Acre**
Bigelow Linanthus	*Linanthus bigelovii*	1
Chia	*Salvia columbariae*	1
Common Horehound	*Marrubium vulgare*	1
Desert Bell	*Phacelia campanularia*	1
Desert Tobacco	*Nicotiana trigonophylla*	1
Goodding Verbena	*Verbena gooddingii*	1
Nama	*Nama demissum*	1
New Mexico Verbena	*Verbena neomexicana*	
Owl Clover	*Orthocarpus purpurascens*	1
Paintbrush	*Castilleja* sp.	1
Scorpionweed	*Phacelia crenulata*	1
Grasses and Grasslike Plants		
Alkali Sacaton	*Sporobolus airoides*	2
Arizona Cotton-top	*Digitaria californica*	1
Big Galleta	*Hilaria rigida*	3
Blue Grama	*Bouteloua gracilis*	2
Bluebunch Wheatgrass	*Agropyron spicatum*	2
Bush Muhly	*Muhlenbergia porteri*	2
Deer Grass	*Muhlenbergia rigens*	1
Feather Fingergrass	*Chloris virgata*	2
Hairy Grama	*Bouteloua hirsuta*	1
Needle and Thread Grass	*Stipa comata*	2
New Mexico Feathergrass	*Stipa neomexicana*	1
Purple Threeawn	*Aristida purpurea*	2
Red Threeawn	*Aristida longiseta*	2
Sand Dropseed	*Sporobolus cryptandrus*	3
Sideoats Grama	*Bouteloua curtipendula*	2
Slim Tridens	*Tridens muticus*	2
Southern Cattail	*Typha domingensis*	2
Spider Grass	*Aristida ternipes*	1
Spike Dropseed	*Sporobolus contractus*	2
Tanglehead	*Heteropogon contortus*	2
Three-square Bulrush	*Scirpus americanus*	1
Tobosa Grass	*Hilaria mutica*	2
Western Wheatgrass	*Agropyron smithii*	3

Inappropriate Species. *DO NOT USE THE FOLLOWING PLANTS*.	
Buffle Grass	*Pennisetum ciliare*
Downy Chess	*Bromus tectorum*
Fountain Grass	*Pennisetum setaceum*
Giant Reed	*Arundo donax*
Red Brome	*Bromus rubens*
Mediterranean/Arabian Grass	*Schismus* sp.
Wild Oat	*Avena* sp.

APPENDIX 4-F
Landscaping Guidelines

A. Plant Materials

- Comply with approved plant list with minimum allowed sizes (see Appendix 4-D)
- Encourage contract growing for plant species currently unavailable
- Plant material to be grown and stockpiled by Pima County

B. Planting Guidelines (Native Plants)

- Planting pit should be five (5) times *wider* than rootball, but no *deeper* than rootball
- Planting pit should have minimum drainage of 6 inches of water in one-half hour
- Four (4) vertical cuts about ¼ inch deep should be made 4 (four) times around rootball and twice on bottom
- Top of rootball should be level or slightly above soil surface
- Planting pit should be backfilled with approved backfill mix. Water should be allowed to settle (do not pack)
- After water is absorbed and soil settled, remainder of pit should be filled with backfill mix and lightly tamped to grade
- Do not prune unnecessarily. Pruning should be done immediately after planting. Up to 1/3 of growth should be removed, including all deadwood, sucker growth, and bruised and broken branches

Hydromulching

- Seed should be fresh, clean, and latest season's crop
- Seed rates are expressed as pounds of pure live seed per acre
- Fertilizer should be commercially produced with a guaranteed analysis of 16-20-0, ammonium phosphate
- Fiber should be virgin wood cellulose fiber with no growth or germination inhibiting factors. Ph range should be between 4.5 and 6.5
- Tackifier should be plantago organic muciloid tackifier, which is an organic muciloid liquid concentrate diluted with water and containing no agents toxic to seed germination
- Soil sulfur should be agriculture grade, 99.5 % sulfur
- Soil should be tilled to a depth of 6 inches
- All weeds and other undesirable vegetation should be uprooted
- Seedbed should be watered to a depth of at least 4 inches immediately after seeding. Water should be applied at such a rate as to prevent puddling or erosion.

Site Soil

- Topsoil and backfill should be native unamended soil, free of objectionable material and toxins harmful to plant growth
- Ph should range between 6.5 and 8.0
- Soil should be screened to pass through a 3/8 inch sieve

C. Irrigation

The purpose of irrigation zoning is to:

- Create irrigation zones based on specific water needs of plant materials
- Conserve water
- Create healthier growing environments
- Achieve higher success rates in plant longevity
- Provide more efficient long-term maintenance

Irrigation components should be standardized for ease of maintenance as follows:

- PVC in right-of-way, no drip polyline
- Low flow bubblers on trees
- Drip on shrubs/groundcover with multiport emitters
- Spray on hydroseed

APPENDIX 4-G
Visual and Aesthetic Resource Evaluation Process

The procedures outlined in this appendix include detailed and specific techniques for characterizing and evaluating visual and aesthetic resources. The implementation of specific procedures and the level of detail associated with this evaluation process should be determined on a case-by-case basis, and applied accordingly as determined in Step 1 below. Specific evaluation tables that have been included as a part of this process are presented as examples (including ratings). Such tables should be used as necessary and modified according to specific conditions.

Steps in Process

Step 1: Discovery/Identification of Visual and Aesthetic Resources

The first step in the Visual and Aesthetic Resource Evaluation (see Figure 4-6 of Chapter) includes a field review by the study team resulting in the identification and inventory of the visual elements associated with (1) viewers from and to the roadway area, (2) the setting of the project, and (3) elements of the project that will result in a change to the setting. The intent of this step is to initially characterize the visual resources, to identify those elements of the project that may have an effect on these resources, and to determine the potential level of analysis and treatment required for the project. Also during this step any specific visual practices and standards of agencies that have jurisdiction in the project area should be identified (e.g., FHWA, U.S. Forest Service, Bureau of Land Management).

Viewers

From the Roadway – Viewers from the roadway include roadway users (i.e., motorists and bicyclists), as well as viewers at special viewpoints associated with the roadway (e.g., trailheads, scenic overlooks, rest areas). When identifying roadway viewers, both directions of traffic should be considered in the evaluation. In situations where additional sidewalks or pathways are a part of the project, the associated views should also be considered.

To the Roadway – Viewers to the roadway include roadway "neighbors," who may consist of users of adjacent residences, businesses, and industrial and recreational facilities.

Setting

Landscape settings of proposed roadway projects may be natural or developed. Natural settings are those that consist of landform, vegetation, and/or water elements, and that demonstrate little if any man-made modifications or disturbance. (Natural settings may include ranching and grazing lands if they do not dominate or detract from natural conditions, i.e., over-grazing.) Developed settings include those areas in which residential, commercial, industrial, recreational, or agricultural uses (e.g., cotton fields, orchards) have been established.

Project Description

To evaluate the effects of a proposed roadway project on the setting and views from and to the roadway, project design features should be well defined. For example, projects may entail (a) the development of a new road requiring the removal of vegetation within an entire corridor area and the modification of landform through grading (cut and fill slopes), (b) only the widening of an existing roadway, resulting in selective vegetation clearing, and the use of retaining walls, or (c) only the addition of small project features to address very localized issues (e.g., barriers, landscaping guard rails, lighting, signage).

Step 2: Visual Analysis

The visual analysis begins with identifying initial visual impacts, which are based on the effects of the proposed project on the setting and views from and to the roadway and contrasted with the existing views from and to the roadway.

Viewers

The analysis of project effects on potential viewers includes the sensitivity of users with views from and to the project from key observation points, the viewing conditions, and any variables associated with those views. Collectively, this information is used to determine the overall visibility levels (high, moderate, or low) of users with views from and to the roadway.

Viewer Sensitivity – Viewer sensitivity measures peoples' concern for change in scenic quality or the image of a particular setting in which a roadway is being developed, modified, or improved. Criteria for the identification of viewer sensitivity include user type (e.g., transportation, residential, recreational); user volume (high, moderate, or low); public interest (national, state, or local); and association with special areas or unique viewer expectations (e.g., scenic highways, special recreational, historic areas). Table 1 shows how these criteria may be used to identify sensitivity levels (high, moderate, or low).

Viewing Conditions – Viewing conditions are defined by a set of viewer variable criteria that assists in characterizing views from and to the roadway with the project in place. Table 2 illustrates three possible condition levels (high, medium, low) associated with the following viewer variable criteria:

- Viewer Orientation, including parallel versus perpendicular views from the road
- Duration of View, including consideration for roadway speed limit
- View Distance, near foreground to background
- Visibility/Edge Condition, open, filtered or screened

Visibility Level Synthesis – Using the criteria presented in Tables 1 and 2, a synthesis of overall visibility levels is assigned to segments of the road characterizing views from and to the roadway area, as well as from specific viewing locations associated with the roadway (e.g., overlooks and trailheads). Table 3 presents a sample visual level synthesis.

Table 1
Sample Sensitivity Level Evaluation

Location (Key Observation Points)	User Type[1]	Use Volume	Public Interest[2]	Special Areas	Sensitivity Level
Travel Routes/Trails					
U.S. Highway 17	Res, Rec, SS	High	N,S,L	–	High
Lower Bushcreek Road	Res, Rec, SS	High	N,S,L	Planned Scenic Byway	High
Big Canyon Road	Rec, SS	High	N,S,L	Planned National Recreation Area	High
County Road 1 (Historic Tour)	Res, Rec, SS	High	N,S,L	Bar "S" Historic Ranch	High
Use Areas					
Sonoran Monument	Rec, SS	High	N,S,L	–	High
USFS Campgrounds					High
Big Mountain	Rec, SS	Moderate	N,S,L	–	
Green Meadows	Rec, SS	Moderate	N,S,L	–	
Creekside	Rec, SS	Moderate	N,S,L	–	
Campground	Rec, SS	Moderate	N,S,L	–	
Red Mountain Campground					
Travel Routes/Trails					
Cedar/Trail Creek Road	Res, Rec, SS	Moderate	S,L	–	Moderate
Lower Wildflower Road	Res, Rec, SS	Moderate	L	–	Moderate
Wildhorn Road	Res, Rec, SS	Moderate	L	–	Moderate
Fox Flats Road	Comm	Moderate	S????, L	–	Moderate
Arizona Gulch Road	Res, Rec, SS	Moderate	L	–	Moderate
Divide Road N. (County 2)	Res, Rec, SS	Moderate	L	–	Moderate
Travel Routes/Use Areas					
Highline Business Park	Comm	Moderate	L	Industrial Area	Low
Business Loop 156	Truck route	High	L	Light Industrial Area	Low

[1]*Residential (Res), Recreation (Rec), Sight Seeing (SS), Commuters (Comm)*
[2]*National (N), State (S), Local (L)*

Table 2
Sample Viewing Condition Evaluation

Viewer Variable Criteria	Viewing Condition Level		
	High	**Moderate**	**Low**
Viewer Orientation – perpendicular vs. parallel views	Viewer attracted, or directed specifically to or from the proposed roadway action	Viewer is neither strongly attracted/directed toward nor away from the location of the proposed roadway action	Viewer attracted or directed away from the location of the proposed roadway action
Duration – considers speed of travel	View is continual or fixed (e.g., residential areas, resorts)	View is intermediate or temporal (e.g., roads and highways, parks, overlooks, campgrounds, commercial areas)	View is brief (e.g., perpendicular road crossings)
Distance – views from and to the roadway	Views from or to the roadway are within the near foreground area (immediate right-of-way), and the foreground area (edge of right-of-way to 0.25 mile)	Views from or to the roadway are within the middle-ground area (0.25 to 3 miles)	Views from or to the roadway are within the background area (3 to 5 miles and beyond)
Visibility – the "edge condition" of the roadway	Views from or to the roadway are open	Views from or to the roadway are partially screened or filtered	Views from or to the roadway are screened or blocked

Table 3
Sample Visibility Level Synthesis

	Viewer Variables		
Location *(Key Observation Point)*	**Sensitivity Level**	**Viewer Orientation**	**Distance**
Wildhorn Road	M	M	L
Sonoran Monument	H	M	H

Setting

Analysis of the project setting includes the characterization of similar patterns of landform, vegetation, land use, and unique features by units. Characterizing these factors permits an evaluation of the potential effect of the proposed roadway project in conjunction with scenic quality (i.e., natural setting), or visual image types (i.e., developed settings).

Natural Setting – Natural landscapes or settings may be characterized in units based on similar patterns of the following elements:

- *Landform*: Topography becomes more interesting as it gets steeper, more massive, or more severely or universally sculpted. Outstanding landforms may be monumental (mountains) or subtle, including low rolling hills or flat valley bottoms, displaying few, if any, interesting landscape features.

- *Vegetation*: Plant life is considered in terms of the variety of patterns, forms, and textures it creates, including short-lived displays when they are known to be recurring or spectacular. Consideration may also be given to smaller scale vegetation features that add striking and intriguing detail elements to the landscape (e.g., Joshua trees, saguaro cactus, ponderosa pine).
- *Water*: Water adds movement or serenity to a scene. The degree to which water dominates the scene may often be the primary consideration in selecting a scenic quality rating (particularly in Arizona).
- *Color*: Overall color(s) of the basic components of the landscape (e.g., soil, rock, vegetation) as they appear during seasons or periods of high use is considered.
- *Scarcity:* Scarcity provides an opportunity to give added importance to one or all of the scenic features that appear to be relatively unique or rare within the region of the proposed roadway project.
- *Cultural Modifications:* Cultural modifications to the landform/water and vegetation and in the addition of structures should be considered for possible enhancement of or detraction from the scenery in a natural setting. Such modifications may complement or improve the scenic quality of a unit or, conversely, may become a negative intrusion and detract from the scenery in a natural setting. Ranching activities, hacienda, and historic settings should all be considered.

The six natural setting elements above are combined (i.e., added) to determine the overall scenic quality of the natural setting as illustrated in Table 5. Three potential ranges of scenic quality are used to express the landscape scenic value of each unit within the context of views from and to the road in a natural setting:

- *Distinctive Scenic Quality:* These units are natural areas containing the greatest diversity of features such as landform, vegetative patterns, water forms, and rock formations that are of an unusual or outstanding visual quality not common in the surrounding area.
- *Common Scenic Quality:* These units are natural areas containing features with a variety of landforms and vegetative patterns that tend to be common throughout the surrounding area and are not outstanding in visual quality.
- *Minimal Scenic Quality:* These units are natural areas characterized by little or no variety of landform and vegetation, and may include specific locations that have been culturally modified in a negative fashion.

It is important to note that the terms used to define the range of scenic quality may need to be modified for public outreach since, for example, an individual living in an area of "minimal scenic quality" may not consider it to be minimal.

Developed Settings – The visual image of developed settings (counterpart to scenic quality in a natural setting) is based on types of use and development patterns that are defined by visual character, planning concepts, and viewer orientation. Visual character regards the composition of design elements including form, line, color, and texture. These elements influence visual dominance and focus within each setting. The planning concept is primarily based on circulation

and building types. Circulation and building types act as major organizing elements that structure the visual environment. Circulation types may include gridded, curvilinear, loop-road, and cul-de-sacs. Building types may be clustered, detached, or attached building placements. Orientation of views from these areas is based on the planning concept. Inward oriented patterns tend to be structured, often with a layout that responds to a central focus or feature. Outward oriented development patterns often have a random or open character.

In general, these patterns may be grouped and classified into the following five image types:

- *Residential Image Type:* A variety of development patterns that display an integration of the visual character and planning concept. There is often a strong repetition of design elements that are organized around circulation patterns.
- *Commercial Image Type:* Clustered development patterns with high visibility and often orientated specifically to the roadway. Structures and architectural treatments are often highly unified.
- *Park–Like Image Type:* Open and landscaped areas that dominate the development pattern, including active recreation areas as well as other greenbelt open space. Many of the light industrial, office park, and institutional development patterns fit this context as well. In these patterns, a central building or group of buildings generally are placed in an open space setting giving the development a park-like image.
- *Industrial Image Type:* Development patterns in which structures dominate the visual character. Buildings and facilities are often large scale and complex. Open space treatment is limited primarily to the perimeter of the development and is not integrated into the overall planning concept.
- *Open/Agricultural Image Type:* Patterns that lack formal development and are generally vacant, rural, or used for crop production. The agricultural image may vary according to the time of year and type of crop.

Similar to the natural setting, special consideration may be given to those image types that are of an historic nature or that exhibit unique architectural features. For example, a commercial area in a historic downtown location should be given special consideration.

Visual Contrast

The visual contrast analysis is a systematic process that is used to analyze the potential visual impacts of the proposed roadway project and associated activities. The degree to which the roadway project affects the visual and aesthetic quality of a natural or developed setting depends on the contrast between the setting with the project in place and the existing setting without the project in place. The contrast can be measured by comparing the design features associated with the project description with the major features in the existing setting (natural or developed). The basic design elements of form, line, color and texture are used to make this comparison and to describe the visual contrast created by the project in a natural setting, while the effects to image type are used to define contrast in developed areas.

Table 5
Sample Scenic Quality Evaluation Chart

Key Factors	Scenic Quality Rating Criteria and Score*		
Landform	High vertical relief as expressed in prominent cliffs, spires, or massive rock outcrops, or severe surface variations or highly eroded formations including major badlands or dunes, or detail features dominant and exceptionally striking and intriguing. **5**	Steep canyons, mesas, buttes, cinder cones, and drumlin, or interesting erosion patterns or variety in size and shape of landforms, or detail features that are interesting though not dominant or exceptional. **3**	Low rolling hills, foothills, or flat valley bottoms, or few or no interesting landscape features. **1**
Vegetation	A variety of vegetative types as expressed in interesting forms, textures, and patterns. **5**	Some variety of vegetation, but only one or two major types. **3**	Little or no variety or contrast in vegetation. **1**
Water	Clear and clean appearing, still, or cascading white water, any of which are a dominant factor in the landscape. **5**	Flowing or still, but not dominant in the landscape. **3**	Absent or present, but not noticeable. **0**
Color	Rich color combinations, variety or vivid color or pleasing contrasts in the soil, rock, vegetation, and water. . **5**	Some intensity of variety in colors and contrast of the soil, rock, and vegetation, but not a dominant scenic element. **3**	Subtle color variations, contrast, or interest, generally mute tones. **1**
Influence of Adjacent Scenery	Adjacent scenery that greatly enhances visual quality. **5**	Adjacent scenery moderately enhances overall visual quality. **3**	Adjacent scenery has little or no influence on overall visual quality. **0**
Scarcity	One of a kind, unusually memorable, or very rare within region. Consistent chance for exceptional wildlife or wildflower viewing, etc. **5**	Distinctive, though somewhat similar to others within the region. **3**	Interesting within the setting, but fairly common within the region. **1**
Cultural Modifications	Modifications add favorably to visual variety (may include ranching or historic features). **5**	Modifications add little or no visual variety to the area. **0**	Modifications are extensive and scenic qualities are substantially reduced. **-4**

Scenic Quality
Distinctive = 19 or more
Common = 12 to 18
Minimal = 11 or less

This analysis process provides a means for determining the visual impacts and for identifying the treatment and measures to mitigate these impacts (see Step 3 below). Where possible this process should be employed early on to assist as a design tool during both project planning and design.

The steps in the visual contrast analysis for natural and developed settings are as follows:

Natural Setting – The steps for evaluating the contrast in a natural setting include the following:

- *Obtain Project Description:* To effectively evaluate the visual impacts of a proposed new or modified roadway, obtain a detailed project description. The level of detail in the description should be commensurate with the type of project proposed.
- *Select Key Observation Points (KOPs):* The contrast rating should be done from the most critical viewpoints associated with views from and to the roadway. Factors that should be used in selecting critical viewpoints are a by-product of the viewer analysis (see Step 2 in this Appendix 4-F) and should include the number and sensitivity of viewers and the orientation and duration of views.
- *Prepare Visual Simulation (Optional):* Visual simulation is an invaluable tool for effective evaluation of impacts. Simulations are strongly recommended for potentially high impact or special projects. The level of sophistication should be commensurate with the quality of the visual resource and the severity of the anticipated impact. Simulations help public groups visualize and respond to roadway development proposals, which makes public participation in the planning process more effective.

The contrast rating process should be completed in the field from the selected KOPs and/or through the use of photographs taken from KOP locations. The process may be undertaken by a landscape architect team that is trained in visual resource assessment or by an individual landscape architect, depending on the sensitivity and impacts of the project and the availability of qualified personnel.

The contrast rating is completed by determining the degree of contrast (e.g., strong, moderate, weak, or none) that the introduction of roadway design features could have on the features of the natural setting (e.g., landform/water, vegetation, structures). As illustrated in Table 6, this rating is accomplished by evaluating changes in the setting to form, line, color, and texture for each of the design features. In general, the contrast ratings are expressed as follows:

- *No Contrast:* Design features associated with the proposed roadway are not visible or perceived from or to the roadway.
- *Weak Contrast:* Design features associated with the proposed roadway can be seen but do not attract attention to views from or to the roadway.
- *Moderate Contrast:* Design features associated with the proposed roadway begin to attract attention and begin to dominate the views from or to the roadway.
- *Strong Contrast:* Design features associated with the proposed roadway cannot be overlooked and dominate views from or to the roadway.

Table 6
Sample Visual Contrast Rating Worksheet

Project Information													
Project Name: _____													
Key Observation Point: _____													
Date: _____													
Existing Landscape Characteristics													
	Land/Water				**Vegetation**				**Structures**				
Form													
Line													
Color													
Texture													
Proposed Activity Description													
	Land/Water				**Vegetation**				**Structures**				
Form													
Line													
Color													
Texture													
Contrast Rating □ Short Term □ Long Term													
DEGREE OF CONTRAST	**FEATURES**												*Levels of change*
	Land/Water Body				**Vegetation**				**Structures**				□ Very Low □ Low □ Moderate □ High
	Strong	**Moderate**	**Weak**	**None**	**Strong**	**Moderate**	**Weak**	**None**	**Strong**	**Moderate**	**Weak**	**None**	*Does project design meet visual resource management objectives? (if applicable)* □ Yes □ No Explain. (Continue on reverse, if necessary)
FEATURES **Form**													*Additional mitigating measures recommended* □ Yes □ No (If "yes," describe. Continue on reverse side if necessary)
Line													
Color													
Texture													

The results of the contrast analysis may be combined with the viewer visibility levels (Table 3) and used to determine the level of change, or visual impact that the proposed project will have on the natural setting as viewed from and to the roadway (Table 7).Furthermore, the contrast analysis will assist in identifying design treatments or mitigation measures that will reduce the visual impacts to an acceptable level and/or enhance the natural setting. If the project is located on land administered by the U.S. Bureau of Land Management or the U.S. Forest Service, the contrast analysis is used to determine whether a project complies with agency visual management objectives.

Table 7
Sample Visual Impact Model

	Overall Viewer Visibility Levels		
Visual Contrast	**High**	**Moderate**	**Low**
High	High Impact	High Impact	Moderate Impact
Moderate	High Impact	Moderate Impact	Low Impact
Low	Moderate Impact	Low Impact	Low Impact

Developed Setting – Similar to the evaluation of contrast in the natural setting, evaluating the contrast in developed areas also requires the definition of the design features associated with the project description. In developed settings, this often may include the use of walls and other structural treatments, as well as consideration for detailed design elements including signage, lighting, associated pedestrian facilities, and landscape treatments.

These design features are then analyzed in conjunction with the visual image types previously identified, and used to document effects to the following:

- *Circulation:* Do the design features associated with the proposed roadway disrupt existing circulation patterns and access to any of the image types associated with the developed setting?
- *Structural:* Do the design features associated with the proposed roadway require structural removal, or affect existing building location and design continuity?
- *Open Space Modifications:* Do the design features associated with the proposed roadway result in the removal or alteration of existing open space within or surrounding the image type?
- *Viewer Orientation:* Do the design features associated with the proposed roadway change significant views either from or to the roadway, including the consideration of effects on viewer orientation within each image type?

Using this information, the impacts may be summarized to discuss the modification to the development pattern or visual image, and effects to views from and to the roadway.

Step 3 - Design Treatment or Mitigation Measures

The purpose of this step of the Visual and Aesthetics Resource Evaluation Process is to identify potential treatment options that may be utilized to enhance viewing conditions and/or address the impacts to views from and to the roadway as previously discussed. This step focuses specifically on the selection of relevant design elements or treatments to mitigate effects; the evaluation of the effects of the measures on addressing visual and aesthetic opportunities and impacts, and the prioritization of identified treatments/mitigation measures.

As described earlier and indicated in Figure 1, this is a "circular" portion of the process that allows for the identification of alternative plans, including design treatments/mitigation measures that are evaluated based on (1) effects to the visibility level associated with sensitive views, and (2) ability to reduce contrast of proposed roadway design features in either a natural or developed setting and to enhance the overall aesthetic of the roadway corridor.

Examples of design treatment and mitigation measures that may be applied to different types of roadway projects are described in Section IV, Mitigation Tools, of this guide.

MEMORANDUM

Department of Transportation

DATE: July 6, 2010

TO: Consultants with current or future DOT contracts

FROM: Ellen Barth Alster, RLA, LEED AP, Senior Landscape Architect

SUBJECT: Update to Step 1 of Appendix 4D of the Environmentally Sensitive Roadway Design Guidelines, Pima County DOT Roadway Design Manual

This memo is an update to both the Introduction and Step 1: Inventory of Protected Plant Species in Appendix 4D of the Environmentally Sensitive Roadway Design Guidelines. It shall substitute for the existing sections. The new name for this section shall be "Step 1: Inventory and Mitigation Calculations for Protected Plant Species"

Introduction

ESR roadways are designed and maintained to preserve the natural character and vegetation density of the area and provide habitat for specific species. The objective is to leave the landscape as natural appearing as possible. Every effort should be made to revegetate with plant species that were removed and/or are commonly found in the project environment, matching density, relative location patterns (e.g. small cactus under shrubs), slope and soil preferences. This process involves inventorying and measuring existing vegetation. The next step is calculating mitigation requirements based on the inventory. These inventories shall be used as a basis for recreating the existing plant communities in new roadway landscaping. They are not intended to be used for plant salvage.

The two types of required Vegetation Measurement are listed below. The first inventory is of all saguaros and Pima County Protected Trees over 3" in caliper (the only exception to the 3" requirement is acacias - only acacias over 8" caliper are required to be inventoried). This inventory is done for the entire project area to be disturbed by construction. The second type of inventory is a sampling which is used to determine densities and types of shrubs, cacti, succulents, and seed mixes.

Inventory Type	What to Inventory	Inventory Area	Inventory Purpose
Saguaros and Pima County Protected Trees	○ All Saguaros ○ All Pima County Protected Trees > 3" caliper (see list under Step 1 below)	Entire disturbed project area of site (cut and fill limits) plus 10' beyond these limits	○ To determine number and sizes of saguaros that should be replaced ○ To determine replacements for Pima County protected tree species
All Other Plants	All plants in determined sampling area. Shall include each specific type of plant community in the project area.	Circular sampling areas (releves). These vary in size and quantity according to the project.	○ To determine seed mix ○ To determine replanting density of Pima county protected cactus and shrub species. This value shall be used as a guide in replanting the remainder of the species.

Step 1: Inventory of Protected Plant Species

A. Determine ESR Multiplier by the following method:

- Calculate disturbed area of project. Disturbed area of project is defined as 10' offset from the project cut and fill limits.
- Calculate the plantable area. Plantable area is defined as the disturbed project area that can be planted with trees and saguaros. It excludes the following:
  - Road
  - Unpaved area between and curb and sidewalk
  - 10' offset from water and sewer lines and manholes
  - Medians
  - 10' offset from pavement edge if no curb
  - Sight Visibility Triangle (SVT)
  - Drainage structures
- ESR multiplier = plantable area / disturbed project area

B. Complete a full inventory of the entire disturbed project area for saguaros and Pima County protected tree species. These plants include:

Scientific Name	Common Name	Minimum Size
Acacia constricta	Whitethorn Acacia	8" Caliper
Acacia greggii	Catclaw Acacia	8" Caliper
Carnegiea gigantea	Saguaro	All
Chilopsis linearis	Desert Willow	3" Caliper
Celtis reticulata	Canyon Hackberry	3" Caliper
Olneya tesota	Ironwood	3" Caliper
Parkinsonia floridum	Blue Palo Verde	3" Caliper
Parkinsonia microphyllum	Foothills Palo Verde	3" Caliper
Prosopis velutina	Velvet Mesquite	3" Caliper
Prosopis pubescens	Screwbean Mesquite	3" Caliper

Notes:

- Only the species listed above are required to be inventoried and only the disturbed area needs to be inventoried.
- If the entire site happened to be inventoried including non-disturbed areas, the trees in the non-disturbed areas should not be included in the total caliper inches.

Assess and document the following for each tree:

1. Caliper
   - Measure 24" above ground with forestry caliper
   - For multi-trunked species, the largest 3 trunks are measured. The species is included if the sum of the trunks is greater than or equal to 3"
2. Location
   - GPS coordinate points should be recorded for each tree species.

C. Calculate mitigation requirements for protected trees and saguaros

Trees:

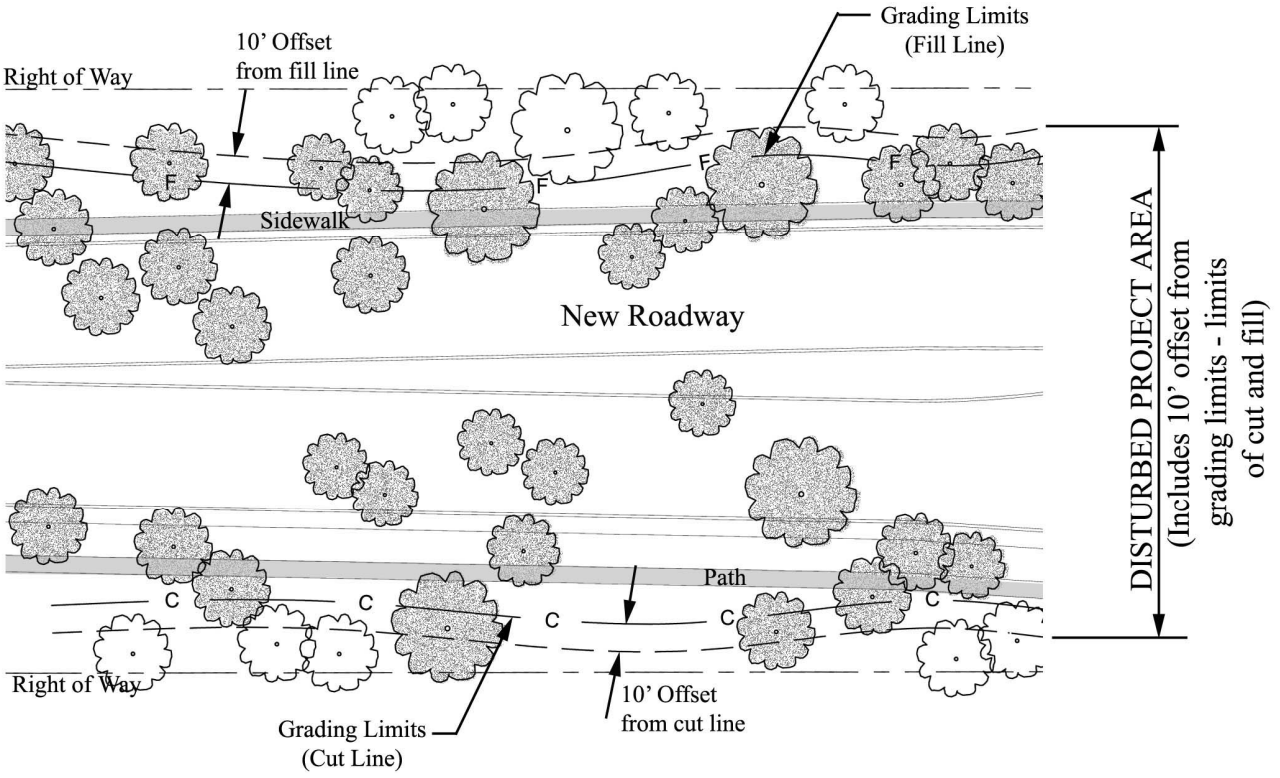
- Add up total caliper inches for each species of tree in the project area that will be disturbed only. Do not include caliper inches for trees in undisturbed areas that will not be impacted by development. (SEE DIAGRAM BELOW)
- Mitigation/species = Total Caliper inches x 125% x ESR ratio

Example:

- 100 caliper inch of palo verde in a disturbed site area of 10 acres. (The overall project area r/w to r/w may be larger than these 10 acres, but **only** the caliper inches in the ***disturbed area*** are counted).
- Only 2.5 acres of the 10 acres are plantable (the rest is roadway, clear zone, drainage, etc.)

Result: 100 cal inch x 125% x ESR multiplier = 31.25 cal inches that must be replaced in the 2.5 acres of disturbed acres

NOTE: ESR Multiplier = Plantable Area/Disturbed Project Area or 2.5 acres/10 acres = 25%



Tree Legend

Tree within limits of disturbed project area (caliper of this tree to be counted in total caliper inches)

Tree outside of limits of disturbed project area (caliper of this tree is NOT counted)

Saguaro:

- Mitigate saguaros at 1:1
- Saguaros will be replaced with replacement saguaros that are as close in height to the original saguaro being removed up to an 8' maximum height for replacement saguaros.
- Replacement standards will be as follows:

Inventoried Saguaro	Minimum Replacement Size
0-2'	1-2'
2-4'	2-4'
4-6'	4-6'
6-8'	6-8'
Over 8'	8' maximum ht.

Example:

- Site contains 10 saguaros. See the table below for replacement sizes.

Inventoried Saguaros	Height of Inventoried Saguaros	Minimum Replacement Size
1	10'	8'
2	12'	8'
3	6'	4-6'
4	4'	4-6'
5	4'	4-6'
6	8'	6-8'
7	2'	2-4'
8	5'	4-6'
9	7'	6-8'
10	15'	8'

D. Convert Total Caliper Inches for Required Tree Mitigation

The final caliper inch value for protected tree species is to be distributed into appropriately sized trees to the extent possible, based on plant availability. A demonstrated effort must be made to mitigate using a variety of plant sizes.

Example:

For a given project, it is determined that 31.25" of caliper inches for Parkinsonia floridum (Blue Palo Verde) need to be replaced. The total inventoried plants = 100 caliper inches. They are originally distributed as follows:

ORIGINAL TREE INVENTORY

Tree #	Tree Species	Caliper Inches
1	Parkinsonia floridum	18
2	Parkinsonia floridum	16
3	Parkinsonia floridum	12
4	Parkinsonia floridum	9
5	Parkinsonia floridum	9
6	Parkinsonia floridum	8
7	Parkinsonia floridum	7
8	Parkinsonia floridum	6
9	Parkinsonia floridum	5
10	Parkinsonia floridum	4
11	Parkinsonia floridum	3
12	Parkinsonia floridum	3
Total Caliper Inches =		**100**

In order to distribute the replacement mitigation trees into a variety of sizes, determine the original distribution of sizes:

DISTRIBUTION OF TREE SIZES IN ORIGINAL INVENTORY

Size ranges	# of Trees	Percentage as Total # of Trees	Total # Required Caliper Inches
> 12"	2	2 trees/12 trees =**17%**	17% x 31.25 =**4.8**
8-12"	3	3 trees/12 trees =**25%**	25% x 31.25=**7.2**
6-8"	3	2 trees/12 trees = **25%**	25% x 31.25=**7.2**
< 6"	5	5 trees/12 trees = **42%**	42% x 31.25 =**12.0**
Totals		**100%**	**31.3**

The next step, once it is determined how many caliper inches are in each size range, is to translate these ratios into sizes of plants that are commercially available. The largest size container available is assumed to be 48" box, with (4) different sizes of plants to be used.

CALCULATING DISTRIBUTION OF TREE SIZES*

Original Caliper Size of Tree	Replacement Container Size	Caliper Inches per Container	Required Caliper Inches/Caliper Inches per Container	Actual # of Trees per each container size
>12".	48" Box	6	4.8/6=**.8**	**1**
8-12"	36" Box	4	7.2/4=**1.8**	**2**
6-8"	24" Box	2	7.2/2.5=**2.9**	**3**
<6"	15 Gal.	1	12/1=**12.0**	**12**

***The largest caliper tree sizes shall be planted 100' within either side of wash areas**

In the process of distributing the required caliper inches among container grown plants, use the standards specified below:

Container Size Tree	Caliper Inches per Container
15 Gal.	1
24"Box	2.5
36" Box	4
48" Box	6

This method assumes a variety of sizes is commercially available. In the event that the required tree species and saguaros cannot be found in the required sizes, the consultant shall proceed by doing the following:

1. Submit a list of nurseries contacted to Pima County's Landscape Architect.

2. Upon reviewing this list, the landscape architect may require additional plant sources be contacted

3. The County Landscape Architect will make a final determination that all possible tree sources have been contacted before allowing smaller tree sizes to be used to meet the ESR requirement or to allow substitution of tree species

4. It is recognized that plant availability may change between the time construction plans are done and the time the project is built. Therefore, if the tree species and sizes specified on the plans are not available at the start of construction, the contractor must verify this by submitting a list of nurseries contacted to the county landscape architect. The county landscape architect may advise one of the following:

    a) Require additional nurseries to be contacted

    b) Make an adjustment to the trees required based on caliper sizes available

    c) Allow alternate species to be used for tree mitigation. Under no circumstance will alternate species be allowed to be used to mitigate for ironwood trees (Olneya tesota).

E. Allow for Plant Salvage:

For plants in the right of way that will conflict with new construction, PCDOT is providing the opportunity for them to be salvaged by other government agencies and non-profit native plant organizations. Permits will be required from the Arizona Department of Agriculture for transplanting all plant material protected by the Arizona Native Plant Law. PCDOT Right of Way Use Permits will need to be obtained prior to any work being performed it the right of way.