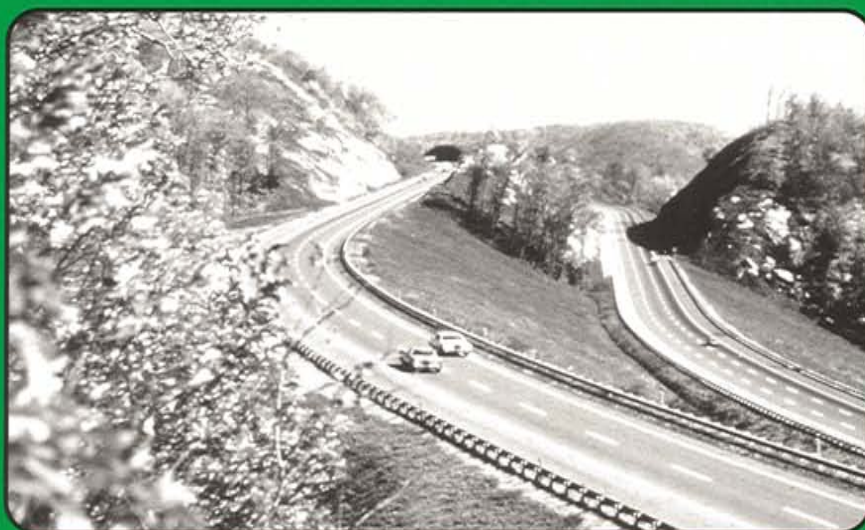


A Guide for Transportation Landscape and Environmental Design



Prepared by the
AASHTO Highway Subcommittee on Design
Task Force for Environmental Design

June 1991



Published by the

American Association of State
Highway and Transportation Officials

A Guide for Transportation Landscape and Environmental Design

**Prepared by the
AASHTO Highway Subcommittee on Design
Task Force for Environmental Design**

June 1991



**Published by the
American Association of State
Highway and Transportation Officials
444 North Capitol Street, N.W.
Suite 225
Washington, D.C. 20001**

©Copyright 1991 by the American Association of State Highway and Transportation Officials.
All Rights Reserved. This book, or parts thereof, may not be reproduced in any form without
written permission of the publisher.

ISBN 1-56051-009-0

Printed in the United States of America.

American Association of State Highway and Transportation Officials

1990 Executive Committee

<i>President:</i>	Kermit Justice, Delaware
<i>Vice President:</i>	Hal Rives, Georgia
<i>Secretary/Treasurer:</i>	Clyde E. Pyers, Maryland
<i>Immediate Past President:</i>	James P. Pitz, Michigan

Elected Regional Members:

<i>Region I</i>	Dana Connors, Maine, 1990 Howard Yerusalim, Pennsylvania, 1991
<i>Region II</i>	Neil Wagoner, Louisiana, 1990 John R. Tabb, Mississippi, 1991
<i>Region III</i>	Bernard Hurst, Ohio, 1990 Darrel Rensink, Iowa, 1991
<i>Region IV</i>	Garth F. Dull, Nevada, 1990 Eugene Findlay, Utah, 1991

Chairpersons of Standing Committees:

Duane Berentson, Washington, *Administration*
Frederick P. Salvucci, Massachusetts, *Planning*
James P. Pitz, Michigan, *Highways*
Ronald Fieldler, Wisconsin, *Highway Traffic Safety*
Franklin E. White, New York, *Water*
Ben G. Watts, Florida, *Aviation*
Ray D. Pethtel, Virginia, *Public Transportation*
Horace B. Edwards, Kansas, *Rail*
Robert N. Bothman, Oregon, *Research*
Arthur J. Rock, Jr., Vermont, *Special Committee of Commissioners and Boards*

Ex Officio Members:

<i>Past Presidents:</i>	Leno Menghini, Wyoming John R. Tabb, Mississippi
<i>Secretary of Transportation:</i>	Samuel K. Skinner
<i>Executive Director:</i>	Francis B. Francois

AASHTO 1990 Task Force for Environmental Design

Chairman: Robert P. Mickelson, Arizona
Vice Chairman: Raymond D. Richter, Delaware
Secretary: Thomas O. Willett, FHWA

Fred W. Bowser - *Pennsylvania*
—Represented by: Wayne Kober
Robert P. Mickelson - *Arizona*
William M. DuBose III - *South Carolina*
Charles Raymer - *Kentucky*
Eb Engelmann - *Oregon*
Raymond D. Richter - *Delaware*
David H. Fasser - *New York*
Charlie Rountree - *Idaho*
Ben Hark - *West Virginia*
Thomas O. Willett - *Washington, D.C.*,
—Represented by: Larry King
Roger M. Hill - *Minnesota*,
—Represented by: Lawrence Foote
Ho-Lum Wong - *Michigan*
Ed Kress - *California*
Raymond D. Richter - *Delaware*

AASHTO 1990 Highway Subcommittee On Design

Chairman: Byron C. Blaschke, Texas

Vice Chairman: Robert W. Gubala, Connecticut

Secretary: Thomas Willett, FHWA

Alabama, Don Arkle, Ray D. Bass
Alaska, Steve Sisk, Timothy Mitchell
Arizona, Robert P. Mickelson, Dallis B. Saxton
Arkansas, Bob Walters, Paul DeBusk
California, Walter P. Smith, Karl Kampe
Colorado, James E. Siebels, Kenneth F. Mauro
Connecticut, Daniel Coffey, Earle R. Munroe
Delaware, William S. Scarborough, Raymond Harbeson
D.C., Gary Burch
Florida, Bill Deyo
Georgia, Walker Scott, Hoyt J. Lively, Charles Lewis
Hawaii, Edward Y. Asato
*Idaho,**Richard Sorenson, Robert R. Elvin
Illinois, Andrew Gazda, Don Wolaver
Indiana, Gregory L. Henneke, David H. Andrews
Iowa, George F. Sisson
Kansas, Bert Stratmann, James Brewer
Kentucky, Glen Kelly, C.S. Raymer
Louisiana, Charles M. Higgins, William Hickey
Maine, Alan L. Smith
Maryland, Anthony M. Capizzi, Robert D. Douglass
Massachusetts, Michael W. Swanson
Michigan, Ho-Lum Wong
Minnesota, Roger M. Hill
Mississippi, E. Lamar Smith, Wendel T. Ruff
Missouri, Frank Carroll, J.F. Roberts
Montana, Stephen C. Kologi, David S. Johnson
Nebraska, Gerald Grauer, Jess E. Truby
Nevada, Michael W. McFall, Steve R. Oxoby
New Hampshire, Gilbert S. Rogers
New Jersey, Kenneth Afferton, Charles A. Goessel
New Mexico, J.L. Pacheco
New York, J. Robert Lambert, Phillip J. Clark
North Carolina, D.R. (Don) Morton, J.T. Peacock, Jr.
North Dakota, David K.O. Leer, Ken Birst
Ohio, Everett J. Schaefer, Theodore J. Stitt
Oklahoma, Bruce E. Taylor, Richard Hankins
Oregon, Duane O. Christensen
Pennsylvania, Fred W. Bowser
Puerto Rico, Efrain Irizarry



Rhode Island, Edmond Parker
South Carolina, Robert L. White, William M. DuBose
South Dakota, Lawrence L. Weiss, Wallace L. Larsen
Tennessee, Ken Wynne, Clellon Loveall
Texas, Frank D. Holzmann, Roger G. Welsh
U.S. DOT, Robert Bates (FAA), Thomas O. Willett (FHWA)
Utah, Les Jester, Stephen Noble
Vermont, Robert M. Murphy, Donald H. Lathrop
Virginia, E.C. Cochran, Jr., R.E. Atherton
Washington, E.R. (Skip) Burch
West Virginia, Norman Roush, Randolph Epperly
Wisconsin, Joseph W. Dresser
Wyoming, Donald Diller

AFFILIATE MEMBERS

Alberta, P.F. (Peter) Tajcnar
Hong Kong, S.K. Kwei
Manitoba, A. Boychuk
Mariana Islands, Nick C. Sablan
New Brunswick, C. Herbert Page
Newfoundland, Terry McCarthy
Northwest Territories, A. Gamble
Nova Scotia, Donald W. MacIntosh
Ontario, Bob Oddson
Saskatchewan, Al Popoff

ASSOCIATE MEMBERS-STATE

N. J. Turnpike Authority, Allen J. Lewis
Mass. Metro. Dist Comm., E. Leo Lydon
Port Auth. of NY & NJ, Harry Schmerl

ASSOCIATE MEMBERS-FEDERAL

Bureau of Indian Affairs, Neil N. Rousseau
U.S. Department of Agriculture-Forest Service, John Holt, Tim Rogan

Chapter Authors

INTRODUCTION Robert L. Jacobsen, FHWA, *Colorado*

CHAPTER I **Integration of Landscape and Environmental
Design in Transportation**

William G.E. Blair, *Washington*

CHAPTER II **Landscape and Environmental Elements in Highway Design**

Charles R. Anderson, *Maryland*

CHAPTER III **Environmental Design**

Bernard L. Chaplin, *Washington*

CHAPTER IV **Landscape and Geometric Design**

Edward N. Kress, *California*, and
Charles R. Anderson, *Maryland*

CHAPTER V **Construction Consideration in Design**

Clyde D. Walton, *Maine*

CHAPTER VI **Roadside Management**

Hans Littooy, *Washington*

CHAPTER VII **Highway Related Areas**

David H. Fasser, *New York*

CHAPTER VIII **Landscape Considerations for Airports,
Mass Transit Facilities, Ports and Railroads**

Barbara M. Schaedler, *New York*

CHAPTER IX **Multiple-Use/Joint Development**

E. Leroy Brady, *Arizona*

GLOSSARY and SELECTED BIBLIOGRAPHY

Leonard E. Wood, FHWA, *Virginia*

Table of Contents

Page

Foreword		xv
-----------------	-------	-----------

Introduction		1
---------------------	-------	----------

General Statement of Objectives	.....	1
Authoritative Basis for the Guide	.....	2
General Environmental Statutes	.....	5

Chapter I	Integration of Landscape and Environmental Design in Transportation	 11
------------------	--	-----------------

Statement of Objectives	.....	11
A. Transportation Modes and Facilities Considered in this Guide	.....	11
B. Objectives of Landscape and Environmental Design	.....	12
1. Conservation and Preservation of Sensitive Land and Water Areas	.....	12
2. Enhancement of Project Compatability with Existing and Potential Land Use	.....	12
3. Enhancement of Project Visual Quality	.....	12
4. Mitigation of Adverse Environmental Impacts	.....	13
C. Transportation Development Process	.....	13
Design Guide	.....	14
A. Scope of Landscape Design	.....	14
B. Visual Quality	.....	14
1. Public Interest and Importance of Visual Quality	.....	14
2. Policy Support for Visual Quality	.....	15
3. Visual Resource Management/Visual Environment	.....	16
4. Visual Assessment Processes	.....	18
C. Hardware and Software Design Aids	.....	20

D. Collaboration Among Professional Disciplines	20
E. Coordination in the Design Process	20

Chapter II	Landscape and Environmental Elements in Highway Design	23
-------------------	---	-----------

Statement of Objectives	23
Design Guide	23
A. Conservation and Preservation of Land, Water Area, and Visual Quality	23
B. Topography	25
C. Existing and Potential Land Use	25
D. Plan Incorporation	26

Chapter III	Environmental Design	27
--------------------	---------------------------------------	-----------

Statement of Objectives	27
Design Guide	27
A. Visual Quality	28
B. Drainage	28
1. Vegetated Drainage Courses	28
2. Rechanneling Streams (Channel Realignment)	29
3. Fish Passage and Culvert Placement	31
4. Stormwater Management	32
a. Stormwater Detention	33
b. Stormwater Retention	34
C. Creation and Restoration of Wetlands and Floodplains	34
1. Functions and Values	35
2. Wetland Losses	35
3. Mitigation for Losses	36
4. Compensation by Creating Wetlands	36
5. Wetland Banking	37
D. Traffic Noise Barriers	38
E. Wildlife Habitat	39

F. Prime and Unique Farmland	41
G. Historical and Archaeological Preservation	42
H. Coastal Zone Management	43
I. Coastal Barrier Resources	43
J. Wild and Scenic Rivers	44
K. Hazardous Waste	45
1. Site Characterization	45
2. Preliminary Assessment	48
3. Site Remediation	46
4. Record Keeping	46
5. Groundwater Monitoring	46
L. Section 4(f) and Section 106	46
M. Collaboration with Other Agencies	47

Chapter IV Landscape and Geometric Design 49

Statement of Objectives	49
Design Guide	49
A. Alignment and Profile	50
B. Cross Section and Grading Design	52
C. Roadsides	56
D. Median	57
E. Interchanges	58
F. Right-of-Way	58
G. Visual Quality	60
1. Structures	60
2. Miscellaneous Hardware Elements	63
H. Facilities for Pedestrians and Bicyclists	64
I. Provisions for the Handicapped and Elderly	66
J. Erosion Control and Soil Stabilization	66
K. Planting	68
1. Planting for Traffic Safety	70
2. Planting for Environmental Mitigation	72

3. Planting for Aesthetics	73
4. Setback Distances for Trees	74
5. Plant Establishment	76
L. Irrigation	76

Chapter V

Construction Consideration in Design 79

Statement of Objectives	79
Design Guide	80
A. Erosion and Sediment Control	80
B. Clearing and Grubbing	82
C. Loam Conservation	83
D. Topsoil Salvage and Use	84
E. Excavation and Grading	84
F. Waste Areas	85
G. Borrow Areas	86
H. Landscape Forestry	87
I. Utility Locations	91
J. Restoration of Construction Staging Areas	92

Chapter VI

Roadside Management 93

Statement of Objectives	93
Process Guide	94
A. Level of Management	94
B. Life-Cycle Cost	95
C. Maintenance Priorities	95
D. Integration of Management Objectives into Design	96
E. Documentation	96

Chapter VII

Highway Related Areas 99

Statement of Objectives	99
Design Guide	99
A. Safety Rest Areas	100
1. Alignment	101
2. Grading and Drainage	101
3. Paving	101
4. Building Design	102
5. Site Design	102
6. Handicapped Accessibility	105
7. Wastewater Disposal and Water Supply	106
8. Landscaping	106
B. Information Centers	107
C. Scenic Overlooks	108
D. Truck Weigh Stations	111
E. Scenic Highways	111
F. Urban Streets and Highways	112
G. Maintenance and Stockpile Areas	114
H. Park-and-Ride Areas	114
I. Bicycles and Other Transportation Modes	115
J. Collaboration with Other Agencies and Professions	116

Chapter VIII

Landscape Considerations for Airports, Mass Transit Facilities, Ports, and Railroads 117

Statement of Objectives	117
Design Guide	117
A. Safety and Security	117
B. Community Acceptance	119
C. Landscape Maintenance	120
D. Airport Design Considerations	121
1. Obstruction to Aircraft	121
2. Approach Roads	122



3. Parking Areas	122
4. Landscaping for Safety and Security	122
E. Mass Transit Facilities	122
F. Ports	123
G. Railroads	123

Chapter IX	Multiple-Use/Joint Development	125
-------------------	---	------------

Statement of Objectives	125
Design Guide	127
A. Corridor Route or Site Selection	127
B. Existing Transportation Facilities	128
C. Financing	128
D. Transportation Types and Potential Multiple Use	129
E. Air Rights	130
F. Right-of-Way Requirements and Acquisition	130
G. Transportation Considerations for Multiple Use	131
H. Landscape Architectural Considerations	131
I. Maintenance Considerations in Design	132
J. Kinds of Multiple Use	132

Glossary of Terms	135
------------------------------------	------------

Selected Bibliography	157
--	------------

Foreword

A Guide for Transportation Landscape and Environmental Design has been prepared by the Task Force for Environmental Design for the AASHTO Highway Subcommittee on Design. The Task Force was assisted by members of the Transportation Research Board Committee on Landscape and Environmental Design who served as technical authors for the Guide. It supersedes the 1970 *Guide for Highway Landscape and Environmental Design*.

The scope of the Guide has been expanded to include all modes of transportation and the interaction of landscape considerations with transportation improvements.

Specific emphasis has been placed on supplying technical information that will assist the planner, designer, project engineer, landscape architect, supervisor, and transportation manager to provide landscape features and integrate them into the transportation system, producing an environmentally pleasing facility.

The Guide should be used as a basic reference to improve landscape and environmental design with specific guidance for the accommodation of transportation features which require aesthetic consideration.

Additionally, this publication is intended to provide guidance in the design of new and major reconstruction projects. The fact that new design concepts are presented does not imply that existing highway and transportation facilities are unacceptable. However, improvement of the landscape and environmental features of existing transportation facilities should be considered in conjunction with other reconstruction projects. Sufficient flexibility is provided to encourage independent designs tailored to specific situations.

The Guide should be used with the AASHTO *A Policy on Geometric Design of Streets and Highways* when incorporating environmental design concepts into transportation improvements. Since it is not possible to completely cover all concepts, values, and data in a single publication, additional references are given in the Introduction and in the Selected Bibliography at the end of the Guide.

Introduction

General Statement of Objectives

The lives Americans lead and the environment in which they live are being influenced by expanding transportation systems. The effects of this expansion are not easy to evaluate, forecast or offset.

It is essential that the transportation facility be considered as an element of a total environment, not apart from it nor in conflict with it. All concerned disciplines and the public must collaborate at every stage of transportation planning, design, and construction to realize the maximum potential from the resultant transportation facilities and their environment. Exchange of information and use of expertise is of paramount importance in the early project stages as well as throughout project development.

At any point, the facility and its surrounding environment are integral parts of a total transportation system. As an example, the highway roadside is an important part of the highway system. The "roadside" generally is the area between the outer edge of the roadway and the right-of-way boundary, including the median areas of divided highways. The treatment given to the roadside during development should conserve, enhance, and effectively display the natural environment, cultural environment, and the beauty of the landscape through which the highway passes.

Safety, utility, economic, social, and environmental considerations must impact effective planning, environmental studies, design, construction, and the maintenance of highways as each contributes to the acceptance and success of the highway system.

The potential for conflict between transportation and environmental values exists in rural as well as urban areas. Cooperation and liaison between transportation agencies and other public sector agencies, relevant federal, state, regional, county and city organizations, and the public is essential. In urban areas, attention needs to be given to the multiple-use/joint development possibilities in areas over, under, and adjacent to the facility in order to ensure that the total environment is being utilized to provide the greatest benefit.

The development and application of a broad philosophy for landscape design by each state to fit its respective natural or man-made situation is necessary to provide continuity of pattern and action within a state.

The complete transportation system is one wherein the elements of design, construction and maintenance have been integrated to provide a facility that possesses the optimum of utility, safety, beauty, resource protection, and economy. This Guide has been arranged to relate the above elements to the preservation and development of the rural and urban landscape.

Authoritative Basis for the Guide

The authoritative basis for the Guide is found in the following statutes and regulations:

United States Code, Title 23: Highways:

- Section 109 *Standards*—economic, social, and environmental guidelines.
- Section 138 *Preservation of Parklands*—preserve the natural beauty of the countryside and public park and recreation lands, wildlife, and waterfowl refuges and historic sites.
- Section 217 *Bicycle transportation and pedestrian walkways*—development and improvement of pedestrian walkways and construction of new or improved lanes, paths, or shoulders, traffic control devices, shelters for and parking facilities for bicycles.
- Section 319 *Landscaping and scenic enhancement*—landscape and roadside development, including acquisition and development of publicly owned and controlled rest and recreational areas.

Requires that native wildflower seeds or seedlings or both be planted as part of any landscaping project undertaken on the Federal-aid highway system. At least one-quarter of one percent of funds expended for a landscaping project must be used to plant wildflowers on that project. This provision requires every landscaping project to include the planting of native wildflowers unless a waiver has been granted.

OPERATION WILDFLOWER is a voluntary, FHWA cooperative program titled "Operation Wildflower" with the National Council of State Garden Clubs and State Highway Agencies since 1973.

Federal-Aid Highway Program Manual 6-2-5, Subsection 1—*Landscape and Roadside Development*

The following regulations emphasize aesthetic and visual quality considerations in the Federal-Aid Highway Program. They cover various aspects of the program and are instrumental in the overall project decision-making process. The regulations are summarized as follows with emphasis added:

23 Code of Federal Regulations (CFR) 635, Subpart E

In prescribing interstate maintenance guidelines, the regulation contains a policy which stresses the development of State highway maintenance programs consistent with necessary practices to provide for *aesthetics*. It also identifies the preservation

of the roadside in a pleasant manner as one of the elements that should direct the development and implementation of each State's program.

23 CFR 645, Subpart B

Regulations that govern the accommodation of utilities require that highway agencies regulate the use and occupancy of utility facilities on the right-of-way to ensure that the *highway or its aesthetic quality is not impaired*. The regulations contain provisions which focus on measures to be taken by highway agencies, to *preserve the operational safety and the functional and aesthetic quality of highway facilities*. The regulations prohibit new utility installation on highway right-of-way or other lands acquired or improved with federal highway funds that are located *within or adjacent to areas of scenic enhancement and natural beauty*. It also requires aerial utility installation to be located and to employ suitable designs and materials so as to *give the greatest weight to the aesthetic qualities of the area being traversed*.

23 CFR 560, Subpart A

Regulations which have been adopted for the location and hydraulic design of encroachments on floodplains require that measures be taken to avoid significant adverse impact by highways on "natural and beneficial floodplain values". The regulations identify *natural beauty* as one of these values. A discussion on measures to restore and preserve natural and beneficial floodplain values impacted by highway projects is required in environmental studies.

23 CFR 660.109

The regulations focus on the construction and maintenance of Forest Highways under the FHWA Direct Federal Program. In identifying the procedures by which projects are selected for fiscal year funding, the regulations cite criteria upon which the selection must be based. One requirement is that the project provide for the *protection and enhancement of the rural environment*.

23 CFR 661

Regulations adopted for the establishment of the Great River Road place emphasis on the *scenic character* of the road system. It specifies location criteria which require that the road be located to take advantage of scenic river views as well as provide convenient access to sites of scenic interest. The regulations also require that the facility have design elements which incorporate features which will allow the user-motorist to enjoy the scenic aspects of the route.

23 CFR 713.204 (O), (U)

Regulations governing the management of airspace require that consideration be given to the design, occupancy, and use of structures over or under a highway facility to *assure that the appearance of the highway will not be adversely affected by the action*. Similarly, consideration must be given to the need for planting or other

screening measures to *improve the aesthetics and appearance of highway right-of-way* prior to approving its use and occupancy for parking motor vehicles.

23 CFR 713.304 (d)

Under the right-of-way disposal program, unneeded portions of highway right-of-way can be conveyed to any public entity or private party. However, the regulations prohibit the disposal of lands that are suitable for retention in order to restore, preserve, or improve the *scenic beauty and environmental quality* adjacent to the highway.

23 CFR 772.13

Landscaping which is undertaken with the construction of noise barriers for *aesthetic purpose* is identified as an expense that is eligible for federal participation under the noise abatement program.

23 CFR 777.7

In determining the extent of Federal-Aid Highway Program participation in measures to mitigate adverse highway impacts on privately owned wetlands, the importance of wetlands is a factor which must be considered. *Aesthetics* is identified as one of the elements of consideration in evaluating wetlands to determine their importance.

**An awareness of the following statutes
and resulting regulations should be maintained.**

General Environmental Statutes

National Environmental Policy Act: 42 U.S.C. 4321-4347	23 CFR 771 Environmental Impact and Related Pro- cedures, 40 CFR 1500- 1508 CEQ Regulations	Consider environmental factors through sys- tematic interdiscipli- nary approach before committing to a course of action.
Public Hearings: 23 U.S.C. 128	23 CFR 771.111 Early Coordination. Public Involvement, and Project Development	Ensure adequate oppor- tunity for public hear- ing(s) on the effects of alternative project locations and major design features, as well as the consistency of the project with local plan- ning goals and objectives.

Noise

Standards: 23 U.S.C 109(1)	23 CFR 772	Promulgate noise standards for highway traffic.
----------------------------	------------	---

Air Quality

Clean Air Act, as amended: 23 U.S.C. 109(1) 42 U.S.C. 7401-7428	23 CFR 770 40 CFR 50-52 49 CFR 623	Protect and enhance quality of Nation's air resources to promote public health and welfare.
--	--	---

Health

Safe drinking water Act: 42 U.S.C. 300f, 300h, and 300j-6	23 CFR 650, Subpart E Water Supply and Sewage Treatment at Safety Rest Areas.	Ensure public health and welfare through safe drinking water.
---	--	---

Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976: 42 U.S.C. 6901, et. seq., see especially, 42 U.S.C. 6961-6964.	23 CFR 751 40 CFR 256-300	Provide for the recovery, recycling and environmentally safe disposal of solid wastes.
--	------------------------------	--

Federal Insecticide, Fungicide, and Rodenticide Act: 7 U.S.C. 136-1364	40 CFR 164-171	Control the application of pesticides to provide greater protection to man and the environment.
---	----------------	--

Historic And Archaeological Preservation

Section 106 of the National Historic Preservation Act as amended: 16 U.S.C. 470f	Executive Order 11593 23 CFR 771 36 CFR 60 36 CFR 63 36 CFR 800	Protect, rehabilitate, restore, and recon- struct districts, sites, buildings, structures, and objects significant in American architecture, archeology, engineering and culture.
---	---	---

Section 110(f) of the National Historic Preservation Act, as amended: 16 U.S.C. 4702	36 CFR 65 36 CFR 78	Protect National Historic Landmarks.
---	------------------------	---

Preservation of Historical and Archeological Data: 16 U.S.C. 469a	36 CFR 66	Preserve historical and archeological data from loss or destruction.
---	-----------	---

Act for the Preservation of American Antiquities: 16 U.S.C. 431-433	36 CFR 251.50-64 43 CFR 3	Preserve and protect paleontological resources, historic monuments, memorials, and antiquities from loss or destruction.
---	------------------------------	---

Archeological Resources Protection Act: 16 U.S.C. 470aa	18 CFR 1312 32 CFR 229 36 CFR 296 43 CFR 7	Preserve and protect archeological resources.
---	---	---

American Indian Religious
Freedom Act: 42 U.S.C. 1996

Protect places of
religious importance
to American Indians,
Eskimos, and Native
Hawaiians.

Land And Water Usage

Wilderness Act: 16 U.S.C.
1131-1136 36 CFR 291
 43 CFR 19
 43 CFR 8560
 50 CFR 35

Preserve and protect
wilderness areas in
their natural condition
for use and enjoyment
by present and
future generations.

Wild and Scenic River Act: 36 CFR 251
16 U.S.C. 1271-1287 36 CFR 261
 43 CFR 8350

Preserve and protect
wild and scenic rivers
and immediate
environments for
benefits of present and
future generations.

Land and Water Conservation
Fund Act Section 6(f):
16 U.S.C. 460L-4 to 460L-11

Preserve, develop, and
assure the quality and
quantity of outdoor
recreation resources
for present, and future
generations.

Executive Order 11990: 23 CFR 777
Protection of Wetlands

Avoid direct or
indirect support
of new construction in
wetlands wherever there
is a practicable
alternative.

National Trails Systems 43 CFR 8350
Act: 16 U.S.C. 1241-1249

Provide for outdoor
recreation needs and
encourage outdoor
recreation.

Rivers and Harbors Act of
1899: 33 U.S.C. 401,
et.seq., as amended
and supplemented. FHPM 6-7-1
 33 CFR 114-115

Protection of
navigable waters
in the U.S.

Federal Water Pollution Control Act (1972), as amended by the Clean Water Act (1977 & 1987): 33 U.S.C. 1251-1376	FHPM 6-7-3-3 23 CFR 650, Subpart B 23 CFR 771 33 CFR 209 40 CFR 120 40 CFR 122-125 40 CFR 128-131 40 CFR 133 40 CFR 135-136 40 CFR 148 40 CFR 230-231	Restore and maintain chemical, physical, and biological integrity of the Nation's waters through prevention, reduction, and elimination of pollution.
Executive Order 11988: Floodplain Management (as amended by Executive Order 12148)	FHPM 6-7-3-2 23 CFR 650, Subpart A 23 CFR 771	Avoid the long- and short-term adverse impacts associated with the occupancy and modification of floodplains, and to restore and preserve the natural and beneficial values served by floodplains.
Marine Protection Research and Sanctuaries Act of 1972, as amended: 33 U.S.C. 1401-1445	33 CFR 323 40 CFR 220-225	Regulate dumping of materials into U.S. ocean waters.
Water Bank Act: 16 U.S.C. 1301-1311	7 CFR 720 7 CFR 752	Preserve, restore, and improve wetlands of the nation.
Coastal Zone Management Act of 1972: U.S.C. 1451-1464	15 CFR 923 15 CFR 930	Preserve, protect, develop, and (where possible) restore and enhance resources of the coastal zone.
Coastal Barrier Resources Act, as amended: 16 U.S.C. 3501-3510 42 U.S.C. 402B	13 CFR 116 44 CFR 71 44 CFR 205	Minimize the loss of human life, wasteful expenditures of federal revenues, and the damage to fish wildlife, and other natural resources.

Farmland Protection Policy Act of 1981: 7 U.S.C. 4201-4209	7 CFR 658	Minimize impacts on farmland and maximize compatibility with state and local farmland programs and policies.
Resource Conservation and Recovery Act of 1976 (RCRA), as amended: 42 U.S.C. 6901, et. seq.	40 CFR 260-271	Protect human health and the environment. Prohibit open dumping. Manage solid wastes. Regulate treatment, storage, transportation and disposal of hazardous waste.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended: 42 U.S.C. 9601-9657	40 CFR 300 43 CFR 11	Provide for liability, compensation cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites.
Endangered Species Act of 1973, as amended: 16 U.S.C. 1531-1543	7 CFR 355 50 CFR 17 50 CFR 23 50 CFR 25-29 50 CFR 81 50 CFR 217 50 CFR 222 50 CFR 225-227 50 CFR 402 50 CFR 424 50 CFR 450-453	Conserve species of fish, wildlife and plants facing extinction.
Fish and Wildlife Coordination Act: 16 U.S.C. 661-667d		Conservation, maintenance, and management of wildlife resources.

Chapter I

Integration of Landscape and Environmental Design in Transportation

Statement of Objectives

A. Transportation Modes and Facilities Considered in This Guide

Transportation is an essential component of our country's infrastructure—the service and utility systems that are needed to support the varied uses of the American landscape. Transportation is also a major land use in its own right. As such, transportation facilities can generate significant public benefits and even pleasures; they are also capable of imposing adverse impacts on the adjacent environment, including other land uses. Landscape and environmental design can help to increase the benefits that accrue from the construction, operation, and maintenance of transportation facilities, and can also help to reduce or eliminate the adverse impacts of these facilities.

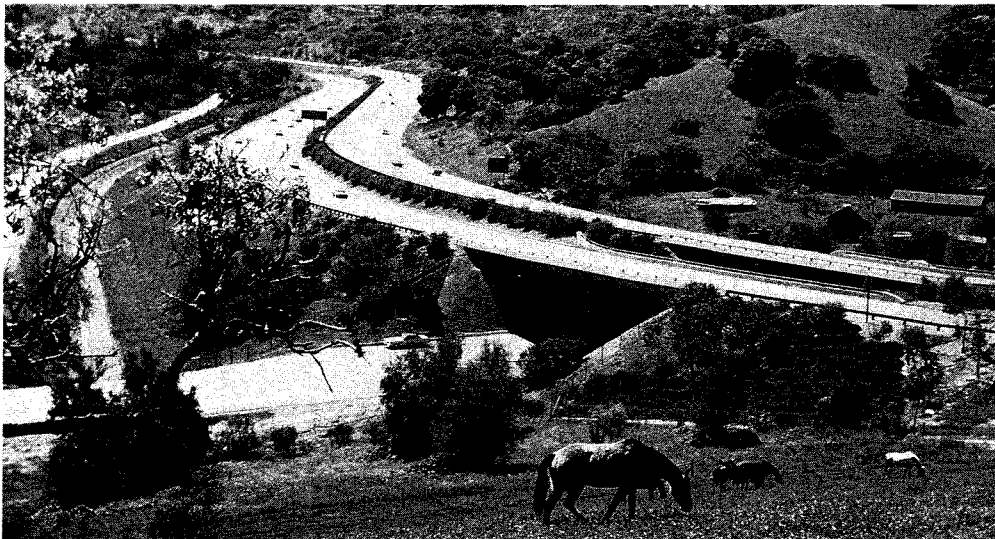


Figure I-1.

The principles of landscape and environmental design that are illustrated in this guide can and should be applied to the full range of transportation modes and facilities. While many of the examples in this guide are drawn from highway facilities, the underlying design principles are equally applicable to public transit, railroad terminals, airports, ferry terminals, and port facilities. Nor is the applicability of these principles limited to the construction of new facilities: landscape and environmental design principles can also be useful and effective in the maintenance and reconstruction of existing facilities.

B. Objectives of Landscape and Environmental Design

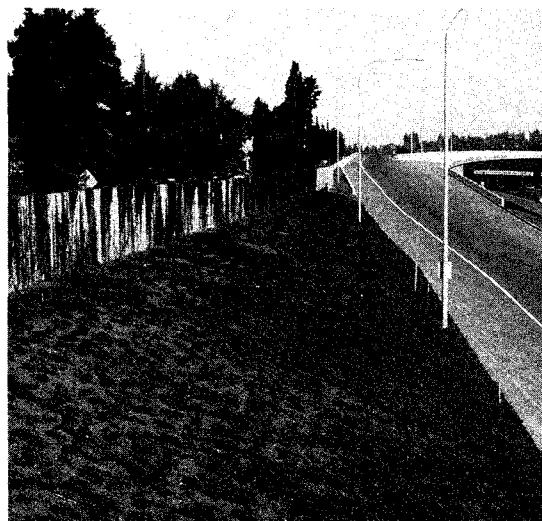
Transportation agencies should incorporate landscape and environmental design within their planning, development, and management processes to help achieve the following objectives:

1. Conservation and Preservation of Sensitive Land and Water Areas

Careful project planning early in the transportation development process can often prevent the displacement of sensitive land or water areas by identifying and avoiding

these resources. Such planning can also provide opportunities to preserve or conserve these resources within or along project lands.

Figure I-2. Compatibility between freeways and residential areas is significantly improved by the provision of attractively designed noise barriers.



2. Enhancement of Project Compatibility with Existing and Potential Land Use

Landscape and environmental design can also help to ensure that a new transportation facility will be environmentally compatible with adjacent land uses, including residential, recreational, and natural areas. The application of these design principles to the maintenance and reconstruction of existing transportation facilities can also help to improve their environmental compatibility.

Figure I-3. The visual quality of this airport approach road contributes to the quality of the travel experience and provides an attractive gateway to the City of Portland.



3. Enhancement of Project Visual Quality

The visual quality of public facilities can and should contribute to the quality of life experienced by the users and neighbors of these facilities. Because transportation is so prominent in work and play, en-

hancement of the visual quality of new or existing transportation facilities should be included among the objectives of all transportation agencies.

4. Mitigation of Adverse Environmental Impacts

Landscape and environmental design principles can be applied to the planning, design, operation, and maintenance of transportation facilities to mitigate the impacts of these facilities. Mitigation can include the creation of offsetting beneficial impacts, as well as the avoidance, elimination, or reduction of adverse impacts.

C. Transportation Development Process

The transportation development process begins with planning and location studies, which include the environmental process mandated by the National Environmental Policy Act. Landscape and environmental design play significant roles in this first phase of the transportation development process. To fully achieve the preceding objectives, however, it is important that the application of landscape and environmental design principles not be limited to this phase, but extended into the design, construction, operation and maintenance of transportation facilities. This is underscored by the likelihood that a large share of future transportation demands will have to be accommodated by upgrading existing facilities and improving their management.

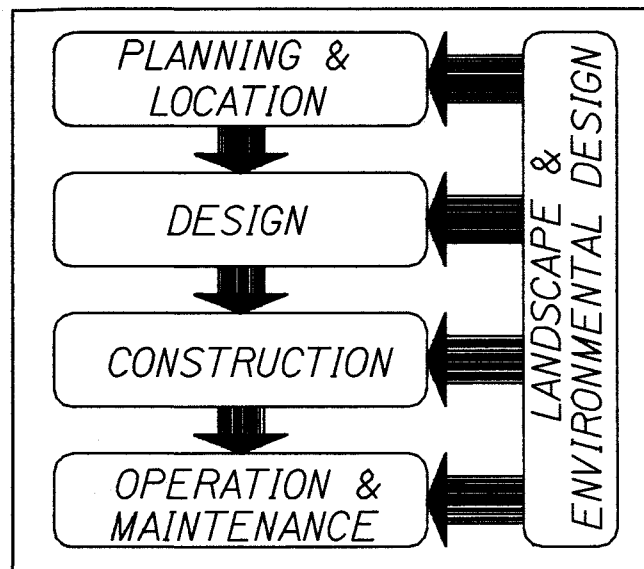


Figure I-4. Landscape and environmental design principles are relevant to all phases of the transportation development process.

During the planning and location phase, the landscape and environmental design principles in this guide are used to help assess environmental effects and identify measures to mitigate adverse impacts. These principles can also be used to help develop the description or specifications of project features and the definition of alternatives to the proposed action, including any committed mitigation measures.

In the design phase, landscaped and environmental design principles should continue to be applied to the design of the transportation facility, including the design

of associated structures and appurtenances, support facilities, landscaped development, and measures to mitigate environmental impacts.

The same principles should also be applied during the construction phase to ensure that mitigation measures achieve their intended effectiveness in reducing impacts and that conditions discovered in the field receive appropriate consideration and response.

Finally, the incorporation of landscape and environmental design principles into the operation and maintenance of transportation facilities can help to assure the continued effectiveness of project mitigation measures. By guiding gradual change, these principles can also help to improve the environmental compatibility and visual quality of facilities that predate current environmental requirements.

Design Guide

A. Scope of Landscape Design

It is usually obvious that landscape and environmental design principles should be applied to the planning and design of new urban freeways, because of the potential significance of their impacts and the number of persons who could be affected. However, these principles are equally relevant to other less dramatic transportation projects. This includes the full range of highway types, from multi-lane freeways to the rehabilitation and improvement of existing local arterials and rural trunk roads. It also includes the full range of highway components or features: the roadway (the travel surface itself), the roadside (the remainder of the right-of-way, with any natural vegetation and/or plantings), ancillary structures (such as bridges, culverts, and retaining walls), and highway appurtenances (such as fences, signs, lights, and traffic barriers).

The landscape and environmental design principles discussed in this guide also apply to other types of transportation facilities, including public transit, railroad terminals, airports, ferry terminals, and port facilities. Again, it is essential to consider not only the primary features of a project when applying these principles, but also to consider the ancillary structures or features associated with the project. Whatever the type of transportation facility or project, the question is not whether to apply landscape and environmental design principles, but what level of effort is appropriate. The answer will depend on the characteristics of the transportation facility, the environmental resources in question, and the public groups who could be affected.

B. Visual Quality

1. Public Interest and Importance of Visual Quality

The public nature and visual importance of transportation facilities makes it essential that these facilities exhibit good visual quality and that transportation planners consider and assess visual impacts—positive as well as negative—in the transportation development process.

Community acceptance of a transportation project is often strongly influenced by the visual effects of the project. These effects are seen both in *views from the project* (as seen by project users) and *views of the project* (as seen by project neighbors). The importance of the first has long been recognized, particularly in relation to the recreational use of highways. In surveys, Americans have repeatedly identified driving for pleasure as a favorite recreational activity. The requirement of scenic roads for this activity links visual quality to tourism, which has become a major component of many state and local economies. Researchers have also shown that the view from the road is the basis for our mental image of our everyday environment and for much of what we know about it. For both reasons, communities are rightly concerned about the visual character of their transportation portals: first impressions do count.

Systematic consideration of views of transportation projects, as seen by project neighbors, is more recent. Particularly in urban or suburban areas, there may be many "eyes per mile" near an existing or proposed transportation facility. If existing views are very high in quality or are valued by large numbers of people, the visual costs borne by persons who live near a proposed facility could outweigh the visual benefits accrued by the persons who would use the facility. In such cases, the facility must be carefully planned to ensure that pleasing vistas for travelers are not developed at the expense of views from surrounding areas.

Public concern over the potential for adverse visual impacts can be a major source of project opposition. This is frequently true of major transportation projects located in urban or scenic areas, but other project types and settings also generate controversies when the visual impacts and the effectiveness of mitigation measures are assessed in a clear and objective manner. This type of assessment can also help determine when actions that create positive visual impacts may reasonably be used to offset other adverse project effects.

2. Policy Support for Visual Quality

A variety of national policies direct us to conserve existing visual resources that are high in quality and to enhance the built environment by good project planning and design. A systematic approach to visual impact assessment will help transportation agencies comply with these policies and achieve attractive projects that are appropriate to their viewers and visual settings.

For example, the Historic Preservation Act of 1966 directs all federal agencies to account for the effects of proposed projects on historic resources; the "criteria of adverse effect" includes "the introduction of visual . . . elements that are out of character with the property or alter its setting."

Coverage of the visual effects of transportation projects was further broadened in 1966 by Section 4(f) of the U.S. Department of Transportation Act. This section declares a national policy to preserve, where possible, "the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites." Transportation projects can only utilize these special lands if there is "no feasible and prudent alternative" and the sponsoring agency demonstrates that "all possible planning to minimize harm" has been undertaken.

The National Environmental Policy Act of 1969 (NEPA) applied environmental awareness policies to all types of federally supported projects and all types of project settings. NEPA declares that it is the "continuous responsibility" of the federal government to "use all practicable means" to "assure for all Americans safe, healthful, productive, and *aesthetically and culturally pleasing* surroundings" (emphasis added). The U.S. Department of Transportation instituted a Design, Arts, and Architecture in Transportation program to help implement NEPA. This program goes beyond the conservation of existing scenic resources by requiring that environmental impact statements document the consideration of design quality in projects that involve public use areas or sensitive locations, such as parks or historic districts.

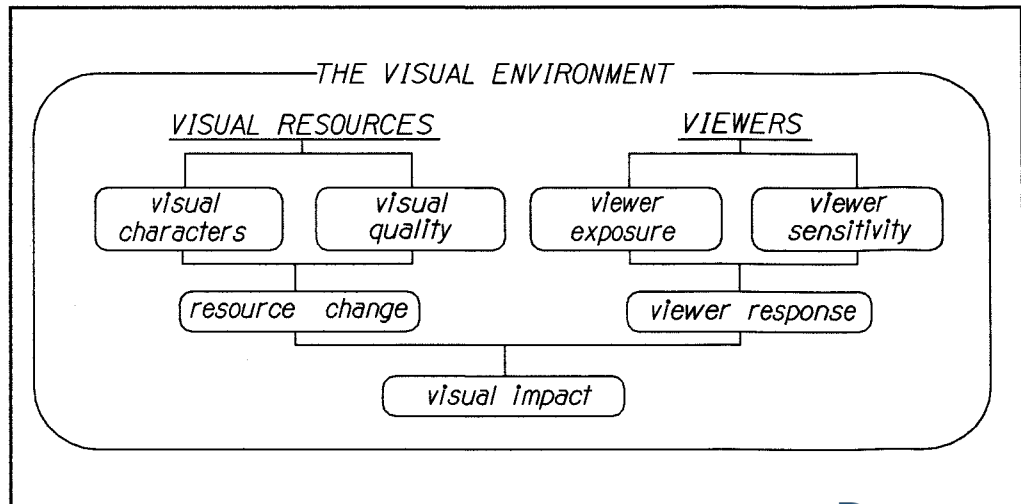
Many states have adopted legislation that is similar to NEPA in purpose and form. Many states have also adopted land-use and coastal zone management laws and regulations that mandate the consideration of visual resources in the planning of public projects and the incorporation of visual quality in their design. Similar policy support for these objectives is also common in local comprehensive plans and zoning regulations.

3. Visual Resource Management/Visual Environment

In response to policy directives such as those summarized above, several federal agencies have developed formal systems for visual resource management (VRM). These agencies include the U.S. Forest Service, the Bureau of Land Management, the Federal Highway Administration, the Soil Conservation Service, and Army Corps of Engineers. Other federal, state, and local agencies have patterned their approaches to VRM on these federal agency systems. A considerable body of academic research in the fields of landscape architecture, geography, forestry, urban design, and environmental psychology has also focused on the federal agency systems and alternatives.

In brief, VRM is a systematic approach for assessing visual resources in a project area and then using the assessment findings to help make management decisions on the project. VRM can be an important link between planning and detailed project design, and can go far to ensure adequate consideration and response to public concerns over the visual effects of projects.

Figure I-5. A conceptual model for Visual Resource Management and impact assessment.



Although the terminology of VRM is not uniform, the broad elements of the various approaches are the same (Figure I-5). All of these approaches consider visual experience to be comprised both of visual resources and viewer response. A project, such as a building or highway, causes visual resource change that can be objectively measured. Viewer response to this change, although subjective, usually displays broad patterns of consensus. Thus, visual impacts comprise both the landscape change and viewer response to that change.

The concept of the "affected environment" contained in the NEPA regulations helps to control and focus the analysis of environmental impacts. The limits of the affected *visual environment* are determined by mapping the project viewshed. This viewshed is the geographic area from which the project will be seen and is a useful tool for identifying the views that the project may actually change. Viewshed mapping can go far to dispel exaggerated community fears over the impacts of a particular project by establishing the physical limits of project visibility.

Within the affected visual environment, the effects of transportation facilities on *visual resources* can be identified at several different levels. A project can alter the visible components that comprise the basic visual resources of the landscape. These include landforms, water bodies, vegetation communities, and development patterns, including the structures associated with these patterns. A new transportation facility involves the removal or displacement of some of these components and the introduction of others; in the process, the viewshed itself may be altered.

On a higher level, people experience the visual environment as an integrated whole, not as a series of separate objects. Visual understanding of the environment is based on the *visual character* of landscape components and their relationship to each other. Descriptive assessments of visual character are based on defined attributes which carry no implications of value in themselves. There are at least two broad levels of such attributes, which can be termed *pattern elements* and *pattern character*. Pattern elements are primary visual attributes of objects in the landscape, including form, line, color, and texture. The visual relationships among these simple pattern elements create secondary visual attributes, both of individual objects and of whole landscapes. These higher-level attributes can be termed pattern character and include dominance, scale, diversity, and continuity. By assessing the existing visual character of an area in terms of pattern elements and pattern character, it is possible to identify the extent to which the visual character of a transportation facility will exhibit *visual contrast* with the landscape or its converse, *visual compatibility*.

Public concerns over the potential effects of a project on the landscape often go beyond its visual character and extend to its effects on the *visual quality* of the landscape of which it is a part. Interpretation and enjoyment of visual experience can involve many preferential and subjective elements, but the visual resources of certain landscapes have obviously high quality on which there is general public agreement. Plans for projects in such areas should therefore be subject to especially careful examination.

There are several useful approaches to the evaluation of visual quality. One approach is to survey the visual preferences of public viewer groups. Another, used by the U.S. Forest Service and the Bureau of Land Management, looks to the regional landscape for specific resource indicators of high visual quality, such as water bodies

or dramatic rock faces. High visual quality is postulated for those landscapes that most clearly or dramatically exhibit the natural processes characteristic of the region. A third approach to the evaluation of visual quality looks for indicators concerned with visual relationships rather than with landscaped components. Evaluative appraisals are judgments of relative visual quality of specific resource or landscapes, based, unlike visual preferences, on implicit or explicit criteria. These criteria are usually derived from research studies in which they have proven to be effective indicators of broad public judgment of visual quality.

This distinction between visual character and visual quality is expressed in adopted public policies and law. For some U.S. landscapes, such as designated historic sites and scenic rivers, the policy objectives may include maintaining the existing visual character and minimizing visible change. In other landscapes, such as airport entries and urban redevelopment zones, the policy objectives may allow and encourage visible change that will improve or enhance the visual quality of the landscape. Architects sometimes come to grief over the distinction, claiming their projects will improve visual quality when community groups want to maintain existing visual character.

To understand and predict *viewer response* to the appearance of a project, one must know something about the viewers who will see the project and the aspects of the visual environment to which they are likely to respond. Vision is an active sense. We generally have a reason for looking at the landscape and what we see is conditioned by what we are looking for. Physical conditions also influence perception; as speed increases, lateral vision declines and sight tends to be confined along the forward line of travel. Viewshed mapping can help to categorize viewer groups by identifying their physical location, the number of people in each group, and the duration of their view. All of these factors help to determine *viewer exposure*.

The receptivity of different viewer groups to the visual environment and its components is varied. This variable receptivity is called *viewer sensitivity* and strongly affects visual perception and the subjective evaluation of that perception. Viewer expectations regarding particular landscapes play a major role in viewer sensitivity. These expectations are closely related to the types of activities in which viewers are engaged. Viewers engaged in activities that require visual amenity, or that are enhanced by it, will be far more sensitive to visual impacts than persons engaged in activities that are unrelated to the visual quality of an area. The principal land use at a specific observer viewpoint can be used as an indicator of viewer sensitivity. Generally, persons engaged in recreation are the most sensitive to visual amenity, followed closely by persons in residential areas. Travelers can be considered moderate in viewer sensitivity, while persons located at commercial or industrial land-use sites may be relatively insensitive to visual considerations.

4. Visual Assessment Processes

A number of government agencies have developed visual assessment processes or systems that are tailored to their specific authorizing legislation and management responsibilities. The systems developed by the U.S. Forest Service and the Bureau of Land Management are among the best known examples of such agency-specific visual assessment processes. The more generalized process diagrammed in Figure I-6 can provide a framework for almost any visual assessment.

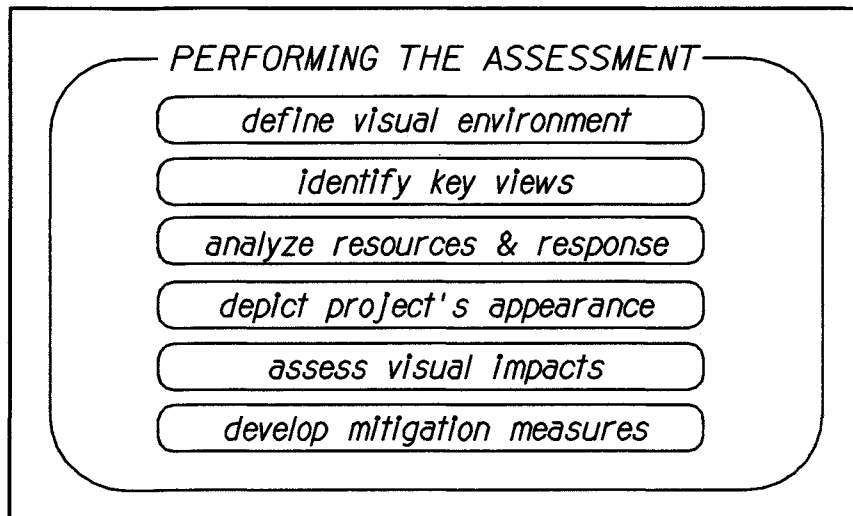


Figure I-6. A generalized, step-by-step process for visual assessment.

The first step in any visual assessment is to define the physical limits of the affected visual environment by mapping the project viewshed. It is often useful to subdivide this viewshed into a series of visual distinct landscape units that serve as an analytical framework for locating visual effects, comparing alternatives, and identifying appropriate visual mitigation measures.

The next step is to identify key views to display alternatives and assess impacts. Generally, choose views that represent the range of resources within the visual environment of the project, including at least one view for each visual assessment unit. Also, choose views that represent major viewer groups, including highway users and neighbors, and take care not to understate the visual exposure of the project to sensitive viewer groups.

The third step is usually to analyze existing visual resources and viewer response to those resources, for the purpose of determining which resources are most valued, as well as for identifying visual problems and opportunities.

Next, it is necessary to depict the appearance of the project, in order to determine its visual effects. Too often, project proponents try to conjure up this appearance with words or rely on an "artist's concept" prepared to show the project's best side. This type of approach may work in a sales campaign, but is not appropriate for projects requiring full environmental disclosure and may arouse suspicion and distrust among members of the public. To ensure adequacy and credibility, accurately depict the appearance of project alternatives as they would actually be seen from key viewpoints. While a *visual simulation* can be prepared at many different levels of detail, depending on the nature of project issues and the availability of time and resources, it should always meet the criteria of geometric accuracy and realistic view point location.

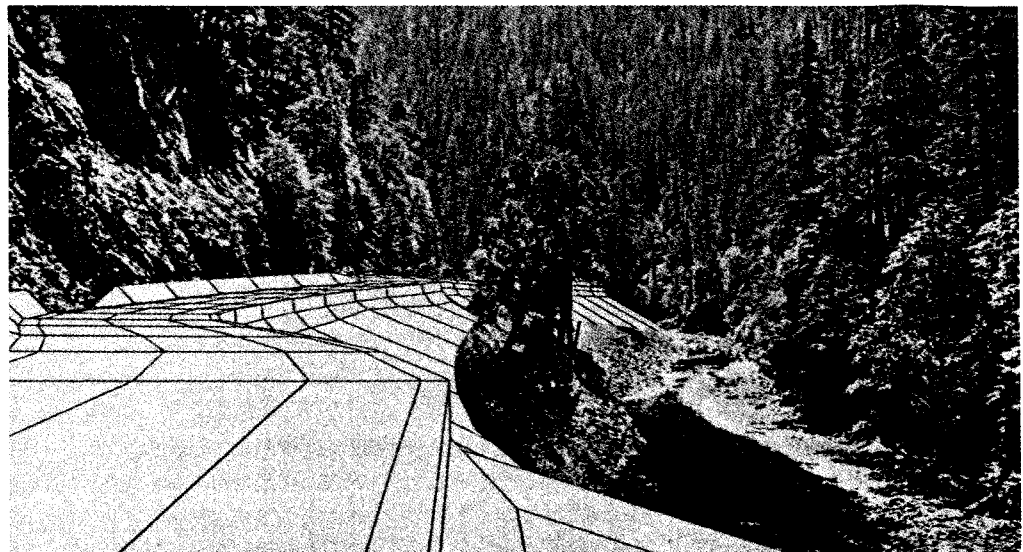
With visual simulations in hand, the next step is to assess the impacts of project alternatives by comparing the "before and after" appearance of key views. If the project would impose adverse visual impacts, the final step is to develop mitigation measures to reduce or offset those impacts. It should be clear that the appropriate way to test the effectiveness of the mitigation measures is to add them to the visual simulations that disclosed the impacts in the first case.

C. Hardware and Software Design Aids

The advent of small, powerful, and accessible computers is providing transportation professionals with an ever-increasing range of tools to assist with landscape and environmental design. These tools include conventional word-processing, spreadsheet and database software for expediting the analysis of verbal and numerical information such as construction specifications and cost estimates. Programs for developing and displaying visual information and spatial relationships are also becoming wide-spread and increasingly easier to use. Thus, computer-assisted design and drafting ("CADD") software not only simplifies the design of earthwork, landscape planting, and structures for transportation facilities, but also simplifies the simulation of three-dimensional appearance of these facilities.

One of the major obstacles to the practical use of such programs has been the effort and cost of collecting and entering the extensive data that is needed to generate realistic three-dimensional views of terrain and structures. However, the increasing memory capacity of mini-computers and micro-computers and the development of external storage devices such as the compact-disk drive both promise to bring geographic information system ("GIS") software within the reach of small departments, agencies, and offices. This type of software can greatly simplify data collection and entry for tasks such as mapping viewsheds and generating views.

Figure I-7. Computer software generated this perspective view of a highway alignment alternative and matched it to a photograph of the actual terrain.



D. Collaboration Among Professional Disciplines

Effective landscape and environmental design is not the province of one profession: it requires the collaboration of many professional disciplines. These include disciplines within the environmental sciences (e.g., soil science, water and air chemistry, biology, botany, horticulture, forestry), the social sciences (e.g., sociology, economics, political science, public involvement), and the planning and design professions (e.g., urban and transportation planning, engineering, architecture, landscape architecture, construction management). This collaboration should begin in the problem

identification or scoping stage of any project, to ensure that the appropriate mix of disciplines is represented on the project team.

E. Coordination in the Design Process

Effective landscape and environmental design also requires coordination among agencies and departments over time as a given project moves from planning through design, construction, operation, and ultimately, repair and rehabilitation. Conscious effort and dedication is needed to retain important information on environmental design objectives and to apply this information to the myriad management decisions that occur over the entire life span of a transportation project. This type of coordination is akin to the requirement for successful completion of a relay race: each member of the team must pass the baton to next runner.

Chapter II

Landscape and Environmental Elements in Highway Design

Statement of Objectives

Man-made features have been integrated into a large portion of our nation's natural landscape. In order to provide optimum consideration of landscape and environmental elements, they must be inventoried early in the development process. The inventory should include: natural landscape elements, topographical and physical characteristics, ecological factors, recreational potential, residential qualities, historical features, visual values, and existing and potential land use. Man-made features that may detract from the road view should be noted in the inventory or visual assessment described in Chapter I and thought should be given to means for making them less objectionable to the motorist. The final design should reflect consideration of all these features to produce a safe, attractive facility compatible with the environment.

Design Guide

A. Conservation and Preservation of Land, Water Area, and Visual Quality

The environmental, aesthetic, and recreational values should be made a part of the design where feasible. Every possible means should be made to avoid disturbing or to mitigate the disturbance to existing wooded areas, wetlands, floodplains, ponds, rivers, and streams. Mature woodland is an extremely valuable feature because it requires several generations to recreate. Wooded areas are rare in urban and suburban locations and, as such, should be retained in their natural state. Woodland has many tangible benefits, such as scenic beauty, aid to erosion control, habitat for wildlife, and screening or reduction of air, noise and visual pollutants. The value of natural scenery is magnified in urban locations simply because of its rarity.

Figure II-1. Attention was provided to the natural environmental elements in the design of this Virginia highway.

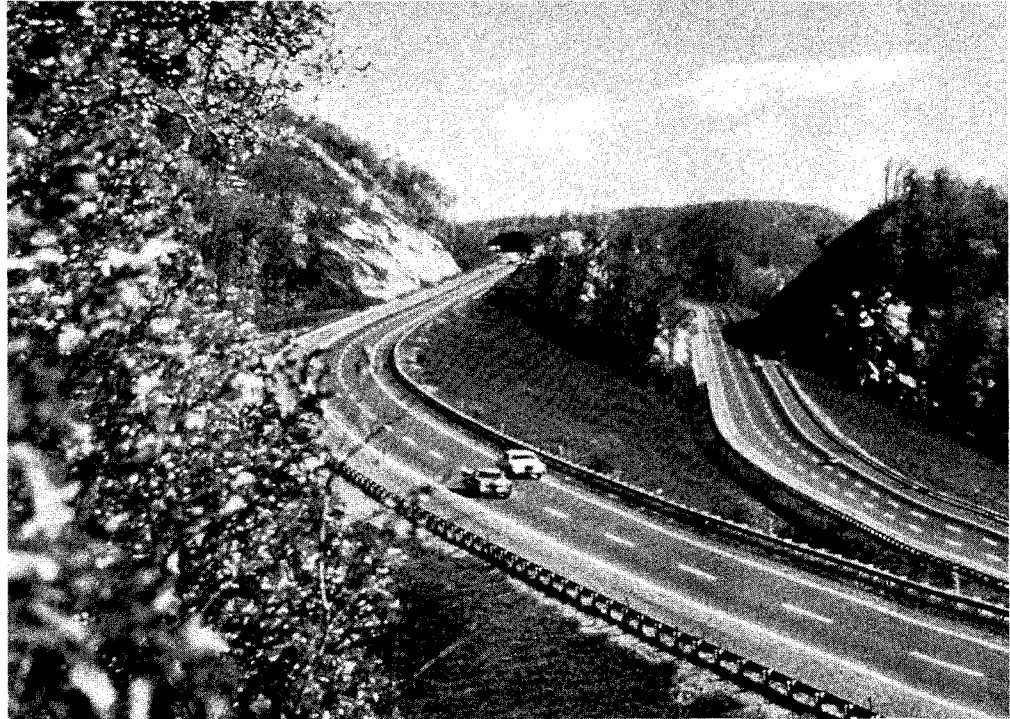


Figure II-2. Conserving natural features in the upgrading of an existing highway in New York.



Farmland, pastures, mountains, villages, historical areas, and attractive structures may be salient elements in the landscape that are typical of an area and these should be considered in design. The alignment and profile may be adjusted to make these features a part of the motorist's experience. An outstanding or typical scene should be considered for a rest area or scenic overlook.

Highways should provide pleasure for those who travel on them. They should be considered important parts of the landscape and developed as integral parts of the environment. Beauty, aesthetics, and visual quality all describe those values that are seen by the motorist. Aesthetic elements combat monotony and contribute to safety. Visual quality is an indispensable ingredient in the concept of design that provides for optimum development of the highway in its environment.

B. Topography

Highway design that is sensitive to the character of its environment has aesthetic design incorporated with geometric and structural design. This combination provides beauty in the roadside transition between the roadways for the traveler and the adjacent communities.

The proper fitting of the highway with the least amount of disturbance to the physical features should be given three-dimensional study in critical areas. Detailed profiles and alignment, grading, and drainage systems must be considered at selected locations. Minimum cuts and fills with warped cross sections and well rounded slopes will result in a safer facility, better erosion control, and less maintenance. Where right-of-way widths, grades, and lack of desirable vegetation permit, design grading may be used to provide variation in roadside slopes or create natural appearing berms for screening or traffic noise attenuation. Areas for borrow or waste of material should be located and graded in a manner that will minimize or avoid scars on the landscape. They should be designed and constructed for long term best use of the land, such as recreational ponds, wetlands, farmland or other development. Approved waste material may be incorporated into fills to create flatter slopes or to create natural appearing mounds or berms.

C. Existing and Potential Land Use

Existing and potential land use should receive prime consideration in the earliest stages of highway design and be carefully evaluated as part of right-of-way takings. The quality and quantity of landscape development that can be achieved are factors inherent in the extent and character of the right-of-way. Examples of the importance of enough space for highway development needs are: buffer and transition zones between the highway and its adjacent environment; protection and preservation of scenic lands, preservation and protection of wetlands, streams, and floodplains; protection of historical areas; and space for the development of motorist conveniences, such as rest areas, scenic overlooks and vista points. There may also be opportunities to cooperate with other agencies in the development of roadside facilities and amenities to enhance the highway.

If the only feasible alignment causes remnant parcels of land, the acquisition and retention of the remnants should be considered because they may have features

advantageous to the highway landscape design. They may be used for buffer strips, screen plantings, and, if sizable, wetland and wildlife habitat replacement areas or for a rest area. The splitting of farmland should be avoided wherever possible. In urban areas, such remnants may be ideal sites for small parks or sitting areas.

Since change in land use is often the result of highway construction it may be desirable to obtain land that may be used for screen planting or retained as a woodland buffer to separate the highway from adjacent properties. The highway right-of-way may provide precious open space and greenery in an urban area. Land for recreational purposes is usually scarce in urban locations and the possible development and joint use of such areas should be thoroughly assessed.

Existing residential subdivisions should be avoided whenever possible. However, when it is inevitable that the route location must encroach on such properties, it is desirable that sufficient land be acquired to provide methods to alleviate traffic and other highway-related disturbances. These methods may include vegetative buffers and screens, earth mounds, and noise barriers to enhance the motorist's view and maintain adjacent land values.

Preservation of landscape and environmental features is not limited to highways on new locations. With the upgrading of highways on existing locations every effort must be made to continue preservation of these features in the upgrading process. This may require the building of retaining walls, acquisition of additional right-of-way, or restoration of the natural feature.

D. Plan Incorporation

Plans and specifications must reflect the design decisions made as a result of the inventory of landscape and environmental features. They must be specific as to action necessary to conserve or enhance the features. Design and construction personnel should be aware of the land-use characteristics and should include in the design those elements that will be of value to the highway and adjacent properties and the construction requirements necessary to complete the design.

Chapter III

Environmental Design

Statement of Objectives

The National Environmental Policy Act (NEPA) is the basic national charter for protection of the environment. Several states also have environmental laws which, along with NEPA, ensure that environmental information is available to public officials, citizens, and decision-makers before decisions are made and before actions are taken. Integration of NEPA requirements as concurrent actions with other planning, design, and environmental review procedures brings about better and more timely decisions.

Objectives of effective environmental design include:

- To identify social, economic, and environmental effects early enough to permit analysis and consideration while alternatives are being formulated.
- To involve other agencies and the public in the planning and design decision process early enough to allow their ideas to influence technical studies and final decisions.
- To identify and assess reasonable alternatives to proposed actions that will avoid or minimize adverse effects of actions upon the quality of the environment.
- To use all practicable means to restore and enhance the quality of the environment.

Design Guide

Accurate, scientific analysis of environmental information is essential to implementing NEPA. This analysis must be concentrated on issues of true significance for the project that is being assessed. The intent is not to make better documents but to reach better project decisions. Transportation agency officials can then make decisions

based on an understanding of environmental consequences and take actions that protect, restore, and enhance the environment.

A scoping process provides for early identification of real issues during project development. This can lead to fully informed decisions, reduce delays through inter-agency cooperation and provide early resolution of disputes. Scoping includes participation by affected federal, state, and local agencies, special interest groups, and the public in the early planning or design of a project with continuing involvement throughout project development.

This section includes some of the more common issues identified as being significant on projects.

A. Visual Quality

The visual quality of a proposed project can play a key role in local community acceptance or rejection of the project. It is critical that project designers graphically or pictorially communicate what the final visual impact will be, including any mitigation measures. Another key purpose for documenting visual quality is that such an assessment can be an aid or tool for tempering all design decisions so that the intended objectives do not get lost or compromised.

Even for projects with little significant impact or controversy, assessment of visual quality is important, although it may not be concise. Since passage of the National Environmental Policy Act in 1969, visual assessments have become critical in evaluating the sensitivity of areas to visual alteration by proposed projects.

Visual assessments are addressed in Chapter I and covered in the FHWA publication, *Visual Impact Assessment for Highway Projects*. A key part of any assessment is the use of photographs, drawings, and other visual aids. Once the visual assessment is complete, it should be considered by the decision makers and summarized for inclusion in the environmental document. The summary should include quantifiable conclusions, photographs, and artist's sketches as needed to make any point.

B. Drainage

Drainage is an essential element in the design, construction, and maintenance of any transportation facility. Drainage can affect the structural integrity or safety of a facility as well as the environmental quality of surrounding areas.

Several environmental design mechanisms are available to help manage water in relationship to transportation facilities. These include vegetated drainage courses, stream rechannelization, fish passage and culvert placement, and stormwater management. Refer to the forthcoming *AASHTO Drainage Manual* for detailed design practices.

1. Vegetated Drainage Courses

Vegetated drainage courses to convey stormwater drainage from highways serve a dual purpose. First, the vegetation protects the roadside and waterway from erosion

and, second, it provides bio-filtration to remove pollutants from highway runoff, thereby reducing degradation of water quality in sensitive receiving waters.

Grass is effective vegetation for both purposes because it provides ground cover, a root system to hold the soil mass in place, and bio-filtration to remove pollutants.

Vegetated drainage courses may be either channels or broad surfaces for overland flow. They should be designed to carry the design flow without erosive velocities. Sufficient space must be available, and soils and moisture must be adequate to support relatively dense grass stands.

For most effective bio-filtration, grass height should exceed water depth, and slope gradient should not exceed 8 percent. Vegetated channels should be at least 200 feet in length, and overland flow bio-filtration areas should be at least 100 feet long.

Vegetated drainage courses must be maintained. Sediment should be removed when hydraulic capacity is no longer adequate. Any necessary sediment removal or mowing should be done as far before the rainy season as practicable so grass has time to regrow. It may be advisable to clean intermittent sections of the waterway so some

drainage treatment is always provided. It may be necessary to restore vegetation after removing sediment from the watercourse.

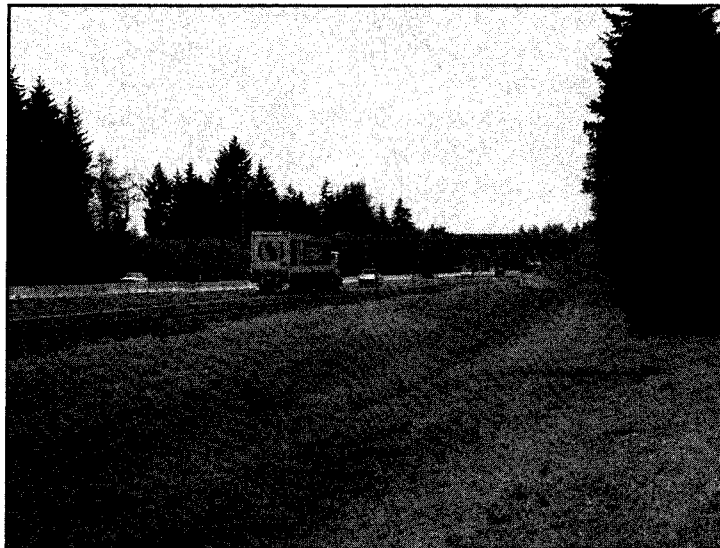


Figure III-1. *Example of vegetated drainage channel.*

2. Rechanneling Streams (Channel Realignment)

Until recently, transportation agencies often used channel realignments without assessing their impacts on stream stability, the fisheries resource, and other environmental aspects associated with the floodplain. Modern technological awareness, as well as environmental and legal considerations, have shown that significant long-term benefits may be realized by avoiding channel realignment altogether and adjusting the highway and drainage structure design as necessary. If avoidance of realignment is not practicable, channel changes should be designed and constructed in accordance with sound physical and environmental principles.

Proper channel realignment involves the full understanding and use of the concepts of open-channel flow, fluvial geomorphology, and river mechanics.

Figure III-2. Example of good channel realignment.



A biologist and other environmental disciplines should work closely with the hydraulic engineer to provide the features necessary for fish habitat and passage. This interaction between the various disciplines results in an environmentally sound, stable channel realignment that provides the same flood response as the existing channel. This in turn produces an economically viable solution to a conflict between a highway and a stream.

All stream characteristics are interrelated. A change in one may result in a change in one or more of the others. It is therefore important that the designer attempt to give a realigned channel the same hydraulic characteristics as the original channel or otherwise ensure the realignment will not adversely affect features upstream or downstream.

The realigned channel should have the same length along the "thalweg" (path of the river's deepest flow) as the original channel. This usually can be accomplished, since the length in a straight line of the realigned channel is normally shorter than the corresponding length of the original channel.

The realigned channel cross section preferably should provide the same depth-to-width ratio for the base flood (100 year) as the original cross section. A wide variety of channel cross sections are possible as long as appropriate channel linings, grade control and transition reaches from and to the natural channel are employed to provide a stable realignment.

The bank and bed material of the realigned channels, including any man-made channel linings or armoring, should be designed to contribute to a stable channel. AASHTO's *Drainage Manual* chapters, "Channel Analysis" and "Bank & Shore Protection", as well as the FHWA's *Hydraulic Engineering Circulars*, Nos. 11 and 15, should be referenced for the appropriate procedures for designing stable channels.

These references give guidance on the type and extent of erosion protection necessary to be consistent with the tractive forces produced by the stream.

The hydraulic design must include the method to shift the streamflow from the existing to the realigned channel. Also, a time window must be considered so as not to have an adverse impact on the fishery related to the stream.

If needed, a low-flow channel may be constructed in the realigned channel. This should ensure sufficient depths for fish passage during periods of low flow in the stream. This low-flow channel should follow the thalweg of the realigned channel.

If necessary, because of the velocity in the realigned channel, resting rocks and root wads may be positioned in the stream bed to enhance fish passage. Extreme care should be exercised in the use of these devices. Too large a resting rock creates local scour around the rock that in time results in the rock burying itself in the stream bed. Too small a resting rock will be carried downstream by the tractive forces in the stream. Root wads or balls should be adequately anchored in the stream bed so that they do not break loose during flooding and become a hazard. Under no circumstance should these devices upset the delicate hydraulic balance in the stream.

Digger logs are logs anchored in the stream bank that simulate a natural tree that has fallen into the stream due to erosion of its roots. The installation of digger logs is an attempt to enhance the fish habitat. Extreme care and caution should be exercised in their use. The enhancement of the fish habitat they may provide should be weighed against the potential hazards they may produce. These digger logs have the potential to trigger a hydraulic jump if they are installed in areas where the stream approaches critical flow. The hydraulic jump can create a severely unstable condition in the stream.

These installations should also be checked for their impact on the base flood water surface elevation, because of the backwater they produce.

3. Fish Passage and Culvert Placement

The ability of a highway culvert to permit upstream fish passage is often as important as its ability to pass flood flows. In many states, statutes require that all culvert designs adequately accommodate upstream fish passage and that adequate maintenance be performed to ensure that fish passage is continued in perpetuity. Some states also have laws that require the owner of the culvert to obtain a permit from the state agency responsible for the fishery prior to construction of the culvert.

Perhaps the most important aspect of culvert design is to ensure that outlet velocity of the culvert will not create an abrupt drop in the stream gradient at the outlet of the culvert. Initially, the culvert should be sized for the design flood flow. This then becomes a starting point in the culvert design. Outlet velocities should be calculated and their effect on stream scour evaluated.

The culvert should not be placed on a gradient steeper than the natural stream. Velocities in the culvert should be determined for partial flow conditions that would be anticipated during times of upstream fish passage. These velocities should be compatible with the athletic ability of the types of fish migrating upstream through the

culvert. Anticipated flow depths during periods of fish migration should be adequate to ensure passage. Wing walls and aprons at the inlet and outlet that spread the flow and adversely impact the depth of flow should be avoided. Adequate armoring should be placed at the outlet to mitigate the effects of scour. In many instances these design features by themselves are sufficient to ensure a good fish passage design.

In some instances an oversized culvert that has its invert buried (countersunk culvert) and is placed on a gradient shallower than the natural gradient of the stream is required to be compatible with the athletic ability of the fish. The invert is backfilled and will silt into the natural stream gradient. At lower flows, and at anticipated fish passage flows, a meandering low-flow channel will form in the bottom of the culvert. This type of installation will provide a certain degree of freedom of erosion without creating an abrupt drop in the stream gradient at the culvert outlet. The hydraulic capacity of a countersunk culvert can be approximated as the capacity of an arch culvert.

Figure III-3. Example of countersunk culvert.



In rare cases it may be necessary to use a culvert that is an arch on individual footings, with the footings buried a sufficient depth to accommodate the natural degradation of the stream bed without causing an abrupt drop in the stream gradient at the culvert outlet.

In most cases, single barrel culverts are preferred.

A design that recognizes the need for fish passage only solves half the problem. An adequate maintenance program must be instituted to ensure that the design retains its capabilities over the years, and to correct the problems of older culverts that were not designed with fish passage in mind. Debris must be removed as soon as practical so as not to block passage. Scouring at the outlet must be mitigated. In some instances, a series of weirs may be constructed in a terrace-fashion downstream from the outlet in order to correct an abrupt drop in the stream gradient. Each "step" in height in this terrace must not exceed the jumping ability of the fish being accommodated.

4. Stormwater Management

Stormwater management is usually concerned with control of the increased rate of stormwater runoff from a highway. Requirements to mitigate increased rate of runoff may be found in state statutes and local land-use ordinances. Runoff water quality

requirements are normally kept separate from these requirements and will not be addressed in this section.

Stormwater management regulations normally require that the rate of runoff from the highway for a given rainfall event (recurrence interval storm) be limited to that which would have occurred on the undeveloped property for the same storm. In some instances, highway runoff may be discharged into a body of water that is of such a size that any development will not have significant impact on the receiving body of water. In these cases, limitations on highway runoff may not be required.

The rate of stormwater runoff from a highway may be controlled by storing the runoff on the property and releasing it at a specified lower rate; or by preventing the stormwater runoff from leaving the property by percolation into the ground, evaporation and transpiration from vegetation, or by a combination of both of these methods.

a) Stormwater Detention

Controlling the rate of stormwater runoff by storing the runoff on the property and releasing it at a specified rate is referred to as stormwater detention. The storage requirements are calculated using flood-routing principles. The storage may be provided on the surface, below ground, or using a combination of both. Detention storage may also be provided on a regional basis for the entire drainage basin.

In this instance, the responsible governmental entity provides a regional detention facility that is of sufficient size to accommodate the entire drainage basin. Each property owner would contribute his equitable share of the cost of the regional facility, and the maintenance of the facility would be the responsibility of the governmental entity.



Figure III-4. Example of detention basin design.

Any facility that stores stormwater for release at a controlled lower rate also functions as a sedimentation basin. It is therefore necessary that provisions be made for cleaning the facility. The material that is removed from the facility should be disposed of in a manner that is both lawful and environmentally sound. Facilities that do not receive adequate maintenance

nance suffer a reduction in storage volume that eventually may cause stormwater to back up onto the roadway, or result in other undesirable conditions.

Surface detention for roadways may be provided in loops of interchanges, swales, or other areas within the right-of-way that are not used for the roadway surface or shoulder area. Open surface basins present a potential hazard to motorists who leave the roadway and to pedestrians, and measures to lessen these potential hazards are recommended.

b) Stormwater Retention

Stormwater retention involves retaining the stormwater on the property on which it originates, allowing zero runoff from this property. This may be accomplished by one or another of the following methods, or by combinations of these methods:

1. Collecting the stormwater runoff in a pond that is adequately sized to store the water until it evaporates. This is only possible in areas where the yearly evaporation exceeds the rainfall.
2. Collecting the runoff in a pond that is adequately sized to permit the runoff to enter the shallow groundwater through percolation from the sides and bottom (a percolative pond), when adequate porosity exists. The stormwater runoff should be channeled through an oil separator and sedimentation basin prior to entering the infiltrative basin in order to prevent contamination of the groundwater.
3. Collecting the runoff in a non-percolative pond that also serves as a sedimentation basin, channeling it through an oil separator and discharging into a shallow system of perforated pipes for disposal into the groundwater, when adequate porosity exists.
4. Collecting the runoff in a non-percolative pond that is sized to permit spray irrigation of the accumulated stormwater, so that the stormwater may be disposed of by evapotranspiration.

All of the above methods of stormwater retention are site specific. Percolative ponds require continued scarification of the sides and bottom in order to maintain their percolative capacity, and subsurface disposal methods may require reconstruction as the fines in the runoff eventually plug the interface between the pipe and the soil. It is suggested that methods that involve some type of percolation into the ground be considered temporary in nature because of their tendency to plug. Comments on detention ponds relative to siltation and hazards also apply to retention ponds.

C. Creation and Restoration of Wetlands and Floodplains

Wetlands are transitional areas that have some of the features of both dry land and water environments. Examples of wetlands include estuaries, mud flats, wet meadows,