NCHRPR-137

Safety

~~TRAFFIC~~

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT **137**

ROADSIDE DEVELOPMENT

EVALUATION OF RESEARCH

HIGHWAY RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT 137

ROADSIDE DEVELOPMENT

EVALUATION OF RESEARCH

WAYNE O. EARLEY
WESTERN STATES LANDSCAPE ASSOCIATES
PHOENIX, ARIZONA

RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION
OF STATE HIGHWAY OFFICIALS IN COOPERATION
WITH THE FEDERAL HIGHWAY ADMINISTRATION

AREAS OF INTEREST:
HIGHWAY DESIGN
ROADSIDE DEVELOPMENT
MAINTENANCE, GENERAL

HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING 1972

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Highway Research Board of the National Academy of Sciences-National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway departments and by committees of AASHO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are responsibilities of the Academy and its Highway Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NCHRP Report 137

Project 16-2 FY '68
ISBN 0-309-02022-0
L. C. Catalog Card No. 72-9485

Price $4.20

This report is one of a series of reports issued from a continuing research program conducted under a three-way agreement entered into in June 1962 by and among the National Academy of Sciences-National Research Council, the American Association of State Highway Officials, and the Federal Highway Administration. Individual fiscal agreements are executed annually by the Academy-Research Council, the Federal Highway Administration, and participating state highway departments, members of the American Association of State Highway Officials.

The study reported herein was undertaken under the aegis of the National Academy of Sciences—National Research Council. The National Cooperative Highway Research Program, under which this study was made, is conducted by the Highway Research Board with the express approval of the Governing Board of the NRC. Such approval indicated that the Board considered that the problems studied in this program are of national significance; that solution of the problems requires scientific or technical competence, and that the resources of NRC are particularly suitable to the conduct of these studies. The institutional responsibilities of the NRC are discharged in the following manner: each specific problem, before it is accepted for study in the Program, is approved as appropriate for the NRC by the Program advisory committee and the Chairman of the Division of Engineering of the National Research Council.

The specific work to be performed in each problem area is defined by an advisory panel that then selects a research agency to do the work, monitors the work, and reviews the final reports. Members of the advisory panels are appointed by the Chairman of the Division of Engineering of the National Research Council. They are selected for their individual scholarly competence and judgment, with due consideration for the balance and breadth of disciplines.

Responsibility for the definition of this research project and for the publication of this report rests with the advisory panel. However, the opinions and conclusion expressed or implied are those of the research agency that performed the research, and are not necessarily those of the Highway Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway Officials, nor the individual states participating in the Program.

Although reports in this category are not submitted for approval to the Academy membership nor to the Council, each report is reviewed and processed according to procedures established and monitored by the Academy's Report Review Committee. Such reviews are intended to determine, *inter alia*, whether the major questions and relevant points of view have been addressed, and whether the reported findings, conclusions and recommendations arose from the available data and information. Distribution of the report is permitted only after satisfactory completion of this review process.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Highway Research Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

(See last pages for list of published titles and prices)

FOREWORD

By Staff
Highway Research Board

This report reviews previous research in the roadside development field and identifies a large number of problems associated with the application of such items as aesthetics, resource conservation, land use, and erosion control to the broad areas of roadway design, construction, operation, and maintenance. Individual problem statements are included for the five top-priority research needs in each of the eight categories into which roadside development has been divided. Highway agency personnel involved in the various roadside development activities should find the evaluation of previous research and experience of practical value. The list of needed research and field study programs should also be useful in delineating the most profitable future research programs within the highway departments.

With increased emphasis on highway beautification and environmental considerations in the late 1960's, questions were raised concerning the adequacy of available information to resolve emerging problems such as the selection of appropriate plantings for highway landscaping and methods for improving survival of the plantings. Aesthetic qualities of a highway obviously were desirable, but how could they be measured? There was a need for a review and evaluation of previous and current research on roadside development and for identification of areas where further research would be most profitable.

The research staff of the Western States Landscape Associates identified from all major highway and many nonhighway sources almost 2,000 documents that had some relationship to roadside development. Each document was classified as being pertinent to one or more of the eight subject categories, and a category evaluation was prepared for each of the subject areas. These evaluations are incorporated in the findings of the report. In addition, visits were made to a number of state highway departments for interviews with appropriate personnel to gain further insight into the practical needs of the roadside development field.

On the basis of the evaluations of available literature and the interviews, five top-priority research needs in each of the eight categories of roadside development were identified and described. It is estimated that funding of $5 million would be required for the conduct of the research described. The dominant types of research needed were found to be:

1. Quantification of intangible values (such as aesthetics) into measurements for incorporation into engineering evaluation systems.
2. Synthesis of existing information into guidelines, standards, and manuals.
3. Development of procedures that incorporate roadside development considerations into total highway design.

During the study it was recognized that some problem categories (such as plant selection and establishment, and erosion control) are more amenable to regionalized research than to nationwide investigations.

One direct result of the study has been selection of the problem of erosion control during construction—the first-priority problem in the erosion control category—by the Special AASHO Select Committee on Research for programming in the FY '73 research program of the NCHRP. As a prelude to the research, a

synthesis study was undertaken under NCHRP Project 20-5 and further research will be initiated in early 1973 as NCHRP Project 16-3, "Erosion Control During Highway Construction." A number of other high-priority research needs identified in this report are the subjects of previous and current studies both within and outside of the NCHRP. For example, under the category of location and design, the identification and evaluation of ecological and aesthetic factors proposes objectives similar to those of current NCHRP Project 8-8(3), "The Impact of Highways upon Environmental Values," and the proposed study of aesthetic considerations of noise abatement designs has been investigated extensively in recent years under NCHRP Project 3-7, "Establishment of Standards for Highway Noise Levels," culminating in the recent publication of *NCHRP Report 117,* "Highway Noise—A Design Guide for Highway Engineers." The objectives of the first-priority problem in the motorist services category—characteristics and design requirements for safety rest areas—are included in a current synthesis study under NCHRP Project 20-5 as Topic 4-04, "Rest Areas—Design, Operation, and Maintenance." An FHWA administrative contract on "Establishment of Roadside Rest Area Water Supply, Water Carriage, and Solid Waste Disposal Requirements" is similar in scope to a problem on rest area water and waste disposal systems described in this report.

CONTENTS

ACKNOWLEDGMENTS

The research reported herein was performed under NCHRP Project 16-2 by Western States Landscape Associates (now Western States Consultants) with Wayne O. Earley as principal investigator. He was aided throughout the study and during preparation of the report by the following associates:

James D. Anderson, Civil Engineer
Mark H. Astrup, Landscape Architect
Wilbur J. Garmhausen, Landscape Architect
Eliot C. Roberts, Agronomist-Horticulturist
Bradford G. Sears, Landscape Architect
Wilbur H. Simonson, Landscape Architect
Louise Nelson, Research Technician

Appreciation is expressed for the assistance rendered by Federal Highway Administration staff personnel, including:

Carl Izzard, Director of Research and Development
Henry Lathrop, Chief, Office of Program Coordination
Mildred W. Helvestine, Chief Librarian
Carmen Bart, Librarian (retired)

Special acknowledgment is made to the many busy highway organization administrators, engineers, researchers, and roadside development practitioners who were so generous with their time and assistance to the project.

Allan Seed, Jr., Executive Vice-President, Keep America Beautiful, was of great assistance in identifying current litter problem research needs.

ROADSIDE DEVELOPMENT
EVALUATION OF RESEARCH

SUMMARY For the purposes of this study the evaluation of research on roadside development was construed in its broadest sense; that is, not only as an evaluation of the state of the art as published in research documents, but also as an evaluation of the conditions of, and for, research on roadside development. This required the identification of roadside development, as well as a description of its role within its administrative, professional, and operational environs.

Several core areas of roadside development are traditional; however, the parameters were found to be intermingled throughout the entire highway process as disciplinary and philosophical contributions to each function.

The traditional core areas are erosion control, planting as a physical highway element, vegetation management, safety rest areas, highway aesthetics, and resource conservation.

Erosion control, rest areas, planting, and vegetation management are physically limited to the "roadsides." However, aesthetics and resource conservation directly involve roadside development with route planning, location, roadway design, and right-of-way acquisition and management. All areas require attention in the construction, operation, and maintenance phases, and contribute to the public relations response.

Roadside development, through its historic focus on erosion, aesthetics, rest areas, and resource conservation, has 40 years of intimate and specific experience with these qualitative characteristics of highways as environmental entities. With recent emphasis, administrators quickly recognized the need for specific information in these areas beyond, and in support of, the intuitive judgment of experienced roadside development design professionals.

The published literature; interviews with highway, research, and industry personnel in the U.S. and Canada; and the knowledge of the researchers were the three principal sources of information used to accomplish this study. The first task was to identify and categorize roadside development by subject area. Each subject area was assigned for evaluation to the associate researcher most knowledgeable in the subject.

The results of field interviews with a broad spectrum of highway personnel were combined with a study of the highway research establishment and roadside development's relationships therein to develop recommendations to fill roadside development research needs and to utilize the results.

It was found that, to the extreme detriment of the entire highway process, there is presently a substantial backlog of roadside development research needs. It was also determined that there is small likelihood of improving this situation under existing conditions. Areas of concern are:

1. Roadside development staffing and organizational structure.
2. Quantity of existing roadside development research effort.
3. Efficiency and productivity of roadside development research as a part of total highway research.

The funds required to accomplish the top five priority research needs in each of the eight roadside development subject area categories are estimated at $4.88 million. This amount does not include non-federal-aid testing and demonstration work.

It was determined that roadside development research receives approximately 0.006 percent of the total money expended for highway construction and maintenance. All highway research receives approximately 0.25 percent. Further, the roadside development share of HPR research funds has declined from 3.03 to 2.39 percent during the past years of emphasis on the subject. This trend must be drastically reversed if a significant portion of the needs are to be met.

Beyond increased funding or research effort, there are several ways to make roadside development research more efficient and productive. The most critical need is to provide a system for sustained communication and decision-making that is representative of roadside development (or any highway specialty area) and its requirements for information. Because these research needs occur and are applied at national, regional, and state levels, this system must include all levels in order for the research planners to match the need with the sponsors and the research project with the researcher. The system also must provide for the dissemination and use of research results.

In addition to a prescribed and organized research system, there must be someone with the responsibility and technical capability to make the system work.

On a national or regional level the American Association of State Highway Officials, or a combination of AASHO and the Highway Research Board, were found to be the only national organizations with the potential for proper and continuing research planning and administration for any specialized area of highway research including roadside development. However, several deficiencies and restraints were found that prevent their performance of this vital function. Further, because of the lack of coordination with and between other highway specialties, relevant roadside development concerns generally have not been included in past or on-going research—to the detriment of both.

Subject Area Categories and Research Needs

In classifying the literature of roadside development, its parameters were also delineated. The following categories were developed and described with the respective project titles representing research needs:

1. *Highway Location and Design* includes the roadside development areas of highway planning, location, and design associated with the disciplines of landscape architecture, including the physical and social environmental sciences. Considerable emphasis is given to aesthetics and psychological impact. Design would include rural, urban, and suburban. Roadside development planning is implied and included in the location and design category. Research needs include:

   a. Highway planning procedures for the identification and evaluation of ecological and aesthetic factors.
   b. Comparison of grading and safety factors with aesthetics, ecology, and independent roadway design.
   c. Environmental design for urban highway multiple-use, joint-development projects.
   d. Aesthetic consideration of noise-abatement designs.
   e. Aesthetics of highway hardware.

2. *Roadside Space* is similar in approach and discipline to Category 1, except that it is concerned more with the planning, acquisition, use, and use controls of the space being occupied by and adjoining the roadway (historically, the right-of-way). Of equal concern are the highway relationships with the adjoining space beyond the normal right-of-way. The term "roadside space" is used because of the increase in the three-dimensional use of air rights, etc. The term "space" indicates a volumetric quantity, which is more accurate than the previous two-dimensional right-of-way concept. Research needs include:

a. Ecological interrelationships between highways, land, and people.

b. Evaluation of research on intangibles and noneconomic values related to highways.

c. Scenic roads and highways criteria.

d. Effects on the environment of differing right-of-way widths.

e. Transportation submodes in highway space.

3. *Resource Conservation* is involved with highway impact on the environment, and the identification, preservation and use of human and natural values as affected by or related to highway construction, use, and occupancy. The category includes the saving and use of something that already exists, as opposed to construction, planting, or establishment of something new. Research needs include:

a. Pleasurable driving—measurement and economic value.

b. Highway and history—guideline for highway administration.

c. Classification and relative values of recreational uses of highways.

d. Highway roadsides—multiple-use land management.

e. Wildlife conservation as related to highway development and maintenance, including its benefits and safety considerations.

4. *Motorist Services* is concerned with "on-highway" services and facilities, other than the travel way and traffic signing, provided for the highway user. Because of the scope and variety of services provided by and on highways, in addition to rest areas (information centers, interpretative aids, etc.), it was believed that a "motorist services" category should be used to embrace all such services. Research needs include:

a. Characteristics and design requirements data for safety rest areas.

b. Motorist information centers—needs and operation.

c. Playground equipment in rest areas.

d. Relationships of public and commercial motorist services.

e. Design guide for rest area water and waste disposal systems.

5. *Erosion Control* is concerned with the stabilization of roadside embankments and drainage channels. It includes the use of vegetation for erosion control, but not "plant material establishment," which is in Category 7. Erosion control is a separate category because of its dominance in the roadside development highway function and because its basic disciplines are inherent in the whole engineering process of grading and drainage design, location, and conservation. Roadside development is involved primarily when it embraces a vegetative channel or slope lining. It also is concerned with the aesthetics of structural erosion control. Research needs include:

a. Effects and remedies of erosion during construction.

b. Erosion control systems for arid regions.

c. Vegetative erosion control manuals for the major climatic zones of the territorial U.S.

d. Velocity control structures and methods.

e. Evaluation of new erosion control methods and materials.

6. *Planting* includes plant establishment or other aspects affecting the horticultural and agronomic aspects of planting. It does not include design or plant uses. Research needs include:

a. Time and care requirements for the establishment of woody plants.

b. Comparison of functional plantings' value to establishment and maintenance costs.

c. Obtaining plant material for highway uses.

d. Direct seeding of woody vegetation.

e. Evaluation of roadside planting material, techniques, and equipment.

7. *Maintenance* includes the maintenance and management of roadside vegetation and those structural and mechanical facilities associated with roadside development. Research needs include:

a. Achievement of lower maintenance costs through design.

b. Safety rest area maintenance.

c. Roadside maintenance equipment.

d. Establishment periods for roadside vegetation.

e. Maintenance of multiple-use areas.

8. *Organization and Administration* includes staffing and internal operational relationships, as well as roadside development programs involving the public. Research needs include:

a. Highway landscape architecture—responsibilities and functions.

b. Landscape architecture's contribution to conceptual design teams.

c. Rest area staffing requirements.

d. Vandalism by highway users.

e. Estimating design time and construction costs for roadside development staffing and programming.

To implement the major results of this study it is recommended that the research needs identified and described be used as the basis for an expanded and continuing program of accomplishing research to fill these needs. Also, applicable portions of the recommendations should be used as the basis for the preparation of a Roadside Development Research Policy or Procedure Guide. Further, because AASHO and HRB are the only national highway organizations with organized committees on roadside development, it is recommended that AASHO be given the responsibility and staff with technical capabilities to administer the system with HRB assistance. It is recommended that the literature identified and classified by this study be used as a data bank and that inputs be made to keep it up to date.

The recommendations in the report describe specific actions for those states and agencies involved in highway research and its implementation for effective roadside development research planning.

The category evaluations describe the principles of roadside development and document their relationships to the "complete" or "ideal" highway design and operation.

CHAPTER ONE

INTRODUCTION AND RESEARCH APPROACH

DEFINITION OF ROADSIDE DEVELOPMENT

Roadside development is: to provide an appropriate integration of the highway with the rural or urban landscape; to conserve, enhance, and display the natural beauty or compatible man-made developments of the landscape through which the highway passes and to improve the aesthetic qualities of the highway and its structures; to provide comfort and convenience facilities—all concerned with environmental quality and directed to the highway concept that combines safety, utility, economy, propriety, and beauty in all its elements.

Roadside development is an integral part of corridor selection and is included in right-of-way determinations, and highway location and design. It is accomplished by: the application of ecological and landscape architectural principles and planning techniques to highway location, design, construction, and maintenance; the development and application of technical criteria for conservation and establishment of roadside vegetation and scenic roadside features, erosion control, planting design, and selection and development of rest areas and other sites of scenic and historic interest.

The scope of roadside development varies with state organization and administrative policies. Proper policies and practices will provide for conservation and enhancement of both human and natural resource values; for improved highway safety; and for the introduction of highway improvements to provide functional excellence and visual satisfaction to both the highway user and its neighbors.

NEEDS FOR STUDY

The highway transportation administrator is responsible for the expenditure and accountability of vast sums of user tax funds. The first goals of our highway program have been achieved. The United States is now "out of the mud," with a system second to that of no other country. It is now recognized that the shortest distance between two points is not always the best location, flat is not always the best grade, economics is not the only highway construction criterion.

Transportation planners are now in the early phases of providing environmental quality and the necessary coordination with ecologic and sociologic systems to highway transportation.

With the advent of the Federal Highway Beautification Act of 1965, the nation's highway administrators suddenly faced additional demands on their overloaded time, budgets, and expertise to meet the challenge for environmentally acceptable roadway systems.

They, in turn, called on their roadside development design staff for counsel and production of construction plans to implement this national program. The roadside development professionals, who had for years been building a sound reservoir of experience and knowledge, were suddenly thrust into a melee of urgency and expanded responsibilities. They had been relatively content to work within the engineering-oriented highway structure to demonstrate the value of their ideas and to let these contributions stand or fall on their own merit.

However, the result was that most state roadside development organizations were not prepared to implement the Highway Beautification Act of 1965. Many were understaffed, underpaid, unqualified, and under pressure to produce certain phases of design without sufficient or tested basic design data. Answers were demanded to many unproven theories, untried techniques, untested materials, and unmeasurable qualities.

Thus began the most comprehensive roadside development "research effort." This "research effort" was the experience gained from accomplishing major project design and construction, and it is the continuing observations made of these projects.

The urgency for this research continues. We have entered a period of widespread concern over environmental pollution and the squandering of our living space and other resources. This is presently manifested in such now-familiar terms as *relocation assistance, multiple use, environmental planning, joint development, design concept teams, urbanology, social engineering,* and *integrated transportation systems.* These concepts present a myriad of new and challenging problems that must be solved. It is now not enough to meet previously generated problems with an evolutionary type of research. Research must be put to work on problems that are arising today. Further, research must be projected into the future for problems known to be arising. There is not time to solve the problems through experience. Roadway and roadside planning guidelines must be enunciated, intangibles must be quantified, actions must be related with reactions, and interdisciplinary cohesiveness and operational coordination must be achieved.

Another major factor contributing to the urgency of this research is the vastly expanded right-of-way area and even volumetric space. Right-of-way is no longer two-dimensional, but must be considered in three dimensions. The miles and acres of roadsides added by the Interstate system, together with the three-dimensional aspects of urban freeway air space, dictate that the maintenance must become highly organized and operate on a mechanized, mass-production basis. More efficient techniques must be learned. Improved and more effective roadside materials and equipment must be developed. More stable minimum maintenance of roadsides and pertinent facilities must now become a reality.

To research a problem, it must have definition. AASHO

determined that this study was needed to identify and define the problems and research needs of roadside development. Many problems in this subject area will require further definitive research in order to accurately approach the specifics of the particular problems. Further, this study was to quantify the relative degree of the urgency of the individual problems and to recommend procedures and actions for resolving those research needs.

RESEARCH APPROACH

This research problem was investigated through three major sources of information: (1) the published literature of the subject area, (2) the recorded interviews with persons knowledgeable or involved in roadside development and research activities, and (3) the personal knowledge and experience of the researchers.

The researchers provided the basic parameters, structure, and scope to the problem and subject area during their conferences, and provided the various judgments and interpretations regarding the state of present knowledge based on the existing literature reviewed.

The interviews produced information regarding the problems and needs of both practice and research. Much of the information related to research is not unique to the roadside development facet, but probably would be similar to many other areas of highway transportation technology.

Information obtained on roadside development practice included historic and topical problems of design, operations, and administration as expressed in the eight major subject area categories used.

It was most difficult to limit interviews to discussion of the problems caused by the lack of technological information rather than a discussion of present practices and the problems caused by administrative conditions or policies.

Because of the universal expression of dominant problems in the administrative area, increased emphasis was given in the information reported. Only those subjects considered amenable to study or research were reported as research needs.

The interviews were also designed to reveal any published or unpublished research efforts not otherwise located or identified in the document search.

The published literature was located, reviewed, interpreted, and evaluated. All major highway literature sources and many nonhighway sources were surveyed for documents. Because of the need for completeness in structuring the area of roadside development in order to identify the research voids, even relevant opinion papers (nonresearch) were included in the evaluation process.

Most documents were evaluated for research on opinion content, geographical application, and relevance within the category of its major content. Some documents were evaluated for their secondary subject area category. All documents were identified as to their major subject areas.

Both the literature information and the field interview results were studied for various areas of interest, activity, expertise, and research need.

BENEFITS ATTAINED FROM STUDY

This study has identified and equated the urgency of the research needs of roadside development. In addition to urgency, other considerations were used in the assignment of priority. From this information the beginning for a research program has been developed, which embraces national, regional, and state interests.

This study has identified and located agencies and individuals with ability for, and interest in, roadside development research. Structure and definition have been given to the scope of roadside development and its literature. Through a better understanding of the subject, the highway administrator will be able to more accurately assign responsibilities and tasks. Simultaneously, his roadside development staff will be better prepared to function as it should.

A by-product of this study was the production of a comprehensive listing of pertinent research and literature published to date. Each publication evaluated was identified as to its research type, geographical application of information, and degree of relevance to roadside development, and all documents were classified as to their subject content by category and subcategory. This will be invaluable in locating and acquiring the existing state of the art in a particular area of need or interest up to the literature search cut-off date of this study (1968). By reference to this listing and the review of the literature and the past research they represent, wasteful repetitious research effort can be avoided in the future.

CHAPTER TWO

FINDINGS

STRUCTURE, STAFFING, AND SCOPE OF ROADSIDE DEVELOPMENT ORGANIZATIONS

To consider roadside development research, evaluate needs, or develop a research plan, the structure, staffing, and scope of roadside development organizations must be defined. The following is a brief resume of those factors.

The organizational structure and staffing of roadside development is varied and sometimes fragmented. The scope of roadside development embraces aesthetic and other environmental aspects of highway design, and is concerned with land planning and the application of natural sciences for the betterment of the internal and external relationships of highways as one of many elements in man's environment.

States

The roadside development organizations or personnel of the various states are placed in nearly every level and operational function existing in a state highway department —from the second to the seventh level below the Chief Engineer. At present, most states have personnel assigned to functions clearly identifiable as roadside development responsibilities.

Some states have centralized roadside development functions and control. Others perform limited functions in the districts, and some have combinations in varying balance. Most favor a strong central organization with district personnel held responsible for liaison, control, and implementation.

Some states' roadside development organizations have complete responsibility for all functions, including planning and design, roadside control, and construction and maintenance. Others are assigned and operate in only design or maintenance units.

A few states have fragmented their roadside development functions into the corresponding highway functional unit, such as:

Highway Design	Rest Area and Planting Design.
Highway Maintenance	Planting Design, Establishment and Maintenance. Vegetation and Erosion Control.
Right-of-Way	Roadside Control (Scenic Strips—Billboard Control).

States with fragmented staffing approaches usually lack the effectiveness of a comprehensive roadside development program that is necessary for the consistency of effort in planning activities, such as: corridor selection, route location, aesthetic design, and environmental coordination of highway geometrics, resource conservation, scenic roads and parkways, and public relations.

Two states divided their roadside development activities on a disciplinary basis with most preconstruction activities under a landscape architect in the highway design section, and most postconstruction activities under a variety of agronomists, horticulturists, and foresters in the highway maintenance section. Even though such a division is preferable to functional fragmentation, the obvious problems in this arrangement are the difficulties of coordination and correlation of the planning and design functions with the maintenance functions. Responsibility for the construction control activities was not clearly identified.

The titles of roadside development personnel are just as inconsistent as their placement with the state highway organizations. The most common are as follows:

Chief Landscape Architect
Landscape Supervisor
Chief Arboriculturist
Chief of Roadside Development
Chief Architect
Chief, Landscape Division
State Manager, Roadside Development
Chief, Environmental Services
Senior Landscape Engineer
Parkway and Landscape Engineer
Director, Landscape Bureau
Agronomist, Roadside Development Branch
Chief, Bureau of Landscape Development
Highway Beautification Coordinator
Chief, Roadside Development Section
Head of Roadside Development
Roadside Development Engineer
Chief, Bureau of Landscape Architecture
Highway Landscape Supervisor
Supervisor of Roadside Development
Chief, Highway Beautification Section
Roadside Improvement Engineer
Waysides and Landscaping Supervisor
State Landscape Superintendent
Landscape Maintenance Engineer
Landscape Engineer

Bureau of Public Roads *

The roadside development function of the Bureau of Public Roads (BPR) was administered by a roadside section of the Highway Standards and Design Division within the office of Engineering and Operations and is administered now by a landscape division in the office of Engineering and Operations. The Division is headed by a Landscape

* Now Federal Highway Administration (FHWA). Reorganization has changed this subsequent to preparation of this report.

Architect who is responsible for all activities within the scope of roadside development. Recent emphasis on the total scope and certain phases of roadside development has resulted in three major administrative changes in BPR participation in roadside development.

Shortly after the passage of the Highway Beautification Act, the landscape division was created and functions were established, with a substantial increase in staff and responsibility. Also, the position of Regional Landscape Architect was created and filled in all regions. The position of Assistant Regional Landscape Architect was created and filled in a number of regions. Similarly, the position of Division Landscape Architect was created and assignments were filled in several large states.

Secondly, Congress created the position of Highway Beautification Coordinator and gave him the responsibility of coordinating all phases of programs for the control of outdoor advertising, the control of junkyards, and for landscaping and scenic enhancement.

Thirdly, the later stages of the Interstate Highway Construction Program in urban and certain sensitive rural areas brought innumerable environmental problems. In responding to these difficulties, the BPR created a multidisciplinary environmental development division in the office of Right-of-Way and Location. The principal relationships of roadside development with this division are included in the categories for Resource Conservation, Roadside Space, and Administration and Organization.

Because of the interrelationships of the objectives of these BPR divisions, it is imperative that complete coordination of their operations be continued. The same applies to their research efforts.

BPR roadside development research is administered and coordinated by the Office of Research and Development through the Engineering Systems Division. Landscape architects assigned to this division are responsible for planning, initiating, guiding, and evaluating research in all phases of roadside development, for providing consultative services to the states and other BPR offices, and for promoting implementation of research results. Studies are conducted both by direct contract between BPR and the research organization and by the states through their federally aided research and development programs, either in-house or by contract with universities or other agencies.

Information or results achieved are disseminated by means of the *Highway Research and Development News,* published and distributed periodically by the BPR.

American Association of State Highway Officials

AASHO is the quasi-official organization representing the state highway departments on national highway issues. In addition to policy statements, AASHO publishes guidelines, standards, and other criteria. These were used as the official expressions of the several states by the BPR.

Internally AASHO is operated by elected officers and a system of standing, operating, and special committees, with the assistance of an executive director and a small staff.

AASHO has four regions that cooperatively operate as separate entities on regional issues.

Roadside development matters are considered and coordinated by the Operating Committee on Roadside Development of the Standing Committee on Standards.

The Chairman of the Operating Committee on Roadside Development also is a member of the Operating Committee on Research Activities. Therefore, for roadside development to receive a proportionate share of AASHO's efforts in research and research implementation, the chairman of this committee, together with other committee chairmen and the Chief Executive Officer of the several states, is empowered to nominate research projects for inclusion in the National Cooperative Highway Research Program (NCHRP). This requires that he be supplied with and transmit considerable background information on roadside development research on a continuing basis.

Roadside development research is also included in the considerations of the following special committees:

Special Committee on Continuing Research Program Evaluation.

Special Committee on Research Policy and Needs.

Special Committee on Utilization of Research Results.

Highway Research Board

The HRB is engaged in many activities to accomplish its mission. The most significant are: the stimulation and publication of highway research papers; sponsoring meetings for the presentation of such papers and conducting other committee research business; coordination of research efforts (HRIP) and promulgation of research results (*Highway Research News,* etc.); and administration of the NCHRP and the Highway Research Information Service (HRIS).

Roadside development research has made contributions to and received benefits from all these activities. Roadside development interests are represented within HRB by the Committee on Roadside Development in the General Design Division of the Department of Design. This committee is one of the most active and has published numerous documents.

The activities of this committee receive HRB's staff coordination from the Engineer of Design, who has similar responsibilities for at least 18 other committees. There is no staff roadside development professional employed by the HRB.

The HRB Committee on Roadside Development has one of the oldest and most active Clearinghouse Subcommittees. This Subcommittee assembles and distributes new standards and other noncommercial publications on roadside development on a quarterly basis to state and BPR operating personnel and others.

Disciplinary Scope

It would be difficult to name a significant highway function to which roadside development could not make meaningful conributions; it is interwoven into the entire fabric of highway business.

Roadside development should begin with a conceptual design process and function within organizations oriented toward engineering and design. Therefore, landscape archi-

tecture should be the lead profession, and landscape architects should be the administrative heads of the roadside development function in most states and agencies. This has led to the creation of the term "Highway Landscape Architect" to connote this specialized area of landscape architecture.

Because of the involvement of planting and vegetation and erosion control work, horticulturists, agronomists, and foresters are important to roadside development. A few states have had programs that were administered by persons with other academic backgrounds. Administrative exigencies have sometimes placed civil and mechanical engineers in roadside development work. Their contribution and success has been a matter of personal ability and adaptability rather than academic training.

Classification of Literature

A system of classifying the roadside development literature by subject area was adopted from a previous system developed by the HRB Committee on Roadside Development in 1950. These classifications also can be used to categorize and define the functions or operational areas of roadside development:

1. Highway Location and Design.
2. Roadside Space.
3. Resource Conservation.
4. Motorist Services.
5. Erosion Control.
6. Planting.
7. Maintenance.
8. Organization and Administration (Roadside Development).

Further subcategories of the specific subjects included in each of these major categories are listed in Appendix A.

A complete listing of the 1,985 documents identified and categorized by subject area and subarea was submitted as Part III of the project report. This listing is not included in the published report, but copies are available on a loan basis by contacting the Program Director, NCHRP.

CATEGORY EVALUATIONS

An associate researcher reviewed the literature and prepared an evaluation of research for each of the roadside development categories.

The common denominator of the differing subjects is the highway environment in a narrow sense and the consideration of the total highway environment, including the impact of the highway upon the land and its occupants, and the reciprocal impact on the highway and its users.

EVALUATION OF CATEGORY 1—HIGHWAY LOCATION AND DESIGN *

Discussing "The Complete Highway as a Boon to Road Users" at the 1954 Ohio Short Course on Roadside Development, Burggraf ** stated:

> Engineering has been defined as "the art of directing the great sources of power in nature for the use and convenience of man." Note the nice distinction between "use and convenience." Engineering does not try to tell man *what* he should want, or *why* he should want it. Rather, it recognizes a *want*—and then tries to meet it. Hence engineers—especially highway engineers and landscape architects, perhaps more than any others—are interested in man, interested in *what* we want—*how* we live—and *how* we react to our environment.
>
> From the standpoint of the safety of highway users it is essential that we know and understand how we, as highway users, react to different roadside conditions—the entire environment of the highway.
>
> The art and science of highway engineering has progressed with the changing needs and desires of highway users. The complete highway of today envisions all elements.
>
> There should be standards for guidance in highway engineering, but not overstandardization. The improvement of roads should not be standardized. Roadsides that have variety and interest attract highway users. . . . Tourism is recognized as big business today.

The expression "complete highway" was coined about 1942 to further the design concept that highways should be built around the four basic qualities of utility, safety, economy, and beauty. In his discussion, Burggraf pointed to the fact that "we are primarily concerned with both traffic and land-use problems, and with the way the highway is fitted into its environment."

Since this discussion in 1954, much research has been done—and is continuing—in the interrelated fields of traffic and land-use problems, either directly or indirectly, relevant to roadside development and the environment of the complete highway. A critical gap in research criteria remains, however, in the area of the visual aspect of highways—and their relationship to the landscape-cityscape; i.e., the fitness or appropriateness of each highway in its natural or man-made environment.

In the beginning of roadside research, the utility and economy of erosion control necessarily held priority in the early field tests and applications. As a result of such investigations and field demonstrations, roadside grading, drainage, and erosion control have been developed as a unit of design and incorporated in the standard specifications as an integral part of regular construction contracts.

In the years of research evolution to 1969, the safety and beauty aspects of cross-section design have been gaining recognition in the full development of wide rights-of-way. The streamlined grading of slopes as an outgrowth of early research into erosion-control problems has furthered the development of economic solutions for a wide variety of design and operating conditions associated with current highway hazards.

Examples of applications of research experience include:

1. Continuity of roadway alinements.
2. Shoulder treatments of merging areas.
3. Clearances for safety of traffic.
4. Streamlined drainage designs.
5. Guardrail locations and transition treatments under varying conditions.
6. Sign locations and offsets.
7. Other design details affecting appearance and safety.

* By Wilbur H. Simonson.
** Fred Burggraf, Past Director, HRB.

There is growing recognition in research that the visual aspects and the safety aspects of roadside development require consideration and evaluation from the very start of sensible planning of highway route locations.

Research relevant to roadside development as a vital part of highway-community planning research in the area of visual design is needed in furthering proper understanding of aesthetic principles. Such basic understanding is essential in furthering due recognition of the place of aesthetic values throughout all phases of location and design.

For these vital reasons, the visual aspects of highway location and design are beginning to receive increased emphasis in research. All elements of design need to be brought into balance for well-ordered application in the construction and development of the highway system. The primary goals and objectives of research in visual design will add much to safety, optimal use of environment, economic efficiency, and support of the national interest.

Of a total of 608 documents listed under Highway Location and Design, the 359 documents evaluated have been cataloged in the following system in pragmatic relation to current survey stages and procedures in highway location and design.

The conceptual process of visual design is indicated in the three-part order of arrangement of survey stages (aerial survey progress stages):

1. Preliminary Planning (reconnaissance surveys, feasible alternates, route comparisons).
2. Route Location (preliminary surveys, selected route location).
3. Detail Design (final location surveys and design plans).

A summarization of the evaluation of documents containing research judged to be oriented primarily to each of these phases of highway location and design follows.

Preliminary Planning

Of the 359 documents evaluated, 15 percent had a general relation to pre-planning or areawide study stage. Many of the reports were general, however, and not too definitive as to classification. These documents were considered a progress form of developmental research, based on the observed experience and judgment of individual opinion and the consensus of committees or other official groups. Few of the documents included supporting research data or factual information, as derived from controlled tests and research records.

Reconnaissance of Corridor-Landscape

Time spent in formulating the general concept in reconnaissance is never wasted. It is the start of the concept for all later steps in the location, design, and development of any particular highway route. Preliminary planning for environmental highway design, like the reconnaissance survey of area, is vital in the first stage of highway location-design. Because preliminary planning of a wide corridor (reconnaissance of area) is a continuing decision-making process leading to the preliminary survey stage for the selected route location, early formulation of the design concept for a specific segment of any highway system sets the governing standards and guidance patterns for the final location staking and design plans. Obviously, the end result of highway construction will be no better than the visualization of the environmental design concept in the pre-planning stage of location-design study.

Resource Inventories.—Sound plans require comprehensive surveys of the available landscape and recreational resources. Airphoto reading, photo interpretation, and qualitative analysis and appraisal of all resource information available from regional and city plans, and related map sources, simplify this systematic survey process of the entire area. The proper combination of inputs and characteristics can be selected only after a thorough understanding and study of the various alternatives. Comprehensive surveys yield useful information on recreational and scenic resources, trends in prospective use, pertinent legislation, zoning, related planning, scenic quality, and development potential. Such basic resource data in hand for systematic appraisal at the start of reconnaissance facilitate identification and qualitative analysis of the nature and dimensions of the impact of alternative route locations on the patterns of economic growth in the area.

Ecological Considerations.—Awareness of ecology is vital to sound planning; it deals with mutual relations between highways as organic (unified) structures and their environment. Review of the literature did not reveal one document with specific developmental research relevant to this phase of roadside development. However, indirect references to ecological considerations were noted in relation to the environmental elements of design. These occasional observations were indicative of a trend toward recognition of the relationship of the highway to the landscape and cityscape.

Environmental Elements.—Specifically, this is the total of all the external conditions and influences affecting the location-design process, and the development of a highway. Twenty-four documents were concerned with the surroundings—the living environment of highways. Ecological and environmental considerations include natural landscape features, watersheds and drainage patterns, topography and soil types, character of vegetation as plant-indicator types, and man-made influences and cultural uses.

We are just now entering an era when highways are understood to be environmental elements, interdependent with all other elements that make up the highway-corridor landscape or cityscape. As such, they are subject to ecological, sociological, and aesthetic phenomena, as well as engineering and economic controls.

Concern for the function, appearance, and impact of the highway obviously cannot stop at the right-of-way, but extends to visual horizons and often beyond.

Collaboration of Interrelated Disciplines

Seventeen documents emphasized the need for team work in highway design and development, indicating a trend toward a team of qualified specialists, working together

on location-design problems. The design team concept depends on each team member knowing the objectives, realizing wherein his work fits, and understanding the significance of the work of others. Review of the documents pointed to the preparation of highway plans by an interdisciplinary team comprising a broad range of skills (professional) to select the corridor, pick the route, and participate in the total highway planning process. Under this concept, consideration was given to the sociological, economic, ecological, land-use planning, engineering, and aesthetic impacts of route-location-design on the environs.

Landscape Factors Affecting Location-Design.—The talents of many professional groups and specialists are involved in the concept of the complete highway. Environmental design considerations in landscape development, particularly for complex urban freeways, must start at an early stage in the location when a specific route is being determined. A detailed inventory of the landscape features along the route is essential in determining the character and design of the landscape development. Residential areas, industrial and commercial developments, apartment houses, and other land-use development traversed by a route will all have a bearing on its design and the appropriate character of highway development.

Visual Continuity.—A number of documents discussed aesthetics of highway alinements, with some emphasis on visual continuity attainable in curvilinear designs through the use of spline line projections. This more flexible type of "flowing alinement" may be defined as a centerline projection that has been produced entirely in accordance with topographic and man-made controls and influences, and developed without the use of straight (tangents) lines as a base. Because of the greater flexibility provided the location-design engineer, curvilinear alinements can be made to fit more closely to terrain or man-made control points, sometimes shortening the line and usually resulting in less severe curvature. Other advantages are savings in both construction and maintenance costs when earthwork may be reduced. More universal use of this desirable design tool is encouraged in the literature reviewed.

Alternate Feasible Route Studies.—Four documents pointed to the importance of comparing alternate feasible routes, leading to selection of a route location. A reconnaissance survey of alternate routes is undertaken, following the general reconnaissance survey of the wide corridor area of the highway landscape. The ultimate objective of this stage is to ascertain which of all route alternatives is the best for optimal use of the environment. This is achieved by comparing the feasible routes determined in the preceding stage, for the highway service, convenience, comfort, and safety that each of them would provide if the highway were constructed.

Route Selection Reports.—One document referred to the importance of route selection reports. However difficult it may be to identify and measure the visual qualities of location designs, recognizing and rating the intangible values of scenery, aesthetics, and historic or other qualities of environmental design are extremely important in the public and the national interest. Isolated references show that some progress has been made in developing subjective guides to evaluate the attractiveness of scenic corridors. The main test is relative superiority on a qualitative (aesthetic) basis. A number of experimental formulas have been attempted, but further research looking toward development and use of an acceptable rating methodology is needed to bring the qualitative values of environmental design into better focus and balance.

Location-Survey Information—Assemblage of Data

Five documents covered the value and effective use of aerial photographs and surveys in all stages of location-design. Other sources of available information useful to the design team in planning also were included in the planning-design process, such as: topographic and other relevant maps (as available); geologic and soils maps; land-use and zoning maps; city plans and regional plans; and other data (as pertinent).

Route Location

Nearly 30 percent of the 359 documents evaluated in the location-design category were concerned primarily with the location as selected. Pertinent to the over-all look at the entire area in the comparison of routes and the decision-making process are the attainable alinements, gradients, cross sections; grade separations, medians, and different roadway levels; structures; and how well the highway could be fitted aesthetically to the topography and bordering land use.

Once the comparisons are completed in sufficient detail on the basis of applicable factors, the route is designated on which subsequent efforts are specifically expended to complete the highway location and design. Variations in the applications of aerial surveys are greater in this stage than in any other.

Aesthetics of Location-Geometrics

Ten documents were relevant to the aesthetic qualities of the geometrics of "flowing" profile-alinements, variable width medians, and different roadway levels, including the advantages of independent roadway designs. Advantageous use of aerial photographs and surveys has benefitted the visual quality of the highway alinement, and advantageous use of spline line projections has benefitted visualization of the highway in three dimensions by:

1. Attaining flexibility and flowing continuity in alinements.
2. Relating profiles to land forms and cross-section controls.
3. Developing well-balanced and well-related alinement-profile combinations.

Scenic Evaluation Criteria

Thirty-three documents, the largest number for any item in this category, were devoted to scenic evaluation criteria. Views outward from the highway are more tangible and readily appreciated than the less noticeable details of the highway. The quality of viewpoints and the landscape

visible from them appear to be receiving due attention, as an integral part of complete highway design and development. An existing corridor segment, a suggested route within an undeveloped corridor, or even an entire project, must be compared and contrasted with alternatives. It is only then that intangible values become meaningful criteria in developing a project or entire program.

Landscapes viewed from the highway must be more varied and more interesting, and have more impact in terms of visible resource uses, panoramas, contrasts, harmony, and significance. None of these factors can be measured precisely, but all can be evaluated in terms of "more" or "less" than the alternatives with which they are compared.

Views of the highway as an aesthetic entity were noted in only one or two documents. The appearance of the highway as viewed from outside the roadway is becoming more important, however, as the communities traversed become aesthetically more conscious of the highway structure as a unified whole, in appropriate relationship to the topography and land use. This environmental aspect of complete highway development needs further research.

Fitness of Highway in its Environment

There were 27 documents on the fitness or appropriateness of the highway to its environment. The relationship of the highway to the landscape-cityscape and the visual quality of the alinement of the road are interrelated, involving the road as seen in the landscape and the landscape as seen from the road.

Environmental Design Goals—Land Use Compatibility—Aesthetic Impact.—Sixteen documents were related to environmental design goals and land-use compatibility; 15 were related to aesthetic impact on environs and communities. These were general documents, not too precise as to criteria for specific applications in design. However, they do form a part of the increasing emphasis on the interrelationships of aesthetics, geometrics, and land use in environmental design—all in appropriate relation and balance visually to other factors in highway location-design and development.

Graphic Techniques—Visual Design Information

Five documents were related to the importance of presentation methods to reveal the three-dimensional-appeal quality of design-locations. These include perspective sketches and drawings, general development conceptual plans, contour grading and drainage plans, three-dimensional design models, and other newer techniques in the aerial-photogrammetric-computer field.

Detail Design

A total of 199 documents were related to detail design at the time field staking of the selected route-location is carried out and the final design plans are prepared for construction of the project.

The areas of detail design are liberally covered by these reports. Three areas appeared to dominate: the geometric aspects (20 documents); cross-section development and safety (24 documents); and the median areas (25 documents). Supplementing these were 13 documents involving land-use planning, and 12 on land-use controls. Types and functions of planting design were covered in 13 documents, and the total design concept was covered in 15 documents.

The remaining documents, about one-third of the 199 total, were related to various more tangible details, more material- and traffic-oriented, such as appearance of major and minor structures, guardrails, light standards, safety barriers and walls, slope grading and drainage details, tree setbacks and clearances for safety, landscape construction specifications, special area designs, and maintenance considerations and economy in location-design concepts.

EVALUATION OF CATEGORY 2—ROADSIDE SPACE *

A few years ago, awareness of the concept of, and concern for roadside space was limited to the relatively few who saw the landscape as a continuum defined by visual boundaries rather than political boundaries. These people, for the most part landscape architects, planners, and a few far-sighted engineers, believed that the development and interrelationship of land uses should add to man's mental well-being, as well as serve his physical needs.

Instances where highways were located for other than political or engineering reasons, and where concern for the uses extended beyond providing a surface for cars to travel on, were so rare that they made no impact on general practice. Only now are highways being understood to be environmental elements, interdependent with all other elements that make up man's habitat. As such they are subject to ecological, sociological, and aesthetic phenomena, as well as engineering and economic controls.

Concern for the function, appearance, and impact of the highway obviously cannot stop at the right-of-way, but extends to visual horizons and often beyond.

Because the traditional concepts of roadside development identify mainly with the land between the pavement edge and the right-of-way line, and because most of the development of highway design criteria has been introspective (in that it has dealt only with functional highway concerns), it is extremely difficult to determine the state of research in regard to any expanded concept of roadside space, as suggested above. Much of it lies in the areas of land planning and the socioeconomics of land use, rather than in past highway research. It is also difficult to separate investigations dealing primarily with roadside space, as such, from those dealing with highway location and design, motorist services, and resource conservation, all of which are interrelated; yet each of these areas was considered important enough to warrant a separate section in this study. Each of those sections should be reviewed, to gain full understanding of the extent of research that has some relation to roadside space.

The items evaluated under Roadside Space and the documents containing research judged to be oriented primarily to each of these subjects are listed and discussed in the following.

* By Bradford G. Sears.

Roadside Space Within the Right-of-Way

An important part of roadside space is contained within the right-of-way immediately adjacent to the pavement. The development and control of this space has long been both the prerequisite and responsibility of highway agencies, and concern for its wise design and maintenance is steadily increasing as understanding of its importance grows. Hopefully the era has passed when this land was considered to have the single purpose of providing a functional transition between the shoulder and adjacent property.

Right-of-Way and Roadside Development

It would be reasonable to assume that there would be considerable published material that would show quantitative as well as qualitative relationships between optimum right-of-way widths and adequate roadside development from both the visual and the functional standpoints and in relation to interaction between the highway and adjacent land. However, this does not seem to be the case. Of the ten related documents, most are more than ten years old and seem to represent opinion more than researched fact. Of some interest are recent studies on the disposition of right-of-way remainders and alternative methods of protecting future rights-of-way, although the investigations were oriented so as to focus on the economic value of such parcels under private ownership rather than on their value if acquired or retained as part of the right-of-way; as such, they could have been assigned to that subcategory.

Integral Roadside Development

The opportunity for research correlating alinement design and roadside development at the location and right-of-way determination stage appears to have been largely bypassed. Only nine documents dealt with aspects of this topic, and they were mostly dated and represented opinion rather than research. Admittedly, current AASHO and BPR standards include recognition of the importance of such concern, and they evolved in part from research as well as from rationale and practice. Such research has tended to focus on factors related to highway location and design, and is reported under that category.

Safety Design

In recent years, research in highway safety has shifted from accommodation of vehicle characteristics to concern for driver reactions. Improvements in vehicular safety features and in mechanical capabilities, in the extension of minimum sight distances and general upgrading of alinement continuity, are positive responses to the proven shortcomings of earlier highway and vehicular standards. This has permitted a sharper focus on man as the least predictable yet most cogent factor in safety design. With present-day geometric design standards guaranteeing predictability of the road ahead, and reasonable room to operate safely within normal lane widths, the attention and judgment of the driver are affected more by factors that are a part of roadside space. Research in and experimentation with medians, guardrails, crash barriers, roadside structures, roadside delineators, signs, and highway lighting was reported in 18 documents; this is indicative of increasing concern for the effect of roadside features on safety.

As was expected, most research in these areas has dealt with the interaction between a specific feature and the driver or the vehicle. Yet to be explored are interactions between the driver and multiple features, some of which are spaces defined by roadside elements rather than the elements themselves. Also largely in the future is measurement of the total impact of the composite features that define and affect roadside space on the psychological behavior of the driver which contributes to poor judgment or rash actions. However, it is becoming understood that driving is as much a psychological process as a physical one, and this will inevitably influence research in safety design, particularly in regard to roadside space.

Multiple Use of Right-of-Way Space

Research attention to the multiple uses of rights-of-way is either well-established or new, depending on one's point of view. The inclusion of public utilities in highway rights-of-way has long been a part of the American scene and, where these have been above ground, a constant bone of contention both physically and visually. Review of the literature, however, seems to indicate that the uneasy marriage has generated more opinion than factual research as to the benefits and disadvantages of such a union. The thrust toward provision of motorist services, particularly on the Interstate system, has stimulated substantial exploration and experimentation in the development of service, rest, and roadside park areas. Research in this direction is documented under the category of Motorist Services.

Of special interest are contemporary studies of other multiple uses that might occur within the right-of-way, such as parks, public buildings, and commercial establishments. These include developments laterally adjacent to the traveled way, and also over and under it. They are undoubtedly harbingers of even more concentrated research and experimentation in this direction, and provide strong evidence of final dissolution of the traditional singular focus of highway location and use in favor of the concept of the highway as an element in the environmental planning process. Thus, although eight items of this nature listed in this subcategory have a specific concern for multiple use of right-of-way space, it should be remembered that they also represent a bridge to the larger concern for environmental planning.

Car Abandonment

In recent years, litter removal has become one of the most costly operations in roadside maintenance (the single largest individual pieces of litter are abandoned automobiles). Increasing concern for this misuse of roadside space is evidenced by three studies, all published in recent years.

Roadside Space Outside the Right-of-Way

Regarding roadside space as herein defined (namely, that it includes all features visible from or underneath the

roadway), it is obvious that it would be impossible to control this space through fee simple ownership. Therefore, the best relationships and interactions between the highway and the adjacent environment can be accomplished only through collaborative planning effort, with all other agencies responsible for the use and appearance of the environment. Unilateral action by any one agency in solving today's complex land use problems is unthinkable if we are to achieve a viable habitat. Thus, the greatest tasks are to determine first through environmental planning what is to be done, and then how best to achieve the results. Sociological, psychological, and economic phenomena must be interrelated with ecological and engineering criteria to achieve the former. Proper land-use controls used in conjunction with public ownership will provide many answers for the latter.

Environmental Planning

The concept that the quality of roadside space beyond the right-of-way is a strong factor in the ultimate determination of the quality of the highway is relatively recent, at least insofar as highway planners are concerned. The traditional singularity of focus centering around engineering and political inputs is, at last, giving way to a much broader base of concern for the multiple aspects of environmental planning. To truly document research efforts in this field would far exceed the identified scope of this evaluation study, because highways are only one part of transportation systems, and these, in turn, are only one element in land-use systems.

Thus, 51 documents focused primarily on the relationship of highways to other environmental factors. Many of them also have relevance to other categories in this study, such as highway location and design, resource conservation, and motorist services. Indicative of the breadth of topic coverage is the following resume of research directions represented.

Nine documents were general in nature, and dealt primarily with highways as environmental elements. Thirteen of them were concerned with specifics of the need for scenic preservation of off-scape features and their importance to the highway user. Although only four documents dealt directly with the interrelationship of highways and recreation, some aspects of this concern were evident in several other studies.

Half of the documents explored specific relationships between highways and other land elements, ranging from the tightly woven fabric of urban environment to the larger aspects of regional planning. They included such diverse concerns as open-space control, noise abatement, studies of interchange development, borrow-area restoration, transportation system corridors, and the quantitative classification of residential neighborhoods according to the perception of visual appearance. Most of all, they pointed to an accelerating appreciation of the need for totality in design, and for establishing quantitative measurements of currently intangible factors that markedly affect the final quality of the highway and its environment.

Roadside Control

The establishment of legal controls on the use of private property has long been recognized as a workable, although imperfect, method of guiding land development toward goals set by environmental planning. Highway planners have studied extensively in this area in attempts to protect highways against visual encroachment of adjacent, unsatisfactory developments, and to determine proper restrictions of physical access to the highway from abutting properties. The well-known tools for implementing control over private property have been zoning and easements. Equally well known is the relative ease of establishing such controls for the preservation of current uses, as compared with their application in an effort to change existing uses. They have also proven to be sensitive to political pressures, both for variances and for the service of other than objective purposes.

The 81 documents dealing with this subject represent the importance that is assigned to a better understanding of the complexities related to the establishment and execution of roadside control; this concern probably will continue to proliferate in the future.

Recently enacted legislation, incorporating provisions in the Highway Beautification Act of 1965 that would encourage the removal or screening of the specific elements of billboards and junkyards on property adjacent to the highway, has generated so much research and opinion that it was considered desirable to separate this material from the studies of controls for other purposes. Hence, the topic of roadside control is divided into (1) zoning and easements, and (2) junkyards and outdoor advertising.

There were 44 documents on zoning and easements, distributed somewhat evenly among topic areas with foci of scenic easements, zoning controls, and control of highway access. Publication dates indicate a constancy of attention over the past 30 years, with some acceleration evidenced over the past ten. As would be expected, most of these studies are either local or regional in character, yet nearly all have a universal applicability in terms of the principles involved. The scenic easement studies obviously have the preservation of natural beauty as their goal; zoning studies usually are directed more toward the rational development and control of land uses. Yet, as this process is predicatory to the realization of order in the environment, and because order is a prerequisite of beauty, the study of any one facet leads hopefully to the solution of all. It seems reasonable to anticipate that the growing national interest in creating a more viable environment will cause future research to focus equally on the achievement of both rational order and beauty.

More than half of the 37 documents on junkyards and outdoor advertising are evaluations of the effect of the 1965 federal legislation, the problems generated, and the progress attained. Obviously, the interest in this effort to improve the visual environment is intense and is likely to remain so until the conflicts of interest inherent in such a dramatic and definitive effort are resolved. Objective measurements of the long-term social reactions to, and economic results of billboard removal and junkyard screen-

ing are vitally necessary to prove the premise that administrators, professionals, business interests, and the general public are ready to seriously and actively support the improvement of the visual environment. Success in this direction will greatly stimulate expanded and more far-reaching actions.

Several studies deal directly with the problem of disposition of junk automobiles rather than screening of junkyards, and have specific value as basic research toward a positive rather than a remedial solution of the problem. Also of interest are three studies of on-premise business advertising signs and proposals for improvement in their size, placement, and design, to the mutual benefit of both the advertisers and the quality of roadside space.

Roadside Socioeconomics

The social and economic impact of highways on adjacent land use is a critical factor, influencing future highway location and design as well as extended application of land-use controls.

Studies oriented to the measurement of these effects, resulting from past decisions and developments, are necessary to determine the wisdom of such actions, as well as to predict the results of future development controls. Accelerating interest in the need for quantitative data to dispel the cobwebs of biased opinion is evidenced by the 46 documents on this subject. Their diversity indicates the complexity of the problem. Naturally, the major concern is for the over-all impact of highway systems, with primary focus on the results of Interstate route construction and interchange development. These take the form of general studies, as well as specific orientation toward modifications of community structure, impact on tourist-related business, and on property values. Other studies deal with the socioeconomics of highway improvement and community bypass routes. Still others explore the relationship of parkways and land values, highway landscape development and adjacent land values, and the effect of land-use controls, such as scenic easements, on market value of real property. One recent study tried to discover the direction and intensity of community attitudes toward planning and zoning in interchange communities. Because, in a democracy, public opinion and response will always be one of the major determinants of the direction and rate of change, this type of study seems inevitably destined for proliferation.

EVALUATION OF CATEGORY 3—RESOURCE CONSERVATION *

Definition

Resource is defined by Webster as a new or reserve source of supply or support; immediate and possible sources of revenue; something to which one has recourse in difficulty; and a means of spending one's leisure time. Conservation is the careful preservation and protection of something; especially planned management of a resource to prevent exploitation, destruction, or neglect.

Thus, resource conservation is the careful preservation and protection of all resources, both natural and human, to prevent exploitation, destruction, or neglect.

The State of the Art

Resource conservation, as it relates to roadside development, is just now becoming a part of the highway planning and construction process. The field is largely unexploited and not well researched, although there are some good papers on the subject. The only area well-covered by past and current research is soil conservation as it relates to roadsides.

In general, the area of natural resources is much better researched than human resources, probably due to the long-standing recognition of the need for conserving natural resources and the more tangible nature of natural resources. The areas of water, vegetation, and wildlife need considerable research, particularly as they relate to design for conservation practices. Minerals are less closely related to the roadside, except as a human value, when unsightly scars are a part of the view from the roadside.

Human resources and their conservation, as they relate to the roadside, need a great deal of research before they will be measurable or even fully understood. Much research probably exists that might be applicable to the subject, but which was not covered by researchers of this report. Specifically, medical research and behavioral research by private industry might provide some answers not found in the documents received.

Documents received totaled 141—60 on natural resources, 30 on human resources, and 51 of a general type. Of this total, only 60 were classified as research; of these, only 24 were basic research. The remainder of the documents (57 percent) were classified as opinion and not research. The documents received represent very incomplete data on the entire field of resource conservation, with the possible exception of soils. Because erosion control constitutes a separate category, and this is the substance of soil conservation, this subject should be well covered. Some of the opinion papers were of great value, well-written, and informative. Little repetition was noted, probably due to the few documents available for review.

The area of resource conservation should be scanned in much greater detail to uncover applicable research already completed before undertaking any new research.

EVALUATION OF CATEGORY 4—MOTORIST SERVICES *

Definition

The new definition of motorist services deals not with the motorist's car but with the physical needs of the traveling public. Generally, these physical services are found in roadside rest areas where safe parking, toilets, water, picnic areas, telephones, and motorist information are provided.

* By James D. Anderson.

* By Wilbur J. Garmhausen.

The State of the Art

Motorist services, as they relate to roadside development, are an integral part of highway planning and design. There is much written on this subject, but most of it has to do in general with the use. The only subject that has had a token of research is roadside rest areas.

Motorist services in the general category of rest areas are much better researched than those in the category of roads. This may be because roadside rests and tables have been in the highway program longer. The subjects of water, disposal systems, spacing, and even use, need considerable research, as all these are related to the design problem.

Preliminary surveys of available landscape resources need to be made so that an intelligent location for roadside rests and overlooks can be programmed.

Emphasis on highway safety measures provided for the motorist has emphasized and stimulated the development of roadside rests, particularly on Interstate highways. The acceptance of roadside rests naturally includes other services for the convenience of the motorist. The highway engineer is concerned with safety of not only the travel way but also the area off the travel way, for motorists who wish to stop and rest for a limited time.

Review of the documents did not reveal specific recommendations relevant to the modern roadside rest construction that is now being developed as a result of the Highway Beautification Act of 1965. The field is largely unexplored and not too well researched, although some of the earlier research that covers specific categories will be of some value as a guide for today's standards.

Motorist services, as they relate to roads, need further study and research. Very little other than turn-outs and telephone service has been provided to date. Disabled car reporting is a service that needs to be researched. Better systems to provide information as to lodging, food, and car service availability are greatly needed.

Document Evaluation

Documents received totaled 70—58 on rest areas, and 12 on roads. Of the total, 56 documents were reviewed and classified; of these, 9 percent were listed as basic research, 16 percent as development research, 50 percent as applied research, and 25 percent as not research.

The papers received had the greatest concentration (12 documents) in the rest area general design category. These reports were of general interest and not too specific. The research was based mostly on observations, experience, and individual judgment.

There were eight documents on rest areas. Because of the favorable recognition of this category, research was more of a documentation activity than reporting research facts and conclusions.

Four documents were on design, in the categories of surveys, land use, and general maintenance of the rest area. There were also four documents on motorist services on roads; these had to do with information the traveling public would use when in need of lodging, food, or car service. All of those documents were found to include supporting research data to be of assistance today.

There were three documents on service buildings. These included tourist information centers as well as a combination building having both toilet and tourist lodge. These would be of some value for limited locations, but today's use of roadside rests generally is too great to obtain any help from these reviews.

There were two documents each on disposal systems, service information, parking designs, multipurpose recreation, and reservoirs—all regarding roadside rests. For roads, they cover emergency calls, national park use, and general road services. Research in these categories was done at a time when use of rest areas was not as great as it is today. For example, parking areas for trucks are treated differently now than when the research on parking areas took place. Today, noise is considered when parking areas are designed, and truck parking is divorced from the car parking area and placed at the rear of the park.

Fourteen documents were reviewed in 14 different subcategories (construction costs and general construction, design of bridges, general facilities, toilets, scenic information, recreation information, historical information, and general maintenance, including the caretaker, overlooks, and parking). Under the category of roads, there were documents on motorist needs and scenic roads. There is little value to these reports; not enough factual data are compiled to provide many answers.

Review of the motorist service literature revealed insufficient documents with specific developments and supporting facts to fully justify present design criteria. It was necessary to determine research needs in the motorist services category and then list these needs by priorities. The listing is as follows:

1. Highway safety is being stressed more and more, and roadside rests are considered a means of implementing this. Research is needed to determine factors for good rest area design, including the use, the facilities involved, and the acreage needed for the park proper and buffer strip.
2. Roadside rests have been accepted by the traveling public as a benefit and a necessity. Research is needed to establish the best spacing for rest areas. A determining factor to research is the feasibility of establishing more small sites or fewer big ones, and the safety of locating rest areas in the median.
3. The Highway Beautification Act of 1965 has made it possible to have modern water flush toilets available in a combination toilet-lodge building. Research is needed as to the most practical and economical type of disposal systems that would serve the use made of the sanitary facility.
4. The trucking industry is aware of the roadside rest areas and regards them as a boon to their drivers. Because truck parking is made available at the rests, research is needed to determine the proper location, considering noise, safety, and isolation factors.
5. Vacation time especially brings out many campers. This not only is an economical way to vacation but, because

of financial circumstances, may be the only way to take advantage of a vacation trip. Research is needed to determine the feasibility of establishing camping areas adjacent to roadside rest areas, or whether camping should be contained within the area and limited to an overnight permit only.

6. Tourism is considered big business for many states. The traveling public needs to know what is available in areas near the rest areas, and about other attractions. Research is needed to determine the kind of information that should be dispensed at rest area lodges.

7. Caretakers in rest areas come in contact with the public; therefore, personal appearance and proper dress are important. Research is needed to define caretaker activities and to show the feasibility, practicality, and economy of providing uniforms for caretakers and other rest area personnel.

8. Car troubles result in lost time and inconvenience, especially on the Interstate highway, because interchanges are often far apart and help is not always available. Research is needed to ascertain what kind of call systems should be provided for the traveling public and the spacing of this service.

EVALUATION OF CATEGORY 5—EROSION CONTROL *

Definition

Erosion control as a research category included consideration of all investigations into causes of soil movement along highways, and structural and vegetative means of controlling this movement. Basic research in the area of soil physics was not considered in this review, unless the investigations were directly related to a specific highway project. Considerable basic information of this type was reported. Developmental research was included only when the results of such research could be identified as relevant to the practices of erosion control. Much of the research evaluated was of an applied nature, such that results could be clearly identified with one or more aspects of roadside erosion control.

The State of the Art

Documents reviewed fell in one of two categories: they were concerned with either (1) vegetative means of erosion control, or (2) nonvegetative means—termed "structural."

Documents on vegetation were concerned either with trees, or with shrubs, or with vines, or with grasses, or with combinations of trees, shrubs, vines, grasses, and other plants. In all of these subjects, the objective of the research was to evaluate the effectiveness of these plants, or combination of plants, in controlling erosion. Thus, it is the evaluation of trees as a means of controlling erosion or the evaluation of grasses or grass mixtures in controlling erosion.

With many documents concerned with vegetative erosion control, there was no clear-cut subcategory. The treatment variables were many and not such that any one could be identified as more important than others. Where some specific treatment variable could be identified, such as the effect of soil type under trees, it was listed. Under shrub and vine evaluations no designations could be given, because of the general nature of the research. Under grasses, however, much more work has been done, and certain documents could be identified as having mostly to do with such subjects as research on mulches; techniques involved with vegetative planting; formulation rate and method of application of fertilizers; seeding rates, mixtures, and methods of application; height of cut of vegetation during establishment period; use of bitumen emulsions and other chemicals to hold soil during the establishment period; types and use of sod; and comparisons of different species and varieties of grass.

Documents that had to do with an evaluation of several types of plants were different in that they were concerned more with specific situations than with over-all use of the plants. For example, they considered use of plants on banks, in drainage channels, on steep slopes, as watershed cover, in range management, where wind was a problem, in ditches, on sand dunes, and in forest locations. The researcher was inclined to group banks and steep slopes together, and drainage channels and ditches together, but the authors of several papers were specific in these situations, so the nomenclature was not changed.

Those documents that had no reference to use of plants, or that had major concern with nonvegetative means of erosion control, were classified in a structural subcategory. They were placed in one of six groups. Some papers had to do with nonliving materials—frequently called "artificial materials." Documents concerned with the general over-all use of these materials were put in this group.

Some documents dealt with research on culverts, others with research on watersheds. Some dealt with soil properties and others with water properties. There was a group in which the research was sufficiently general that it could not be classified as materials, or culverts, or watersheds, or soil, or water.

Under the structural subcategory there was considerable variation in major emphasis. Many documents were concerned with a number of topics, and thus it was difficult to identify one as of major importance. Under *materials,* channel linings, mulches, bound rock, asphalt binding, and soil additives were most easily identified. Under *culverts,* inlets and outlets, flood protection, and ditch design seemed most important. Under *watersheds,* hydrologic studies and piping phenomena were noted. Under *soil properties,* unit weight, sedimentation, infiltration, acidity, type, profile, and stabilization were used as special topics. Under *water,* turbulence, yields, drainage practices, and energy relationships seemed to be good breakdowns. Under *general,* engineer was the only specific item noted.

Subcategories at all levels were based on actual subject matter content of documents reviewed and not on the basis of what one might expect to find. Because about 50 percent of the available document were not reviewed, there may be some question as to the value of this category breakdown.

* By Eliot C. Roberts.

Significance of Research Effort to Date

Research concerned with erosion control on roadside locations has been viewed with importance throughout the U.S. Projects have been conducted by Agricultural Experiment Stations and Engineering Experiment Stations at land grant colleges and universities, by state highway departments, by the Soil Conservation Service, and by private industry. Various geographical and climatic regions of the U.S. have been represented in this research effort. Investigations on both wind and water erosion have been reported, and both structural and vegetative means of erosion control have been considered.

Erosion control research has covered a wide spectrum of topics and has been concerned with basic, developmental, and applied projects. So that the research effort to date might be evaluated completely with a minimum of overlap between project areas, the four aspects of erosion control are described briefly in the following paragraphs.

Investigation of Factors Influencing Soil Erosion

Basic, developmental, and applied research have contributed to current levels of understanding concerning soil erosion processes. Significant advances have been made in the following six areas of investigation.

Topographic and Other Physical Features as Related to Soil Erosion

Physical characteristics of the site for roadside development have been demonstrated to be of value in predicting the nature of soil erosion problems and in specifying erosion control measures. Slope gradients (degree), exposure, and protection are critical determinants of the destructive nature of soil erosion processes. The over-all design of control measures for soil erosion may involve contouring or terracing of the slope and of adjacent land. Conservation and land-use practices in the area (such as tillage and cropping systems) often contribute to the reduction of soil loss along roadsides. Poor agricultural practices are likely to contribute to roadside erosion problems. Geological factors in the area, as related to the development of cut or fill sections, are also important in diagnosis and correction of erosion-prone situations.

Effect of Climatic Variables on Soil Erosion

Basic studies concerning the climate have been essential for an improved understanding of its effect on soil erosion. Precipitation patterns have been developed, and, in conjunction with information on storm frequencies and intensities, have been used in rainfall simulators to program rainfall of various types on soil with varying degrees of erosion potential. Maximum and minimum air temperature data and detailed studies of temperature fluctuations within the freeze-thaw range have had an important bearing on soil stability and erodability. Snowfall data also are correlated with fluctuations in air temperature within this range. Wind velocities and directions not only influence movement of water, but are considered basic causal agents for movement of soil particles, as evidenced in wind erosion. In addition, such components of the climate as light intensity (such as at high altitudes as compared with sea level), radiant energy, relative humidity, and related evaporation and transpiration have direct effects on vegetation in the area, and consequently are related to erosion control.

Influence of Chemical and Physical Soil Properties on Soil Erosion

Chemical and physical properties of soils determine to a large measure how erodable the soils will be. Studies concerning soil colloids have focused attention on mineralogy, and have included investigations concerning the physical and chemical environment of suspensions, their viscosity, the dispersion and flocculation of particles, static rigidity, sedimentation, and volume characteristics. This basic research has provided background information for interpretation of results from investigations of soil profiles. Soil survey and classification as to type have been meaningful in describing topsoil and subsoil conditions and their relations to soil erosion. Investigations of soil pH (within the range acid to alkaline) have yielded information correlated with both physical and chemical soil properties. Soil stabilization and soil compaction properties are directly related to movement of particles as sediment. They affect erosion by virtue of physical resistance of particles, as well as by creating conditions more or less favorable for trapped air to exert an influence on infiltration. Soil moisture and temperature change in response to climatic variables, and these changes have pronounced effects on soil erodability. Treatment of soils with chemical conditioners or with sterilization procedures have some effect on erosion, but little compared with improved management through conservation practices.

Water as an Agent for Transport of Soil Materials in the Erosion Process

Flow characteristics of water have been investigated, with the objective of determining more accurately the properties related to this agent in the transport of soil materials in the erosion process. Runoff from graded terraces yields data on peak rates, volume, frequency, duration, and accumulation. Factors related to the impoundment of water in reservoirs and in its diversion to other locations are related to peak flow and continuity of stream flow characteristics. Energy dissipation of water in the flow process is related to turbulence and the fall velocity of particles. These forces are causal agents in erosion whether related to the disposal of surface water or involved with flow of subsoil water. Drainage design, practices, and procedures hold only as long as they are subjected to predetermined surface water yields. Infiltration rates are seldom rapid enough through soil to create optimum drainage conditions.

Properties of Mulches and Influences of Mulching Practices on Soil Erosion

A major research effort concerned with erosion control has been directed in the area of mulches and mulching

practices. A wide variety of materials has been evaluated alone and in various combinations. Wood materials and by-products (such as chips, fibers, cellulose, excelsior, silvacil, bark residues, and pine needles) have been investigated. Oat hulls, corn cobs, straw, hay, and prairie hay have been studied. Glass root, fiberglass, and glass fiber have received attention. "Turf fiber," "Bagasse," "Chempact," "Soil Set," and various petrochemical materials, asphalt tacking, emulsifiable asphalts, bitumen emulsions, and elastomeric polymer emulsions have been included in various tests. Mulch nets, erosion net, and jute nets and mats have been used, with and without other materials. Waste and by-product materials, such as sewage sludge, have been included in investigations, together with mineral materials such as gravel and vermiculite. Physical and chemical properties of materials such as these determine, to a large measure, how they may be applied, and expected degree of erosion control. Criteria used in evaluation of mulches include cost and availability of materials, method of application, soil and weather conditions, and effective erosion control.

Evaluations of Combinations of Factors in Soil Erosion Control

Erosion control is seldom related to a single factor or construction or maintenance practice. Combinations of factors and practices result in highest degree of erosion control in each specific situation. Research to relate costs of construction, maintenance of vegetation, renovation of vegetation, and revegetation practices with erosion control has identified the following items as critical for the roadside situation, in terms of decreased soil erosion:

1. Use native plants where possible.
2. Where native plants are not available, select species and varieties capable of withstanding roadside soil and climatic conditions.
3. Methods of seeding and/or planting must assure a high survival rate.
4. Mulches must be selected to provide the degree of protection required.
5. Methods of applying mulches must assure uniform distribution.
6. Critical periods for germination and establishment must be timed in accordance with existing climatic conditions in the area.
7. Where sod is used, only well-adapted species and varieties should be included.
8. Methods of sodding should assure a high survival rate.
9. Cover crops (annuals) may be advantageous in some locations.
10. The cropping system must be adjusted to the plant cover established.
11. As plant competition changes with time, the components of the stand change, and further adjustments in the cropping system are required.
12. Fertilizer and lime must be provided in eastern and other acidic soils to create favorable conditions for plant growth. Soil tests, prior to planting and after establishment, must form the basis for fertilizer recommendation. Rates of application ratios used are critical in most instances.
13. Control weeds and undesirable brush with herbicides whenever these plants increase in the population.
14. Growth regulators to control rate of foliar production and seedhead formation may improve appearance and hardiness of the stand.
15. Pesticides for insect and disease control may be required under some conditions.
16. Rock and gravel or other structural features may be necessary in conjunction with plant materials or used alone.

Development of Structural Features for Soil Erosion Control

Several types of projects have been directed toward developing a scientific and engineering basis for control of soil erosion. Among those of greatest importance, attention is called to the following:

1. Rock for control of erosion at the outlet of culverts has been evaluated in terms of the velocity of water required to cause incipient motion of the bed. Size and shape of the ultimate equilibrium hole, the time and rate of progression of erosion, and the protective effect of submergence and dense packing of the bed have been evaluated.
2. Design criteria required to establish methods for construction and the physical requirements of materials necessary to control erosion downstream of highway culverts have been determined.
3. Characteristics of gravel or crushed rock liner have been related to the design of channels and to the control of erosion.
4. Terrace channel designs using spatially varied flow and tractive force theories and canopy inlets, have been investigated for closed conduits.
5. Direction of water from a conduit downward, by means of a vertical pipe into a basin where flow is then turned upward before being discharged into the downstream channel, reduces forces responsible for soil erosion.
6. Rock sausages placed on a properly graded base protect noncohesive materials. Design, development of mechanized fabrication for low-cost installation, and protection of erodable materials have been studied.
7. Methods of anchoring cobbles and riprap for improved erosion control are being investigated.
8. There is a need for development of a scientific and engineering basis for the control of piping, which as an erosional process destroys irrigated fields, grazing lands, earth dams and ditches, canals, highway and railway fills and embankments, bridge abutments and concrete-lined drainage channels.

Evaluation of Plants in Soil Erosion Control

Plants have varying degrees of capability of holding soil in place against the forces of wind and water. Aerial portions of plants reduce the force of wind and water, and thus help to prevent erosion. Roots of plants vary in their capacity to hold soil in the root zone. Research on vegeta-

tive means of erosion control has been conducted, as an evaluation of the following three plant types:

1. *Grasses:* Evaluations of native and introduced species and varieties of grasses have provided information on those types most suitable for use under roadside conditions where erosion is a problem. Speed of germination and seedling establishment, and wide range of climatic conditions suitable for establishment are important criteria in these evaluations. Development of a tight ground cover and an extensive root system are essential for these plants. In addition, they must tolerate soil and climatic conditions associated with the roadside environment. Types of plants that retain dominance over weeds throughout long periods of time are most desirable. Research has indicated that vegetative planting of types not available from seed can be successful.

2. *Vines and Legumes:* Low-growing vines that develop a heavy canopy of vegetation as well as an extensive root system are suitable for use in erosion control. Research has indicated that these plant types are most successfully used in conjunction with an overseeding of grasses. In time, they gradually assume dominance in the area. Because some of these plants are legumes, the soil must be innoculated with the appropriate soil microorganisms for the nitrogen fixation process to proceed. Less nitrogen fertilizer is required on stands of this type than on grass. Use of herbicides on slopes covered with vines and legumes is prohibited. Undesirable plants that encroach in these areas must be controlled by other means.

3. *Woody Plants (Trees and Shrubs):* Woody plants may be transplanted as seedlings, or may be direct-seeded to areas along the highway. Where the ultimate intention is erosion control, a protective cover of grasses or other plant types must be provided during the period of stand establishment. Evaluations of woody plants for this purpose have included flowering types, which may add to the roadside environment in ways other than by the control of soil erosion.

Study of Specific Roadside Situations as Related to Soil Erosion Control

Basic information concerning soil erosion has been related to specific roadside situations. In the final analysis, it is research of this type that determines the applicability of information from more highly controlled studies. Numerous tests and demonstrations are required to determine specifications for erosion control in the following situations:

1. Where large watersheds are involved, including adjacent and adjoining land.
2. On roadbanks, including steep, flatter, and flat slopes, involving either cuts or fills.
3. In and adjacent to drainage slopes, ways, swales, or structures, including situations from over-all drainage relief to open drains and subdrains.
4. On terraces and terrace channels.
5. In waterways, open ditches, and runoff ditches, including heading, caving, and erosion gullies.
6. Around channel banks of various shape, slope, or gradient, including stream and open channels, and where channel alinement and discharge considerations are important.
7. Along highway embankments adjacent to streams, lakes, surface water, or tide water.
8. Where sand and/or soil is subject to wind erosion, requiring use of dead vegetation, stubble mulching, cover cropping, strip cropping, windbreaks, establishment of woody plants, or mulching for protection of soil surfaces.
9. Around culverts to direct water flow and for flood protection, including large structural plate and other engineering features designed for flood and erosion control, such as outlets, overfalls, and bridges.
10. Around wells, where contamination of subsurface with surface water creates problems.

EVALUATION OF CATEGORY 6—PLANTING *

Definition

Planting as a roadside research category included consideration of all investigations concerned with soil preparation, seeding, or planting of vegetative or woody plant materials, and establishment or early maintenance of these various plant types. Planting, as related to erosion control, was considered in the erosion control category. Basic research in the areas of seed technology and plant propagation were not considered in this review, unless the investigations were directly related to specific roadside planting projects. Little basic research information of this type was reported. Developmental research was included only when the results of such research could be identified as relevant to practical planting operations. Much of the research evaluated was of an applied nature, so that results could be easily related to one or more aspects of roadside planting.

Literature Review and Evaluation

Documents reviewed fell in one of five categories: either they were concerned with trees, or with shrubs, or with vines, or with grasses, or with combinations of trees, shrubs, vines, grasses, and other plants.

Documents concerning trees were grouped according to conditions for use, such as on coastal sand dunes, on cuts and fills, on level area, and in general situations that were not related to the other three.

Documents concerning shrubs had to do with either control of undesirable types, or the evaluation of miscellaneous shrubs on the roadside.

Documents concerning vines had to do with either the development and planting of dwarf types or the evaluation of miscellaneous vines on the roadside.

Numerous documents dealt with grass. One large group had to do with seeds and seeding, and another was concerned with the evaluation of grasses under varying sets of conditions.

Documents listed under the general category, because of the variation in plant type considered, were placed in one of five subcategories:

* By Eliot C. Roberts.

1. Pesticides for control of undesirable plants.
2. General aspects of erosion control.
3. Seeds and seeding.
4. Selection of plant materials.
5. Evaluation of plant materials used along the roadside.

Under trees on coastal sand dunes, only research on mulches was identified. Under trees on cuts and fills, soil testing research and soil erosion control research were noted to be important. Under trees on level areas, salt contamination of soil fertilization studies was noted. Under the general listing for trees, climax vegetation research, use of trees in urban situations, sources of trees, problems related to aesthetics, and a general evaluation concerning the use of trees along the roadside were noted.

Documents regarding shrubs were concerned with either getting rid of undesirable types or an evaluation of desirable types. The main variables under study were, for example, the evaluation of shrubs under the influence of salt; the evaluation of shrubs when seeded directly to the roadside area; the evaluation of shrubs under specific soil and climatic conditions; the evaluation of specific types of shrubs as compared with others under varying conditions; the evaluation of shrubs to stop headlight glare, or snow, or as a crash barrier.

Under vines, seeding rate and seedling competition were noted under dwarf types. No other specific topics were identified. Vines were evaluated under specific soil and climatic conditions and under specific fertilizer practices. A large number of documents dealt with grass.

Regarding evaluation of plant materials, some papers had to do mostly with soil and climatic effects; others with such topics as drought tolerance, salt contamination, soil conditioners, water tables, species and varieties, automobile exhaust, fertilizers, and mulches.

Significance of Research Effort to Date

Research concerned with roadside planting has not received the attention or support justified by the importance of this feature of highway development. Much information in use today has resulted from costly trial and error experiences at the local level. Coordinated research efforts have been inadequately supported, and, often, research information concerning principles of planting suitable in other situations has been applied to the roadside location, generally with poor results. Only in recent years, as population increases and pressures have made us more sensitive to the needs of preserving natural beauty and of creating a planned environment in which to live, work, and play (all involving travel and highway systems), have we begun to think in terms of increased research in ornamental horticulture. The ornamental plant is being viewed more as a necessity and less as a luxury than at any previous time in our history. Despite this previous lack of recognition and support, plantsmen across the U.S. have made the most of the resources available, and have accumulated a wealth of information on roadside planting. Research projects have been conducted by Agricultural Experiment Stations at land grant colleges and universities, by state highway departments, and by private industry. Various U.S. geographical and climatic regions have been represented in this research effort.

Roadside planting research has covered a wide spectrum of topics, and has been concerned with basic developmental and applied projects. In order that research effort to date might be evaluated completely, with a minimum of overlap between project areas, five aspects of roadside planting are described briefly in the following.

Evaluation of Grasses for Roadside Use

The evaluation of grasses for roadside use has taken the following 12 factors into consideration.

Growth Characteristics of Native or Prairie Grasses

Native or prairie grasses have great potential for roadside use throughout large sections of the grassland areas of the U.S. Not all of these grasses have establishment and persistence characteristics that indicate suitability for the highway environment. Research has demonstrated the value of these grasses on back slopes and other areas that need not be mowed. The inflorescence and seedhead developed on many of these grasses are attractive, and thus add to the scenic value of the area. Sufficiently dense stands may be expected to stabilize soils against erosion; however, weedy-type plants have become more competitive under some conditions. Herbicides generally provide satisfactory control.

Growth Characteristics of Introduced Species and Varieties

Introduced species and varieties of grasses are generally more tolerant of mowing practices than are native or prairie grasses. Roadside research has determined specifications for the use and maintenance of several important grasses of this type. No single species or variety has been found that does equally well over wide variations in soil and climatic conditions. Thus, local or regional research has been important in the evaluation of grasses for specific situations.

Advantages of Seed Mixtures in Comparison with Pure Seedings

Research has produced no single species or variety of grass that grows equally well over wide variations in soil and climate. The climatic variable has a pronounced influence on grass establishment and persistence; and, because of the changing or cyclic nature of the climate, no single species or variety of grass is likely to do equally well all the time. Use of several species or varieties, having somewhat different growth characteristics, in a seed mixture assures improved stand establishment over that expected from a pure or single seeding. Different mixtures have been found desirable for medians and foreslopes, in comparison with back slopes. Soil and climatic conditions differ in these locations, as do maintenance practices.

Methods of Seedbed Preparation

Research on preparation of seedbeds for grasses along highways has produced important changes in methodology. Because topsoil often is discarded in the highway construction process and is assumed to be unimportant for plant growth, grass establishment and growth must take place on subsoil. Areas involved generally are too large to permit use of soil amendments to improve the physical properties of the subsoil. Thus, methods used in the preparation of the seedbed become critical for the creation of conditions favorable for plant growth. Machinery and equipment have been developed that loosen compacted soil resulting from the grading operation and leave it friable to sufficient depth to encourage grass stand establishment.

Seeding Methods, Including Depth of Seeding

Research concerned with seeding methods has resulted in the development of new machinery and equipment and produced new methods for assuring improved stand establishment. Comparisons of hoe-type deep furrow drills with rangeland drills, soil scarifiers coupled with broadcast seeders, hydroseeders, compressed air seeders, and aerial seeders have led to improved techniques for use under widely varying conditions. Research has indicated that, within limits, fertilizers and seed can be applied together, using either water or air as a carrier. Methods of this type permit application of fertilizer seed and mulch to the soil without traffic on the seedbed.

Date of Seeding

Timing of the seeding operation is often a critical limiting factor in establishment of grasses along roadsides. Where hundreds of miles of roadside must be seeded, not all areas will have seed applied at a favorable time to assure development of an adequate stand. Research to extend the optimum date of seeding, by use of cultural practices to protect seeds and seedlings of permanent grasses, has been of value. Improved methods for anchoring vegetative mulches, including use of chemicals and asphalt formulations and mechanical means such as stubble mulching and creation of wicker dams, have been widely accepted.

Rate of Seeding, Seedling Vigor, and Rate of Establishment

Relationships between rate of seeding, seedling vigor, and rate of seedling establishment have been well worked out for many grasses and grass seed mixtures. Vegetative density meters and devices have been used to characterize stands of individual grasses and of mixtures of grasses. Reductions in rates of seeding have resulted in some instances, while increases have been recommended in others. Information on soil properties and climatic conditions has been used in conjunction with improved planting methods to produce more cover for the amount of plant material used.

Effect of Mulches on Establishment

Research on uses of mulches in improving stand establishment of grasses has been important in roadside improvement. Grasses that may look poor under unmulched conditions appear of considerably greater value where mulched. Not all mulches are equally effective in modifying temperature and moisture conditions in the seedbed. Thus, evaluation of mulches and mulching practices is an important adjunct to evaluation of grasses for roadside planting.

Importance of Fertilizer and Lime

A critical need in the establishment of roadside grasses is the application of more than the one-shot fertilization at seeding now specified. Research has indicated that fertilizer needs of roadside grasses are not being adequately met in many instances where only a seedbed fertilizer application is made. Additional applications of fertilizer, based on soil test information, will assure better stands and more rapid sod establishment, with lower maintenance costs and less soil erosion. Single applications of lime are more likely to meet long-term grass needs. However, soil pH should be checked by soil test and lime, used particularly where there are indications that acid soils have created conditions of mineral toxicity.

Effect of Salt from Deicers on Grassy Plants

Use of deicers on highway pavements during winter months has resulted in salt accumulations in roadside soils. Sodium chloride has reached such concentrations in some locations that both physical and chemical properties of the soil have become unfavorable for growth of roadside grasses. Research to identify the extent of this problem, and to fully describe its nature, has been conducted at several locations throughout the northern U.S. Ways and means of coping with this problem have not yet been determined.

Effect of Growth-Regulating Chemicals and Herbicides on Establishment of Grasses

Use of growth-regulating chemicals has been most important to date in the selective control of weedy plants. Research to identify specific chemical compounds with growth regulatory processes in various groups of plants has significantly improved selective weed control within roadside locations. Grasses generally are resistant to chemicals that affect growth of broad-leaved plants. Some research effort has been directed toward development of chemicals for growth control of grasses. Chemicals to speed up or slow down vegetative growth can be important aids in increasing rate of grass establishment, in improving its persistence and hardiness, and in reducing the frequency of seedhead production and frequency of mowing.

Renovation and Revegetation of Roadsides Using Grasses

Over time, changes occur in plant populations, and roadside grass stands tend to deteriorate. Research is being conducted on ways and means of renovation and revegetation of roadsides. Combinations of mechanical operations and cultural practices are required to establish grasses where existing stands have been lost. Erosion control may become an important problem where a weakness in the grass stand fails to respond to renovation procedures. Basically, the same principles apply to renovation and revegetation practices as apply to construction and establishment operations. The scale of the endeavor is reduced, thus requiring specially designed equipment and procedures.

Evaluation of Vines and Legumes for Roadside Use

Research on the evaluation of ground covers has indicated that low-growing vines and legumes, that form a dense canopy over the soil surface and develop an extensive root system, are desirable for use on areas that are difficult to mow and where close mowing is not required. Many of these plants produce attractive vegetation and flowers that add variation in texture and color to the roadside. Research on seed inoculation has been important in developing improved methods of establishment for certain leguminous plants. Seed quality and the necessity for scarefication treatments have been investigated, so that more rapid stand establishment is now possible. Evaluations of cover and companion crops have led to improved seeding specifications. A grass cover is often required to stabilize an area while the slower growing vines are becoming established. Requirements of these plants for fertilizer and specific soil pH ranges have been well worked out for a variety of soil types and under many different climatic regimes.

Evaluation of Woody Plants for Roadside Use

Roadside research involved with woody plants has been concerned almost completely with the evaluation of various types for use in the highway environment. Major emphasis has been on the suitability of native trees and shrubs in the various geographic sections of the country. Evaluations of commercially available species and varieties have been important, because sources of many types of woody plants are limited. Studies have been conducted to develop improved sources of trees and shrubs; some of these investigations have been concerned with improving methods of propagation. Plants more readily propagated should be available in larger quantities. Nurserymen have established a landscape materials information service as a cooperative venture to improve communications between suppliers and consumers. Despite this effort, the most desirable types of woody vegetation often are not available in the quantities required or at a price suitable for roadside use.

Research on seedling vigor of woody plants has led to new information on the effects of soil surface temperature and mulching, soil moisture, fertilization, and such practices as summer fallow, cultivation, and scalping on the establishment of trees and shrubs. Based on this knowledge, direct seeding techniques for woody plants have been developed. Various coatings and treatments for seeds have been evaluated, to determine their value in dryland seeding operations.

Investigations concerning the general culture of woody plants have been important in the development of specifications for use of soil amendments, fertilizers, and lime and mulches in the establishment and maintenance of trees and shrubs. Information of this type, related to nutrient and moisture requirements of plants, is essential for developing maintenance programs that will produce hardy vegetation.

Salt concentrations in some roadside soils have interfered with the establishment and maintenance of woody plants. Leaf scorch symptoms have been common on trees grown where large quantities of de-icers have been used during winter months. Research to identify and describe the problem has been conclusive. Ways and means for combatting the problem are still being studied.

Control of undesirable woody vegetation is essential in providing space for desirable types to develop. Investigations involving both mechanical and chemical means of weed control have been useful in further evaluating the potential of certain types of woody vegetation. Renovation and revegetation of roadsides with woody plants can serve as an important means of upgrading the quality of roadside cover.

In the final analysis, development of grades and standards specifications for woody vegetation will relate plant condition with use specifications such that more reliable establishment and maintenance procedures can be developed.

Investigations Concerning General Use of Plant Materials Along the Roadside

Research on the use of plant materials along roadsides has been concerned with some general areas of investigation in which information gained crosses lines for trees and shrubs, vines and legumes, and grasses, and applies in general to the over-all roadside situation. These investigations have been grouped in the following five categories.

Ecological Considerations in Roadside Planting

Ecological considerations form the basis for roadside plantings. Plants compete with one another in the highway environment; and through natural processes of plant succession, a climax vegetation is developed. Where well-adapted species and varieties are used, erosion control will be realized and aesthetic values of the roadside will be maintained. Where poorly adapted species and varieties are used, plant losses will be great, and the succession of plants resulting probably will lead to increased erosion and to a deterioration of roadside aesthetics. Research based on ecological principles is essential in evaluating the nature and extent of plant losses, and in the evaluation and selection of well-adapted types. It has been found necessary under some conditions to modify the environment temporarily with companion crops or plants, until such time as the desired species can become sufficiently well-established to compete on their own. Controls of this

type are essential in developing the roadside landscape in accordance with predetermined plans.

Soil Properties and Their Relationship to Roadside Planting

It is often assumed that the cost of stockpiling topsoil and the redistribution of this material on the roadside is too great in relation to the importance of the topsoil in plant growth. Thus, roadside soils are likely to consist of subsoil, whether they be cuts or fills. These soils are characteristically low in organic matter; and, except for use of soil amendments around trees and shrubs, the large acreage of ground involved prohibits general use of these materials for grasses and other ground covers. Roadside soils are subjected to heavy compaction during the highway construction process; and, because the physical and chemical properties of subsoils normally make them compaction-prone, they are likely to retain poor physical properties for a considerable time following construction. Chemical properties related to lack of fertility, and acid conditions that favor toxic accumulations of some minerals often present serious limitations to plant growth. Low levels of organic matter generally are indicative of microbiologically inactive conditions. All of these factors are clearly related to the justification for soils research under specific roadside conditions. Research in this area becomes increasingly important as use of deicers increases sodium chloride levels adjacent to highway pavements, and further disrupts physical and chemical processes essential to continued plant growth.

Climatological Considerations in Roadside Planting

Over-all climatological characteristics of an area are reduced to an unlimited number of specific microclimates, associated with plants growing along roadsides. The exposure or angle of a slope will influence temperatures at the soil surface and immediately above. Hardiness of some plants may be determined by small temperature changes caused by exposure differences. Air currents along highways and the various components of exhaust gases carried in these currents impose restrictions on the growth of some plants. Lead, zinc, arsenic, iron, and cadmium have been identified and measured in this respect. Light intensity, quality, and duration, rainfall and humidity characteristics of an area, and wind patterns further prescribe specific growth conditions for different locations. Other plants in the area modify the climate for those growing in association with them by changing light intensity and quality through shade, and by influencing air drainage and humidity changes through screening processes. Thus, the characteristics of the roadside climatic environment are unique, and have been given high priority for detailed research effort.

Relationships Between Soils, Climate, and Ecology in Roadside Planting

Each roadside situation presents a combination of specific soil, climatic, and ecological conditions. These factors do not influence plant growth separately, but always are in conjunction with others. Thus, it is essential that roadside research be replicated and repeated often enough to be specific for local and regional needs. What often appears to be a duplication of effort is essential for the complete understanding of factors which influence roadside planting. At the same time, it is recognized that coordinated research planning and complete communication between various agencies conducting roadside research is essential for elimination of the unproductive duplication of effort that does exist.

Specifications and Costs as Related to Roadside Planting

Early attempts to obtain information for use in roadside planting were mostly of a trial and error nature. Problems were solved one at a time and seldom related to underlying conditions. More recent research approaches involve evaluations of conditions such that when it is complete, the scope and nature of the problem were thoroughly identified and described, so that future investigations may involve the most productive and direct approaches to problem solving. This procedure has led to the development of specifications for planting that were not believed possible a few years ago. A continued effort must be made to relate research information to the development of planting specifications. This is a critical need. As this is being accomplished, cost relationships between planting and subsequent maintenance must be considered. False economy may result from looking at planting costs and ignoring maintenance costs.

Special-Purpose Uses of Plant Materials Along the Roadside

Plantings along roadsides often are related to special-purpose situations that require specific plant types. Waterways or other areas subject to erosion require use of grasses and other plants that will stabilize the soil and hold it in place. Shrubs and other woody plants may be used to form crash barriers in specific situations. Intrusions of plants along the roadside may function to control drifting snow or screen out headlight glare. They may be used to help guide traffic or in noise abatement. They may be strategically placed for beautification, varying from intensive through intermediate to nonintensive. Plantings help reduce driver monotony and may be used quite differently, depending on location—industrial and urban, residential or rural. Plantings may harbor wildlife and provide food and shelter for birds and animals, and in this way aid in over-all conservation programs in specific areas. At other times, when in the wrong location, plantings may obstruct sight and reduce safety by increasing the likelihood of vehicles hitting them. They may obstruct drainage and increase maintenance costs of roadsides. Plantings may interfere with illumination and overhead utilities and create hazards during windstorms. Careful selection of plant materials and proper placement based on best research information are essential.

EVALUATION OF CATEGORY 7—ROADSIDE MAINTENANCE *

Today the increased acreage dictates new and improved methods of roadside maintenance, making this almost a specialized operation. A decade ago this maintenance was taken care of chiefly by mowing operations. Today, special mechanical equipment, new control methods (chiefly herbicides) and new plant materials are available for more effective and economical operations.

The State of the Art

Roadside maintenance is an integral part of highway planning and design. It is important that the maintenance procedure be established at the time the highway is designed so that the design and maintenance factors can be coordinated. The landscape architect needs to know the kind of maintenance the roadside is to receive so that he can specify a turf that will be compatible with the maintenance programmed; e.g., mechanical mowing, no mowing, or the use of grass retardants. He may wish to design flatter slopes to benefit the mechanical mowing operation.

Roadside maintenance is a matter of study and research. Very little control other than herbicides has been undertaken. New herbicides need to be researched; so does application, which needs to include calibration of nozzles. Growth inhibitors need to be evaluated and better information is needed about materials to be planted on slopes to reduce maintenance.

Types of mowing equipment for turf need to be considered, because economy and efficiency of operation are very important with the ever-increasing acreage in roadsides.

Roadside maintenance in the days of the early road system often consisted only of a ditch to carry the water run-off from the road surface. There was limited concern for the function and appearance of the roadside. Today the roadsides are of greater importance, and in many states comprise of more than 50 percent of the highway right-of-way. However, roadside maintenance personnel often are the only ones conscious of the many related factors. For example, the addition of scenic acreage extends beyond the normally recognized fence line and now needs to be considered for maintenance.

Document Evaluation

A total of 199 documents were received; of these, 193 were reviewed and classified. Of this total 6 percent were listed as basic research, 10 percent as development research, 63 percent as applied research, and 21 percent as not research.

Most of these subjects were local, yet nearly all could be applied regionlly, as far as the value of the study applied. Many of the reports were opinions, rather than proven facts. Much of the research was based on the observed conclusions and experience of individuals and the general consensus of the committee members.

The greatest number of documents (34) pertained to general maintenance (which covered all phases of maintenance operations) and the use of herbicides. The herbicide documents generally dealt with roadside spraying of turf areas for the control of weeds.

The interest in turf retardants to reduce maintenance, mowing operations, and costs is evidenced in that ten documents dealt with this subject. This research applied generally to a local situation and was not always objective as to the species of grasses involved. Favorable results depend on the application being made at the proper time; this varies with different species.

Two categories—the general cost of maintenance operation, and the consideration of maintenance in the design stage of highways—had nine documents each.

The need for new and improved maintenance methods is reflected in the seven documents dealing with maintenance equipment and the seven that deal with turf establishment. Four documents reported on mowing equipment. It was definitely established that turf establishment for erosion control was the first prerequisite, and that conservation and beauty would follow with proper maintenance procedures. Five documents reported on this subject.

Turf maintenance and its cost had six documents each. Plant establishment also had six documents, but most of this reporting on the research projects was ten years old or older.

To maintain the appearance and function of the shoulder of the road, foreign growth must be controlled from establishing itself in the asphalt shoulder. Three documents deal with a pre-emergent herbicide being applied to the subgrade prior to the asphalt application.

Two documents were received on each of the following subjects: roadside maintenance research; herbicides and their use on brush, shoulders, and turf; herbicide costs; a survey on litter; litter in general; pruning of existing plantings; and turf establishment.

Only one document was received on each of the following subjects: helicopter equipment; general development and land use; herbicides for use under guardrails; pre-emergent herbicides; sprayers; planting of trees and shrubs; plant preservation; mulch for turf establishment; and maintenance by mechanical mowing.

Roadside maintenance was identified mainly within the right-of-way line. The control of this acreage is the responsibility of the maintenance engineer. There is now a growing concern about the importance of the roadside, and the outdated concept that it needs to serve only functionally has now been revised to include appearance, which does not stop at the fence line. The motoring public neither cares about nor remembers the difficulties encountered in providing the highway but it does appreciate that well-cared-for roadsides add to their motoring pleasure.

The Highway Beautification Act of 1965 has triggered a growing national interest in creating a more livable and enjoyable environment; this will cause all future research on roadside maintenance to be concerned with the practical aspect and recording the achievements, and also with the realm of beauty.

A review of the roadside maintenance documents re-

* By Wilbur J. Garmhausen.

veals a need for further research in many of the categories reviewed. The research needs are listed by priority, as follows:

1. More can be accomplished by including preventive maintenance in the design stage of highway planning than at any other time. A research project is needed that will lead to coordination of the efforts of the landscape architect and the highway engineer and that will conserve and enhance the landscape and reduce maintenance costs.
2. There are many economical ways to maintain turf. Because much of the roadside is of this type of ground cover, more research would be justifiable to review new methods, both mechanical and chemical, to obtain the most practical.
3. Siltation has been stressed, and precautionary measures are to be taken to avoid this. New chemicals have been developed to prevent this from happening, but research has yet to determine which are practical and feasible.
4. As roadside acreage increases there is a tendency to allow fill slopes and cut slopes of turf to mature to full height. This is acceptable to the motoring public if the turf is kept free of weeds. Research is needed to determine the best chemicals to maintain weed-free turf.
5. Mechanization is almost a must for roadside maintenance operations. Research is needed on many kinds of equipment, including sprayers, mowers, and litter pickers, and helicopter use.
6. Roadside maintenance becomes more and more involved in many operations. Research is needed to determine the value of stage construction for plant and turf establishment, and the number of years the establishment work should be in force.
7. The greatest misuse of the roadside is littering. Each year litter removal becomes more costly. The problem is significant and of increasing concern; research with specific recommendations that have proven successful is needed.
8. Scenic easements are obtained mainly to preserve and enhance natural beauty. This use, as well as the various uses of the land within the right-of-way, will affect adjacent property values. This is also true for a location for outposts. Research is needed to establish those values as a guide for proper land-use controls and their administration or maintenance in conjunction with public ownership.
9. Improvement of the visual environment has been emphasized by the efforts made to screen junkyards. Research is needed to define good practices for screening undesirable areas or views and also for noise abatement and fume dispersement.

EVALUATION OF CATEGORY 8—ORGANIZATION AND ADMINISTRATION *

Background

Early land-service roads fitted the terrain of the countryside by swinging with the land contours for utility and economy. Then the needs of time-saving speed and traffic safety required much straightening and widening, with scars of construction resulting from the heavy cuts and fills. The hazardous eroding ditches required attention, and roadside development began to be applied here and there as a corrective to these unsightly and unsafe conditions.

Roadside development has progressed from this early piecemeal approach, as an afterthought to construction, to the team approach as an integrating process in highway construction. Research review indicates the trend is toward the conceptual approach of environmental design, as a blending of the construction into the environment or natural surroundings.

In turning toward the total concept of optimum highway development, in which roadside development is effectively and economically integrated in the completed construction, obviously some reorientation will be required in organization and administration.

The environmental design concept of land-use compatibility deals with the visual-functional aspect of highways and their relationship to the landscape-cityscape, or, more specifically, the fitness or appropriateness of each highway in its natural or man-made environment.

These compatability goals of the complete highway concept require that organization and administration be geared and streamlined to the continuous process of decision-making, from early planning and reconnaissance of route corridors to the final maintenance and operation of the completed highway construction.

Category Review-Analysis

A total of 164 documents were reviewed and categorized in relation to highway organization and administration; about 20 percent of these were evaluated. About one-half of those evaluated were classified as developmental research. Few were considered as either basic research or as applied research in the area of organization and administration. About 40 percent of the documents contained little or no research.

The content of most of the documents was framed around individual opinion. Some of the opinion papers, especially those of the consensus, were of great value, and very useful.

With few exceptions, due to the nature of the problem, most of the documents would have general application among the several states.

Category Relevance

Ninety percent of the documents had complete relevance (60 percent) or major relevance (30 percent) in this category. The remaining 10 percent either were not relevant or contained only a small amount of relevant material. It is of interest to note that 20 percent of the documents (32) related to roadside development personnel; 50 percent (85) were concerned with the roadside development program; and 30 percent (47) were involved with public relations phases of roadside development.

Forty-three documents (25 percent) were landmark documents, containing background information of value in the personnel, program, and public relations subcategories,

* By Wilbur H. Simonson.

from the viewpoint of history and progress in these phases of highway organization and administration relevant to roadside development.

Roadside Development Personnel

Review of the research needs points to a growing national concern for well-trained people to carry on the many facets of roadside development. Analysis of the literature reveals the need for the professional level of approach to these problems, particularly in the beginning of planning and reconnaissance for a route location selection. The potential for correlation with the various members of the organization involved in the reconnaissance of highway corridors and in the route-selection process depends on the position of the landscape architect in the highway department organization and administration. The model organizational set-up on a Bureau level strengthens this need for correlation in the decision-making process at the start of planning and reconnaissance.

Roadside Development Programs and Public Relations

Review of research reveals the value of the professional approach on a collaborative basis throughout all stages of planning and development, as a means of effecting a quality design in good order fitting the environment.

RELATIONSHIPS OF ROADSIDE DEVELOPMENT IN HIGHWAY RESEARCH PROGRAMS

State Programs

Research administrative organizations and activities in the states visited varied from minimal to intensive. Minimal programs found the Part II (research) portion of the 1½ percent HPR program being combined with other duties (usually planning). California, Texas, and Louisiana were three of several states having intensive and specialized research organizations that included roadside development in their programs.

The most common practice is that the roadside development research planning and coordination is done by the state roadside development personnel, with the 1½ percent fund officer providing administration and contract control.

In those states having in-house non-federal-aid testing or demonstration projects, these usually were accomplished by the roadside development or maintenance staff, or a combination of the two. Most states with an active roadside development staff had such in-house programs (more than 50 percent of the states). However, from the field interview results, it was observed and concluded that more than 70 percent of the value of this work is lost, other than to the personnel directly involved, because these observations usually are not written up and/or published. These projects are conducted informally and seldom come to the attention of others, except to illustrate a point of discussion. Occasionally they do provide leads and stimulate formal research work. Next to the lack of regional research planning, the loss of this type of roadside research and experience was found to be the greatest loss of research effort.

Many state roadside development research programs were oriented toward testing for the self education and reassurance of the roadside development staff as well as the demonstration of previously proven principles and practices known to be superior to the ones in use. It is estimated that approximately one-third of the roadside development research effort goes for "educational and reassurance" testing, one-third for "demonstration," and only one-third for "research" to generate new knowledge. It is unfortunate that communication failures and reluctance to accept staff recommendations result in this additional loss of research effort.

This type of "research" is not unique to roadside development, and is considered desirable and valuable until the communication and administrative problems can be overcome. In some instances the roadside development research activity has even led to the establishment or upgrading of the roadside development function.

Coordination

Despite the tremendous efforts of the BPR, Office of Research and Development, the AASHO Committee on Roadside Development, and the Highway Research Board to coordinate roadside development research, the most apparent and damaging omission in roadside development research administration is the lack of communication and coordination overview in this area of highway specialization.

The BPR is restricted by statute and policy to a role mostly of reaction rather than initiation, except at top-level administration, and by practice to research project evaluation and surveillance.

ROADSIDE DEVELOPMENT RESEARCH EXPENDITURES

Research Efforts Using Highway Tax Funds

Federal-Aid Research Projects

As of May 1969, there were 36 active studies, 3 recently completed studies, and 1 proposed study using part, or all, federal funds. Of the active studies, 33 were being conducted with state-matched HPR funds (in the aggregate amount of $3,357,185), 2 with state-matched NCHRP funds ($300,000), and 1 with unmatched BPR administrative funds ($340,000).

There were also reported three recently completed ($237,200) and one proposed ($234,000) HPR studies.

The subject area categories of these studies are as follows: Single category studies have three on highway location and design, none on roadside space or resource conservation, one on motorist services (rest area water supply), two on erosion control, nine on planting, five on roadside maintenance, and one on organization and administration (research needs).

Combined or multiple-category studies had highway location and design subjects in three studies, roadside space in none, resource conservation in one, motorist services in none, erosion control in eight, planting in 18, maintenance in 16, and none in organization and administration.

Except as a by-product of erosion control or some other subject area, there is only one present research effort directed toward resource conservation. There is also only

one study directed toward motorist services problems. There is no research effort directed toward roadside space (its design, management, or use) except as related to its planning through the highway location and design studies. There is one study directed toward roadside development organization and administration problems. There are six studies on the design aspects of aesthetics and plant material; only two of these are directly and specifically design-oriented, and both are recent.

These are contrasted with 27 studies with emphasis on planting subjects, 21 on roadside maintenance, and 10 on erosion control. The dominance of these activities parallels the historic subject areas of roadside development involvement. However, it is significant that the most urgent informational needs expressed during the field interviews involved (1) the staff-relationships aspects of organization and administration, (2) the identification and quantification of the intangibles and design procedure development for highway location and design and roadside space, and (3) the rest area design elements of motorist services.

Non-Federal-Aid State Research Projects

No complete listing is available of past or present studies using state highway funds exclusively. However, the field interviews gave some indications as to the quantity of this type of activity.

Of the states interviewed, more than 50 percent were conducting or had conducted non-federal-aid in-house research. Also, most were supplementing their HPR studies with additional state resources, such as field personnel or administrative funds. Some had non-federal-aid contract roadside development research projects.

The cost accounting procedures used by many states preclude an accurate tabulation of the actual amounts spent by them for non-federal-aid roadside development research efforts. The actual division of HPR funds used for roadside development research becomes clouded by matching ratios in the division of state and federal funds.

Research Efforts Using Nonhighway Revenue Funds

Those agencies that are not supported by highway taxes have also provided considerable funds or other resources to roadside development research. Some of these resources have been applied directly to highway problems, and other studies have produced relevant information as a by-product of their work. There is no way of even estimating the dollar value of these studies. It is known to be considerable and can be a great assistance to roadside development and highway transportation if harvested.

Industry contributes millions of dollars annually * to roadside development research through product development and testing. Except for certain specialized items, highways can share in utilization of these products with many others if this research effort is directed to highway needs and the research results are related or "harvested" for highway applications. Industry's product development for a broad market does not diminish its value to roadside development but adds to the benefits by spreading the cost base of their development and production. Such products as equipment, agricultural chemicals, and plant material contribute immeasurably to the reduction of construction and maintenance costs. It would be impossible for the highway industry to sustain a comparable research and development program.

* "Con-Expo, 1969." *Better Roads* (Dec. 1968).

Relationship of Roadside Development Research to Highway Funding

According to *NCHRP Report 55,** highway research is conducted in the amount of 0.25 percent of the total expenditures for highway construction and maintenance. Total research and development amounts to 3.0 percent of the gross national product. Department of Defense research, development testing, and engineering is 12.4 percent of the total defense expenditures.

Using the HPR 1½ percent funds as an index for roadside development research, and beginning with the federal trust fund allocations to the states, 1.5 percent goes to planning and research development. Of this 1.5 percent, 70 percent goes to planning. This leaves 0.45 percent for research and development. Assuming that the state's matching funds add 50 percent, this would increase the amount to 0.67 percent. Further assuming that the states spend an additional 50 percent in non-federal-aid research, this would result in a total research and development expenditure equal to 1.0 percent of the amount of the federal-aid allocations.

To relate this to roadside development research we find that the HPR program Part II funds with state matching money were as given in Table 1 for the total research and development program and for the roadside development portion.

Using 0.25 percent of the total highway expenditures for construction and maintenance as the ratio of highway research and 2.39 percent (Table 1) for the roadside development research share of highway research, the net ratio of roadside development research to total highway expenditures is less than 0.006 of 1 percent.

Even though the total funds expended have risen 6.54 percent in recent years, the ratio of roadside development research to total research has declined 0.64 percentage points, from 3.03 percent to 2.39 percent. It is significant that this has occurred during a period of roadside development emphasis.

The number of roadside development studies has increased from 29 to 33 during the same period, but the average cost per study has declined, while the average for all HPR highway research has increased.

SCOPE AND STATUS OF ROADSIDE DEVELOPMENT RESEARCH ESTABLISHMENT

The major participants of the roadside development research establishment are listed in "List of Colleges or Universities and Areas of Roadside Development Research"; "Partial List of Agencies, Associations, and Conferences Contributing to, or Stimulating Publication of

* Bertram D. Tallamy and Associates, and Wilbur Smith and Associates, "Research Needs in Highway Transportation." *NCHRP Report 55* (1968).

TABLE 1

COMPARISON OF ROADSIDE DEVELOPMENT RESEARCH FUNDS IN THE HPR PROGRAM (1965–1968)

ITEM	1965	1966	1967	1968
Total HPR budget ($)	25,556,820	29,384,480	30,608,000	24,494,000
Roadside development portion ($)	774,336	807,534	1,053,000	825,000
Percent of Funds	3.03	2.75	3.44	2.39
Total studies	1,155	1,175	1,043	1,108
Roadside development studies	29	32	35	33
Percent of Projects	2.15	2.72	3.36	2.98
Average cost of study ($)	22,137	25,008	29,346	31,132
Average cost of roadside development study ($)	26,701	25,235	30,085	25,000

Source: USBPR, Office of Research and Development, Highway Research and Development Studies (May 1965, Oct. 1966, Nov. 1967, Nov. 1968). Includes NCHRP studies.

Roadside Development Research and Experience"; and "List of Private Organizations That Have Conducted Roadside Development Research." *

The capability, interest, and understanding of the operational aspect of their research subject area problems were found to be excellent among those researchers interviewed. The only problems mentioned were the administrative problems of serving two masters (state and federal). Some expressed the desire to be engaged in the production of new knowledge (basic research) rather than "problem-solving" activities (applied research).

There appeared to be more than sufficient expertise available for, and experienced in, all category subjects of roadside development to successfully complete needed research.

Current lists of industries engaged in "harvestable" roadside-development-related research and development are available in the "Buyers Guide" section of several landscape trade magazines.

* Available on request from the Program Director, NCHRP.

CHAPTER THREE

TOP FIVE ROADSIDE DEVELOPMENT RESEARCH NEEDS, BY CATEGORY

Certain features were observed to be unique to roadside development and its research. Living plants vary in their reactions to soils, management practices, and use. Sufficient research has been accomplished to provide basic information. This knowledge should be synthesized to produce design guides, and installation and maintenance manuals.

Research is lacking on environmental design elements, with the result that there is a void of knowledge in this area. Furthermore, most literature is vague, unsubstantiated, and theoretical. Research in this field is urgently needed.

Legal research needs are beyond the scope of this project. However, because of the direct and total involvement of the Highway Beautification Act of 1965 with roadside development, it is appropriate to suggest further research to perfect this law and to facilitate its administration. Such research should be done with a positive approach that will provide legislative information to accomplish the worthy objectives of highway environmental preservation, restoration, and enhancement.

The top five priority needs for each category of research appear in the next sections. The code number identifies the project category subject areas, study identification number, and origination date.

Additional research needs and ideas are listed in Appendix C, by title.

PROJECT ESTIMATING GUIDE AND KEY

ESTIMATE OF TIME REQUIRED:
How long must the period (in months) be for:
Project Organization and set-up?..... _____
Observations and/or data collection..... _____
Prepare Report?..... _____
Total?..... _____

ESTIMATE OF FUNDS REQUIRED:
Number of Investigators:
_____Professional.....@$2,000 per mo. X ____ months = _____
_____Sub-Professional.....@$1,000 per mo. X ____ months = _____
Cost of Travel, if any..... _____
Cost of Special Equipment, Supplies, etc..... _____
Sub-Total..... _____

Add project set up cost of 25% of sub-total..... _____

PROJECT CODE: 24-318-02-69
Examples: 24-318-04-69
24-460-02-69
Meaning: 24- (1) (2) (3) - (4) (5) - 69
24 = Subject Area - Roadside Development
Position: (1) Dominant Category
(2) Second Related Category
(3) Other " "
318 = 3 - Resource Conservation, 1 - Highway Location and Design, 8 - Organization and Administration. (Assign second and third category numbers, if any, otherwise use 0).
Positions (4) & (5) for numbering projects consecutively, 01 through 99, within each category. Example: 01, 02, 19, 25, etc.
69 - 1969, Year of entry into HRIS or subsequent revision.

PRIORITY: _____

Group	Rating within Group
A = 1st Five Projects - Top Priority	1 Top Priority of Group
B = 2nd Five "	2
C = 3rd Five " - Lower Priority	3
Examples: A-1, A-2, B-4, C-3	4
	5 Lower " " "

Figure 1. Project estimating guide and key.

The system used and meaning of the project code number and the priorities, together with the system of estimating the time and funds, is shown on Figure 1.

Those research needs were selected for each category based on the evaluation of the literature, the field interview results, and the researchers' personal knowledge of the subject areas.

Priority assignment was based on the researchers' subjective judgments of such factors as the value of the information to be developed, the scope of application of the research results, and the ease or difficulty of accomplishing the research and implementing the research results.

Table 2 gives the aggregate funds estimated to investigate the top 40 research needs.

RESEARCH NEEDS FOR CATEGORY 1—HIGHWAY LOCATION AND DESIGN

Highway Planning Procedures for Identification and Evaluation of Ecologic and Aesthetic Factors

Project Code: 24-123-01-69 Time: 18 months
Priority: A-1 Funds: $235,000

Project Statement

Develop guidelines and procedures for identifying and evaluating ecological and aesthetic factors of the highway environment in preliminary planning and alternate route-location studies. Incorporate photointerpretation methods and graphic techniques in the process of roadside development analysis and comparison to ascertain (1) effects of location on the natural ecology of the corridor-landscape in rural areas, and (2) impact of location on the man-made environment of the cityscape in urban areas.

Needs for Study *

Highway roadside development suffers from inadequate inputs from such areas as the visual, ecological, and behavioral aspects, essential to adequate solutions. Although studied piecemeal heretofore, these aspects are somewhat fragmented and isolated from each other, particularly in the preliminary planning stage when alternate feasible route comparisons are evaluated in the route-selection process.

A critical gap in research criteria exists in the area of the visual aspects of highways—and their relationship to the landscape-cityscape—the fitness or appropriateness of each highway in its natural or man-made environment. All elements of design need to be brought into balance. Relevant to roadside development as a vital part of highway-community planning, research in the area of visual design is needed to further proper understanding and application of ecological and aesthetic principles. Such basic understanding is essential in furthering due recognition of

* HPR Study No. FH-11-6620, conducted by Harvard University, investigates many elements of this subject. However, the need for this information, in guideline form, remains paramount.

TABLE 2

ESTIMATED FUNDS FOR FIRST 40 ROADSIDE DEVELOPMENT RESEARCH NEEDS

	FUNDS ($1,000), BY CATEGORY								
PRIORITY	1	2	3	4	5	6	7	8	TOTAL
1	235	280	125	162	350	250	100	100	1,602
2	175	80	50	100	150	75	80	50	760
3	100	125	150	70	250	50	50	75	870
4	100	150	100	100	300	75	150	50	1,025
5	100	100	200	100	—[a]	—[a]	75	50	625
Total	710	735	625	532	1,050	450	455	325	4,882

[a] State non-federal-aid testing and evaluation programs. The funding level for each state would be as recommended in Chapter Four.

visual values from the very start of sensible planning of highway route locations.

Research in visual design is needed in furthering highway safety, optimal use of environment, economic efficiency, and support of the national interest.

Study Objectives

Unknowns to be solved: 1. This research shall facilitate identification of ecological and aesthetic factors as basic resource data in hand for systematic appraisal at the start of reconnaissance (preliminary planning stage). 2. This research shall simplify the qualitative analysis of the nature and dimensions of the impact of alternative route locations on the patterns of economic growth in the corridor area as related to ecological and visual environmental considerations such as natural landscape features, watersheds and drainage patterns, topography and soil types, character of vegetation, and man-made influences and cultural uses.

Guidelines to be produced: 1. Develop general lists of ecological and aesthetic elements as typical examples for guidance in the process of identifying and evaluating landscape resources in rural highway corridors and in urban highway environments. 2. Show photointerpretation methods and use of graphic techniques in the process of roadside development analysis and comparison of route locations in rural and urban areas, particularly for complex urban freeways.

Benefits Expected from Research

Research results will facilitate preliminary planning of a wide corridor as the first step in continuing decision-making process—leading to the preliminary survey stage for the selected route location, and early formulation of the design concept for a specific segment of any highway system.

Development of guidelines and procedures in environmental design will facilitate the working together of qualified specialists on location-design problems, to select the corridor, pick the route, and participate in the total highway planning process, with due regard to the impact on the "environs." Systematic inventory of environmental landscape factors and land-use development along the route will benefit determination of the character and design of landscape development.

Area of Application

This research should be conducted and the results should be applied on a national basis.

Comparison of Grading and Safety Factors with Aesthetics, Ecology, and Independent Roadway Design

Project Code: 24-123-02-69 Time: 24 months
Priority: A-2 Funds: $175,000

Evaluate present standards and practices affecting highway geometrics and grading requirements resulting from efforts to enhance safety. Determine the degree of effectiveness for each design in the differing conditions encountered such as traffic volume, speed, abutting use influences, terrain, and curvature.

Determine the impacts caused by these standards and practices on the aesthetics and ecology of the highway corridor.

Develop guidelines for more accurate assessment of both the safety and the aesthetic and ecological design factors that will provide for the optimum balance of reasonable design and proper proportioning that incorporates the closely related criteria of safety, aesthetics, and economy.

Conduct and apply nationally.

Environmental Design for Urban Highway Multiple-Use—Joint-Development Projects

Project Code: 24-123-03-69 Time: 15 months
Priority: A-3 Funds: $100,000

Evaluate existing multiple-use and joint-development projects for design sequence with highway design and the resultant development, use, and environmental compatibility. Develop guidelines to inventory the human and physical needs and resources in the areas of proposed projects.

Recommend the optimum point in the design sequence time at which multiple-use—joint-development projects should be considered.

Develop a comprehensive formula for urban multiple-use—joint-development projects, giving due consideration, where applicable, to cost of design or location change, environmental and aesthetic effects, and socioeconomic benefits.

Conduct and apply nationally.

Aesthetic Considerations of Noise-Abatement Designs

Project Code: 24-128-04-69 Time: 18 months
Priority: A-4 Funds: $100,000

Describe and evaluate the presently known systems and techniques for the abatement of traffic noise in relation to aesthetic impact. Develop aesthetic criteria for noise abatement for highway locations in rural, suburban, and urban conditions. Consideration shall be given to terrain, cross-section configuration, barriers, screens, and thermal deflectors, as well as the aesthetic acceptability of materials used for mechanical sound deflectors or suppressors.

Conduct and apply nationally by major condition variables.

Aesthetics of Highway Hardware

Project Code: 24-100-05-69 Time: 15 months
Priority: A-5 Funds: $100,000

Evaluate the aesthetics of highway hardware. Identify the positive and negative aesthetic elements of existing designs. Recommend improved design solutions for each type of highway hardware, such as delineators, guardrail, lighting, structures, signing (individually), and design solutions or improvements for highway hardwares as it acts (i.e., viewed) in system (collectively).

Conduct and apply regionally by climatic conditions.

RESEARCH NEEDS FOR CATEGORY 2—ROADSIDE SPACE

Ecological Interrelationships Between Highways, Land, and People

Project Code: 24-213-01-69 Time: 24 months
Priority: A-1 Funds: $280,000

Project Statement

Identify and correlate specific ecological factors in terms of their relationships to highway development. Develop value scales to correlate these factors with those traditionally used to determine the location and design of highways.

Needs for Study

Much more information is needed to understand fully the relationships of ecological balance, particularly as highway development affects more and more of the environment, and created imbalances adversely affect these developments as well as nature and man's well-being.

Study Objectives

Unknowns to be solved: 1. What are qualitative and quantitative impacts of highway development on natural ecology? 2. What are similar impacts on existing man-made developments? 3. Can these be correlated with other more easily measured factors such as acquisition costs, construction costs, and maintenance?

Guidelines to be produced: 1. Identification of specific ecological factors on a comparative basis. 2. Scalar value systems for quantitative measurement of above questions.

Benefits Expected from Research

Any positive results of such research would greatly benefit highway organizations and society through improvements in (1) future highway location and design and (2) development of roadside space.

Area of Application

This research should be conducted and applied in regions having similar ecological conditions.

Evaluation of Research on Intangibles and Noneconomic Values Related to Highways

Project Code: 24-213-02-69 Time: 12 months
Priority: A-2 Funds: $80,000

Investigate the successes and failures of on-going and past research attempting to quantify the intangible sociological and psychological aspects of highway use and presence. Also, investigate the similar research on the noneconomic aspects, such as the ecological and environmental values affecting or affected by highways.

Evaluate the research approach and methodologies of such research for productivity and potential utilization of the research product.

Describe continuing research needs, evaluate the feasibility, and recommend solutions to the problems of research in the various areas of this subject.

Conduct and apply in high-density urban conditions.

Scenic Roads and Highways Criteria

Project Code: 24-231-03-69 Time: 18 months
Priority: A-3 Funds: $125,000

Investigate the characteristics of scenic roads, parkways, and recreation highways, and determine and evaluate the types, amount, and impact of recreation travel.

Develop criteria for the selection, acquisition of control rights, development, management, and operation of such highways. Consideration shall be given to new routes, but emphasis shall be on the use of existing routes for these purposes.

Conduct and apply nationally.

Effects of Differing Right-of-Way Widths on the Environment

Project Code: 24-231-04-69 Time: 24 months
Priority: A-4 Funds: $150,000

Investigate and compare the relationships between right-of-way width and the positive and negative environmental impacts of highways in urban, suburban, and rural settings.

Determine the salient factors in selecting the environmentally optimum right-of-way width for the typical conditions existing nationwide.

Describe any exceptions or variances from those considered typical.

Develop criteria and guidelines for the determination of optimum right-of-way width and prepare models to compare the optimum with the traditional right-of-way width on a *total* cost/*total* benefit ratio and short- and long-term basis.

Conduct and apply nationally by similar conditions.

Transportation Submodes in Highway Space

Project Code: 24-213-05-69 Time: 12 months
Priority: A-5 Funds: $100,000

In urban areas the automobile is being increasingly attacked because of space and air pollution aspects.

In light of environmentalists' recommendations for lifestyle changes incorporating the increased use of human power for transportation (walking and bicycles), investigate existing right-of-way cross-sections to determine the problems and possible design solutions to incorporate pathways into existing roads and streets.

Recommend design solutions and additional research to accommodate this possible trend on new or reconstructed motor vehicle traffic facilities. Consider the compatibility factor of the two transportation modes. Design solutions shall also consider the gradual evolutionary aspects of mode transition.

Conduct and apply nationally in urban areas.

RESEARCH NEEDS FOR CATEGORY 3—RESOURCE CONSERVATION

Pleasurable Driving—Measurement and Economic Value

Project Code: 24-312-01-69 Time: 12 months
Priority: A-1 Funds: $125,000

Project Statement

A large percentage of annual total driving mileage is for purposes of pleasure. Reliable measures of the factors that contribute positively to pleasurable driving are needed. This research will determine such factors and assign value scales to them for use in planning, designing, and building highways.

Needs for Study

No criteria are available at this time to guide administrators and designers toward providing pleasurable driving experiences for the traveling public. Definitive studies of what factors contribute most to pleasurable driving and what value is assignable to pleasurable vs nonpleasurable driving are nonexistent.

Research is needed to define the factors that generally contribute to pleasurable driving, and to assign economic values thereto in order to make this factor available on a recognized standard for highway planning.

Study Objectives

Unknowns to be solved: 1. Define the factors that contribute to pleasurable driving experience. 2. Determine economic values to pleasurable driving on a scale from pleasurable to disagreeable.

Guidelines to be produced: 1. Enumeration of pleasure factors. 2. Value scale for pleasant and nonpleasant driving experiences.

Benefits Expected from Research

Research results can be applied nationally to design of new facilities and in all phases of highway work to provide more pleasurable driving experiences for the public. The results will apply to all types of highways.

Area of Application

This research should be conducted and the results applied on a national basis.

Highway and History—Guideline for Highway Administration

Project Code: 24-341-02-69 Time: 12 months
Priority: A-2 Funds: $50,000

Because of the importance of preserving and presenting our national and state history, research needs to be conducted to determine the best procedures to: 1. Use highways and roadsides to present historical facts. 2. Establish coordination between highway departments and historical societies.

Conduct and apply nationally.

Classification and Relative Values of Recreational Uses of Highways

Project Code: 24-312-03-69 Time: 24 months
Priority: A-3 Funds: $150,000

Classify the recreational uses of highways for national application and determine values, including regional differences, by sampling the driving public and their habits. Values shall be derived from sampling the driving public and analyzing the data so obtained. Emphasis shall be on rural highways.

Conduct and apply nationally by the major types of highways and recreational uses.

Highway Roadsides—Multiple-Use Land Management

Project Code: 24-381-04-69 Time: 18 months
Priority: A-4 Funds: $100,000

Study existing multiple-use land management for potential application to highway roadsides. Prepare guidelines for the multiple-use of rural highway rights-of-way. Describe the uses to be considered.

Conduct and apply nationally by major ecological types.

Wildlife Conservation as Related to Highway Development and Maintenance: Its Benefits, and Safety Considerations

Project Code: 24-321-05-69 Time: 36 months
Priority: A-5 Funds: $200,000

Determine methods and practices suitable for incorporation into highway construction and operations for the conservation of wildlife. Define the benefits to wildlife thus achieved, and equate to values suitable for administrative determinations.

Conduct nationally for regional applications by wildlife types and ecological conditions.

RESEARCH NEEDS FOR CATEGORY 4—MOTORIST SERVICES

Characteristics and Design Requirements Data for Safety Rest Areas

Project Code: 24-412-01-69 Time: 18 months
Priority: A-1 Funds: $162,000

Project Statement

Because of the increasingly important role of safety rest areas in highway transportation, research must be conducted to provide quantitative definition to their services, design, and use. The characteristics of existing facilities and rest area use data shall be analyzed and a design guide shall be developed to illustrate and relate the variables of facility needs for the rest area types established.

Needs for Study

Research should establish, for the highway administrator, standard roadside rest area nomenclature and use; for the designer, the basic facilities to be developed and services to be provided.

Study Objectives

Unknowns to be solved: 1. Define motorist safety rest area needs. 2. Determine the use relationships between desirable roadside facilities such as toilets, parking shelters, and picnic and information facilities. 3. Determine the feasibility of providing buffer strips to protect rest areas from undesirable conflicts.

Guidelines to be produced: 1. Develop guidelines for rest area capacity design. This will include, but not be limited to, the consideration of ADT, spacing, climatic zone, peak season, traffic type, quality of rest area site, and route characteristics. 2. Develop guidelines for the design of rest area facilities to accommodate handicapped persons. 3. Develop guidelines for roadside rest area mechanical systems for proper and adequate design.

Benefits Expected from Research

The result of this research will improve the accuracy of highway cost estimating, evaluate right-of-way needs, and assist in more accurate rest area designs for present and future use loads. The loss of construction funds through overdesign can be minimized. More uniform services provided at similar areas will increase use and thus better perform the safety function of rest areas.

Area of Application

This research should be conducted and the results applied on a national basis.

Motorist Information Centers—Needs and Operation

Project Code: 24-481-02-69 Time: 18 months
Priority: A-2 Funds: $100,000

Describe and evaluate the needs and different systems of providing motorist information in rest areas. Prepare recommendations for the operation of information centers, including consideration for motorist's requirements.

Conduct and apply nationally by differing traffic types.

Playground Equipment in Rest Areas

Project Code: 24-481-03-69 Time: 12 months
Priority: A-3 Funds: $70,000

Determine the desirability and prepare guidelines for the rest area playground equipment and other recreational facilities. Consider the safety and liability requirements.

Conduct and apply nationally by rest area type.

Relationships of Public and Commercial Motorist Services

Project Code: 24-480-04-69 Time: 24 months
Priority: A-4 Funds: $100,000

Determine the impact of motorist services provided by highway organizations on those commercial enterprises offering similar services.

Recommend criteria for division of service responsibility.

Conduct and apply nationally by services concerned.

Design Guide for Rest Area Water and Waste Disposal Systems

Project Code: 24-417-05-69 Time: 12 months
Priority: A-5 Funds: $100,000

Prepare design guide for rest area water and waste disposal systems. Include information for different use load levels and site conditions.

Conduct and apply nationally by major types of conditions.

RESEARCH NEEDS FOR CATEGORY 5—EROSION CONTROL

Effects and Remedies of Erosion During Construction

Project Code: 24-518-01-69 Time: 36 months
Priority: A-1 Funds: $350,000

Project Statement

Determine the effects and magnitude of erosion on typical soils left unprotected during construction. Determine and recommend practices or procedures to reduce and/or eliminate such erosion and its detrimental effects.

Needs for Study

Erosion on the disturbed surfaces of highway construction and the dust or siltation from such areas is a major pollution problem in many areas. Information quantifying this problem and describing remedial practices is needed. Soil erosion during highway construction increases costs and causes delay and repairs.

Study Objectives

Unknowns to be solved: 1. What are the problems caused by dust and siltation from highway construction areas? 2. How serious are these problems under the various typical conditions? 3. What means are available to eliminate these problems or ameliorate their impact?

Guidelines to be produced: 1. Prepare a checklist of dominant conditions. 2. Develop a system of evaluating the potential problems prior to construction so that corrective actions may be incorporated into the construction contract.

Benefits Expected from Research

The application of research results would significantly contribute to the reduction of air and water pollution. Stream siltation from highway and other construction sources is causing critical damage to fish and wildlife habitat in many areas.

Area of Application

This research should be conducted and applied nationally in areas typical of the major climatic and pedological conditions.

Erosion Control Systems for Arid Regions

Project Code: 24-517-02-69 Time: 24 months
Priority: A-2 Funds: $150,000

Develop economically feasible and aesthetically satisfactory systems to control erosion in low-rainfall areas. Research shall include consideration of vegetative, structural, and combined systems in the major arid soil types. Conduct and apply in regions having similar weather and soil conditions.

Vegetative Erosion Control Manuals for the Major Climatic Zones of the Territorial U.S.

Project Code: 24-571-03-69 Time: 18 months
Priority: A-3 Funds: $250,000

Delineate regional, climatic, and pedological zones, and synthesize existing knowledge into plant establishment and maintenance manuals for vegetative erosion control in regions having similar conditions. Relate to grading, drainage, and slope conditions.

Conduct nationally and apply regionally by zones determined.

Velocity Control Structures and Methods

Project Code: 24-516-04-69 Time: 36 months
Priority: A-4 Funds: $300,000

Investigate new concepts in drainage velocity control structures and methods using advanced technology and recently developed materials. Determine and describe systems suitable for highway applications.

Conduct and apply nationally.

Evaluation of New Erosion Control Methods and Materials

Project Code: 24-587-05-69 Time: Continuing
Priority: A-5 Funds: As a part of state level non-federal-aid roadside development testing and evaluation program.

Establish and maintain programs in regions having similar conditions to test and evaluate the highway erosion control potential of new or introduced plant material, mulches, and structural systems.

Conduct by states. Plan and apply regionally.

RESEARCH NEEDS FOR CATEGORY 6—PLANTING

Time and Care Requirements for the Establishment of Woody Plants

Project Code: 24-671-01-69 Time: 60 months
Priority: A-1 Funds: $250,000

Project Statement

Determine the establishment periods and cultural requirements for the woody plant material most commonly used in roadside plantings in the major climatic zones or regions.

Needs for Study

Improper and inadequate horticultural care during the establishment period is recognized to be the most dominant reason for functional and aesthetic planting loss and failure to achieve the design purpose.

This study is needed to properly and uniformly delineate plant establishment from "normal" plant maintenance.

Unknowns to be solved: 1. Determine the mean period of time and cultural requirements necessary to establish the major plant types used for highway plantings under the major climatic zones.

Guidelines to be produced: 1. Develop a criterion for determining plant establishment vs plant maintenance. 2. Delineate and describe relevant climatic zones. 3. Evaluate administrative and fiscal problems of plant establishment work and recommend procedures to resolve these problems.

Benefits Expected from Research

The application of research results would define and quantify plant establishment work and delineate plant establishment as a construction process from normal highway vegetation maintenance.

Area of Application

This research should be conducted and applied nationally for each major variable.

Comparison of Functional Plantings' Value to Establishment and Maintenance Costs

Project Code: 24-687-02-69 Time: 18 months
Priority: A-2 Funds: $75,000

Determining the values of functional plantings under varying conditions. Equate these values to planting establishment and maintenance costs.

Conduct and apply nationally.

Obtaining Plant Material for Highway Uses

Project Code: 24-618-03-69 Time: 12 months
Priority: A-3 Funds: $50,000

Survey problems of obtaining desirable seed and other plant materials for highway uses, with emphasis on native types. Describe present activities and recommend procedures to solve the major problems of this area.

Conduct and apply regionally.

Direct Seeding of Woody Vegetation

Project Code: 24-657-04-69 Time: 18 months
Priority: A-4 Funds: $75,000

Review and evaluate past research on direct seeding of woody vegetation and existing plantings of this type to determine their feasibility and desirability. Prepare a manual of successful practices and recommend specific research or other actions needed to facilitate the use of this planting technique.

Conduct and apply nationally by climatic and pedological region.

Evaluation of Roadside Planting Material, Techniques, and Equipment

Project Code: 24-617-05-69 Time: Continuing
Priority: A-5 Funds: Fund as a part of state level non-federal-aid roadside development testing evaluation program.

Establish and maintain programs to test and evaluate new and improved planting techniques, material, and equipment.

Conduct by states. Plan and apply regionally.

RESEARCH NEEDS FOR CATEGORY 7—MAINTENANCE

Achieving Lower Maintenance Costs Through Design

Project Code: 24-718-01-69 Time: 18 months
Priority: A-1 Funds: $100,000

Project Statement

Determine the planning and design characteristics of major roadside elements, and define the areas of design correlation and collaboration between highway landscape architects and engineers that contribute to reducing maintenance requirements.

Needs for Study

This study is needed to assist highway designers, including landscape architects, reduce maintenance requirements and cost through maintenance coordinated design.

Study Objectives

Unknowns to be solved: 1. Identify and rate roadside maintenance functional elements by necessity, difficulty, and cost. 2. Analyze the elements identified for service, including safety and construction vs maintenance costs.

Guidelines to be produced: 1. Prepare design guidelines describing the positive and negative findings of the study. 2. Recommend procedures for design analysis for maintenance coordination.

Benefits Expected from Study

The application of these research results should reduce the roadside development maintenance operations.

Area of Application

Conduct and apply nationally by each element or major function (such as erosion control, rest area operation, vegetation control and management, snow, ice, and litter prevention and/or removal). Consideration shall be given to highway service and aesthetic quality.

Safety Rest Area Maintenance

Project Code: 24-748-02-69 Time: 18 months
Priority: A-2 Funds: $80,000

Determine and compare the maintenance costs for the different types of rest area construction and operations related to quality of service and public acceptance. Prepare comprehensive rest area maintenance manual of tasks, materials, and techniques.

Conduct and apply nationally.

Roadside Maintenance Equipment

Project Code: 24-756-03-69 Time: 12 months
Priority: A-3 Funds: $50,000

Determine and describe the roadside maintenance tasks amenable to mechanization. Evaluate the present uses of roadside maintenance equipment under the varying conditions and controlling factors (e.g., slope, soils, weather, drainage, vegetative cover, obstacles, traffic). Prepare a manual matching task with optimum equipment. Recommend needed equipment modifications or development to overcome deficiencies observed.

Conduct and apply nationally.

Establishment Periods for Roadside Vegetation

Project Code: 24-768-04-69 Time: 24 months
Priority: A-4 Funds: $150,000

Select areas and existing projects representative of major growth condition zones in the U.S. From cost records and other available data, determine the yearly establishment and maintenance levels (task, treatment, and cost) required for commonly used roadside trees, shrubs, and grasses during the first 5 years after planting. Analyze similarities or differences between types and areas. If significant differences are found, define regions and periods with similar establishment characteristics for each type of planting and area.

Compare results with similar data on plantings more than 5 years old, and determine the average time period of establishment for each classification determined.

Conduct and apply regionally.

Maintenance of Multiple-Use Areas

Project Code: 24-786-05-69 Time: 18 months
Priority: A-5 Funds: $75,000

Investigate presently allowed types of multiple use and joint development to determine existing policies and practices regarding: (1) division of maintenance responsibility and cost, and (2) security and perpetuity of care. Special attention shall be given such considerations as architectural style, repairs, and upkeep of structures, vegetation establishment and care, and recreational developments and uses.

Conduct and apply nationally.

RESEARCH NEEDS FOR CATEGORY 8—ORGANIZATION AND ADMINISTRATION

Highway Landscape Architecture—Responsibilities and Functions

Project Code: 24-817-01-69 Time: 18 months
Priority: A-1 Funds: $100,000

Ascertain the benefits that may be derived from collaboration between landscape architects or other roadside development personnel and engineers in mutual decision-making

in each of the successive stages of reconnaissance, planning, route comparison and selection of location, preparation of design plans, specifications, and construction estimates; and the coordination of maintenance with the design intent.

Needs for Study

To effectively administer highway programs looking toward optimum highway development as a part of the total environment, much more information is needed to understand fully the relationships of landscape architects in the working and planning staffs of state highway organizations.

Study Objectives

Unknowns to be solved: 1. What functions and responsibilities can best be served by the landscape architect in collaboration with the various engineers and other members of the highway staff team in the sequence of stages usual to the planning and development of highways? 2. Survey the different ways of staffing the highway department organizations, show the different positions, responsibilities, and capabilities keyed in to the organization structure, and determine which organizational arrangement can be of optimum assistance to the various bureaus in the highway organization.

Guidelines to be produced: Develop criteria to define and explain the relationships of the landscape architect and roadside development as a serving unit to all highway functions in the organization, including a listing of the proper functions of the landscape architect. Catalog in the various departments what contribution the landscape man or team can make to design, right-of-way, bridge, etc., and to public relations.

Benefits Expected from Research

Positive results of such research would greatly benefit highway organizations and highway transportation through improved disciplinary collaboration and the development and use of more complete planning and design information.

Area of Application

This research should be conducted and applied nationally in each highway organization.

Landscape Architecture's Contribution to Conceptual Design Teams

Project Code: 24-812-02-69 Time: 6 months
Priority: A-2 Funds: $50,000

Determine the optimum role of the landscape architect on interdisciplinary, conceptual design teams. Define this role in terms of the landscape architect's prime responsibilities and contributions within the work phases and the decision-making process. Relate planning aspects such as multiple use, aesthetics, socioeconomics, and environmental factors.

Conduct and apply nationally.

Rest Area Staffing Requirements

Project Code: 24-847-03-69 Time: 18 months
Priority: A-3 Funds: $75,000

Determine the factors affecting rest area staffing needs such as, but not limited to, ADT, remoteness, use, size, age, services and facilities provided, area and type of landscaping, history of vandalism, climate, and season.

Develop a system to determine and project rest area staffing needs in both man-hours and time-of-day coverage.

Conduct and apply nationally.

Vandalism by Highway Users

Project Code: 24-817-05-69 Time: 12 months
Priority: A-4 Funds: $50,000

Investigate and evaluate existing laws, enforcement practices, administrative policies, and design or maintenance innovations for their effectiveness in combatting highway vandalism.

Special consideration shall be given to: 1. Destruction or defacement of rest area facilities or other highway structures. 2. Mutilation of plant material, including lawns. 3. Defacement of rocks and other natural roadside features. Describe presently successful actions being taken to reduce the incidence and effect of vandalism. Recommend research needed to develop new systems and techniques for vandalism control, including the identification and apprehension of the vandal.

Conduct and apply nationally.

Estimating Design Time and Construction Costs for Roadside Development Staffing and Programming

Project Code: 24-800-05-69 Time: 12 months
Priority: A-5 Funds: $50,000

Analyze recent roadside development projects for construction costs, considering work and material items, service units, area and/or mileage covered. Determine high, low, and average construction cost and design time for the different items classified by the major conditions found nationwide.

Relate design time to construction costs and prepare design and construction tables for roadside development staffing and programming purposes (not project estimating).

The guidelines shall define the differing conditions and include a rationale describing the relationships between the dominant conditions and the cost variables.

Conduct and apply nationally.

CHAPTER FOUR

RECOMMENDATIONS

To be of value, the results of a research project must be implemented and used. The following are the specific recommendations from this study to accomplish this objective.

Three apparent opportunities exist for implementation. There also are several possibilities for use of this research product by highway administrators, operational personnel, roadside development practitioners, research planners, researchers, and academicians.

Even though these recommendations are addressed specifically to roadside development as one facet of highway business, several portions may be equally relevant to other facets, and it is expected that similar studies in those other areas would produce similar recommendations.

IMPLEMENTATION

To implement the results of this study it is recommended that:

1. The roadside development research needs identified and described be used as the basis for an expanded and continuing program of accomplishing research to fill these needs.
2. Applicable portions of these recommendations be used as the basis for the preparation of a *Roadside Development Research Policy or Procedure Guide* for adoption by AASHO.
3. The literature identified and classified by this study be used as a roadside development data bank, and that inputs be made to keep it up to date.

To fill the needs of roadside development for new or more usable information, and improved materials and procedures, there must be:

1. A sponsored program.
2. A full-time professional specifically designated to recommend or initiate actions and be responsible for the administrative communications to meet the planning, coordination, implementation, and use requirements.
3. A system of research planning and coordination in the administrative structure of roadside development as a part of total highway administration.
4. A system of research implementation and use in the same structures.

MEETING RESEARCH NEEDS THROUGH EXISTING PROGRAMS AND SPONSORS

It must be stated that highway research was shown to be grossly under-funded * (0.25 percent of the total expenditures for highway construction and maintenance). Roadside development research receives approximately 0.006 of 1 percent of the total highway expenditures.

This study has shown, identified, and quantified the roadside development research effort needs. The following actions are recommended to provide this effort.

There are several ways this may be accomplished with available highway revenues. One is to increase the existing share of highway funds allocated to research at all levels and thus increase the resources available for roadside development share of the present funds being allocated for all highway research.

Because of roadside development's unique broad involvement in other areas of highway transportation, desirable opportunity exists for collaborative research between roadside development and most other areas. Many of the research needs of roadside development can be filled by including its concerns and objectives in the research of other areas.

Conversely, their needs, concerns, and objectives should be included in those research efforts initiated by roadside development. This can be accomplished only by a review of each other's proposed research projects and the appropriate communications (such as cross-area representation on NCHRP advisory panels).

For roadside development research, it is recommended that these approaches be used. Because of the tremendous value and importance of highway planning (which takes 70 percent of the 1½ percent funds on a national average, and more than 90 percent because of mandatory requirements in some states with low revenues) it is not possible or desirable to reduce the amount of funds available for planning.

It is therefore recommended that for highway technology to remain competitive, Congress be requested to increase the percentage of HPR funds from 1½ percent to 2 percent, with the additional 0.5 percent specifically designated for research. This total of slightly less than 1 percent compares more favorably to the national research ratio average of 3 percent.*

To provide a reasonable share of the existing highway research funds for roadside development research and development, the following listing of suggested sponsorship levels for the major potential sponsors within the highway establishment is proposed.

National Level Programs

National Cooperative Highway Research Program (NCHRP)

According to the *NCHRP Summary of Progress through June 30, 1968,* there are 144 completed or on-going studies

* *NCHRP Report 55.*

* *NCHRP Report 55.*

in 20 subject areas. They range from 19 projects in Area 3, Operations and Control, to one each in Areas 13, 14, 17, 18, and 19, covering maintenance, materials, safety, and finance. This report is the second study in the roadside development area. There appears to be a great imbalance of research attention within areas, or an imbalance of areas.

The budgeted or final expenditures for NCHRP studies reported for fiscal years 1963 through 1969 totaled $13,517,223. Roadside development received $300,000, or 2.22 percent of the funds. It is recommended that this share be raised to at least 3 percent (the average ratio of roadside development in the HPR program). Based on the 1970 NCHRP program ($370,000), this would provide $81,000 yearly. This would be enough to provide for a two-project level in the NCHRP program (based on the average cost of past HPR roadside development studies). Considering the backlog of needs identified by this study, and the estimated costs of the top-priority studies, this will not be adequate. It is therefore suggested that a 4-year funding level of $150,000 per year be adopted. After this catch-up period, the program level could drop back to the 3 percent level as total research funds are increased and as the research needs of the other areas become identified and articulated.

BPR Staff or Administrative Studies

To provide flexibility and depth to national-level roadside development research, it is recommended that one new study, of limited duration, be sponsored each year by the BPR administrative research program. This non-state-aid program corresponds to the non-federal-aid projects at the local state level. The characteristics of the type of projects adopted for this program would be unique to federal highway requirements as the state non-federal-aid studies would tend to be unique to local requirements. As a functional and operational unit of the highway establishment, roadside development must participate in both research programs.

It is suggested that the funding level of sponsorship be as necessary to complete investigation on one research need subject per year ($30,000 to $100,000).

Regional Level Programs

Because the roadside development area research needs appear to lend themselves most readily to regional solutions and application, and because regionalization of research effort is more efficient, it is recommended that a strong, active, well-sponsored system of regional roadside development research be established and continued.

There are two major potential sponsors of this research: (1) Highway Planning and Research Group (Pool Fund) Studies, and (2) Highway Planning and Research-State (Pool Projects) Studies.

HPR Group Studies (Pool Fund)

To accommodate the existing highway and roadside development administrative structure and to provide coordinated research planning and implementation activities, it is recommended that the existing AASHO administrative and geographical structure be used as a base for regionalized research.

Using HPR Pool Funds, each AASHO region would establish and sustain a roadside research project. These projects might vary from $10,000 to $50,000 per project, but should have an average funding level of slightly more than $35,000 each, for a total of $150,000 for all four regions per year.

HPR-State Studies (Pool Projects)

Because expenditure of state highway revenues outside a state is sometimes precluded by law, it is recommended that the existing program of HPR-state roadside development studies be planned and coordinated on a regional "pool projects" basis, and that these studies be expanded to include one study in each state. Each state would contribute one project to its regional pool, funded by a minimum amount of 3 percent of that portion of its 1½ percent research funds used for research, or $30,000, whichever is greater.

State-Level Programs

Because of unique local conditions of a state, and because of the necessity and importance of transitioning research results from the research data product to its evaluation through applied research, it is recommended that each state initiate and sustain a continuing state-sponsored program to accomplish these objectives. This program could be funded in an amount equal to the state's matching portion for roadside development HPR-state studies, or $15,000 per year, whichever is greater. Adjustments may be necessary for some states with unusually low or high total highway revenues and expenditures.

Sponsors Other Than Highway

A tremendously large, varied, and potentially productive source of research effort relevant to roadside development and highways exists in several diversified, nonhighway-funded areas; e.g., the research efforts of other governmental agencies, private foundations, professional societies, business associations, and industry. This potential effort exists for all types (basic developmental, applied, and synthesis) and levels (national, regional, and local) of research.

For roadside development to avail itself of this potential, all that is necessary is to bring its research needs to the attention of these potential sponsors and to harvest their relevant research product.

Any effective action taken to achieve the benefit of this tremendous research potential will have to be initiated by the highway establishment. Because this is best represented by AASHO, it is recommended that the AASHO Committee on Roadside Development sponsor one continuing project to:

1. Provide the necessary identification of need and matching with the sponsor, in the research accomplishment phase.
2. Gather this research product.
3. Promote and coordinate the transition of the non-

highway-sponsored research product to a form suited for roadside development and general highway use in the research "harvest" phase.

It is suggested that the funding level for this project be as considered desirable by the AASHO Committee on Roadside Development, and as feasible by the appropriate AASHO administrative officials. This activity could be combined with other AASHO and/or HRB roadside development staff function needs.

On a trial basis, this service could be provided for as little as $15,000 per year. Adjustments could be made as the productivity and potential of this activity is assessed. However, it would take at least two to three years to establish the necessary communications to reach full effectiveness. It is expected that more than $500,000 worth of relevant research could be harvested annually by initiating this activity.

RECOMMENDED MODIFICATIONS TO RESEARCH SYSTEM

Because (as indicated by *NCHRP Report 55* and corroborated by this study) the lack of coordinated or unified planning is the greatest limiting factor precluding adequate and proper roadside development research, and because there is no designated (or effective de facto) national initiator of specific roadside development research activities, it is recommended that a committee known as the AASHO—HRB Joint Committee on Roadside Development Research, or the Research Subcommittee of the AASHO Operating Committee on Roadside Development, be formed for this purpose and empowered to perform those functions necessary to provide such planning and initiative.

Because this committee must represent the prime interests involved, and operate within the existing administrative structures of roadside development, highways, and the research establishment, it is recommended that the proposed committee be composed of: The Chairman of the AASHO Operating Committee on Roadside Development (who would serve as chairman) and a representative from each of the four AASHO regions (these representatives also should serve as chairmen of the AASHO roadside development research committee created for each region). The BPR regional landscape architects should serve as members of the regional committees, as should the Chairman of the HRB Committee on Roadside Development (who would serve as Vice-Chairman); four of his committee's members (preferably, he would designate one from each geographical area corresponding to the AASHO regions); and the BPR landscape division chief, who might also serve as secretary to the research subcommittee.

Because present and increasing information needs of roadside development functions greatly exceed research efforts for their solution, and these needs and the opportunities for research occur at state, regional, and national levels, it is recommended that the proposed committee be empowered to prepare, adopt, and maintain research plans and make recommendations for national-level programs, and that this committee furnish planning and coordination assistance to the regional and state programs.

As in industry, roadside development research should be a "wholistic" process of complete continuity from the need or idea to the user or consumer.

Similarly, to produce a product, or, more importantly, a usable product, actions must be taken by those involved at every phase, from the research need identification to the research product use. The 11 phases generally involved are discussed in the next sections.

Proposed System for Research Planning and Coordination

It is recommended that roadside development research be initiated, planned, and coordinated as follows, by the persons indicated.

Phase 1: Identification and Nomination of Research Need or Idea

1. Because research needs tend to be topical and transitory, it is recommended that those needs identified and described herein be used as the beginning stockpile of current roadside development research ideas.
2. The operating practitioner of roadside development is most aware of his information requirements. They are organized in the AASHO membership, which contains both state and federal representation on a national basis. As defined by the AASHO organizational structure, the Operating Committee on Roadside Development has been designated and made responsible as the prime nominators of needed research effort for their subject area.
3. Because this must be a continuing process, it is recommended that AASHO committee members be polled annually for their nominations of current research needs.

The nation's state and federal highway administrative officers will provide and interpret the current national highway transportation research goals to roadside development practitioners through the AASHO Operating Committee on Roadside Development. In turn, roadside development practitioners will study and transition these goals to specific roadside development research to meet the goals.

Directly, or through the proposed research subcommittee of the regional AASHO committees on roadside development, the practitioners will forward these needs to the Research Subcommittee of the national AASHO Operating Committee on Roadside Development.

The subcommittee will review, evaluate, and accept or reject these research needs as nominations for future research program efforts.

Phase 2: Articulation and Existing Data Identification

1. A research need or idea must be carefully defined in a form meaningful to the researcher in terms of project depth, subject area, parameters, and objectives, and must include background information on its costs and expected benefits for administrative considerations; therefore, it is recommended that each expressed need be articulated into finished project statements.
2. Because the HRB Committee on Roadside Development is composed of both practitioners and researchers,

and because the articulation usually must bridge the communication difficulties between operational and research approaches, it is recommended that the HRB committee be designated and made responsible for this activity in the first stage.

The subcommittee will annually survey the prominent potential nominators, collect the nominated needs, and refer them to the HRB. With the assistance of the Roadside Development Committee and the NCHRP staff, the HRB will articulate the research needs to project statements. With HRIS assistance, they would be placed in the computers for future retrieval. All highway research needs should be together in a common format at this point. Because almost all of the past roadside development literature has now been identified as to subject content, it would be relatively simple with the proposed data bank to provide a complete bibliography on the proposed research project at that time. Other highway areas could get and review the existing HRIS abstract printouts to determine if the information was already available, or which aspects of it were missing. The research planners would then be guided in the structuring of the project statement and would determine the research type. If enough knowledge existed, only synthesis research might be needed. The articulation would include the cross-referencing to other highway areas and would provide the research time and cost estimate.

Roadside development staff assistance may be needed by the HRB at the articulation and data identification phase.

Phase 3: Research Planning and Coordination

From the HRIS stockpile of project statements the AASHO roadside development subcommittee would determine priorities, research type, area of application, or optimum program level, and the proper or best potential sponsor.

Research planning and coordination should occur at all three program levels independently (national, regional, and state). Also, overview-type planning should occur, combining all levels and programs.

The research program should have a proper balance of basic, developmental, applied, and synthesis projects. Roadside development research presently suffers from a disproportionate share of applied research and a lack of basic and synthesis-type work.

Consideration should be given to the establishment and recognition of "academic centers of excellence" to accomplish the research in a specific disciplinary field. These may be established on one geographical location, or artificially by coordination and communication. Plant science studies lend themselves best to this approach; other subject areas of roadside development lend themselves more readily to a multi-disciplinary approach.

Artificial regions (nongeographic) should be used as with "academic centers of excellence" for research projects lending themselves most readily to regionalization on the basis of traffic volumes, population, densities, etc. Of the roadside development literature evaluated, 57 percent had national application; 34 percent, regional application; and only 9 percent, state or local application. It is not recommended that research in or by the states be reduced. It is recommended that, through planning and coordination on national and regional levels, the states help each other accomplish much of their needed research by exchanging and pooling projects, not state dollars. There will also be some projects that can best be accomplished by nonstate participating HPR "pool fund" studies. These usually would be urgent "perishable-opportunity" studies.

In establishing priorities it is well to consider the needs for, and benefits expected from, the particular research, the urgency of the need, the perishability of the utilization opportunity, and the probabilities of a successful and productive research effort. To this the research planner must add his own subjective judgment as to the relative priority rating.

In addition, the planner must balance the research program to equitably fill the needs at each program level and area of application. The planner should give equal attention to the subject area categories of roadside development.

Even though the project statement should be well articulated for the guidance of the researcher, it is beneficial to begin investigations on a new subject, or in a state with no previous roadside development research experience, with a study having the project statement written to allow the researcher to better define the problem or opportunities for productive future investigation. Each study area will require a separate determination of these factors.

Phase 4: Project Referrals to Sponsors

Lists of projects with the preceding information would be referred directly to national sponsors by the chairman of the AASHO roadside development subcommittee, in his capacity as the chairman of the full AASHO Operating Committee on Roadside Development. Approval of the program by the full committee would be time-consuming and unnecessary.

Projects best suited for regional research would be referred to the appropriate regional AASHO roadside development research subcommittees for planning within the regions. The regional subcommittees would refer selected projects to their respective states and the BPR for sponsorship.

State projects would be referred directly to the state AASHO roadside development representative. The national AASHO research subcommittee's principal functions with regard to state-level planning and coordination would be to provide assistance in the data search, articulation of the project statements, and coordination between the states, regions, and national research efforts and products. The state AASHO roadside development representative, as a member of his state's regional committee, together with his state's highway research administration engineer, would plan his state program with the information supplied by the national subcommittee.

It is important that there be an exchange of research needs and efforts with other highway operations and functions at this level, as previously described for the national level.

HPR state studies should be regionalized as "pool project" studies. The state highway research committee must

be apprised of the background information leading to their selection as sponsors of specific projects in this program by the state's member of the regional research subcommittee; i.e., the full AASHO Committee on Roadside Development.

Phase 5: Acceptance by Sponsor

As projects are accepted for sponsorship, the sponsors will make the desired revisions to the project statement and will notify the national AASHO subcommittee chairman or staff. Those projects will become part of and constitute the annual research program.

Phase 6: Assignment of Project to Researcher

Each sponsor will independently assign the accepted project to the researcher he selects, whether by contract or in-house. At the sponsor's request, the AASHO subcommittee will provide a list of the available expertise in the research subject area or category.

Phase 7: Project Initiation and Accomplishment by Researcher

The researcher will execute the project work. Copies of his progress reports should be forwarded to the AASHO roadside development research subcommittee for review of results, problems, and other needs or ideas (similar to the NCHRP progress report procedure).

Proposed System for Research Implementation and Use

Phase 8: Interpretation of Results

The sponsor should forward copies of their research reports to the AASHO research subcommittee, who will interpret these results and report on the possible applications contained in report. They will also outline a program of evaluation, testing, or demonstration, and communications that will lead to effective implementation and use of the results.

Phase 9: Dissemination to Highway Management or Potential Users

Simultaneously with the actions of Phase 8, to expedite the use of the research results by those concerned, the subcommittee chairman shall advise the sponsor of the number of copies and the individuals in highway organizations who might use the research product. He will arrange for distribution to them by the sponsor, the subcommittee, or others.

Phase 10: Evaluation (Market Testing) of Research Product

The Chairman of the AASHO Committee on Roadside Development or other AASHO operating committee chairmen affected by or concerned with the research report contents (research product) will appoint one or more of his members as the research product evaluation committee for each major element of the research product.

These committee members should be selected with regard to their individual interest in the subject and the geographic locations having the conditions best suited for the evaluation work. Eventually, in many instances, this activity might comprise the bulk of the state non-federal-aid research program.

In most cases the evaluation will consist only of an analysis of the research report findings and recommendations, and the preparation of evaluation and implementation reports. As they become available, both the evaluation recommendations report and the evaluation and implementation report should be appended to and become a part of the full research report.

Phase 11: Implementation and Use of Research Product

On receipt of the evaluation and implementation report, the AASHO operational committee chairman will present it to his full committee; each committeeman will transmit it for use, together with his comments, to the appropriate individuals in highway management and/or operations in his state.

A high degree of cooperation and reliance on the evaluator's judgment will be necessary for full implementation and use of the research results. Therefore, careful attention must be given in the selection of the evaluators.

Regarding someone specifically designated to initiate actions and be responsible for the operation of the foregoing procedures, it is noted that these procedures are detailed and time consuming, and entail considerable effort by many individuals at a number of points. The AASHO committee system is considered to be a perfect operational framework. It appears, however, that historically (perhaps to maintain the member state dues contribution at a low level) it has relied on staff work by the members to sustain its operational activities. In some areas and at different times this has worked satisfactorily. However, highways and highway research is a multibillion-dollar business, and more positive, sustained communications and procedures within this business must be achieved.

Highway research scholars frequently refer to the "missing link." He is described as a disciplinary generalist who can channel and coordinate all highway research effort. The existence of such a person is doubted. It is proposed that the "missing link" is, rather, any of those research functions in the previously listed sequence of research events, from idea or need identification to implementation and use of the research product.

It is suggested that, insofar as the research effort is concerned (particularly roadside development research), there are too many functions that must be activated, sustained, coordinated, and expedited for the practitioner, who is deeply involved and concerned with his normal duties, to consistently initiate and provide the required actions. To make the proposed systems work, roadside development staff assistance must be provided the AASHO Committee on Roadside Development. For research matters it may even be desirable that this assistance be by, or from, the same person or persons, shared and sponsored by all agencies concerned. The duties could, and perhaps should, be combined at first with those activities to harvest

the roadside development aspects of the relevant nonhighway research effort.

Research Policy or Procedure Guide

To quickly begin to fill the research needs of roadside development, it is recommended that the first action (after the described research needs are forwarded to all potential highway sponsors) be that the AASHO Operating Committee on Roadside Development review and evaluate these recommendations and then adopt an interim procedure guide.

Then, in the normal manner, but as expeditiously as possible, it should prepare and publish a permanent guide for the purposes defined herein. These recommendations could be used as the outline or base document for the guide preparation.

Data Bank

Almost 2,000 documents (including research papers, technical reports, books, and articles) on some aspect of roadside development have been identified, described, and listed by this study. Those documents represent the bulk of existing knowledge on the subject. There are a few significant nonhighway sources that remain to be surveyed for additional information. Document search and input was ended in 1968.

It is recommended that this listing and all new and missing documents be placed in the BPR library and that there be a continuing review, classification, and evaluation of them. This task might best be performed by the HRB Committee on Roadside Development or an HRB staff member knowledgeable in the area.

It is recommended that greater diligence be used to ensure that all relevant new documents are being placed in the HRIS computer system. Eventually the computers should be used as a bibliographical listing repository and retrieval system for all roadside development documents, regardless of age. The practice of removing documents from the present system is considered undesirable because many old documents contain basic principles that are perpetually valid. Also, they are the source of previously accomplished research work and contain descriptions of problem approaches that stimulate research ideas.

It is recommended that through the BPR library system the outstanding or landmark documents of roadside development (especially those in short supply or out of print) be placed in the Federal Clearinghouse so that practitioners, researchers, and others can obtain copies of the full document.

The objective of these actions would be to provide a system whereby the HRIS computers would be used to identify and locate documents on a specific subject or subcategory area, the BPR library would serve as the collector and repository of the original documents, and the Federal Clearinghouse would duplicate and make copies of the documents available on request to fill the needs. The state highway libraries could play a major role in reducing the number of reproductions necessary through the Clearinghouse by maintaining active and complete libraries with cross-indexing to the HRIS, the BPR, and the Federal Clearinghouse.

UTILIZATION RECOMMENDATIONS

The use of the research product of this study should be of value and assistance to highway administrators, highway and roadside development researchers and research planners, roadside development practitioners, and academicians.

The highway administrator can obtain information on the structure, scope, and staffing of roadside development and on the present state of knowledge, information voids, and operational objectives and problems.

The highway research planner will find the roadside development research program needs, procedures to fill these needs, and their relationships to the total highway research program. This research delineation of one highway area may be of assistance in planning other definitive research projects to delineate other highway areas and to relate "area concerns" through research. Several "missing links" of highway research were recognized, and recommended solutions were offered.

The roadside development research planner should be assisted by all the data and procedures contained herein, with his own interpretations or modifications, to create and sustain an aggressive, organized, and coordinated research program.

The roadside development practitioner should measure his activities and contributions against all these described in the "Category Evaluations" and scope of roadside development. He should study the needs for any solutions he may supply, as well as for problems needing research.

The academician should study the research needs so that he can offer solutions. Other delineations and definitions of roadside development areas should be used as class reference material and to guide potential roadside development professionals' interest into these important endeavors.

The researcher will find many suggestions and guides to help him improve and relate his research product and to help him spend his efforts more productively.

OTHER RECOMMENDATIONS

For better communication of research results, it is basic that the research report be addressed to the anticipated reader audience. Therefore, it is recommended that future research be reported in four forms, or components, as follows:

1. The *Technical Report* for other researchers.
2. The *Extension Report* or *Guidelines* for the practicing roadside development professional.
3. The *Information Summation Report* for the highway administrator.
4. The *Implementation Report* or *Operational Manual,* with visual aids and guides, for the designers or field operators.

The first three forms correspond to the NCHRP style and organization of interim and final reports.

The fourth form of report—the *Implementation Report* or *Operation Manual*—is lacking. If the researcher has sufficient operational highway experience, or can collaborate with someone who does, he could provide this report form. In the previously described system of research implementation and use, the AASHO evaluation committee would accomplish this, to a lesser degree, through the evaluation and implementation report.

In addition to conducting formal research projects, universities should encourage and guide class and staff projects on roadside development subjects, preparation of synthesis research reports, transitioning research reports to operation informational guides (journalism classes). They should also encourage the inclusion of appropriate subjects and applications in the curriculum of major roadside development disciplines, including engineering, to produce more knowledgeable roadside development professionals and researchers.

The 1968 AASHO reference book of member department personnel and committees contains a directory of college or university engineering departments that receive copies of all AASHO technical publications, which are used for reference material in their curricula. It is recommended that a similar list of the departments of the various disciplines of roadside development be prepared and maintained; that they be provided information on such existing and new publications; and that they be sent copies on request. Similarly, roadside development publications should be made available to the engineering departments that are training the future highway administrators using roadside development.

To obtain the greatest benefits of highway and roadside development research there must be informed, viable, active research organizations at the state level. Therefore, it is recommended that the activities of state research administration organizations and research evaluation committees or advisory councils be established, encouraged, or expanded.

These activities could encompass attention to the document library and retrieval system development and utilization; in-house research news digest preparation and distribution; publication and dissemination of in-house research and development activities and findings; state research needs identification, planning and project administration; appropriate investigations, reports, and recommendations to the chief administrators; and informing all staff personnel of the value and use of HRIS, HRIP, and other research aids. The state roadside development staff should establish and maintain a close relationship of participation with and contribution to this research organization.

State libraries should be developed and used to the fullest degree. The latest systems of document indexing, classification, and retrieval should be studied to determine the system best suited for a particular state's needs.

The roadside development staff should contribute to the development of the system and classification of the input. A subscription to HRIS should be maintained by the HRB Committee on Roadside Development, and the research information obtained from that and other sources should be summarized in a newsletter and distributed regularly to all state roadside development staffs and the BPR. This function could be combined with the existing clearinghouse activity of the HRB committee.

To lessen the need for research of the "educational and demonstration" type, it is recommended that states without full staffs of professionals in the major disciplines of roadside development immediately fill the positions with high-caliber professionals where deficiencies exist, and organize these personnel into coordinated, functioning units with responsibility and authority to accomplish all phases of roadside development work.

APPENDIX A

LITERATURE EVALUATION

CATEGORY ESTABLISHMENT AND USE

In the creation of a categorization system for roadside development, a system devised in 1950 by the HRB was used as a base. Categories were added, deleted, and combined in an attempt to provide a systematic approach within which the scope and literature of roadside development could be classified conveniently and explicitly.

Those areas that were good and basic were incorporated into the system and stand as a reaffirmation of their basic principles.

An operational system of categorization (e.g., planning, programming, design, construction, and maintenance) was considered. Also considered was categorization by subject and function (e.g., planting, rest areas, and erosion control). Systems based on objectives such as safety, aesthetics, and economic savings, and even a structural system (e.g., roadway, shoulder pavement, structures, and slopes)

were considered. The consensus of the researchers was to tailor the basic compartmentalization of categories strictly from the point of view of roadside development. The result was the decision to use a combination of operational and subject matter category system. The different components of categorization can be related to the operational aspects of the highway organization, as needed.

It was recognized that the categorization system should be open-ended so that more explanatory or additional categories could be added as additional information was developed. The original categories, promulgated in 1950, have stood the test of time very well.

In the consideration of the categories, it was determined that specialized techniques or disciplines (e.g., agronomy, horticulture, landscape architecture, city planning) were restrictive and inappropriate.

Safety was excluded as a first-level category, because it is an objective, not a function. In organizing the categories, it was the consensus that safety should not be a separate category any more than should aesthetics, utility, economy, or propriety, because all these are objectives that are an integral part of roadside development. Those bibliographies wherein safety is a separate category are taking it out of context with other basic elements or subdivisions of roadside development. An example of this might be in the planting of multi-floral roses as crash barriers. These documents would not be classified under safety, but under design, for functional planting.

The word "roadside" is implied to precede all eight categories. Roadside is not stated, because this report is limited to those areas within the scope of roadside development.

Descriptions of category content of the eight categories appear in the Summary of this report. In addition there is a Category 9—Appendix. This contains items not included in the scope of this study, such as documents on legal subjects involving roadside development, the recorded history of the roadside development profession or outstanding practitioners, and any other relevant papers on miscellaneous subjects not specifically identifiable with another category.

Subcategories were established within each category for further identifying the species of the document content (see Fig. A-1).

CHRONOLOGICAL ANALYSIS

Literature reviewed and listed was plotted chronologically by year to determine the activity within the field, to demonstrate future needs, and for comparison of the trends of various subareas (Fig. A-2).

The first publication located by this study was written in 1891 by Lewis C. Haupt, and was prophetically entitled "Roadside Development, 'A Move for Better Roads.'"

Subsequent interest and activity were sporadic until the late 1920's and early 1930's, after which they began a steady increase, probably paralleling the highway construction programs. It was noted that no voids occurred during the years of World War II. There was only a slight leveling off of the mean during that period. A small rise is noted in the late 1940's and early 1950's. From a low point in 1954, interest doubled in two years and was still rising in 1967. The literature shown in 1968 was for only a partial year up to the data acquisition cut-off date. A projection of the increase of the three complete years, disregarding the information available but not obtained from the Soil Conservation Service, indicates that more than 200 relevant documents containing usable information have not been listed, evaluated, or classified as to subject content from the researchers' prime sources, as of January 1969. As indicated by total roadside development literature volume, activity is increasing at a fantastic rate. Inherent in this activity are questions and problems requiring solutions, answers, and guides that can be expressed as research needs to a proportionate degree.

Analysis of activity within roadside development subject categories shows a few significant trends.

In Category 1, Highway Location and Design, which has the preponderance of published literature, activity increased at a rate parallel to the total of all categories for roadside development. There was a slight decrease in 1967.

In Category 2, Roadside Space, activity rose more dramatically in 1957 and has been erratic in its increase to a relatively high present level. It has the third highest volume of published information.

Category 3, Resource Conservation, had practically no activity until 1963, then rose abruptly and is still increasing. This is considered indicative of an increased awareness and demand for the highway establishment's consideration of resource values.

In Category 4, Motorist Services, literature was almost nonexistent until the 1960's and declined in 1967 from its peak in 1965. This was surprising, because rest areas, a major component of motorist services, is one of the major historic activities of roadside development. No explanation can be given for this trend. (Refer to Appendix B for possible implications.)

In Category 5, Erosion Control, activity rose abruptly in 1960-1961 and has remained at a fairly constant level. There appears to have been a catch-up effort after the completion of Interstate mileage construction.

Category 6, Planting, which also contains plant establishment for erosion control, has the second largest category of published information. It has varied somewhat from year to year, but generally follows the average of total activity. Interest and activity are still increasing.

In Category 7, Maintenance, literature has shown the most consistent interest and increase of all categories, and has reached a plateau after a nearly 100 percent increase in 1965.

Category 8, Organization and Administration, was of second highest interest (after Highway Location and Design) until 1956, when it was exceeded by Roadside Space, Planting, and Maintenance. Organization and Administration, Highway Location and Design, and Motorist Services are the only three categories showing a decline from the 1965 peak. This may be significant when compared with the field interview results.

1. HIGHWAY LOCATION AND DESIGN (1 000)
   1. Preliminary Planning (1 100)
      1. Reconnaissance of Area (1 110)
         1. Aerial Surveys (1 111)
         2. Topography and Contour (1 112)
         3. Geology and Soils (1 113)
      2. Ecology and Environment (1 120)
         1. Natural Landscape Features (1 121)
         2. Watersheds and Drainage (1 122)
         3. Soils and Vegetation (1 123)
      3. Aesthetic Considerations (1 130)
         1. View FROM the highway (1 131)
         2. View OF the highway (1 132)
      4. Land-Use Amenities (1 140)
         1. Recreational Uses (1 141)
         2. Cultural Uses (1 142)
      5. Land-Use Controls (1 150)
         1. Scenic Protections (1 151)
         2. Other Controls (1 152)
      6. Community Relationships (1 160)
         1. Existing Land Uses (1 161)
         2. Present Zoning (1 162)
         3. Impact Studies (1 163)
         4. Planning (1 164)
         5. Potential Land Uses (1 165)
      7. Geometrics and Alignment (1 170)
         1. Design Team (1 171)
         2. Graphic Techniques (1 172)
         3. Development Concept (1 173)
   2. Location (1 200)
      1. Determining Route (1 210)
         1. Surveys (1 211)
         2. Feasibility Studies (1 212)
         3. Qualitative Analysis (1 213)
      2. Aesthetic Land Use (1 220)
         1. Fitting to Landscape (1 221)
         2. Geometric Aspects (1 222)
         3. Structures (1 223)
   3. Design (Visual/Functional Aspects) (1 300)
      1. Alignment and Profile (1 310)
         1. Conservation of Features (1 311)
         2. Potential Sites (1 312)
         3. Cross-Section Development (1 313)
      2. The Right-of-Way (1 320)
         1. Contour Grading (1 321)
         2. Drainage and Erosion Control (1 322)
         3. Median Areas (1 323)
         4. Marginal-Land Use (1 324)
         5. Joint Development (open space) (1 325)
      3. Construction (Landscape) (1 330)
         1. Specifications (Contract) (1 331)
         2. Land Use (Borrow Pits) (1 332)
         3. Material Salvage (1 333)
         4. Planting Considerations (1 334)
      4. Structures (1 340)
         1. Aesthetic Considerations (1 341)
         2. Overpasses and Bridges (1 342)
         3. Separations and Interchanges (1 343)
         4. Barriers and Walls (1 344)
         5. Incidental Structures (1 345)
         6. Sign Supports (1 346)
         7. Light Standards (1 347)
         8. Pedestrian Safety (1 348)
      5. Planting Design (1 350)
         1. Urban Areas (1 351)
         2. Erosion Control (1 352)
         3. Traffic Functions (1 353)
         4. Screening (sight-sound) (1 354)
         5. Snowdrift Control (1 355)
         6. Other Functions (1 356)
      6. Special Areas (1 360)
         1. Safety Rest Areas (1 361)
         2. Overlooks and Turnouts (1 362)
         3. Picnic Areas (1 363)
         4. Paths and Trails (1 364)
         5. Historic Sites (1 365)
         6. Memorial Sites (1 366)
         7. Scenic Strips (1 367)

2. ROADSIDE SPACE

   1. Roadside Space within the Right-of-Way (2 100)
      1. Right-of-Way and Roadside Development (2 110)
      2. Integral Roadside Development (2 120)
      3. Safety Design (2 130)
      4. Multiple Use of Right-of-Way Space (2 140)
      5. Car Abandonment (2 150)
   2. Roadside Space Outside the Right-of-Way (2 200)
      1. Environmental Planning (2 210)
      2. Roadside Control (2 220)
         1. Zoning and Easements (2 221)
         2. Junkyards and Outdoor Advertising (2 222)
      3. Roadside Socio-economics (2 230)

3. RESOURCE CONSERVATION

   1. Natural Resources (3 100)
      1. Soil (3 110)
         1. Erosion Control, Design for (3 111)
         2. Erosion Control, remedial measures (3 112)
      2. Water (3 120)
         1. Underground (3 121)
         2. Surface (3 122)
      3. Vegetation (3 130)
         1. Vegetation Conservation, design for (3 131)
         2. Vegetation Conservation, remedial measures (3 132)
      4. Wildlife (3 140)
         1. Conservation of Wildlife, design for (3 141)
         2. Conservation of Wildlife, remedial measures (3 142)
      5. Minerals (3 150)
         1. Mineral Conservation, design for (3 151)
         2. Mineral Conservation, remedial measures (3 152)
   2. Human Resources (3 200)
      1. Time Values (3 210)
      2. Recreational values (3 220)
         1. Water-oriented (3 221)
         2. Land-oriented (3 222)
      3. Historical Values (3 230)
         1. Before 1492 (3 231)
         2. After 1492 (3 232)
      4. Sociological Values (3 240)
         1. Preservation of aesthetic qualities (3 241)
         2. Remedial aesthetics (3 242)
      5. Physiological Values (3 250)
         1. Measurement of aesthetics (3 251)
         2. Assigning Value to aesthetics (3 252)
   3. General (3 300)

Figure A-1. Category numbering system.

4. MOTORIST SERVICE

1. Rest Area (4 100)
    1. Construction (4 110)
        1. Cost (4 111)
    2. Design (4 120)
        1. Bridge (4 121)
        2. General (4 122)
        3. Survey (4 123)
        4. Land Use (4 124)
    3. Facilities and Service Buildings (4 130)
        1. Toilet (4 131)
        2. Disposal System (4 132)
        3. Service Information (4 133)
        4. Scenic Information (4 134)
        5. Recreation Information (4 135)
        6. Motorist Service (4 136)
        7. Historic Information (4 137)
    4. General (4 140)
    5. Maintenance (4 150)
        1. Caretaker (4 151)
    6. Overlooks (4 160)
    7. Parking (4 170)
    8. Recreation (4 180)
        1. Multi-purpose (4 181)
        2. Reservoirs (4 182)
    9. Roads (4 190)

2. Roads (4 200)
    1. Emergency Calls (4 210)
    2. Motorist Services (4 220)
    3. Motorists Needs (4 230)
    4. National Parks (4 240)
        1. Use (4 241)
    5. Scenic Roads (4 250)

5. EROSION CONTROL

1. Vegetative (5 100)
    1. Tree Evaluation (5 110)
        1. Soil Type (5 111)
    2. Shrub Evaluation (5 120)
    3. Vine (legume) Evaluation (5 130)
    4. Grass Evaluation (5 140)
        1. Mulches (5 141)
        2. Vegetative Planting (5 142)
        3. Fertilizers (5 143)
        4. Seeding (5 144)
        5. Height of Cut (5 145)
        6. Bitumen Emulsions (5 146)
        7. Sod (5 147)
        8. Species and Varieties (5 148)
    5. General Evaluation (5 150)
        1. Banks (5 151)
        2. Drainage Channels (5 152)
        3. Steep Slopes (5 153)
        4. Water Sheds (5 154)
        5. Range Management (5 155)
        6. Wind (5 156)
        7. Ditches (5 157)
        8. Sand Dunes (5 158)
        9. Forest Management (5 159)

2. Structural (5 200)
    1. Materials (5 210)
        1. Channel Linings (5 211)
        2. Mulches (5 212)
        3. Round Rock (5 213)
        4. Asphalt Binding (5 214)
        5. Soil Additives (5 215)
    2. Cluverts (5 220)
        1. Inlets and Outlets (5 221)
        2. Flood Protection (5 222)
        3. Ditch Design (5 223)
    3. Watersheds (5 230)
        1. Hydrologic Studies (5 231)
        2. Piping Phenomenon (5 232)
    4. Soil Properties (5 240)
        1. Unit Weight (5 241)
        2. Sedimentation (5 242)
        3. Infiltration (5 243)
        4. Acidity (5 244)
        5. Type (5 245)
        6. Profile (5 246)
        7. Stabilization (5 247)
    5. Water Properties (5 250)
        1. Turbulence (5 251)
        2. Yields (5 252)
        3. Drainage Practices (5 253)
        4. Energy Relationships (5 254)
    6. General (5 260)
        1. Engineer (5 261)

Figure A-1 (continued).

6. PLANTING
   1. Trees (6 100)
      1. Coastal Sand Dunes (6 110)
         1. Mulches (6 111)
      2. Cuts and Fills (6 120)
         1. Soil Tests (6 121)
         2. Soil Erosion (6 122)
      3. Level Areas (6 130)
         1. Salt Contamination (6 131)
         2. Fertilization (6 132)
      4. General (6 140)
         1. Climax Vegetation (6 141)
         2. Urban Situations (6 142)
         3. Plant Sources (6 143)
         4. Aesthetics (6 144)
         5. Evaluation (6 145)
   2. Shrubs (6 200)
      1. Growth Control (6 210)
         1. Herbicides (6 211)
      2. Evaluation (6 220)
         1. Salt Contamination (6 221)
         2. Direct Seeding (6 222)
         3. Soil and Climatic Effects (6 223)
         4. Plant Types (6 224)
         5. Headlight Glare (6 225)
         6. Snow Control (6 226)
         7. Crash Barrier (6 227)
   3. Vines (legumes) (6 300)
      1. Dwarf Types (6 310)
         1. Seeding Rate (6 311)
         2. Seedling Competition (6 312)
      2. Evaluation (6 320)
         1. Soil and Climatic Effects (6 321)
         2. Fertilizers (6 322)
   4. Grasses (6 400)
      1. Seeds and Seeding (6 410)
         1. Fertilizers (6 411)
         2. Soil Moisture (6 412)
         3. Mixtures of Grasses (6 413)
         4. Soil Type (6 414)
         5. Climate (6 415)
         6. Native Grasses (6 416)
         7. Growth Regulators (6 417)
         8. Costs (6 418)
         9. Companion Crops (6 419)
      2. Evaluation (6 420)
         1. Microclimate (6 421)
         2. Salt Contamination (6 422)
         3. Soil Indices (6 423)
         4. Fertilizers (6 424)
         5. Mulch (6 425)
         6. Height of Cut (6 426)
         7. Herbicides (6 427)
         8. Natural Plant Selection (6 428
         9. Growth Control (6 429)
   5. General (6 500)
      1. Pesticides (6 510)
         1. Herbicides (6 511)
         2. Soil Effects (6 512)
      2. Erosion Control (6 520)
         1. Soil Properties (6 521)
      3. Seeds and Seeding (6 530)
         1. Mulches (6 531)
      4. Selection (6 540)
         1. Propagation (6 541)
      5. Evaluation (6 550)
         1. Soil and Climatic Effects (6 551)
         2. Drought tolerance (6 552)
         3. Salt Contamination (6 553)
         4. Soil Conditioners (6 554)
         5. Water Tables (6 555)
         6. Species and Varieties (6 556)
         7. Automobile Exhaust (6 557)
         8. Fertilizers (6 558)
         9. Mulches (6 559)

7. MAINTENANCE
   1. Roadsides (7 100)
      1. Maintenance (7 111)
      2. Research (7 112)
   2. Erosion (7 120)
      1. Stabilize Soil (7 121)
   3. Equipment (7 130)
      1. Maintenance (7 131)
      2. Mowers (7 132)
      3. Turf Establishment (7 133)
      4. Helicopter (7 134)
   4. General (7 140)
      1. Cost (7 141)
      2. Development (7 142)
      3. Maintenance (7 143)
      4. Land Use (7 144)
   5. Herbicides (7 150)
      1. Asphalt (7 151)
      2. Vegetation-Brush-Weeds (7 152)
      3. Cost (7 153)
      4. Guardrail (7 154)
      5. Pre-surface (7 155)
      6. Shoulders (7 156)
      7. Sprayers (7 157)
      8. Turf (7 158)
      9. Use (7 159)
   6. Litter (7 160)
      1. Survey (7 161)
   7. Parking (7 170)
      1. Maintenance (7 171)
   8. Planting (7 180)
      1. Establishment (7 181)
      2. Maintenance (7 182)
      3. Trees (7 183)
      4. Shrubs (7 184)
      5. Preservation (7 185)
      6. Pruning (7 186)
   9. Turf (7 190)
      1. Cost (7 191)
      2. Establishment (7 192)
      3. Maintenance (7 193)
      4. Mulch (7 194)
      5. Retardant (7 195)
      6. Mowing (7 196)

Figure A-1 (continued).

8. ORGANIZATION AND ADMINISTRATION

1. ROADSIDE DEVELOPMENT PERSONNEL (8 100)
   1. Staffing the Department (8 110)
   2. Correlation (8 120)
      1. Administrator (8 121)
      2. Engineer (8 122)
      3. The Design Team (8 123)
      4. The Consultant (8 124)
      5. The Nursery Man (8 125)
   3. The Landscape Architect (8 130)
      1. Functions and Responsibilities (8 131)
2. ROADSIDE DEVELOPMENT PROGRAM (8 200)
   1. The Overall Program (8 210)
      1. Costs (8 211)
      2. Specifications (8 212)
      3. Scenic Roads and Parkways (8 213)
      4. State Programs (Reports) (8 214)
   2. Beautification (8 220)
      1. Landscaping (8 221)
      2. Safety Factors (8 222)
   3. The Future (8 230)
   4. Research (8 240)
      1. Bibliography (8 241)
      2. Aesthetics (Complete Highway) (8 242)
3. PUBLIC RELATIONS (8 300)
   1. The Highway Administrator (8 310)
   2. Citizen Participation (8 320)
      1. Organized Groups (8 321)
      2. Community Action (8 322)
   3. Educating the Public (8 330)
   4. Beauty Conferences (8 340)

9. APPENDIX ITEMS

1. History of Roadside Development (9 100)
2. Legal Studies Related to Roadside Development areas (9 200)
3. Bibliographies (9 300)
4. Miscellaneous (9 400)

Figure A-1 (continued).

RESEARCH CONTENT ANALYSIS (TABLE A-1)

In a comparison of total literature evaluated, the distribution of the research content was as follows:

Basic research	08.0 percent
Developmental research	23.7 percent
Applied research	38.6 percent
Not research	29.7 percent

Considering research only, past roadside development research effort has been devoted to:

Basic research	11.4 percent
Developmental research	33.8 percent
Applied research	54.8 percent

With the accomplishment of this report's recommendations for implementation of research, it is reasonable to expect that increased efficiency in the use of developmental and applied research would permit raising basic research to 20 percent. This would amount to an increase of more than 75 percent in the rate of generating new knowledge. Combining national, regional, and local research programs, developmental research could be planned at 30 percent and applied research at 50 percent. This would allow for the continued pyramidal effect of the transition of new knowledge generated by basic research, through developmental research, to applied research, which leads to the pay-off or implementation stage of new knowledge.

The "not-research" documents represent both new ideas that stimulate basic research and the testing and observation of the use of applied research. No distinction was made in this report between these two types of not-research documents. Therefore, this relationship was not established.

Within categories it was noted that the percentage of basic research was above average for Categories 1, 2, and 3, and below average for Categories 4, 5, 6, 7, and 8. Developmental research was significantly above average for Categories 1, 2, 3, and 8, and below for Categories 3, 5, and 7. Conversely, applied research was above average for Categories 4, 5, 6, and 7, and below for Categories 1, 2, 3, and 8. All not-research papers were below average, except for Categories 3 and 8. Category 3 was unusual in that it was the highest category in applied research and not-research document types.

Different evaluators would account for some differences. However, the differences and patterns noted here are considered indicative, and should be of value in research planning.

The extreme variance below the mean of applied research in Categories 1, 2, 3, and 8, and developmental research in Category 3, is considered in the comparison with the needs expressed during the field interviews.

GEOGRAPHICAL APPLICATION ANALYSIS

"Geographical application" was divided into those documents containing information relevant or applicable to the entire U.S.; those that would be of value to more than one state but not to all states; and those containing information

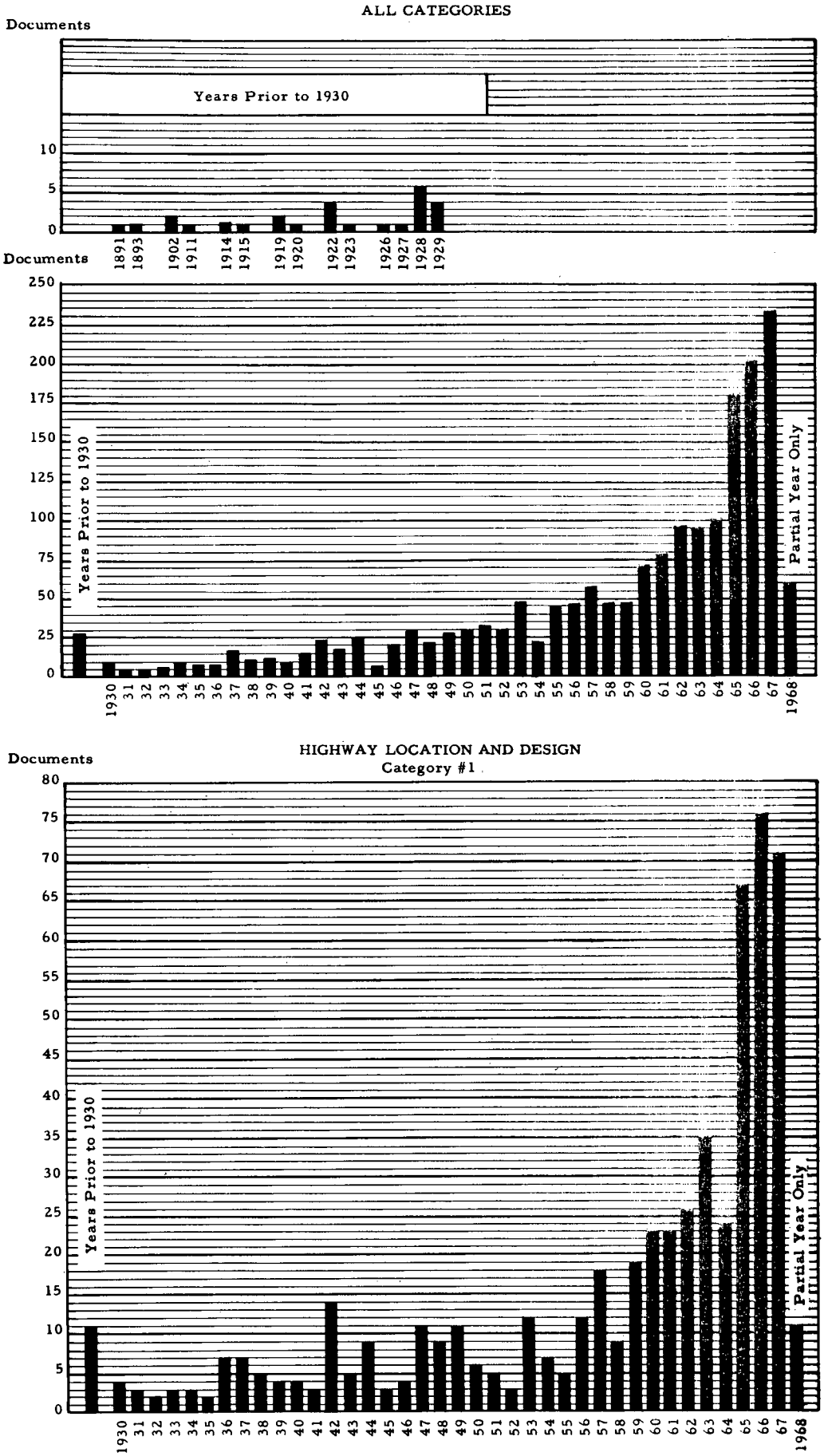

Figure A-2. Chronological analysis of roadside development documents.

applicable to only one state or a small unique area with well-defined local conditions.

Total documents evaluated, excluding not-research documents to show geographic scope characteristics of the literature being generated, indicate that: 57 percent apply nationally; 34 percent apply regionally; and 9 percent apply locally.

It is suggested that at least four factors contribute to the low level of "local research" input to the National Archives and retrieval systems surveyed. It must be remembered that the HRIS is continually screening the states for document input, and, for this report, documents were solicited from most states visited, and universities and other research agencies in all states were surveyed.

The factors contributing to the low level of local documents are:

1. Most documents are written for regional or national audiences.
2. Much research, accomplished locally, could be applied regionally.

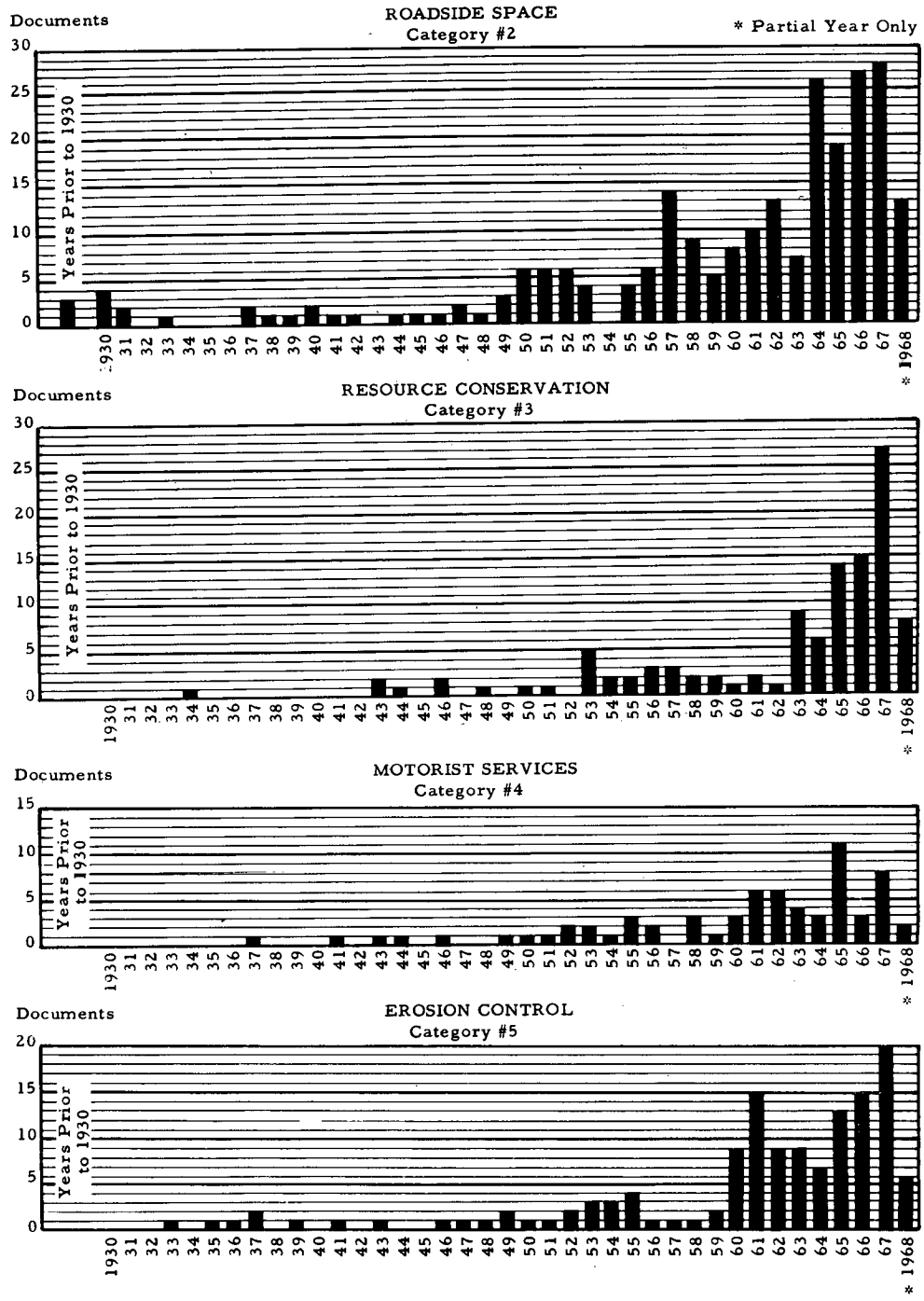

Figure A-2 (continued).

3. The majority of local research or experience is not written up and/or published but remains with the observer-researcher.

4. Most local research, conducted in a manner other than by contract, is done informally.

It is estimated that one-third of the total local research is of a demonstrational nature to assist in the acceptance or promulgation of a recommendation, and one-third is of an educational nature, to provide experience and reassurance, in his judgments, to the roadside development practitioner.

A comparison of the categories by percentage with and without the not-research documents shows that Categories 2 and 3 are more susceptible to opinion, theorizing, and the philosophical type of writing. To the same degree, Category 7, Maintenance, contains a greater percentage of truly research literature. The other categories parallel the average closely.

Analysis of geographical application shows Categories 8, 1, and 2, in descending order, having strong affinity for research with national application. They are weak in regional application but average in local application.

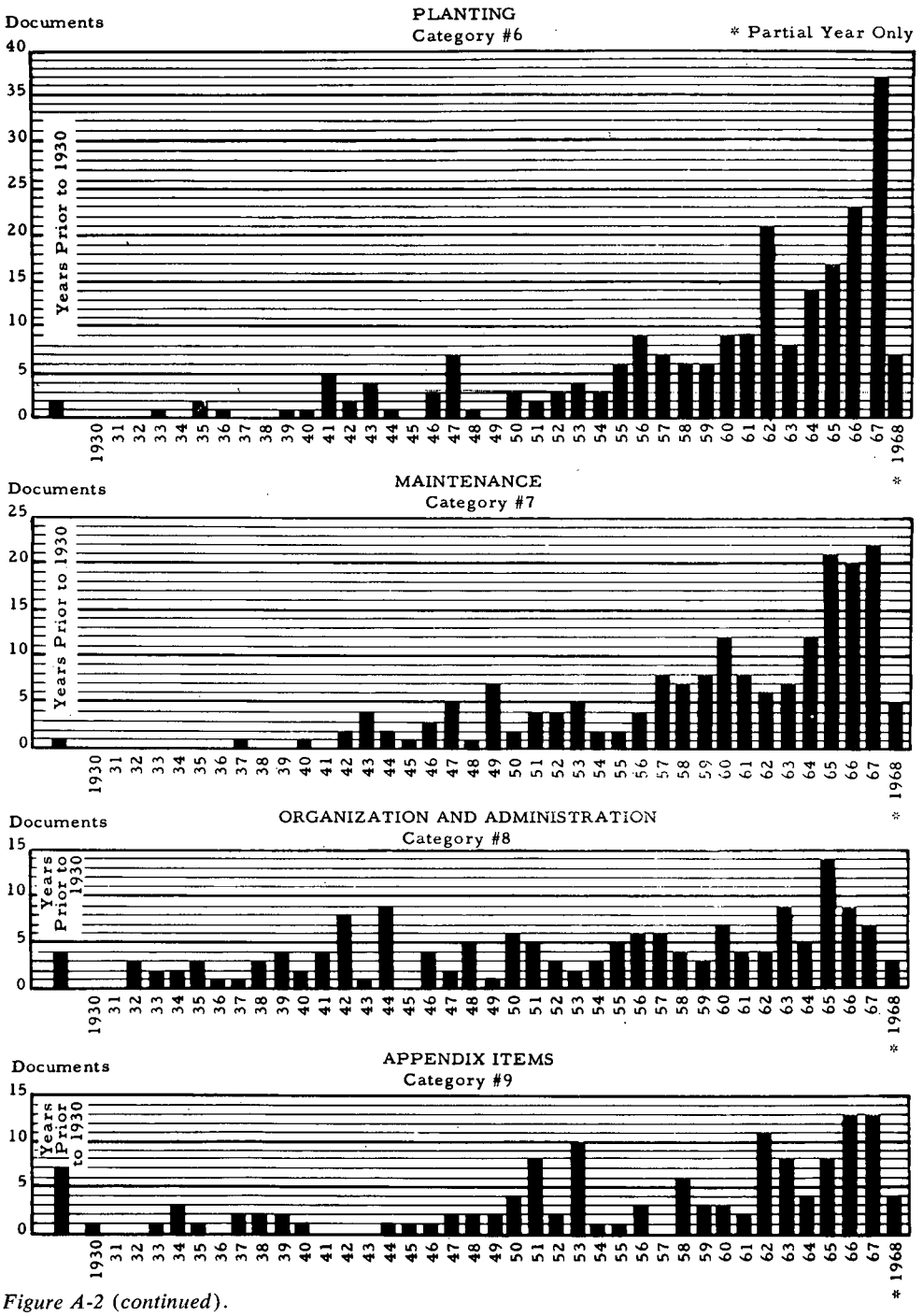

Figure A-2 (continued).

TABLE A-1

RESEARCH CONTENT

CATEGORY NO.	APPLICATION NAT.	REG.	LOC.	TOTAL	% EXCLUDING NOT RESEARCH	% INCLUDING NOT RESEARCH
1	220	26	27	273	31.2	29.0
2	84	23	15	122	13.9	18.2
3	34	14	14	62	07.1	11.5
4	30	15	4	49	05.6	05.6
5	11	76	1	88	10.0	08.3
6	11	80	—	91	10.4	09.1
7	89	65	13	167	19.1	15.2
8	22	—	2	24	02.7	03.1
Total	501	299	76	876		
Percent	57.2	34.1	08.7	100.0		

Categories 5 and 6 are very weak in national, very strong in regional, and a little below average in local research application.

Category 3 was the strongest in local application. Categories 4 and 7 were near average in all applications. The variances shown closely correspond with the evaluation assignments (1-8, Simonson; 4-7, Garmhausen; 5-6, Roberts). However, the differences are so great that they are considered significant because there are parallels with categories done by other evaluators.

RELEVANCE EVALUATION ANALYSIS

Of the 1,985 documents listed (Table A-2), 135 were appendix papers on law, history, bibliographies, and miscellaneous relevant to roadside development but not included in the evaluation scope of this report. Of the remaining 1,850, 1,226 (66.3 percent) were evaluated for Category 1. The 23 documents shown as "no relevance" were those in which the evaluator disagreed with the reviewer's opinion as to relevance. This is not inconsistent,

TABLE A-2

DOCUMENT RELEVANCE

CATEGORY NO.	1[a] COMPLETE RELEVANCE NO. DOC.	%	2 MAJOR RELEVANCE NO. DOC.	%	3 SOME RELEVANCE NO. DOC.	%	4 NO RELEVANCE (ADDED TO 3)	TOTAL DOCUMENTS EVALUATED	% OF SAMPLE	LISTED	%
1	154	43.3	118	33.1	84	23.6	(1)	356	58.5	609	32.9
2	46	20.6	56	25.1	121	54.3	(1)	223	90.3	247	13.3
3	37	26.2	38	26.9	66	46.8	(1)	141	95.3	148	8.0
4	10	14.5	25	36.2	34	49.3	(7)	69	97.2	71	3.9
5	58	57.4	32	31.7	11	10.9	—	101	59.8	169	9.1
6	85	75.9	15	13.4	12	10.7	—	112	44.8	250	13.5
7	33	17.7	89	47.8	64	34.4	(12)	186	96.9	192	10.4
8	22	57.9	10	26.3	6	15.8	(1)	38	23.2	164	8.9
9	—		—		—		—	—		135	—
Total	445		383		398		(23)	1,226		1,985	
										—135	
										1,850	
Percent		36.3		31.2		32.5	(1.9)				

1,226 = 66.3% sample of 1,850

[a] Numerical designation of evaluation used in listing.

because many times the reviewer had the benefit of the full document in preparing the interpretation, and the evaluator had only the written interpretation or the abstract. Those documents in question were re-checked and the ones having relevance were included in the listing. However, the evaluator's determination was indicated in the listing. They should be considered as having "some relevance."

The relevance distribution of the documents evaluated is as follows:

Complete relevance.....445 documents (36.3 percent)
Major relevance.....383 documents (31.2 percent)
Some relevance.....398 documents (32.5 percent)
Sample percentage of total documents.....66.3 percent

Analysis of the data on relevance provides two indications considered significant. The first is that the high major relevance percentages for plant science (Categories 5 and 6) indicate that most research plant science is relevant and applicable to roadside conditions. This means that:

1. Considerable roadside development knowledge is available from others researching plant science.
2. Planting and erosion control subjects are most indigenous to roadside development.

The high percentage of major relevance of Category 8 is not considered significant because of the literature sources and selection achieved during the review and interpretation process.

The second significant indication is the low percentage of major relevance in Category 4. It is suggested that most knowledge on Motorist Services has come from other related experiences but not "Highway Services," specifically. This lends further emphasis to the premise that there is a void in the existing knowledge on Motorist Services, particularly on rest areas and information services. The same indication exists with Categories 2 and 3, to a lesser degree.

TABLE A-3

DOCUMENT DISTRIBUTION, BY CATEGORY

CATEGORY NO.	SUBJECT CATEGORY	DOCUMENTS, BY SUBJECT CATEGORIES: ONE ONLY	2ND CAT.	3RD CAT.	TOTAL LISTED	DOCUMENTS OF 2ND AND 3RD SUBJECT CATEGORIES, BY CATEGORY: 1	2	3	4	5	6	7	8	9	TOTAL
1		412													
	2nd		197		609	0	109	34	6	5	14	6	14	9	
	3rd			43		0	8	5	2	3	6	6	5	8	
2		131													
	2nd		116		247	29	0	29	4	1	2	0	2	49	
	3rd			33		17	0	6	1	1	1	0	0	7	
3		79													
	2nd		69		148	24	21	0	7	8	3	4	0	2	
	3rd			20		4	9	0	2	1	0	0	0	4	
4		47													
	2nd		24		71	3	9	6	0	0	0	6	0	0	
	3rd			6		3	1	1	0	0	0	0	0	1	
5		116													
	2nd		53		169	8	0	6	0	0	34	5	0	0	
	3rd			4		0	0	0	0	0	2	2	0	0	
6		188													
	2nd		62		250	6	1	3	1	33	0	16	1	1	
	3rd			8		0	0	0	0	0	0	6	1	1	
7		159													
	2nd		33		192	4	4	5	2	6	8	0	3	1	
	3rd			6		0	5	1	0	0	0	0	0	0	
8		140													
	2nd		24		164	8	1	2	0	0	3	1	0	9	
	3rd			4		1	2	0	0	0	0	0	0	1	
9		124													
	2nd		11		135	1	10	0	0	0	0	0	0	0	
Total		1,396	589	124	1,985	108	180	98	25	58	73	52	26	93	713
Total documents listed						609	247	148	71	169	250	192	164	135	1,985
Total															2,698

TABLE A-4

NUMBER AND DOMINANT CATEGORY OF DOCUMENT PUBLICATION BY STATES

Example: Alaska AK 2 3–4–0
Alaska—State
AK—Abbreviation
2—Number of documents published.
3—Category of most documents published in State.
4—Category of second highest volume of documents.
5—Category of third highest volume of documents.

STATE	ABB.	CODE		STATE	ABB.	CODE	
Alaska	AK	2	3–4–0	Montana	MT	13	6–5–3
Alabama	AL	7	5–2–7	Nebraska	NB	5	5–6–7
Arizona	AZ	12	2–6–7	Nevada	NV	4	5–6–1
Arkansas	AR	5	5–6–0	New Hampshire	NH	3	1–3–6
California	CA	66	1–2–5	New Jersey	NJ	23	1–2–6
Colorado	CO	8	1–3–7	New Mexico	NM	10	6–8–2
Connecticut	CT	19	1–2–7	New York	NY	31	1–2–6
Delaware	DE	1	7–0–0	North Carolina	NC	18	1–5–7
Dist. of Col.	DC	24	2–1–8	North Dakota	ND	2	7–2–0
Florida	FL	8	3–5–2	Ohio	OH	32	1–7–6
Georgia	GA	17	5–1–2	Oklahoma	OK	5	5–6–1
Hawaii	HI	0	—	Oregon	OR	11	1–6–2
Idaho	ID	8	1–6–0	Pennsylvania	PA	29	2–3–1
Illinois	IL	37	1–6–4	Rhode Island	RI	5	7–1–0
Indiana	IN	32	1–5–7	South Carolina	SC	2	5–2–0
Iowa	IA	23	5–6–8	South Dakota	SD	10	6–5–1
Kansas	KS	5	1–5–0	Tennessee	TN	12	2–7–4
Kentucky	KY	5	2–6–1	Texas	TX	31	1–7–5
Louisiana	LA	11	2–6–7	Utah	UT	4	5–6–4
Maine	ME	22	1–6–5	Vermont	VT	0	—
Maryland	MD	8	1–2–6	Virginia	VA	21	6–1–8
Massachusetts	MA	4	1–6–7	Washington	WA	20	2–3–1
Michigan	MI	29	2–7–1	West Virginia	WV	7	2–5–6
Minnesota	MN	22	1–2–5	Wisconsin	WI	30	2–7–8
Mississippi	MS	11	5–3–1	Wyoming	WY	1	5–0–0
Missouri	MO	9	7–2–5				

CATEGORY ANALYSIS

Table A-3 shows that certain relationships exist. These are associated mostly with and indicated by the aforementioned overlaps. These relationships should be considered and accommodated in the design of any research project.

The most associated second category of Category 1, Highway Location and Design, is Category 2, Roadside Space, with the next being Category 3, Resource Conservation. Conversely, Category 2 has Categories 1 and 3 as the most associated categories. Also, Category 3 has Categories 1 and 2 prominent in both second and third categories.

Category 4, Motorist Services, is associated mostly with Categories 2, 3, and 7.

Category 5, Erosion Control, is associated prominently with Category 6 and concerned with Category 1. This relationship probably is due to the involvement of drainage design.

Category 6, Planting, is associated very strongly with Category 5, because of the preponderance of erosion control planting in relation to functional and aesthetic plantings. Category 7, Maintenance, is the next most associated because of the maintenance requirements.

Category 7, Maintenance, is associated mostly with planting, but is unique in that it has a comparatively uniform level of association with all other categories. This is considered desirable.

Category 8, Organization and Administration, is associated mostly with Category 1 because of the necessity of roadside development landscape architects' involvement in the total highway creation process from the very beginning at the planning stage.

Of 1,985 total documents listed, 1,396 (70.3 percent) were single-subject documents having a second category, and 124 (6.3 percent) had the third subject category. Of the documents listed, 1,226 (66.3 percent) were evaluated; 124 (100 percent) of the third categories were not evaluated.

The remaining documents and categories not evaluated represent that amount of existing information not classified into specific subcategory subject areas. Thus, in its present form it is not readily available for specific retrieval and literature search.

This amounts to 624 of the first category, 524 of the second category, and 124 of the third category, for a total of 1,272 items of relevant information. This is slightly more than 100 percent additional potential yield to the

state of knowledge adaptable to a specific retrieval system available from accomplished document search.

PUBLICATION LEVEL AND PROMINENCE ANALYSIS

The states were listed (Table A-4) by the top three dominant categories of interest. The volume of publications in relation to other states was not considered in this grouping. Because of obvious inconsistencies, any similarity between states so listed is not immediately apparent for most categories. An analysis of total states showing interest in a category by percentage indicates that Erosion Control and Planting are about two to five times higher by number of states than is indicated in the total literature tabulation. This is considered a good indication of roadside development maturity in each category and similarly in the total scope of roadside development. Any future study involving roadside development expertise would do well to study the states on these lists.

The states showing published preference by categories are as follows:

1. Highway Location and Design.—Most published activity: CA, CO, CT, ID, IL, IN, KS, ME, MD, MA, MN, NH, NJ, NY, NC, OH, OR, TX—18 states. Second highest published activity: DC, GA, RI, VA—4 states. Third highest published activity: KY, MI, MS, NV, OK, PA, SD, WA—8 states. Grand total—30 states.

2. Roadside Space.—Most published activity: AZ, DC, KY, LA, MI, PA, TN, WA, WV, WI—10 states. Second highest published activity: AL, CA, CO, MD, MN, MO, NJ, NY, ND, SC—10 states. Third highest published activity: FL, GA, NM, OR—4 states. Grand total—24 states.

3. Resource Conservation.—Most published activity: AK, FL—2 states. Second highest published activity: CO, MS, NH, PA, WA—5 states. Third highest published activity: MT—1 state. Grand total—8 states.

4. Motorist Services.—Most published activity: None. Second highest published activity: AK—1 state. Third highest published activity: IL, TN, UT—3 states. Grand total—4 states.

5. Erosion Control.—Most published activity: AL, AR, GA, IA, MS, NB, NV, OK, SC, UT, WY—11 states. Second highest published activity: FL, IN, KS, ME, MT, NC, SD, WV—8 states. Third highest published activity: CA, MN, MO, TX—4 states. Grand total—23 states.

6. Planting.—Most published activity: MT, MN, SD, VA—4 states. Second highest published activity: AZ, AR, ID, IL, IA, KY, LA, MA, NB, NV, OK, OR, UT—13 states. Third highest published activity: ME, MD, NH, NJ, NY, OH, WV—7 states. Grand total—24 states.

7. Maintenance.—Most published activity: DE, MO, ND, RI—4 states. Second highest published activity: MI, OH, TN, TX, WI—5 states. Third highest published activity: AL, AZ, CO, CT, IN, LA, MA, NB, NC—9 states. Grand total—18 states.

8. Organization and Administration.—Most published activity: None. Second highest published activity: NM—1 state. Third highest published activity: DC, IA, VA, WI—4 states. Grand total—5 states.

The top ten states published in each category, in descending order of published volume, are given in Table A-5.

The most active state publishers in combined categories of roadside development research in descending order are: CA, MI, WI, IL, OH, TX, IA, NY, CT, PA.

TABLE A-5

PUBLISHED LEVEL, BY STATES

	STATES, BY CATEGORY							
HIGH	1	2	3	4	5	6	7	8
1	CA	PA	PA	OH	IA	IL	TX	MI
2	IL	CA	WA	WI	GA	IA	OH	IN
3	NY	WI	CA	CA	CA	MT	WI	WI
4	NJ	MI	IL	MI	ID	OH	MI	IA
5	IN	NY	FL	IA	AL	SD	IN	NM
6	OH	WA	NY	MD	MN	TX	RI	VA
7	TX	MN	OH		MI	VA	CT	CT
8	MI	TN	TX		MT	NM	NC	AZ
9	MA	CT	VA		NC	NY	MO	IL
10	CT	IL	WI		TX	PA	AZ	GA

APPENDIX B

FIELD INTERVIEW RESULTS

RESEARCH NEEDS EXPRESSED

Research needs expressed by the interviews during the field interviews were restated as summarized research project statements and grouped by category.

The number of states and/or individuals stating each need also was tabulated. This information was used to rate the need according to dominance. The data also were studied for geographical and regional connotations.

By use of the previously developed system of subject classification by category and subcategories, subject code numbers were assigned to each need expressed. This illustrates the adaptability for retrieval from a computerized research project pool.

The field interview results for research needs are listed as follows: summary project statement, category code, number of nominations, geographical application (national, regional, local).

Category 1—Highway Location and Design

Develop guidelines and procedures for roadside development aspects of preliminary planning and location studies in urban areas. 1100, 1200, 2210, 8131, 10 nominations, national application.

Determine the degree of psychological impact and response of motorists to highway aesthetics. Study such elements of the visual environment as highway plants and plantings, structures, terrain, geometrics, and billboards. 1356, 7 nominations, national application.

Define techniques and prepare guidelines for aesthetic and environmental analysis of the geometrics of a proposed highway. 1120, 1132, 1170, 1220, 1300, 6 nominations, national application.

Analyze quantities and cost differences of separate divided roadway alignments in the various types of topographic conditions and roadway widths (lanes). 1210, 5 nominations, national application.

Determine and quantify the socioeconomic impact of highway plantings. 1160, 4 nominations, national application.

Compare guardrail costs with the cost of slope flattening. 1344, 2 nominations, national application.

Define and rate the dominant positive and negative aesthetic elements of the driving experience, both within and beyond right-of-way limits. 1000, 2 nominations, national application.

Determine uses and develop a manual of aerial photography and photogrammetric techniques of assistance to roadside development operations. 24-1111, 7196, 21-1000, 2 nominations, national application.

Develop criteria for right-of-way taking, define legal and demonstrable needs for highway warrants. 1150, 1320, 1 nomination, national application.

Relate right-of-way area and costs by degree of shoulder slope. 1313, 7141, 1 nomination, national application.

Develop materials and construction techniques with high aesthetic quality, including fencing, concrete, paving, guardrails, and other hardware. 1341, 1 nomination, national application.

Develop criteria of need and guideline of objectives for planting urban roadside areas. 1351, 1 nomination, national and regional application.

Category 2—Roadside Space

Evaluate the interest costs, acquisition, administration, and maintenance of the land interest taken and the purpose of scenic strips acquired to date. 2221, 7 nominations, national application.

Analyze the long-term economics and other benefits of wide and variable vs minimal and standard right-of-way takings. 2100, 5 nominations, national and regional application.

Determine and quantitatively define the urban impact relationships of the highway on the community, and the community on the highway. 2200, 4 nominations, national application.

Determine the benefits and problems of creating urban open spaces with highway right-of-way. 2110, 2210, 3 nominations, national application.

Determine the recreation potential and possibilities on highway right-of-way within the multiple-use concept. 2140, 2 nominations, national application.

Investigate and define safety considerations involved in joint development and multiple use in urban conditions. 2130, 2140, 1 nomination, national application.

Develop guidelines for equitable distribution of costs of multiple-use developments. 2140, 1 nomination, national application.

Determine the major opportunities and benefits of multiple use in rural areas. 2140, 1 nomination, national and regional application.

The scenic easement concept is a facet of multiple use. All multiple-use policies should incorporate policies for scenic use.

Category 3—Resource Conservation

Prepare a checklist and definition of possible roadside environmental resources and values. Develop a system for their evaluation in engineering terms. 3100, 3200, 7 nominations, national application.

Quantitatively determine the impact on the various types and species of wildlife by the various functional classes of

highways and typical traffic types and volumes. 3140, 3 nominations, regional and local application.

Prepare guidelines and a checklist for stream channel changes, to give maximum protection to existing natural values and aesthetics. 3100, 3 nominations, national application.

Determine the requirements and prepare guidelines for the use of temporary sediment dams and basins on highway grading projects. 3111, 3122, 5000, 5253, 2 nominations, national application.

Determine the ways highway construction and operations contribute to air and water pollution. Rate findings by their impact on public health, economic loss, and damage to the environment, including wildlife. 1 nomination, national and regional application.

Determine the benefits to wildlife by timing or elimination of mowing operations. 3140, 1 nomination, regional application.

Develop an economical method to quickly re-weather and blend rock cut scars. 3241, 1 nomination, national application.

Category 4—Motorist Services

Investigate and determine rest area right-of-way facility and spacing requirements, based on traffic user motivation and other considerations, such as season, time of day, holiday, and site. 4100, 18 nominations, regional application (by traffic volumes).

Describe and evaluate the needs and the different systems of providing motorist information in rest areas, and prepare recommendations for operation of information centers. 4133, 4134, 4135, 4136, 4137, 13 nominations, national application.

Determine desirability of and prepare guidelines for rest area playground equipment and recreation facilities. 4130, 4180, 7 nominations, national application.

Develop standards for motorist information literature for distribution in state highway rest area facilities. 4133, 4134, 4135, 4136, 4137, 6 nominations, national application.

Determine the impact of highway motorist services on private enterprise. 4140, 5 nominations, national application.

Prepare systems, capacities, and site conditions related to the various user load levels for rest area water and waste disposal requirements. 4132, 4 nominations, national and local application.

Determine the desirability of vending machines in a rest area and prepare a criterion for selecting or rejecting items that might be dispensed. 4136, 3 nominations, national application.

Evaluate the desirability of contract motorist service plazas on controlled-access highways. 4140, 3 nominations, national application.

Develop a design guide for emergency communications, showing what, when, and where facilities are needed. Continue systems development. 4210, 3 nominations, national application.

Compare advantages and disadvantages of frequently spaced small rest areas vs fewer large rest areas. 4120, 2 nominations, regional application (by traffic volume).

Determine the need, feasibility, and public acceptance of portable toilets for temporary rest area facilities for use during breakdown, repair, construction, and overload periods. 4150, 1 nomination, local application.

Develop systems for the control and apprehension of vandals. 4150, 1 nomination, national application.

Evaluate the relative merits of rest area maintenance by contract, caretaker, and road patrol. 4150, 4151, 1 application, national application.

Category 5—Erosion Control

Evaluate existing materials and develop new systems and materials for wind and water erosion control in low-rainfall regions. 5100, 5200, 7 nominations, regional application.

Evaluate new or introduced plants and materials for erosion control. 5120, 5130, 5143, 6 nominations, regional and local application.

Evaluate the different methods of soil stabilization during pre-emergence. 5247, 5150, 5 nominations, regional and local application.

Continue development and testing of new plants and materials to control erosion. 5210, 4 nominations, local application.

Determine the effect on cost, establishment, and survival of seeding dates for the major roadside grasses. 5144, 3 nominations, regional application.

Evaluate drainage channel cross-section and length, and relate to failure or erosion index. 5220, 2 nominations, national and regional application (by rainfall).

Category 6—Planting

Evaluate plant material and develop lists of desirable and undesirable plants for roadside use in various ecologic conditions of all states. 6556, 16 nominations, regional and local application.

Investigate opportunities for direct seeding of woody vegetation. 6222, 11 nominations, regional and local application.

Investigate and determine the establishment period requirements for the various vegetation and ecological types. 6550, 11 nominations, national and regional application.

Investigate the benefits and opportunity for the creation of a plant material source clearinghouse, including seeds and native-type plants. 6100, 9 nominations, national and regional application.

Conduct continuing evaluation of sprinkler irrigation systems equipment and material. 6600, 7180, 6 nominations, regional application.

Develop mulch for new plantings that will more effectively conserve moisture and control weeds. 6559, 4 nominations, regional application.

Investigate and develop practical chemicals and methods to control soil pH. 6554, 8 nominations, regional and local application.

Develop criteria for decision on inclusion or exclusion of sprinkler irrigation (supplemental water) system, based on such considerations as traffic volume, water cost, abut-

ting land use, and system continuity. 1300, 6600, 2 nominations, regional application.

Determine the economics of plant sizes, considering original planting cost vs maintenance costs. 6700, 7140, 2 nominations, regional application.

Determine the variables in the value of topsoil salvage and use in typical soil and terrain types. Relate to subsoil conditioning and use. 6500, 6551, 2 nominations, regional application.

Determine the effect of traffic-generated pollutants on roadside vegetation, and develop systems and evaluate plants to overcome the problems caused by these pollutants. 6500, 1 nomination, regional and local application.

Develop techniques of developing micro-climates in place vs mulch addition. 6412, 6415, 1 nomination, regional application.

Category 7—Maintenance

Develop more efficient equipment for roadside construction and maintenance. 7130, 7180, 7190, 8 nominations, national application.

Determine maintenance practices that best promote renaturalization and climax growth cover on roadsides. Consider both chemical and mechanical vegetation control. 7100, 5100, 6100, 6200, 6300, 6400, 7 nominations, regional and local application.

Determine the fertilizer requirements to benefit dry land grasses in arid and semi-arid states. 7193, 3 nominations, regional application.

Develop an optimum tree and shrub fertilization program for local conditions. 7182, 3 nominations, local application.

Determine and compare maintenance costs and problems of the various construction types and qualities of rest area facilities. 7141, 2 nominations, national application.

Develop a comprehensive rest area maintenance manual. 7000, 4150, 2 nominations, national application.

Develop an inert nontoxic salt substitute of equal or less cost. Nonchemical systems may be considered. 7000, 6553, 1 nomination, regional application.

Prepare guidelines for the development of plant establishment and maintenance programs and cost estimates for consideration with each planting construction project designed. 7142-3, 7181-2, 7191-2, 1 nomination, national application.

Determine causes of low litter law enforcement, including the effect of high or low fines. 7160, 1 nomination, national application.

Determine the optimum designs, locations, and servicing requirements of litter deposits. 7160, 1 nomination, national application.

Investigate and illustrate examples of the relationships of grass and shrub heights and locations vs snowdrift patterns. 7100, 7143, 7196, 1 nomination, regional application.

Determine the problems and benefits of contract vs state force roadside vegetation maintenance or control. 7140, 7180, 7190, 1 nomination, regional application.

Category 8—Organization and Administration

Define problem and relate administrative attitude. Investigate, define, and prepare guidelines or operational manual for the roadside development personnel's contribution to the various functions of a highway department. 8131, 17 nominations, national application.

Develop training programs for roadside development activities in design, inspection, and maintenance, for use in universities and highway organizations. 8100, 9 nominations, national application.

Prepare indoctrination film depicting the aesthetic and safety differences of good and bad alignments. Relate the differences to their causes. 8120, 8320, 1172, 2 nominations, national application.

Determine optimum placement of roadside development staff in highway organizations (consider centralized, or fragmented among operational functions or units). 8100, 2 nominations, national application.

Develop functional classification and nomenclature of scenic interest acquisitions. 8200, 8213, 1 nomination, national application.

Determine opportunities in roadside maintenance programs for improving public relations. 8300, 7140, 1 nomination, national application.

Define methods of stimulating maintenance and engineering personnel to accomplish roadside plantings. 8310, 1 nomination, national application.

Other Considerations

Several administration and motivational problems of roadside development not amenable to research solution were expressed, such as: enforcement of litter and vandal laws; lack of administrative understanding and support of roadside development programs; inter-departmental cooperation and inter-disciplinary understanding; lack of authority to implement roadside development recommendations; low end of funding scale for salaries, construction, maintenance, and research; obtaining and keeping qualified personnel and contractors; and destruction of plants and sprinkler irrigation equipment by maintenance operators.

APPENDIX C

ADDITIONAL ROADSIDE DEVELOPMENT RESEARCH NEEDS OR IDEAS

CATEGORY 1. HIGHWAY LOCATION AND DESIGN

Determine probabilities of vehicle-tree collisions for various setback distances and slope conditions.

Develop criteria for a scenic corridor.

Devise criteria for establishing depth of scenic strips.

Study roadside impacts of elevated vs. depressed urban sections of freeways.

Investigate and evaluate the uses of exposed aggregate and colored concrete to enhance highway structures.

Demonstrate and quantify roadside visual impact beyond the right-of-way limits.

Determine methods and/or devices available for the best presentation of roadside aspects of highway locations.

Investigate methods and procedures that best assure proper evaluation of roadside features in highway location studies.

Evaluate feasibility of assigning economic values to scenic features.

Study design possibilities to relieve monotony on unchanging natural terrain and conditions.

Establish criteria for initiating corrective measures for traffic noise.

Investigate different textures and materials for shoulders from the standpoint of design, construction, and maintenance.

Develop alternative to structural guardrails.

Determine salient ecological relationships to consider in vegetative design or plant material selection.

Study cost ratios for different slopes of construction vs. maintenance.

Investigate criteria for providing motorist services.

Analyze the relationships of parks and highways.

Develop systems for graphic representation of roadside views as a design tool --

three-dimensional plotters, models, etc.

Ascertain best applications for photogrammetry to roadside design.

Study factors related to the total needs of an area which will insure that highway development will fit those needs.

Establish guidelines on such matters as when to depress or elevate. How to relate freeways to parking facilities. How to coordinate with public transportation facilities in highways or otherwise. Air rights, vehicular-pedestrian separations, road plans related to urban renewal program.

Develop techniques for articulating land use planning goals, for evaluating alternatives, and for formulating a scale for relating community values to development form.

Determine importance of aesthetics as a traffic service quality and determine technique for measuring its importance.

Devise economical guidelines and techniques for the improvement of highway aesthetics.

Analyze importance of aesthetics as a traffic service quality and analyze technique for measuring its importance.

Investigate desirability of landscape lighting in urban conditions along the roadside and in the medians.

Study benefits obtained by the use of plant material along the roadside to improve visibility at night and during periods of bad weather.

Evaluate criteria for the evaluation of function, design, and location of rest areas.

Ascertain how the recreational traveler's needs should influence highway design.

Determine if present bridge designs fit the landscape of the surrounding countryside.

Determine the types of plants which might contribute to the landscape of areas where normal planting and maintenance methods are impractical because of lack of space and limited access.

Analyze the types of color combinations which provide attractive relief from the traditional landscape of a specific area.

Determine how can plant materials placed along the roadside be used to direct attention to signs containing travel information and directives.

Ascertain how can plant materials placed along the roadside be used to direct attention to the highway and specific driving conditions.

Study how plant materials placed along the roadside can be best used to focus attention on areas on scenic grandeur.

Evaluate ways woody plants can be used as replacements for snow fences.

Evaluate ways woody plants can be used more effectively as wind screens along roadsides.

Establish what plant materials have most value as screens along roadsides.

Determine what native grasses in each climatic and horticultural zone provide the most desirable effect in roadside beautification.

Analyze how can the use of native trees and shrubs of each climatic and horticultural zone provide the most desirable effect in roadside beautification.

Ascertain what lighting features might be used to identify sights of interest to the motorist traveling at night.

Establish how landscaping may be used to better the compatability of existing structures and the surrounding landscape.

Study how designs of bridges and overpasses may better fit in with the surrounding environment.

Determine how clean-up and removal of undesirable billboards, buildings, public and private dumps, automobile junk yards and similar detractions and undesirable views from highways can be supplemented with use of plant screens.

Assess the value of landscape design and the values of a scenic corridor.

Evaluate which factors are considered important in evaluating the permanence and value of a scenic corridor.

Identify factors that contribute to the selection of a location for a scenic corridor.

Determine what effect time has on the desired landscape feature.

Analyze how time-related changes are correlated with known ecological

principles and how these principles can be used to best advantage in achieving the desired landscape feature.

Assess what procedures are feasible for controlling population changes on abutting areas.

Establish whether timetables predicting change in vegetative dominance can be useful in planning roadside management.

Determine what plants adapted to roadside use are most fire resistant.

Study how landscape design can be worked out to increase ease of fire control operations.

Since water for irrigation may be abundant in some locations, determine how may this best be used in developing the landscape potential of these areas.

Ascertain what types of plants might be considered for use where irrigation practices are feasible.

Investigate what plant materials suitable for roadside use are winter hardy in the various horticultural zones in the country.

Determine what design situations are most conducive to protection of plants lacking winter hardiness to some degree.

Establish whether plantings of wild flowers, native grasses and other indigenous plants around rest areas will be of interest and value in relief of fatigue to the motorist.

Study whether recreational facilities (of specific types) are of value in relief of driver and motorist fatigue.

Assess what ways and means are available to provide overnight parking and camping.

Evaluate what landscape features provide most relief of driver fatigue.

Determine how roadside development contributes to driving safety.

Analyze how walkways, crosswalks and fencing can be made safer for vehicular traffic as well as the pedestrian.

Investigate how surrounding communities can contribute to highway safety and beautification by way of long-range planning.

Study how safe entrances to and exits from major highways and community streets can be realized.

Investigate quantification of nonuser benefits of a highway by means of an index of impact.

Determine the role of aesthetics as a community decision-making factor in alternative transportation systems selection, design and location.

Make a determination of best design for medians on urban expressways where right-of-way is costly or otherwise limited.

Develop economical guidelines and techniques for the improvement of highway aesthetics.

Develop guidelines on such matters as when to depress or elevate. How to relate freeways to parking facilities. How to coordinate with public transportation facilities in highways or otherwise. Air rights. Vehicular-pedestrian separations. Road plans related to urban renewal program.

Determine importance of aesthetics as a traffic service quality and determine techniques for measuring its importance.

CATEGORY 2. ROADSIDE SPACE

Determine effectiveness of federal provisions affecting outdoor advertising and identify the differing techniques for control of outdoor advertising.

Evaluate relationship between the value of scenic easement and the value of the fee simple title of the property.

Make a determination of rules for acquisition and evaluation of air rights and easements for scenic purposes.

Determine the best and compatible utilization of air rights above and below public highways.

Study the effect that various forms of landscape development have on property values adjacent to highways.

Make a determination of techniques of land use control along highways, taking into account the costs, effectiveness and public acceptance of land use guidance measures.

Study the economic and social effects of highways on neighborhoods.

Investigate the use of highway right-of way by utilities and of problems of removing utilities from right-of way property.

Determine the positive and negative impacts of billboards on the motorists.

Investigate how roadsides can promote pride from residents of nearby communities.

CATEGORY 3. RESOURCE CONSERVATION

Determine what methods best utilize roadsides abutting rivers, streams or lakes to best advantage for the maximum good for the majority of the people.

Determine what methods best utilize the roadside and the highway features for replenishing the ground water resources.

Determine what methods and procedures can be developed or promulgated for maximum conservation of desirable vegetation on new construction of highways.

Determine what benefit is obtained by maximum conservation of desirable vegetation.

Determine what methods best conserve and protect wildlife along roadsides.

Determine what methods can be developed to alleviate problems along highways where they conflict with wildlife uses.

Determine what benefit values can be assigned to wildlife conservation practices as they relate to highways.

Determine what the best methods of fish conservation are where highways adjoin streams or lakes.

Determine what economic factors can be assigned to fish conservation measures.

Determine what research performed by the mineral industry can be utilized to minimize scars caused by mining activities.

Determine what methods can be used to minimize scars caused by mining activities.

Determine what value people place on their time spent on recreational activities.

Determine what are the relative amounts of time spent driving for recreation as opposed to all other uses.

Determine if the relative beauty of the scenery along a highway can be related to the time people spend traversing a given unit of highway.

Determine what value can be placed on recreational uses of a highway located near a stream or lake.

Determine what value can be placed on recreational uses of a highway traversing scenic areas.

Determine to what extent can ecological factors contribute to best location of highways for scenic purposes.

Determine what method can be developed for nationwide application to better depict our history to the traveling public utilizing the highways and roadsides.

Determine by regions, what can be done to utilize the highway to best advantage for presenting regional historical significance to the traveling public.

Determine if a plan can be developed to utilize historical societies on a national scale to advise highway administrators.

Determine if the multiple-use concept of land management can be applied to highway roadside. If so, determine the relevant uses and their application.

Determine how an ecological approach can be utilized combined with socio-economic factor to best use the highway roadsides.

Determine if a scale can be developed which provides a measure of aesthetic qualities along a roadside.

Determine if a measurement can be made of relative pleasure or displeasure of the traveling public while traversing a unit of highway.

Determine if a relative value can be assigned to pleasurable driving as opposed to unpleasurable driving.

Determine what factors make up a pleasurable driving experience.

Determine what value people place on pleasurable experiences as related to anticipation and later recollection.

CATEGORY 4. MOTORIST SERVICES

Investigate and determine rest area, right-of-way, facility, and spacing requirements based on traffic user motivation and other considerations such as season, time of day, holiday, and site.

Describe and evaluate the needs and the different systems of providing motorist information in rest areas and prepare recommendations for operation centers.

Determine desirability and prepare guidelines for rest area playground equipment and recreation facilities.

Develop standards for motorist information literature for distribution in State Highway rest area facilities.

Determine the impact of highway motorist services upon private enterprise.

Prepare design guidelines for various systems, capacities, and site conditions related to the user load levels for rest area water and waste disposal requirements.

Determine the desirability of vending machines in a rest area and prepare a criteria for selecting or rejecting items that might be dispensed.

Evaluate the desirability of contract motorist service plazas on controlled access highways.

Develop design guide for emergency communications showing what, when and where facilities are needed.

Compare advantages and disadvantages of frequently-spaced small rest areas vs. fewer large rest areas.

Determine the need, feasibility, and public acceptance of portable toilets for temporary rest area facilities for use during breakdown, construction and overload periods.

Develop systems for the control and identification of vandals.

Evaluate the relative merits of rest area maintenance by contract, caretaker, and road patrol forces.

Prepare guidelines for the design and placement of interpretive aid facilities in rest areas and on interstate, primary and rural secondary roads. Include

the listing of desirable and undesirable types of information and styles of presentation.

Survey the motoring public to determine: 1. The relative demand for the various roadside services and facilities. 2. Those services and facilities that they feel should be provided with and without charge. 3. Those facilities and services that should be constructed or provided with highway user tax funds.

List, describe, and evaluate the most feasible rest area design and construction elements that prevent or discourage vandalism, and are other-wise conducive to easy maintenance.

Establish and define the various types of recreation travel and develop a practical system for accurately determining the amount of travel generated on a specific highway route or segment by the types of recreation travel established.

Define and develop criteria and standards for the selection and operation of existing roadways or the design, construction and operation of new routes as scenic roads.

Evaluate the merits and problems of providing or allowing boating and other recreational uses of bodies of water within or contiguous with rest areas.

Evaluate the compatibility of campgrounds within or adjacent to and accessible from interstate rest areas.

Analyze the value and problems of providing separate rest areas for commercial (trucks and buses) and private vehicles.

Evaluate the impact on rest area design and operation of overnight parking by the various types of vehicles, and determine if there is a need and make recommendations for occupancy time restrictions.

Prepare rest area operation manual including staffing and maintenance guidelines.

Develop a system to determine and measure the impact of rest areas upon traffic safety under the major typical conditions.

CATEGORY 5. EROSION CONTROL

Continue current studies in the area of soil/water relations as related to erosion, determine effects of climatic variables in the soil erosion process.

Continue evaluation of erosion control situations on specific roadside locations; survey erosion control needs and evaluate erosion control methods.

Develop new concepts in erosion control using advanced technology and knowledge concerning recently developed structural materials.

Continue current evaluations of plant materials suitable for erosion control; coordinate evaluations over wide-spread geographic areas and differing climatic conditions.

Evaluate new chemicals and mulching materials for effectiveness in stabilizing soil surfaces and protecting slopes from erosion; determine improved ways to apply chemicals and mulches for better results.

Determine physical and chemical characteristics of new materials suitable for use as mulch in the establishment of vegetation and in the prevention of soil erosion.

Review erosion control data generated by the USDA Soil Conservation Service. Synthesize into guidelines for highway applications.

CATEGORY 6. PLANTING

Determine new soil amendments that may be used in conjunction with planting of trees and shrubs that will increase percent establishment.

Determine which grasses are most salt tolerant and adaptable to roadside use.

Determine what trees and shrubs are most salt tolerant and suitable for landscape purposes in areas where deicers are used.

Develop computerized plant selection program.

Determine feasibility of living snow fences.

Determine microclimate influences on highway vegetation.

Devise methods to be used in the systematic evaluation of new types of trees and shrubs.

Determine procedures to be followed for developing an adequate root zone environment for plants located in restricted locations.

Ascertain what new equipment and machinery may be used for planting of trees and shrubs that will result in speed up of the operation and decrease plant mortality.

Determine what are the specific growth characteristics that are most desirable for broadleaf ground covers to be used on roadside locations.

Analyze the specific growth characteristics that are most desirable for trees and shrubs to be used in roadside locations.

Ascertain if there is sufficient genetic variability within existing tree and shrub types to make a breeding and selection program feasible.

Evaluate the problems associated with propagation of woody ornamental plant material that may limit availibility of these plants.

Investigate problems associated with seed production of roadside type grasses that may limit availability of seed.

Determine what incentive is needed to make supply of seed and specific type of plant material more readily available.

Ascertain whether there is an adequate supply of grass seed and woody ornamental plant material for use in specific areas.

Analyze what plant types are suitable for establishment by seed or vegetative material under roadside conditions.

Study whether the coating of seed or vegetative material from other plants protect them prior to occurrence of favorable conditions for germination and/ or establishment.

Determine how seed or vegetative material from other plants can be applied to the soil for most effective establishment.

Evaluate what procedures are needed to encourage regeneration of plant materials.

Study what types of plants can be regenerated on a worked-over roadside.

Investigate what conditions make regeneration feasible and when re-establishment by seeding and planting is essential.

Analyze what selective chemical herbicides can be used to help control the re-establishment of specific vegetation during regeneration of roadside areas.

Determine how mulches should be applied to the soil surface and anchored for best results.

Ascertain what mulches may be used effectively to stabilize soils during turf establishment so that the slope is protected from erosion.

Develop a method for applying chemicals to the soil for best results during turf establishment.

Evaluate what chemicals may be used effectively to stabilize soils during turf establishment so that the slope is protected from erosion.

Determine whether soil test data, weather data, plant data and construction methods data can be correlated with the establishment of high quality plants.

Analyze how procedures may be scheduled so that seedbed preparation, seeding, fertilizing and mulching is feasible.

Investigate what equipment and machinery is best suited for seedbed preparation and seeding of roadside areas.

Study how a limited period for execution of construction and seeding operations can be made better use of by more intensive mechanical procedures.

Analyze how soils can be worked in preparation for seeding when wet or in otherwise poor physical condition.

Determine what machinery is best suited for working various types of subsoil into acceptable seedbed conditions.

Ascertain how subsoil can be modified physically and chemically so that it will function more like topsoil.

Evaluate what methods are most suitable for establishment of grass on various types of subsoil.

Determine what use can be made of new computer technology in analysis of soils, climatic and plant data for drawing up construction and maintenance specifications.

Evaluate what methods might be used in the systematic evaluation for new types of ground covers.

Study whether there is sufficient genetic variability within existing grass types to make a breeding and selection program feasible.

Determine what are the specific growth characteristics that are most desirable

for grasses to be used on roadside locations.

Analyze what methods might be used in the systematic evaluation of new types of ground covers.

Ascertain whether there is sufficient genetic variability within existing ground covers to make a breeding and selection program feasible.

Study what effect night lighting would have on growth of roadside vegetation.

Determine what uses may be made of various coatings for seed to improve conditions for establishing grasses and woody plants on roadside locations.

Evaluate what specific situations call for the use of sod in roadside turf establishment.

Analyze the best types of sod for roadside use.

Determine what cultural practices should be used for producing sod for roadside use.

Investigate practices of care during construction in establishing sod covers.

Study what methods of planting and establishment are most effective for vegetation used for dune stabilization.

Investigate if there is a use which might be made of helicopters in the construction and establishment of turf in specific situations where traffic on or adjacent to the roadside is undesirable.

Decide what influence change in roadside microclimate has on plants grown in these areas.

Determine what effect passing traffic has on the microclimate or roadside vegetation.

Evaluate whether different woody plants should be used on slopes with different exposures.

Analyze what effect roadside design has on water relationships to vegetation in the area.

Determine whether soil test data, weather data, plant data and maintenance practices data be correlated with quality plant production.

Determine if materials such as pine bark and other residues of forest operations or agricultural production are suitable for use in roadside construction (assuming ample quantity is available, unit cost is low and shipping expenses are reasonable).

Study whether materials such as processed garbage or composted leaves and other residue are suitable for use in roadside maintenance operations (assuming ample quantity is available, unit cost is low and shipping expenses are reasonable).

Ascertain whether industrial wastes such as slags and fly ash are suitable for use in roadside construction and maintenance operations (assuming ample quantity is available, unit cost is low and shipping expenses are reasonable).

Determine characteristics, application and desirability of various types of vegetation in different geographic locations.

CATEGORY 7. MAINTENANCE

Develop more efficient equipment for roadside construction and maintenance.

Determine maintenance practices that best promote renaturalization and climax growth cover on roadsides. Consider both chemical and mechanical vegetation control.

Determine the fertilizer requirements to benefit dry land grasses in arid and semi-arid states.

Develop optimum tree and shrub fertilization program for local conditions.

Determine and compare the maintenance costs and problems of the various construction types and qualities of rest area facilities.

Develop comprehensive rest area maintenance manual.

Evaluate major roadside grasses for durability and aesthetic quality when left unmowed.

Develop inert non-toxic salt substitute of equal or less cost. Non-chemical systems may be considered.

Prepare guidelines for the development of plant establishment and maintenance programs with cost estimates for consideration with each planting construction project designed.

Determine causes of low litter law enforcement, including the effect of high or low fines.

Determine the optimum designs, locations, and servicing requirements of litter deposits.

Investigate and illustrate examples of the relationships of grass and shrub heights and locations vs. snowdrift patterns.

Determine the problems and benefits of contract vs. state force roadside vegetation maintenance or control.

Evaluate roadway and structural design elements and prepare design guide illustrating the elements contributing to lower maintenance effort and cost without sacrificing the environmental qualities, including aesthetics.

Evaluate roadside maintenance practices affecting vegetation and relate these practices to roadside quality considering short and long term cost or savings.

Investigate the need for operating mowing and other equipment on steep slopes and develop methods to reduce or eliminate the damage caused by such equipment.

Determine the prominent features desired by surveying personnel involved in highway vegetation planting, establishment, control and maintenance. This equipment would include, but not be limited to: mowers, soil augers, applicators of mulch, water and agricultural chemicals, litter removal machinery, parking area oil stain removers and soil tillage equipment. Prepare findings for distribution to equipment industry.

Develop techniques and materials to achieve weed control by sterilizing base material under asphaltic concrete medians and shoulders.

Evaluate the value of helicopters for seeding and roadside maintenance uses.

Chemical research (other than fertilizer). 1. Coordinate existing information on chemical herbicides and growth regulators used in roadside maintenance into a field manual (including trans-location and residual effects). 2. Make plan and recommendations for further research. 3. Prepare listing of potential researchers in public agencies and private industry who may be interested in accomplishing the needed research.

Evaluate the drift hazards of the principle herbicides and develop uniform system to rate the drift potential of liquid chemical applicators.

Continue evaluation of the use of herbicides for use in special areas such as slopes, under guard-rail, paving joints, shoulders, etc.

Develop new concepts to reduce litter problems including, but not limited to, education, litter prevention and removal, and enforcement.

List, define, and evaluate the cost and other considerations necessary to make the best decision regarding the transplanting and utilization of existing trees or the establishment of new ones.

Evaluate the several types and components of sprinkler irrigation systems for durability and trouble-free maintenance.

Determine the impact of cutting height and frequency upon the clumping and encroachment of weeds for the major roadside grasses.

Determine how widespread is the problem of deicers on roadside vegetation.

Determine useful applications of aerial photography to roadside maintenance.

Determine if mechanized litter removal is feasible and economical.

Investigate ways in which growth control chemicals may be used to reduce infestation of weeds.

Evaluate how growth control chemicals may be used to reduce presence of seed heads on grasses.

Study how growth control chemicals may be used to increase hardiness of turf.

Ascertain what new growth control chemicals have potential for use on roadside locations.

Determine what new chemical herbicides have potential for use on roadside locations.

Study new equipment and machinery which may be used for application of herbicides with a reduction in drift.

Analyze granular formulations of herbicides to provide effective weed control on roadsides.

Study some of the newer chemicals to provide more effective control of some of the hard-to-kill weeds.

Study and evaluate what equipment and machinery is needed for routine year to year renovation of turf killed out by unfavorable summer or winter growth conditions.

Determine how plants used on roadside locations can be made more fire resistant.

Investigate what chemicals may be used to protect woody vegetation from winter desiccation.

Evaluate injury to turf caused by deicers to determine its economic importance.

Ascertain if injury to trees and shrubs by deicers is of economic importance.

Analyze contamination of underground water sources by the use of deicers and its importance in lowering water quality.

Determine how mechanization can assist in reducing maintenance costs.

Develop procedures which can be followed that will maintain grass uniformity and allow a reduction in the frequency of mowing.

Determine how growth control chemicals may be used to reduce frequency of mowing.

Devise means that can be used to cut down on litter deposits on highways and roadsides.

Evaluate highway design features - such as irregular or narrow turf areas, steep slopes, inaccessible areas, etc. - to permit mechanization of maintenance activities such as mowing, cleaning and painting. The use of hand labor is costly and often dangerous.

Develop guidelines for reducing maintenance costs since slope erosion, mowing 2/1 slopes, ditch cleaning and other roadside maintenance activities are increasingly costly on wide rights-of-way yet interest in aesthetics makes good maintenance mandatory.

Develop guidelines for maintenance operations and services to improve public relations and win public support of the highway program.

CATEGORY 8. ORGANIZATION AND ADMINISTRATION

Study guidelines and methods for establishing highway advertising rights.

Determine an effective method of administrative responsibility for urban highway extensions, so that those affected by the consequences of highway improvement are considered.

Ascertain how educational training in the fields of landscape architecture, ornamental horticulture and agronomy can be promoted within state and federal highway safety-beautification engineering centers.

Study the capability of highway and other public agencies to establish and administer corridor area land use controls and exploration of the range of authority to achieve desired scenic corridor development.

Investigate what methods can best be used to improve communication between landscape architects, ornamental horticulturists and agronomists, and highway engineers.

Evaluate the benefits of having the landscape architect available through all stages of site acquisition and planning.

Ascertain procedures to be followed to reduce vandalism and increase respect of highway users for the scenic value of the area through which they travel.

Determine what type projects are suitable for garden clubs and civic groups who desire to assist in roadside beautification.

Analyze what labor sources are available and sufficiently well qualified for use in specific roadside maintenance operations.

Investigate how clean-up, paint-up campaigns can be carried out along major highways and community streets.

Evaluate the capability of highway and other public agencies to establish and administer corridor area land use controls and exploration of the range of authority to achieve desired scenic corridor development.

Determine which highway location presentation method is best for highway administrators relative to the public.

Study the best application of aerial photography to roadside construction.

Establish optimum roadside organization within a highway department.

Determine training aids needed for roadside development methods personnel.

Analyze needs and prepare a program of training roadside construction inspectors.

Establish best means of disseminating roadside information to highway constructors.

Prepare roadside development training aids program or seminars, etc.

Determine manpower needs for rest area maintenance.

CATEGORY 9. APPENDIX

Determine techniques of land use control along highways, taking into account the costs, effectiveness and public acceptance of land use guidance measures.

Determine achievement of control of unsightly junkyards and vehicle graveyards by legislation.

Study sovereign powers of the state as they apply to lands and land use in roadside areas around expressway interchanges.

Study control of esthetics along highway right-of-way under police power.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Highway Research Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

Rep. No. *Title*

—* A Critical Review of Literature Treating Methods of Identifying Aggregates Subject to Destructive Volume Change When Frozen in Concrete and a Proposed Program of Research—Intermediate Report (Proj. 4-3(2)), 81 p., $1.80

1 Evaluation of Methods of Replacement of Deteriorated Concrete in Structures (Proj. 6-8), 56 p., $2.80

2 An Introduction to Guidelines for Satellite Studies of Pavement Performance (Proj. 1-1), 19 p., $1.80

2A Guidelines for Satellite Studies of Pavement Performance, 85 p.+9 figs., 26 tables, 4 app., $3.00

3 Improved Criteria for Traffic Signals at Individual Intersections—Interim Report (Proj. 3-5), 36 p., $1.60

4 Non-Chemical Methods of Snow and Ice Control on Highway Structures (Proj. 6-2), 74 p., $3.20

5 Effects of Different Methods of Stockpiling Aggregates—Interim Report (Proj. 10-3), 48 p., $2.00

6 Means of Locating and Communicating with Disabled Vehicles—Interim Report (Proj. 3-4), 56 p. $3.20

7 Comparison of Different Methods of Measuring Pavement Condition—Interim Report (Proj. 1-2), 29 p., $1.80

8 Synthetic Aggregates for Highway Construction (Proj. 4-4), 13 p., $1.00

9 Traffic Surveillance and Means of Communicating with Drivers—Interim Report (Proj. 3-2), 28 p., $1.60

10 Theoretical Analysis of Structural Behavior of Road Test Flexible Pavements (Proj. 1-4), 31 p., $2.80

11 Effect of Control Devices on Traffic Operations—Interim Report (Proj. 3-6), 107 p., $5.80

12 Identification of Aggregates Causing Poor Concrete Performance When Frozen—Interim Report (Proj. 4-3(1)), 47 p., $3.00

13 Running Cost of Motor Vehicles as Affected by Highway Design—Interim Report (Proj. 2-5), 43 p., $2.80

14 Density and Moisture Content Measurements by Nuclear Methods—Interim Report (Proj. 10-5), 32 p., $3.00

15 Identification of Concrete Aggregates Exhibiting Frost Susceptibility—Interim Report (Proj. 4-3(2)), 66 p., $4.00

16 Protective Coatings to Prevent Deterioration of Concrete by Deicing Chemicals (Proj. 6-3), 21 p., $1.60

17 Development of Guidelines for Practical and Realistic Construction Specifications (Proj. 10-1), 109 p., $6.00

18 Community Consequences of Highway Improvement (Proj. 2-2), 37 p., $2.80

19 Economical and Effective Deicing Agents for Use on Highway Structures (Proj. 6-1), 19 p., $1.20

* Highway Research Board Special Report 80.

Rep. No. *Title*

20 Economic Study of Roadway Lighting (Proj. 5-4), 77 p., $3.20

21 Detecting Variations in Load-Carrying Capacity of Flexible Pavements (Proj. 1-5), 30 p., $1.40

22 Factors Influencing Flexible Pavement Performance (Proj. 1-3(2)), 69 p., $2.60

23 Methods for Reducing Corrosion of Reinforcing Steel (Proj. 6-4), 22 p., $1.40

24 Urban Travel Patterns for Airports, Shopping Centers, and Industrial Plants (Proj. 7-1), 116 p., $5.20

25 Potential Uses of Sonic and Ultrasonic Devices in Highway Construction (Proj. 10-7), 48 p., $2.00

26 Development of Uniform Procedures for Establishing Construction Equipment Rental Rates (Proj. 13-1), 33 p., $1.60

27 Physical Factors Influencing Resistance of Concrete to Deicing Agents (Proj. 6-5), 41 p., $2.00

28 Surveillance Methods and Ways and Means of Communicating with Drivers (Proj. 3-2), 66 p., $2.60

29 Digital-Computer-Controlled Traffic Signal System for a Small City (Proj. 3-2), 82 p., $4.00

30 Extension of AASHO Road Test Performance Concepts (Proj. 1-4(2)), 33 p., $1.60

31 A Review of Transportation Aspects of Land-Use Control (Proj. 8-5), 41 p., $2.00

32 Improved Criteria for Traffic Signals at Individual Intersections (Proj. 3-5), 134 p., $5.00

33 Values of Time Savings of Commercial Vehicles (Proj. 2-4), 74 p., $3.60

34 Evaluation of Construction Control Procedures—Interim Report (Proj. 10-2), 117 p., $5.00

35 Prediction of Flexible Pavement Deflections from Laboratory Repeated-Load Tests (Proj. 1-3(3)), 117 p., $5.00

36 Highway Guardrails—A Review of Current Practice (Proj. 15-1), 33 p., $1.60

37 Tentative Skid-Resistance Requirements for Main Rural Highways (Proj. 1-7), 80 p., $3.60

38 Evaluation of Pavement Joint and Crack Sealing Materials and Practices (Proj. 9-3), 40 p., $2.00

39 Factors Involved in the Design of Asphaltic Pavement Surfaces (Proj. 1-8), 112 p., $5.00

40 Means of Locating Disabled or Stopped Vehicles (Proj. 3-4(1)), 40 p., $2.00

41 Effect of Control Devices on Traffic Operations (Proj. 3-6), 83 p., $3.60

42 Interstate Highway Maintenance Requirements and Unit Maintenance Expenditure Index (Proj. 14-1), 144 p., $5.60

43 Density and Moisture Content Measurements by Nuclear Methods (Proj. 10-5), 38 p., $2.00

44 Traffic Attraction of Rural Outdoor Recreational Areas (Proj. 7-2), 28 p., $1.40

45 Development of Improved Pavement Marking Materials—Laboratory Phase (Proj. 5-5), 24 p., $1.40

46 Effects of Different Methods of Stockpiling and Handling Aggregates (Proj. 10-3), 102 p., $4.60

47 Accident Rates as Related to Design Elements of Rural Highways (Proj. 2-3), 173 p., $6.40

48 Factors and Trends in Trip Lengths (Proj. 7-4), 70 p., $3.20

49 National Survey of Transportation Attitudes and Behavior—Phase I Summary Report (Proj. 20-4), 71 p., $3.20

Rep. No.	Title
50	Factors Influencing Safety at Highway-Rail Grade Crossings (Proj. 3-8), 113 p., $5.20
51	Sensing and Communication Between Vehicles (Proj. 3-3), 105 p., $5.00
52	Measurement of Pavement Thickness by Rapid and Nondestructive Methods (Proj. 10-6), 82 p., $3.80
53	Multiple Use of Lands Within Highway Rights-of-Way (Proj. 7-6), 68 p., $3.20
54	Location, Selection, and Maintenance of Highway Guardrails and Median Barriers (Proj. 15-1(2)), 63 p., $2.60
55	Research Needs in Highway Transportation (Proj. 20-2), 66 p., $2.80
56	Scenic Easements—Legal, Administrative, and Valuation Problems and Procedures (Proj. 11-3), 174 p., $6.40
57	Factors Influencing Modal Trip Assignment (Proj. 8-2), 78 p., $3.20
58	Comparative Analysis of Traffic Assignment Techniques with Actual Highway Use (Proj. 7-5), 85 p., $3.60
59	Standard Measurements for Satellite Road Test Program (Proj. 1-6), 78 p., $3.20
60	Effects of Illumination on Operating Characteristics of Freeways (Proj. 5-2) 148 p., $6.00
61	Evaluation of Studded Tires—Performance Data and Pavement Wear Measurement (Proj. 1-9), 66 p., $3.00
62	Urban Travel Patterns for Hospitals, Universities, Office Buildings, and Capitols (Proj. 7-1), 144 p., $5.60
63	Economics of Design Standards for Low-Volume Rural Roads (Proj. 2-6), 93 p., $4.00
64	Motorists' Needs and Services on Interstate Highways (Proj. 7-7), 88 p., $3.60
65	One-Cycle Slow-Freeze Test for Evaluating Aggregate Performance in Frozen Concrete (Proj. 4-3(1)), 21 p., $1.40
66	Identification of Frost-Susceptible Particles in Concrete Aggregates (Proj. 4-3(2)), 62 p., $2.80
67	Relation of Asphalt Rheological Properties to Pavement Durability (Proj. 9-1), 45 p., $2.20
68	Application of Vehicle Operating Characteristics to Geometric Design and Traffic Operations (Proj. 3-10), 38 p., $2.00
69	Evaluation of Construction Control Procedures—Aggregate Gradation Variations and Effects (Proj. 10-2A), 58 p., $2.80
70	Social and Economic Factors Affecting Intercity Travel (Proj. 8-1), 68 p., $3.00
71	Analytical Study of Weighing Methods for Highway Vehicles in Motion (Proj. 7-3), 63 p., $2.80
72	Theory and Practice in Inverse Condemnation for Five Representative States (Proj. 11-2), 44 p., $2.20
73	Improved Criteria for Traffic Signal Systems on Urban Arterials (Proj. 3-5/1), 55 p., $2.80
74	Protective Coatings for Highway Structural Steel (Proj. 4-6), 64 p., $2.80
74A	Protective Coatings for Highway Structural Steel—Literature Survey (Proj. 4-6), 275 p., $8.00
74B	Protective Coatings for Highway Structural Steel—Current Highway Practices (Proj. 4-6), 102 p., $4.00
75	Effect of Highway Landscape Development on Nearby Property (Proj. 2-9), 82 p., $3.60
76	Detecting Seasonal Changes in Load-Carrying Capabilities of Flexible Pavements (Proj. 1-5(2)), 37 p., $2.00
77	Development of Design Criteria for Safer Luminaire Supports (Proj. 15-6), 82 p., $3.80
78	Highway Noise—Measurement, Simulation, and Mixed Reactions (Proj. 3-7), 78 p., $3.20
79	Development of Improved Methods for Reduction of Traffic Accidents (Proj. 17-1), 163 p., $6.40
80	Oversize-Overweight Permit Operation on State Highways (Proj. 2-10), 120 p., $5.20
81	Moving Behavior and Residential Choice—A National Survey (Proj. 8-6), 129 p., $5.60
82	National Survey of Transportation Attitudes and Behavior—Phase II Analysis Report (Proj. 20-4), 89 p., $4.00
83	Distribution of Wheel Loads on Highway Bridges (Proj. 12-2), 56 p., $2.80
84	Analysis and Projection of Research on Traffic Surveillance, Communication, and Control (Proj. 3-9), 48 p., $2.40
85	Development of Formed-in-Place Wet Reflective Markers (Proj. 5-5), 28 p., $1.80
86	Tentative Service Requirements for Bridge Rail Systems (Proj. 12-8), 62 p., $3.20
87	Rules of Discovery and Disclosure in Highway Condemnation Proceedings (Proj. 11-1(5)), 28 p., $2.00
88	Recognition of Benefits to Remainder Property in Highway Valuation Cases (Proj. 11-1(2)), 24 p., $2.00
89	Factors, Trends, and Guidelines Related to Trip Length (Proj. 7-4), 59 p., $3.20
90	Protection of Steel in Prestressed Concrete Bridges (Proj. 12-5), 86 p., $4.00
91	Effects of Deicing Salts on Water Quality and Biota—Literature Review and Recommended Research (Proj. 16-1), 70 p., $3.20
92	Valuation and Condemnation of Special Purpose Properties (Proj. 11-1(6)), 47 p., $2.60
93	Guidelines for Medial and Marginal Access Control on Major Roadways (Proj. 3-13), 147 p., $6.20
94	Valuation and Condemnation Problems Involving Trade Fixtures (Proj. 11-1(9)), 22 p., $1.80
95	Highway Fog (Proj. 5-6), 48 p., $2.40
96	Strategies for the Evaluation of Alternative Transportation Plans (Proj. 8-4), 111 p., $5.40
97	Analysis of Structural Behavior of AASHO Road Test Rigid Pavements (Proj. 1-4(1)A), 35 p., $2.60
98	Tests for Evaluating Degradation of Base Course Aggregates (Proj. 4-2), 98 p. $5.00
99	Visual Requirements in Night Driving (Proj. 5-3), 38 p., $2.60
100	Research Needs Relating to Performance of Aggregates in Highway Construction (Proj. 4-8), 68 p., $3.40
101	Effect of Stress on Freeze-Thaw Durability of Concrete Bridge Decks (Proj. 6-9), 70 p., $3.60
102	Effect of Weldments on the Fatigue Strength of Steel Beams (Proj. 12-7), 114 p., $5.40
103	Rapid Test Methods for Field Control of Highway Construction (Proj. 10-4), 89 p., $5.00
104	Rules of Compensability and Valuation Evidence for Highway Land Acquisition (Proj. 11-1), 77 p., $4.40

Rep. No. Title

105 Dynamic Pavement Loads of Heavy Highway Vehicles (Proj. 15-5), 94 p., $5.00
106 Revibration of Retarded Concrete for Continuous Bridge Decks (Proj. 18-1), 67 p., $3.40
107 New Approaches to Compensation for Residential Takings (Proj. 11-1(10)), 27 p., $2.40
108 Tentative Design Procedure for Riprap-Lined Channels (Proj. 15-2), 75 p., $4.00
109 Elastomeric Bearing Research (Proj. 12-9), 53 p., $3.00
110 Optimizing Street Operations Through Traffic Regulations and Control (Proj. 3-11), 100 p., $4.40
111 Running Costs of Motor Vehicles as Affected by Road Design and Traffic (Proj. 2-5a and 2-7), 97 p., $5.20
112 Junkyard Valuation—Salvage Industry Appraisal Principles Applicable to Highway Beautification (Proj. 11-3(2)), 41 p., $2.60
113 Optimizing Flow on Existing Street Networks (Proj. 3-14), 414 p., $15.60
114 Effects of Proposed Highway Improvements on Property Values (Proj. 11-1(1)), 42 p., $2.60
115 Guardrail Performance and Design (Proj. 15-1(2)), 70 p., $3.60
116 Structural Analysis and Design of Pipe Culverts (Proj. 15-3), 155 p., $6.40
117 Highway Noise—A Design Guide for Highway Engineers (Proj. 3-7), 79 p., $4.60
118 Location, Selection, and Maintenance of Highway Traffic Barriers (Proj. 15-1(2)), 96 p., $5.20
119 Control of Highway Advertising Signs—Some Legal Problems (Proj. 11-3(1)), 72 p., $3.60
120 Data Requirements for Metropolitan Transportation Planning (Proj. 8-7), 90 p., $4.80
121 Protection of Highway Utility (Proj. 8-5), 115 p., $5.60
122 Summary and Evaluation of Economic Consequences of Highway Improvements (Proj. 2-11), 324 p., $13.60
123 Development of Information Requirements and Transmission Techniques for Highway Users (Proj. 3-12) 239 p., $9.60
124 Improved Criteria for Traffic Signal Systems in Urban Networks (Proj. 3-5) 86 p., $4.80
125 Optimization of Density and Moisture Content Measurements by Nuclear Methods (Proj. 10-5A), 86 p., $4.40
126 Divergencies in Right-of-Way Valuation (Proj. 11-4), 57 p., $3.00
127 Snow Removal and Ice Control Techniques at Interchanges (Proj. 6-10), 90 p., $5.20
128 Evaluation of AASHO Interim Guides for Design of Pavement Structures (Proj. 1-11), 111 p., $5.60
129 Guardrail Crash Test Evaluation—New Concepts and End Designs (Proj. 15-1(2)), 89 p., $4.80
130 Roadway Delineation Systems (Proj. 5-7), 349 p., $14.00
131 Performance Budgeting System for Highway Maintenance Management (Proj. 19-2(4)), 213 p., $8.40
132 Relationships Between Physiographic Units and Highway Design Factors (Proj. 1-3(1)), 161 p., $7.20

Rep. No. Title

133 Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects (Proj. 7-8), 127 p., $5.60
134 Damages Due to Drainage, Runoff, Blasting, and Slides (Proj. 11-1(8)), 24 p., $2.80
135 Promising Replacements for Conventional Aggregates for Highway Use (Proj. 4-10), 53 p., $3.60
136 Estimating Peak Runoff Rates from Ungaged Small Rural Watersheds (Proj. 15-4), 85 p., $4.60
137 Roadside Development—Evaluation of Research (Proj. 16-2), 78 p., $4.20

Synthesis of Highway Practice

No. Title

1 Traffic Control for Freeway Maintenance (Proj. 20-5, Topic 1), 47 p., $2.20
2 Bridge Approach Design and Construction Practices (Proj. 20-5, Topic 2), 30 p., $2.00
3 Traffic-Safe and Hydraulically Efficient Drainage Practice (Proj. 20-5, Topic 4), 38 p., $2.20
4 Concrete Bridge Deck Durability (Proj. 20-5, Topic 3), 28 p., $2.20
5 Scour at Bridge Waterways (Proj. 20-5, Topic 5), 37 p., $2.40
6 Principles of Project Scheduling and Monitoring (Proj. 20-5, Topic 6), 43 p., $2.40
7 Motorist Aid Systems (Proj. 20-5, Topic 3-01), 28 p., $2.40
8 Construction of Embankments (Proj. 20-5, Topic 9), 38 p., $2.40
9 Pavement Rehabilitation—Materials and Techniques (Proj. 20-5, Topic 8), 41 p., $2.80
10 Recruiting, Training, and Retaining Maintenance and Equipment Personnel (Proj. 20-5, Topic 10), 35 p., $2.80
11 Development of Management Capability (Proj. 20-5, Topic 12), 50 p., $3.20
12 Telecommunications Systems for Highway Administration and Operations (Proj. 20-5, Topic 3-03), 29 p., $2.80
13 Radio Spectrum Frequency Management (Proj. 20-5, Topic 3-03), 32 p., $2.80
14 Skid Resistance (Proj. 20-5, Topic 7), 66 p., $4.00
15 Statewide Transportation Planning—Needs and Requirements (Proj. 20-5, Topic 3-02), 41 p., $3.60

THE NATIONAL ACADEMY OF SCIENCES is a private, honorary organization of more than 700 scientists and engineers elected on the basis of outstanding contributions to knowledge. Established by a Congressional Act of Incorporation signed by President Abraham Lincoln on March 3, 1863, and supported by private and public funds, the Academy works to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance.

Under the terms of its Congressional charter, the Academy is also called upon to act as an official—yet independent—adviser to the Federal Government in any matter of science and technology. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date the Council of the National Academy of Sciences, under the authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

THE NATIONAL RESEARCH COUNCIL was organized as an agency of the National Academy of Sciences in 1916, at the request of President Wilson, to enable the broad community of U. S. scientists and engineers to associate their efforts with the limited membership of the Academy in service to science and the nation. Its members, who receive their appointments from the President of the National Academy of Sciences, are drawn from academic, industrial and government organizations throughout the country. The National Research Council serves both Academies in the discharge of their responsibilities.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

THE DIVISION OF ENGINEERING is one of the eight major Divisions into which the National Research Council is organized for the conduct of its work. Its membership includes representatives of the nation's leading technical societies as well as a number of members-at-large. Its Chairman is appointed by the Council of the Academy of Sciences upon nomination by the Council of the Academy of Engineering.

THE HIGHWAY RESEARCH BOARD, organized November 11, 1920, as an agency of the Division of Engineering, is a cooperative organization of the highway technologists of America operating under the auspices of the National Research Council and with the support of the several highway departments, the Federal Highway Administration, and many other organizations interested in the development of transportation. The purpose of the Board is to advance knowledge concerning the nature and performance of transportation systems, through the stimulation of research and dissemination of information derived therefrom.

HIGHWAY RESEARCH BOARD
NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue Washington, D. C. 20418

ADDRESS CORRECTION REQUESTED

NON-PROFIT ORG.
U.S. POSTAGE
PAID
WASHINGTON, D.C.
PERMIT NO. 42970

000015
TRAFFIC ENGR

IDAHO DEPT OF HIGHWAYS
P O BOX 7129
BOISE ID 83707