Chapter 1

Factors Affecting Selection of the Highway Route

In this chapter, we briefly review some of the main factors affecting selection of the route that can be discerned from available maps, photographs, and other sources. The basic philosophy underlying the relationship between costs and design levels is described to provide some perspective on the appropriateness of specific routes.

A major determinant of the route in a system-wide context is the estimated traffic volume. However, this and highway systems planning in general are beyond the scope of this book. Therefore, the discussions assume that the traffic volumes, vehicle classification, and end points of the proposed highway have been decided as part of a system-wide plan.

EXAMINATION OF NATURAL AND MAN-MADE FEATURES

Selection of a possible route for a proposed highway is -- apart from traffic considerations -- determined largely by relating topographic features, human habitation, and environmental features of the area under consideration to geometric design controls. Therefore, before starting the route selection process, a review of the area's major topographic and other features likely to affect the route selection is needed. Several sources of information are available to assist the review. They include:

1. Topographic Maps. Usually the maps of the United States Geological Survey (USGS) at a scale of 1:25,000 and a contour interval of 3 m provide the minimum required detail for preliminary route selection. Larger scale maps may also be used if available.

2. Aerial Photographs. The two main types of aerial photographs employed in route design are stereographic and oblique. Stereographic photographs, usually at the same scale as the topographic maps, may assist in determining important geological, ecological, and cultural information. Also, with the assistance of appropriate measuring devices, they form the basis for automated route selection and design, including the use of computer-aided methods. Oblique aerial photographs may be used to supplement the stereophotographs.

3. Geological and Soil Maps. These are available through the USGS, the U.S. Soil Conservation Service, or through state agencies, and may provide useful information, particularly concerning pavement design, although more detailed information is usually necessary for preliminary design.

4. Ground Surveys. Reconnaissance or more detailed surveys should be made of the area, especially if the terrain is rugged or if additional details are required. As early as possible in the process, the design engineer should "walk the route," but practicalities may preclude this procedure early in the project.

In this book, we will rely primarily upon the information that can be obtained from USGS topographic maps; in practice, the designer may use a combination of several sources of information. The items used and the major steps in the review may typically include the following:

Topographic Maps -- Examine the terrain in general between the start and end points of the proposed route and make note of the following information, usually available from a topographic and geological maps. Typical kinds of information shown on most topographic maps are illustrated in the Appendices. An inspection of the maps should include the following steps:

1. Identify unsuitable ground conditions such as wetlands, rock outcrops, areas subject to flash floods or avalanche, and other features of an obviously difficult terrain for highway construction.

2. Examine the contour lines to obtain an initial estimate of the gradients that exist on undulating or mountainous parts of the potential route. The steepness of the terrain may be approximately determined by observing the number of contour lines and their vertical interval along a horizontal distance located at right angles to them. Slopes steeper than, say, approximately 10%, may be delineated on the map.

3. Define streams, rivers, ravines, or other topographic features that indicate the possible need for bridges or other extensive ancillary works to the highway itself.

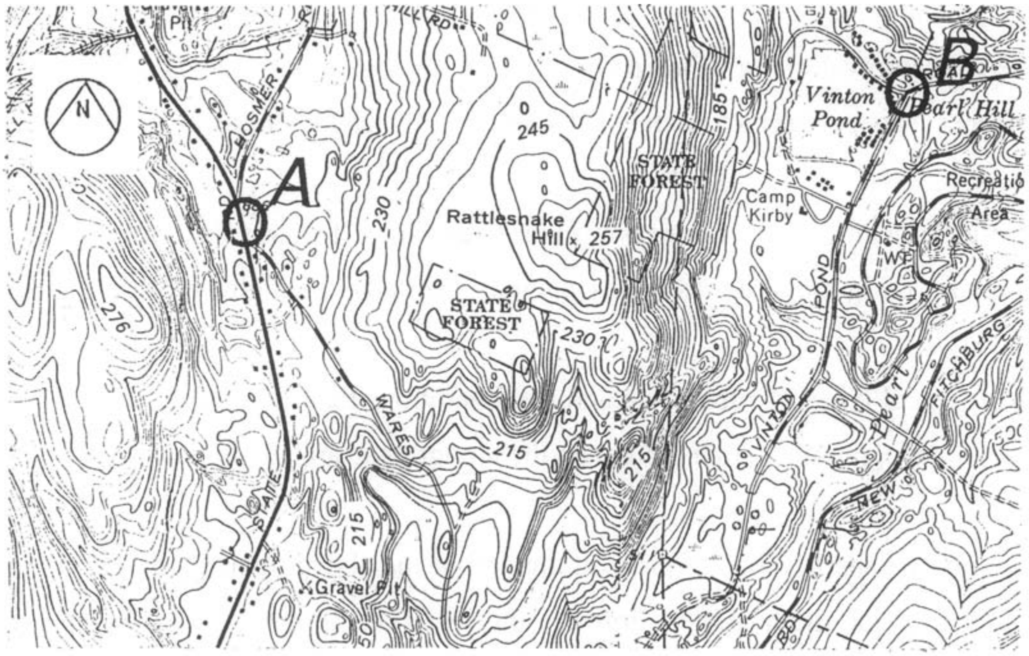
4. List typical types of subsurface and soil conditions that may be expected, as indicated by the topographic features found on the topographic and geological map.

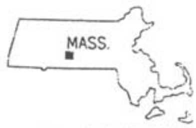
5. Summarize the findings of the examination of the above items on maps or overlays in order to guide the next steps in the route selection. Items 1 through 4 are described graphically in Figures 1-1 through 1-3 where, as an example, the route of a highway connecting points A and B is being considered.

Other features that may be identified at this time, and that may be directly related to the effectiveness of the route, include consideration of sunlight availability to reduce the effects of snow and ice accumulations, avoidance of possible avalanche areas, and the effects of the route on habitation and other cultural activities such as schools and community centers. The physical characteristics defined by these considerations can significantly affect the alignment of the route and its ultimate benefits to local and wider communities.

Aerial Photography -- The next step is to examine available aerial and other photography, when available, to confirm or modify the information on the map. The following procedure is usually appropriate:

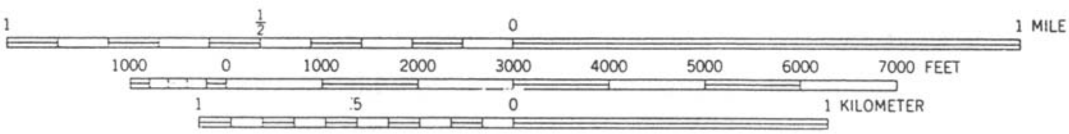
Examine the stereoscopic aerial photographs to determine whether topographic and cultural features are different from those shown on the map. Document any changes on an overlay so this may be recorded on the map. The type of features found might include human activity, swamp or marsh areas that no longer exist, or areas that may be sensitive





QUADRANGLE LOCATION

Scale: 1:25000



Contour interval 3 m

End points of proposed highway, A ◯ B ◯

FIGURE 1-1

SELECTED AREA OF INTEREST

Source: Overlay of Figure 1-1

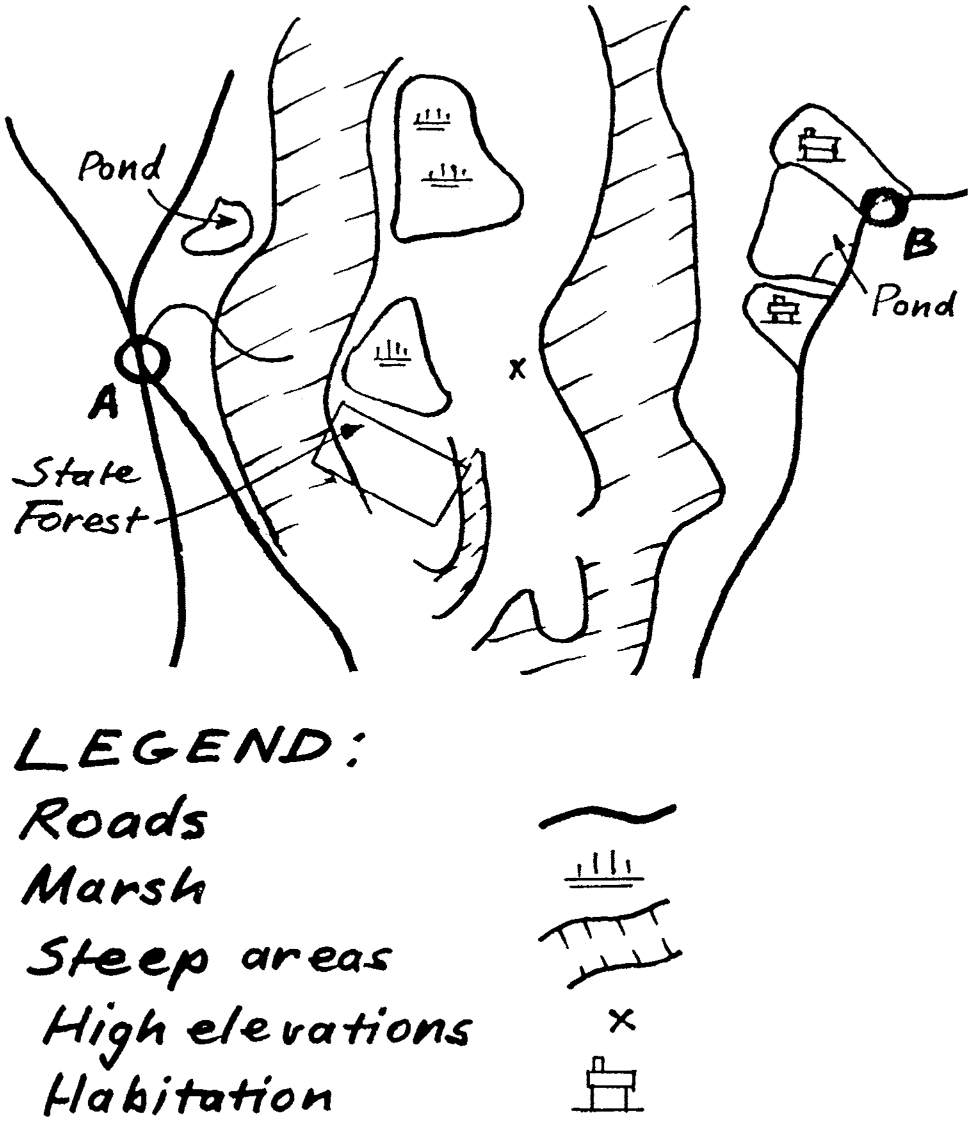


FIGURE 1-2

EXAMPLES OF TOPOGRAPHIC AND CULTURAL FEATURES

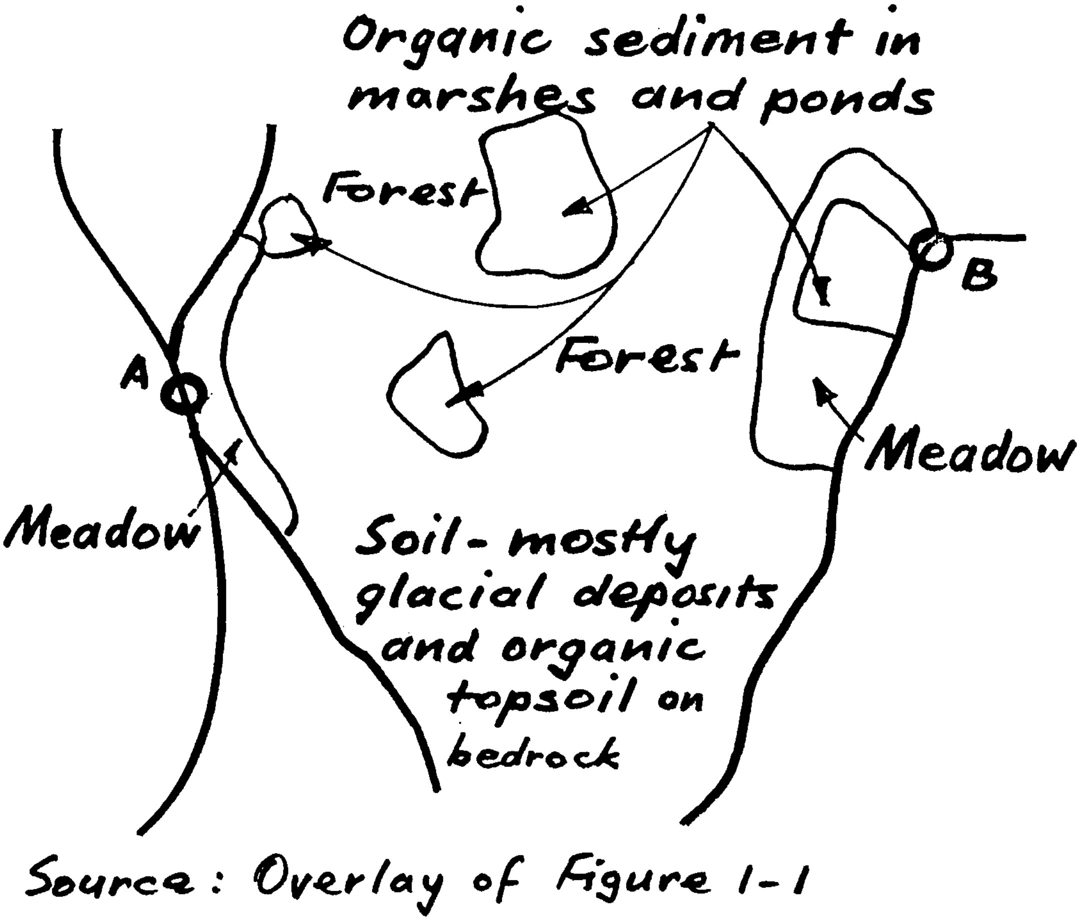


FIGURE 1-3

EXAMPLES OF SOIL AND VEGETATION FEATURES

due to presence of wildlife or other ecological factors. In addition, conditions potentially hazardous to a highway such as avalanches, mudslides, or flooding may be evident. Aerial photography can provide excellent indications of anticipated ground conditions. Examples of the stereoscopic photographs are presented in Figure 1-4.

Examine the oblique photographs to obtain a sense of the developmental and esthetic features of the area and a general idea of the grades and other topographic characteristics. These, of course, should be cross-checked with those on the map to ensure correspondence. Figure 1-5 provides several oblique photographs of the project area.

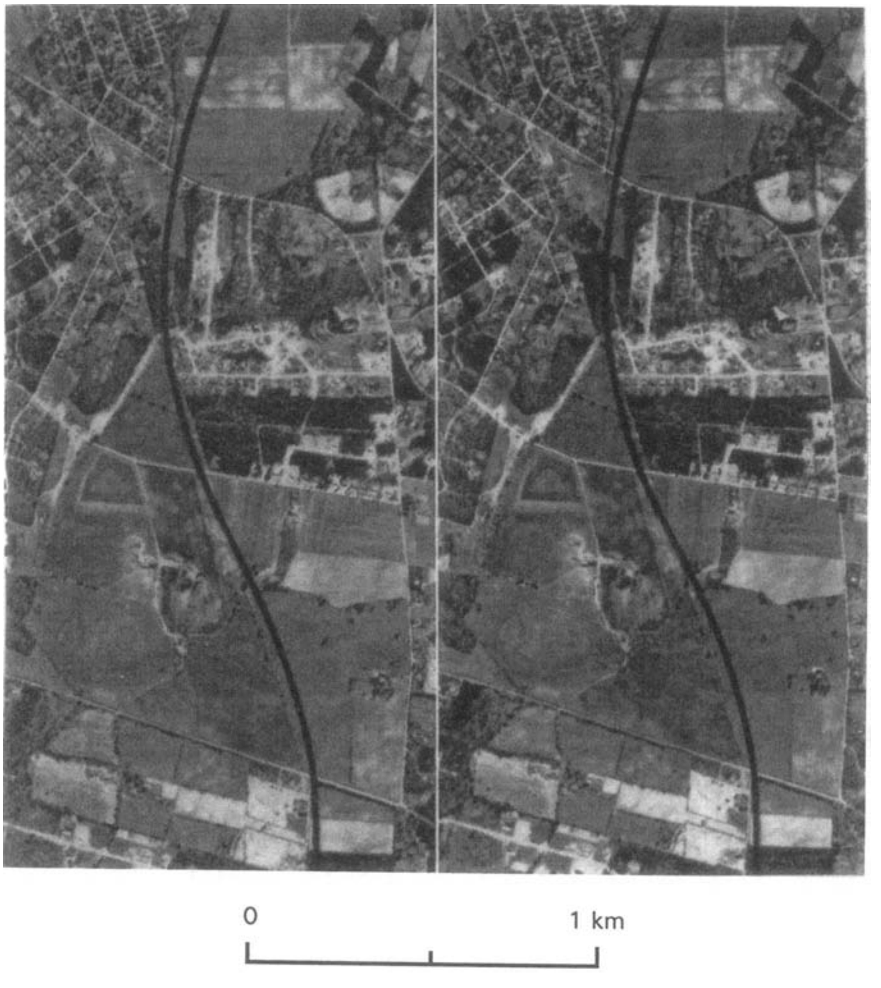
Note in particular the presence of trees that may make identification of the ground surface features difficult on the aerial photographs.

In addition to the above considerations, make note of local features which may be environmentally sensitive to the presence of a proposed highway. Guidelines for identifying these features and mitigating the effects of potential highways on the environment are described in several documents listed in the bibliography.

IDENTIFICATION OF TECHNICALLY FEASIBLE ROUTES

The guiding principle in designing a possible route is to improve the transportation between specified points. Within the economic and social framework that typically applies, the term "improve" may be broadly interpreted as "to make less expensive and safer for the public in general as well as for the highway's users, while at the same time maintaining or contributing to the improvement of environmental quality." Furthermore, the route should be "technically feasible" in that no excessive construction or maintenance problems are envisaged, and such that the design controls and policy on geometric design of the highway agency having jurisdiction are adhered to. In this book, the policies of the American Association of State Highway and Transportation Officials (AASHTO) are generally used.

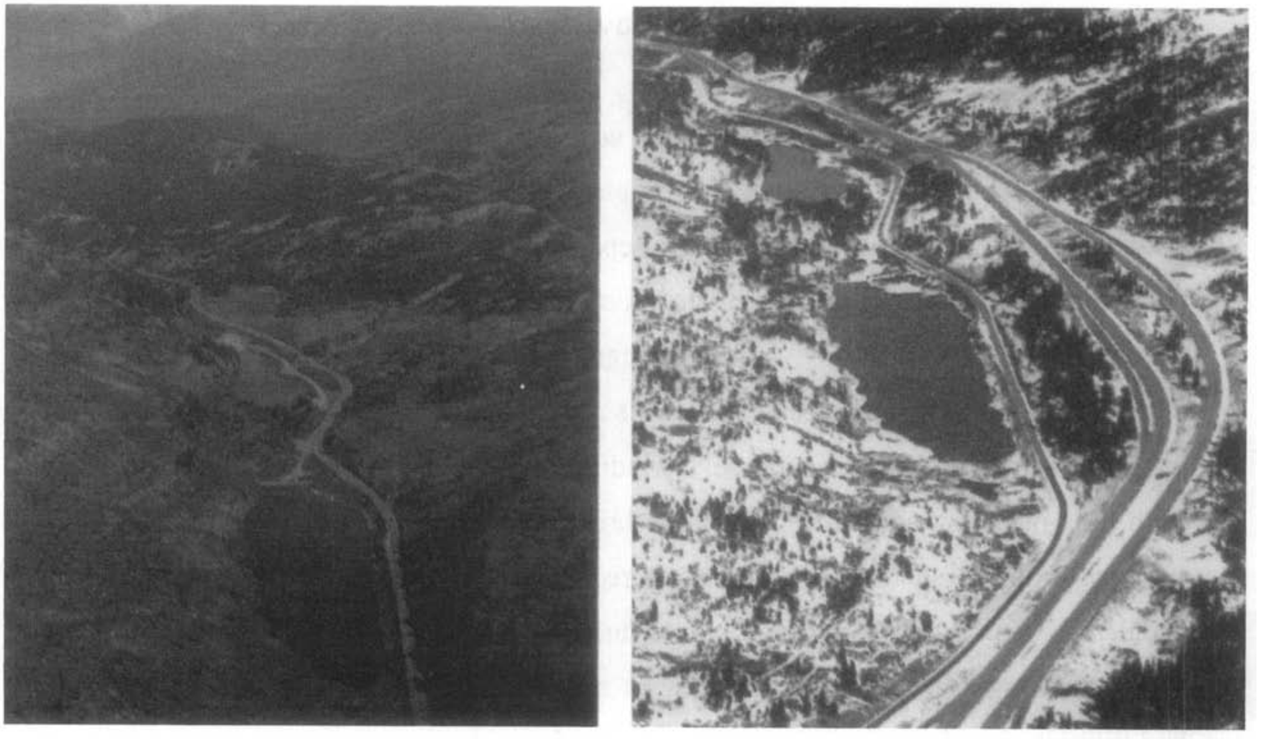
A highway improvement may be an upgraded existing highway or a completely new route and should always be considered as a component of the overall transportation system.



Source: Belcher, Donald J. "Photo Interpretation in Engineering." Manual of Photographic Interpretation. Ed. Robert N. Colwell. Washington, DC: American Society of Photogrammetry, 1960. page 425.

FIGURE 1-4

EXAMPLES OF STEREOGRAPHIC AERIAL PHOTOGRAPHS



Source: Federal Highway Administration, "I-70 In a Mountain Environment" Report No. FHWA-TS-78-208, Washington. D.C., 1978.

FIGURE 1-5

EXAMPLES OF OBLIQUE AERIAL PHOTOGRAPHS

OBJECTIVES IN IDENTIFYING ACCEPTABLE ROUTES

In defining a broadly acceptable route, therefore, the approach typically involves compromising between the user costs and construction costs while seeking the route and physical conditions that result in the least adverse environmental impact.

How is a balance struck between user costs and construction costs? A rather extreme example may be used to illustrate this problem: suppose the objective is to define a route between two points on existing highways separated by mountainous terrain. The least cost route for vehicle users on a "per vehicle kilometer" basis would clearly be a horizontal and vertical alignment permitting a high design speed (long sight distances, large radius curves, etc.) route with bridges and tunnels and extensive cuts and fills to overcome the rugged terrain. At the other extreme, a winding road following the contours of the terrain, with little or no cut and fill sections, few bridges, and no tunnels, would result in higher user costs due to sharp curves, resultant reductions in speed, and greater likelihood of accidents. However, such a road would undoubtedly cost less to build, even if it were somewhat longer than the first, because of the reduced amount of expensive excavation and filling and construction of bridges and tunnels.

In a more formalized way, as developed by the World Bank, the Highway Design and Maintenance Model states that (in selecting a particular highway) " ...the basic task is to predict total life-cycle costs – construction, maintenance, and road user costs – as a function of the road design, maintenance standards and other policy options which may be considered", and adds that a broader definition of societal costs would include such examples as air pollution as it affects non-road-users.

For any given volume of traffic, the relationship between the user cost, construction cost, and total cost can be shown conceptually, as in Figure 1-6. The lower the design standards, the lower the construction costs (because of the reduced need for cut, fill, bridges, and tunnels). Conversely, the travel cost to users increases due to the reduced speed and increased travel time, and the increased likelihood of accidents due to the lower geometric design standards. Examples of higher and lower geometric design standards

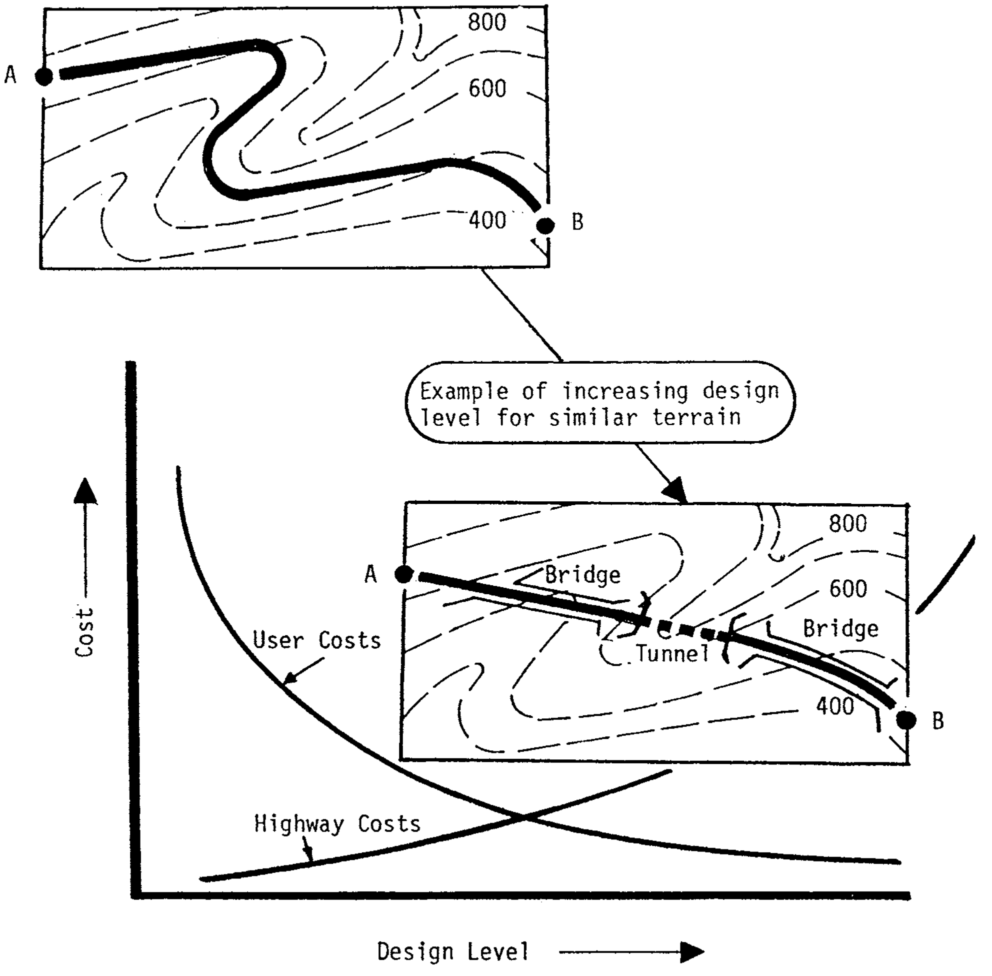


FIGURE 1-6

COST AND DESIGN LEVEL RELATIONSHIPS

applied to highways are shown in Figure 1-7. It must be emphasized that both of these highways satisfy specified criteria in terms of their function and role within the overall system, and the terms "higher" and "lower" should not be construed as meaning "better" and "worse" designs.

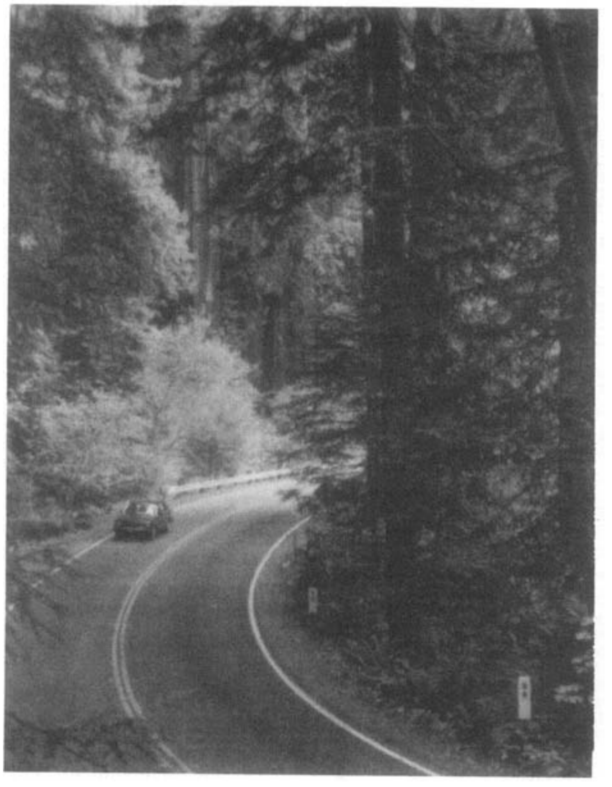
The preferred route can only be determined by comparing the total costs for users and the construction and maintenance costs incurred by the implementing agency, for each technically feasible alternative, and selecting that alternative with the least monetary cost and acceptable non-quantifiable impacts.

The economic analysis involved in this process is described in several publications. See the bibliography for these. In the examples provided in this book, however, we are concerned primarily with establishing the technical feasibility of each alternative, and its capital cost. In the worked example in Chapter 4 we also include approximate maintenance costs and approximate vehicle operating cost as an aid to indicating the relative merits of the alternatives.

ROUTE SELECTION AND THE DESIGN PROCESS

Preliminary Design Related to Total Design Process -- As indicated in the Preface, the material discussed in this book involves only a part of the full highway design process, and each organization will have its own guidelines and procedures to be adhered to.

An example process is that for a state highway design in Massachusetts, as shown in Table 1-1. A total of 55 steps are required; Nos. 16 through 22 typify the activities of the highway designer as described in this book. The next step, No. 23, enables the 25% project review to be conducted. In this step the preliminary design and cost estimates are reviewed by federal and state officials. This ensures that any problems in the project can be adequately identified and addressed and that the project is sufficiently advanced to proceed with public hearings and the subsequent permitting, detailed design, and approval process.



Lower
design
standard

Higher
design
standard

FIGURE 1-7

EXAMPLES OF HIGHWAYS BUILT TO DIFFERENT DESIGN STANDARDS

Source: U.S. Department of Transportation, Federal Highway Administration

TABLE 1-1
EXAMPLE OF HIGHWAY DESIGN PROCESS STEPS

01	DOCUMENT ROAD IMPROVEMENT NEED
02	PROJECT REVIEW COMMITTEE ACTION
03	PROJECT INCLUDED IN THE TRANSPORTATION IMPROVEMENT PROGRAM (TIP)
04	MDPW INITIATES PROJECT
05	COMPILE EXISTING PROJECT DATA
06	WALK THE PROJECT
07	REFINE PROJECT LIMITS
08	DETERMINE MEPA AN NEPA PROJECT CATEGORY
09	DETERMINE OTHER APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL LAWS AND REQUIREMENTS
10	DETERMINE PUBLIC PARTICIPATION REQUIREMENTS
11	BEGIN INTERAGENCY COORDINATION
12	PROCESS ENVIRONMENTAL DOCUMENT
13	HOLD PUBLIC HEARINGS
14	ORDER NECESSARY SURVEY DATA
15	REDUCE AND PLOT SURVEY DATA
16	REQUEST NECESSARY TRAFFIC DATA
17	DEVELOP HORIZONTAL AND VERTICAL GEOMETRICS
18	DEVELOP TYPICAL CROSS SECTIONS
19	DEVELOP PRELIMINARY RIGHT-OF-WAY PLANS
20	DEVELOP DRAFT TRAFFIC SIGNAL PLAN (IF REQUIRED)
21	DEVELOP BRIDGE TYPE STUDIES AND SKETCH PLANS FOR BRIDGES, CULVERTS, AND WALLS (IF REQUIRED)
22	DEVELOP PRELIMINARY COST ESTIMATE
23	CONDUCT 25% PROJECT REVIEW
24	OBTAIN 25% PROJECT APPROVAL
25	START PERMIT PROCESSES
26	REVIEW PROJECT CHANGES FOR MEPA PURPOSES
27	INTERAGENCY COORDINATION
28	REVIEW PROJECT CHANGES FOR NEPA PURPOSES
29	COMPLETE PERMIT PROCESSES
30	COMPUTE HORIZONTAL AND VERTICAL GEOMETRY
31	PREPARE SUBSURFACE EXPLORATORY PLAN (IF NECESSARY)
32	DEVELOP CROSS SECTION TEMPLATES
33	DEVELOP CONSTRUCTION TRACINGS
34	TRANSMIT PLANS TO RAILROAD-UTILITIES ENGINEER
35	DEVELOP TRAFFIC-RELATED PS&E DATA
36	DEVELOP PAVEMENT DESIGN
37	DEVELOP FINAL DRAINAGE DESIGN
38	DEVELOP PRELIMINARY RIGHT-OF-WAY AND/OR LAYOUT PLANS
39	COORDINATE UTILITY RELOCATIONS
40	UPDATE CONSTRUCTION TRACINGS
41	UPDATE COST ESTIMATE
42	CONDUCT 75% PROJECT REVIEW
43	75% PROJECT APPROVAL
44	REVIEW PROJECT CHANGES FOR MEPA PURPOSES
45	INTERAGENCY COORDINATION
46	REVIEW PROJECT CHANGES FOR NEPA CHANGES
47	DEVELOP TRAFFIC CONTROL PLAN (TCP) THROUGH CONSTRUCTION ZONES
48	DEVELOP TRAFFIC CONTROL AGREEMENT WITH MUNICIPALITY (IF REQUIRED)
49	FINALIZE LAYOUT PLANS AND ORDER RIGHT-OF-WAY
50	FINALIZE RIGHT-OF WAY PLANS
51	FINALIZE CONSTRUCTION PLANS
52	FINALIZE COST ESTIMATES
53	DEVELOP SPECIAL PROVISIONS
54	TRANSMIT CONSTRUCTION PLANS TO RAILROAD UTILITIES ENGINEER
55	PS&E SUBMITTAL

Area of emphasis in this book

16. REQUEST NECESSARY TRAFFIC DATA

The designer must request traffic operational characteristics. Both existing and projected traffic data is obtained. This data includes ADT, peak-hour volumes, directional distribution, K factor, design-hour volumes (DHV), and percentage of trucks.

17. DEVELOP HORIZONTAL AND VERTICAL GEOMETRICS

The designer must develop the basic horizontal and vertical curvature and grade data.

18. DEVELOP TYPICAL CROSS SECTIONS

Based on design requirements, typical cross sections are developed. Typical cross sections show design elements that will predominate throughout the project.

19. DEVELOP PRELIMINARY RIGHT-OF-WAY PLANS

Preliminary right-of-way plans are developed based on horizontal and vertical geometrics, typical cross sections, and visual and environmental/planning considerations.

20. DEVELOP DRAFT TRAFFIC SIGNAL PLAN (If required)

Based upon guidelines provided in the *Manual on Uniform Traffic Control Devices*, a Draft Traffic Signal Plan is developed.

21. DEVELOP BRIDGE TYPE STUDIES AND SKETCH PLANS FOR BRIDGES, CULVERTS, AND WALLS (If required)

The Type Studies are a preliminary presentation of the overall concept of the proposed structure which shows all pertinent details for the preparation of sketch plans and contract plans.

22. DEVELOP PRELIMINARY COST ESTIMATE

Prepare an estimate based on the latest project information. Refinements are to be expected as the design develops, but this estimate should reflect project costs as accurately as they can be defined at the 25% design stage.

Source: Based upon Massachusetts Department of Public Works, Highway Design Manual, 1990.

Environmental Reporting Requirements -- The level of detail of the preliminary route selection and design is also consistent with Class III actions in accordance with the Federal Highway Administrations' level of documentation as described in the appropriate code of Federal Regulations, Title 23 Part 771. A Class III action is an action in which the significance of the impact is not clearly established. These actions require the preparation of an Environmental Assessment describing the environmental impacts of the proposed works and its alternatives. This assessment assists in deciding the nature of further environmental analysis and needed documentation. If the Federal Highway Administration determines that a proposed project will not have a significant impact on the environment, a statement to that effect may be prepared. The level of detail of the project described in this book would in many respects be appropriate for guiding the preparation of such an environmental assessment document. Further details of federal and state requirements are described in Chapter 2, examples are presented in Chapter 3, and key issues of importance are briefly noted in the design project of Chapter 4.

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