Chapter 3

Application of Geometric Design Principles to Route Design

The fundamental objective in the highway geometric design process is the establishment of the new highway's centerline and cross sections in relation to the terminal points and to the topography through which the highway will pass. The vertical and horizontal alignment of the centerline determines the amount of cut and fill, cross section details, drainage design, construction and user costs, and environmental impacts.

The process of establishing a centerline is described in this chapter by means of examples. The design controls and designations will be assumed in order to illustrate the geometric configurations only. The process of establishing the design controls and designation as a basis for the geometric configuration was discussed in Chapter 2. The principles described are applicable to any classification of highway, from a local access road to a multi-lane freeway. In addition, a brief review of drainage and cost estimates is made, particularly as they pertain to the design projects described in Chapter 5.

PRELIMINARY ROUTE LAYOUT AND GEOMETRIC DESIGN

In selecting a preliminary, technically feasible route, the designer should attempt to envisage the topography in three dimensions. This may be difficult initially, but some practice will assist. The major activities may be divided into: defining design controls; establishing an initial alignment; balancing cut and fill; and, refining the design. These activities are described below. The reader may also wish to consult Chapter 4, where a more formal computational approach is presented as part of a route selection and design project.

Defining Design Controls -- As indicated in Chapter 2, the alignment of a highway is subject to design controls that ensure that it will provide suitable service for the traffic within the topography for which it is designed. As well as the controls noted earlier, it is necessary to specify several other variables that are inputs to establishing a preliminary route. These variables are described as follows:

1. Minimum radius of horizontal curves, based upon the design speed and the permissible superelevation.

2. Minimum length of vertical curves, based upon design speed and difference between intersecting grades.

3. Maximum grade at any point on the highway, determined from consideration of road classification, truck traffic, and terrain.

4. Maximum grade in proximity to existing intersections. The vertical alignment of the proposed route should allow for a minimum to moderate grade approaching the intersection with the existing highway in order to assist in safe stopping on downhills and improved sight distance on uphill approaches. See also the comments in Chapter 2 regarding coordination of horizontal and vertical alignments. Ideally, this grade should be no more than is required for adequate drainage. Because this approach grade may intersect with a vertical curve ascending or descending the hillside, a vertical curve may be required at this location. The length of this curve is determined by consideration of the design speed and intersecting grades. For preliminary design purposes, it is suggested that within a distance of about 30 m from the intersection's stop line, the grade be no more than 2%. This value will be used in the design projects presented later and will allow for any necessary modifications in the detailed design stage.

5. Minimum grade at any point on the highway to ensure adequate drainage. A minimum of 0.5% is suggested for preliminary design purposes.

6. Maximum horizontal approach angle at intersections. It is desirable to design the route to ensure that intersections with existing highways are of suitable alignment and configuration from a safety and capacity point of view. Therefore, the horizontal alignment should feature as nearly as possible a right-angled intersection with the

existing highway (within, say, 90° ± 15°). It is suggested that for preliminary design purposes, the proposed approach to the intersection be a tangent section for a distance of at least 30 m to aid drivers' visibility at the approach.

7. Maximum depth of excavation and height of fill. For the reasons specified in Chapter 2, a maximum depth of cut and height of embankment must be specified in order for the designer to establish an initial vertical alignment.

Establishing an Initial Alignment -- Development of the alignment is a trial and error process involving defining a trial alignment, then checking to see if it complies with the horizontal and vertical controls, then modifying it in successive iterations until all the controls are complied with. One approach to this process is illustrated by the problem example shown in Figure 3-1. In addition to these steps, the following points may help to guide the process.

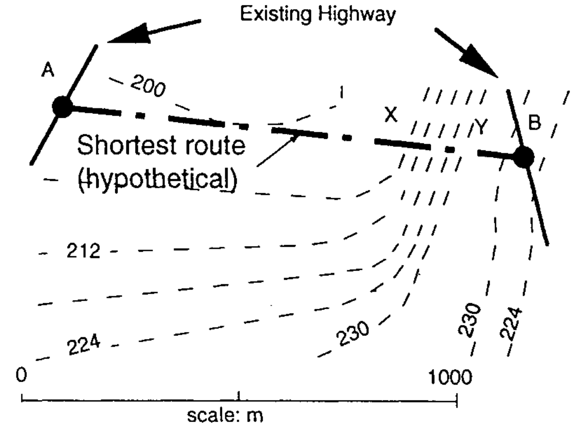
Horizontal Alignment. A first step is usually to determine if the shortest route possible will comply with the controls, because this is likely to be the least-cost solution. Examination of how this first trial route complies with the controls will suggest how the route may be modified for the next trial. The highway should be constructed as close to the existing ground (or slightly above it to assist adequate drainage) as possible, provided that the design controls are complied with. Thus, any horizontal centerline should be checked, first of all, for its grade. This may be done approximately by measuring the length of a given segment of highway and counting the contour lines that are crossed. The vertical distance covered, divided by the horizontal length, indicates the approximate grade. If this grade is significantly more than the specified amount, the alignment must be readjusted.

Where the rounded topography of a mountain or a hill must be negotiated in a transverse fashion, the curve of a highway should preferably conform approximately to the surface of the hill itself, or excessive cuts or fills are likely to result. At this point, the designer must sketch a curve that approximately conforms to the topography, by using compasses or templates. This curve must then be checked for conformity with the maximum allowable radius and also for the grade the highway negotiates throughout the curve. The latter must also conform with the maximum allowable grade requirement and be adjusted if necessary.

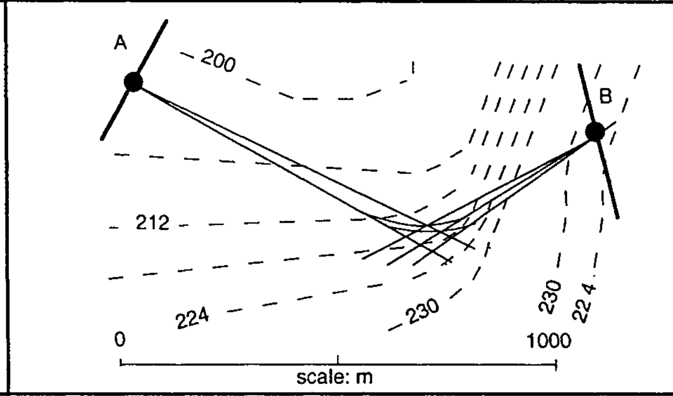
FIGURE 3-1
OUTLINE OF STEPS IN DETERMINING A POTENTIAL HORIZONTAL ALIGNMENT

PROBLEM: Connect points A and B below with a highway having a maximum grade of 6%, minimum grade (for drainage) of 0.5%, a minimum horizontal radius of 240 m, a minimum vertical curve length of 120 m, and maximum cut and fill depths of 10 m.

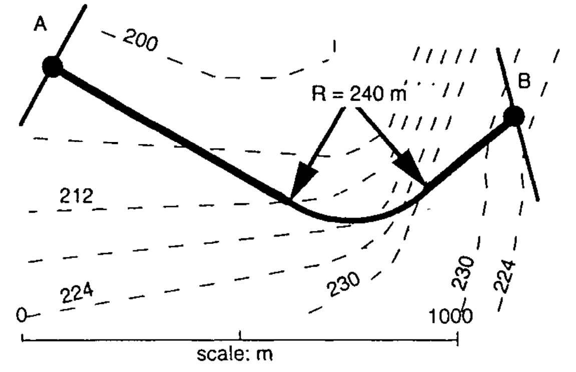
STEP 1. Examine the contours along the shortest possible route (hypothetical) and estimate the steepest ground slope along this route. The steepest slope is between points X and Y (from examination of contour lines) - a vertical rise of nearly 38 m in 240 m horizontally. This represents a slope of over 15%. This is more than twice the allowable maximum grade of 6% and would result in excessive depths of cut and heights of fill. Therefore a less steep route should be examined, as shown in Step 2, below.



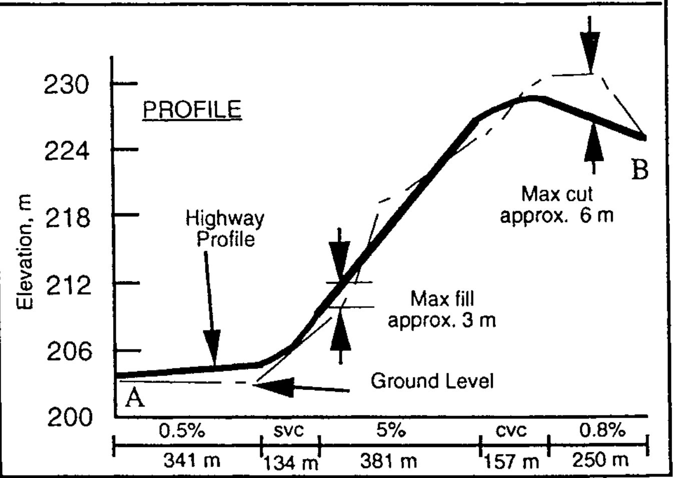
STEP 2: Sketch a new trial alignment with a reduced ground slope. The one shown here is sketched freehand and includes a curve, the radius of which is approximately the same or larger than the 240 m minimum specified. Notice the grade between points X and Y of Step 1 will be less steep because the horizontal alignement of the highway crosses the contour lines at a greater angle than in Step 1.



STEP 3: Convert the sketch of Step 2 into a dimensioned tangent and circular curve alignment by scaling and the use of compasses or a template for constructing and measuring the curve. It is also usually desirable to ensure that the intersection of the proposed highway with the existing road is within about 15 degrees of a right-angle in order to assist driver sight distance requirements.



STEP 4: Construct a profile of the ground levels as a basis for defining a profile of the highway pavement which does not exceed the 6% slope and the 10 m cut and fill requirements. This is usually done to balance the cut and fill amounts also, and an acceptable (though not necessarily unique) solution is shown here, for the alignment of Step 3 above. It is also usually desirable to ensure that the grade of the proposed road where it intersects the existing road is a maximum of about 2% to assist stopping and sight distance requirements. Note also that the minimum grade requirement of 0.5% has been complied with. The diagram indicates the combination of sag vertical curve, (svc) straight grades, and crest vertical curve (cvc) that together comprise the total length of the potential route. The total length of the route is 1261 m.



Existing Ground Profile and Vertical Alignment. Once a preliminary route has been defined using the above steps, the next step is to examine the profile. This means first drawing a longitudinal section of the existing ground level along the horizontal alignment. To do this quickly but approximately, a strip of paper may be laid along the centerline of the proposed highway. The contour line elevations along the alignment are then marked off along the edge of the paper and the results are transferred to the profile sheet to provide a profile of the ground level along the proposed route. This is an approximate method but it will save considerable time and can be refined later. A more accurate method is to use dividers or an engineer's scale to measure the horizontal distance and transfer these measurements and the elevations to the profile. Care should be taken to ensure that the horizontal distances between contour lines are measured accurately -- especially along curves.

Balancing Cut and Fill. If the vertical profile mentioned above meets all of the design controls it should now be checked to see if the cuts and the fills approximately balance - to ensure that excessive amounts of soil need not be imported to or removed from the site. Any adjustment of the grade may be done initially by visual, trial and error means using a straight edge and a circular or French curve together with approximate measurements at peaks and valleys to ensure that the maximum cut and fill dimensions along the centerline are not exceeded and that all grades and curve lengths are complied with, based upon the appropriate stopping sight distance. Also, it is desirable where possible to minimize the amount of cut and fill, as well as the amount of uphill haul of fill material. These requirements may be addressed by modifying the initial profile. Note that it may not be possible to balance the cuts and fills while still conforming with the other design controls. Nevertheless, the horizontal and vertical alignments should be adjusted to obtain the best possible balance.

Note: The vertical scale of the profile is usually exaggerated on drawings to provide a better visual image and permit scaling of cuts and fills. Also, it is often useful to draw to one side of the profile the maximum grade and cut and fill dimensions as an aid to the sketching process. The suggested requirements for the horizontal alignment and vertical grades adjacent to intersections are shown graphically in the Appendices.

Refinements to Selected Route -- Once an initial, technically feasible route has been defined and examined, the alignment may be adjusted to ensure that the relevant K values have been complied with, address coordination of horizontal and vertical curves, and explore other routes that involve, for example, less depth of cut or height of fill or reduce the proximity to sensitive features such as wetlands.

The alignment selection process can now be followed for a number of alternatives. There are several reasons for doing this. For example, the shortest highway that is feasible in a technical sense may not be the least expensive. Detailed economic analysis will be needed to determine these relative costs. Also, in practice, the provision and estimation of several alternatives will provide information for decisionmakers who may favor certain alignments over that considered preferable by purely engineering evaluation. If possible, at least three alternatives should be initially defined, all of which are technically feasible and conform to the specified design controls.

EXAMPLE OF DEVELOPING AND CHECKING ALTERNATIVE ALIGNMENTS

In applying the procedures outlined above, we now examine the main features of developing alternative alignments through a particular topographic area. The details for this particular example are described as follows:

1. We wish to make a preliminary analysis of a highway route connecting points A and B shown in Figure 3-2.

2. A design speed of 80 km/h and a maximum allowable superelevation of 10% have been specified. Thus, the minimum allowable horizontal curve radius is 210 m, as indicated in Table 2-8.

3. The maximum allowable grade is 10% (except as specified for the areas adjacent to intersections), based upon the anticipated vehicle types.

4. The horizontal intersection angle and the maximum grade of the proposed highway at the intersection are as described earlier (horizontal intersection angle to be 90±15 degrees within 30 m of an intersection, maximum grade to be ±2% for a distance of 30 m from the existing highway, minimum grade at all locations ±0.5%).

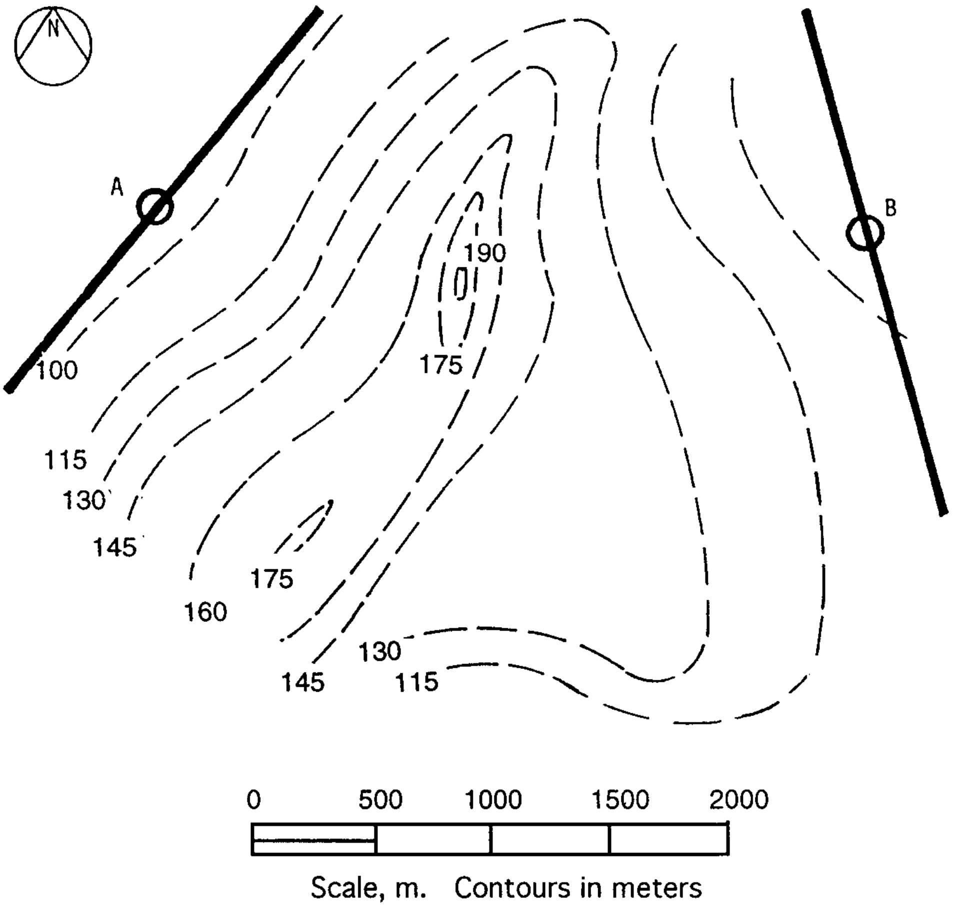


FIGURE 3-2

LOCATION OF END POINTS OF PROPOSED HIGHWAY

5. The minimum allowable vertical curve lengths are obtained from Figures 2-8 and 2-9. The "worst case" crest curve length will be where a 6% positive grade intersects a 6% negative grade, giving a length of 590 m (A = 12%, V = 80 km/h, Figure 2-8). Correspondingly, from Figure 2-9, the "worst case" minimum sag curve length is 385 m. At this point we are not considering the K value for drainage purposes, which would normally be done before the alignment is finalized.

6. No environmental/cultural features are described in this example in order to focus on the technical design requirements only. The presence of these features would impose constraints on the alignment, similar to those described in Chapter 1 and in the section on environmental impacts presented later in this chapter.

Investigating an Initial Possible Route -- A reasonably short route for which we might wish to make a preliminary analysis is Route 1, shown in Figure 3-3A. Even though a brief visual check on the contours along this route indicates a ground slope well in excess of the 6% specified, we will make a more detailed examination in order to illustrate the problems. The steps are as follows:

1. Draw the horizontal alignment to scale along the route.

2. Examine the location where the existing grade appears to be the steepest along the route. This is obviously between points X and Y in Figure 3-3A. By examining the horizontal scale and the vertical contour interval, we can see that between points X and Y the existing grade is approximately 30 m/300 m = 10%. Clearly, this exceeds our maximum allowable grade of 6% for some considerable horizontal distance. However, we check by sketching a profile to scale in order to examine the depth of cut and fill and, therefore, the practicality of the route, in more detail (Step 3 below).

3. By drawing a ground profile along Route 1, together with a profile of the centerline of the highway with a maximum of 6% grade, as shown in Figure 3-3B, it is obvious that this route will result in an unacceptable cut (over 15 m deep) and nowhere to use the cut material as fill. Even with a slight adjustment of the alignment, it is apparent that no satisfactory improvement in these cuts and fills will be possible for this route.

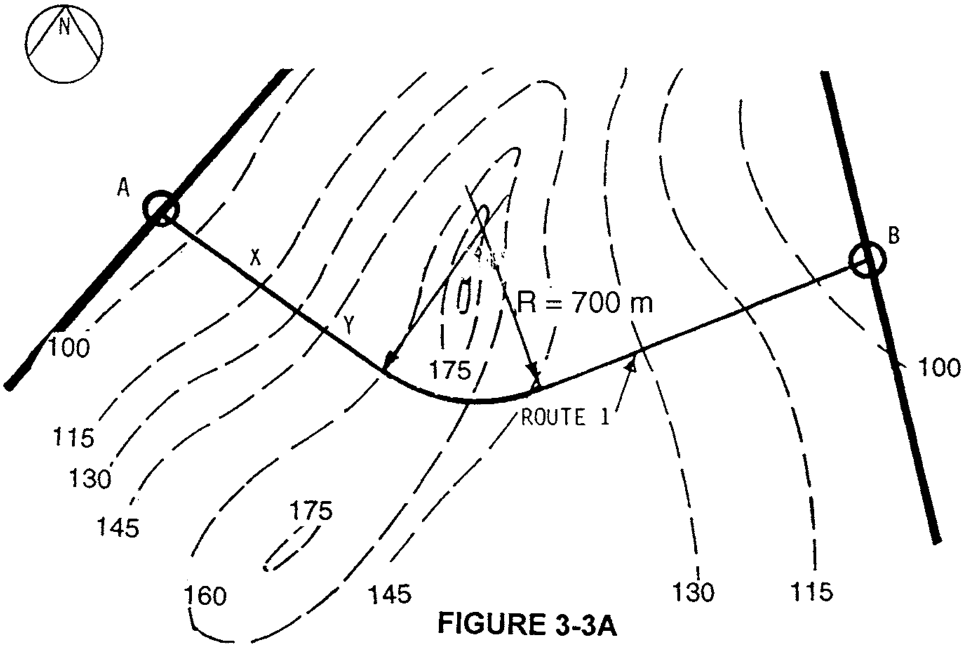


FIGURE 3-3A

PLAN OF ROUTE 1

0 500 1000 1500 2000

Scale, m. Contours in meters

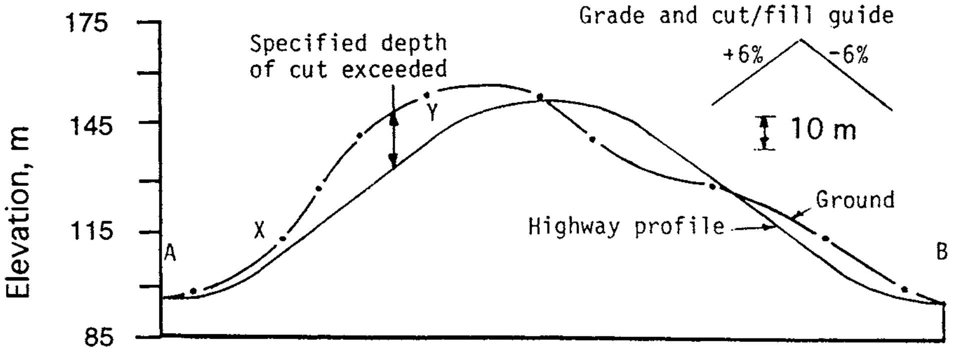


FIGURE 3-3B

PROFILE ALONG ROUTE 1

4. Summarize conclusions as follows:

   a) The inability of Route 1 to provide a gradient within the required 6%, while simultaneously satisfying the cut and fill requirements, makes Route 1 and any adjacent or somewhat similar route unacceptable alternatives.

   b) Knowing the implications of Route 1 in terms of cut, fill, and allowable grade, it is therefore necessary to explore several other alternative routes to attempt to establish a technically acceptable alignment.

Investigation of Routes 2 and 3 -- After examination and preliminary sketching, it is apparent that Routes 2 and 3 might offer more gradual grades and be worth investigating. These routes are shown sketched in Figure 3-4 and are examined in greater detail below.

Route 2. Using the procedures outlined earlier as a guide for checking the route's technical feasibility, and as shown in Figures 3-5A and 3-5B,

1. Convert the sketch of Route 2 into a series of tangents and curves.

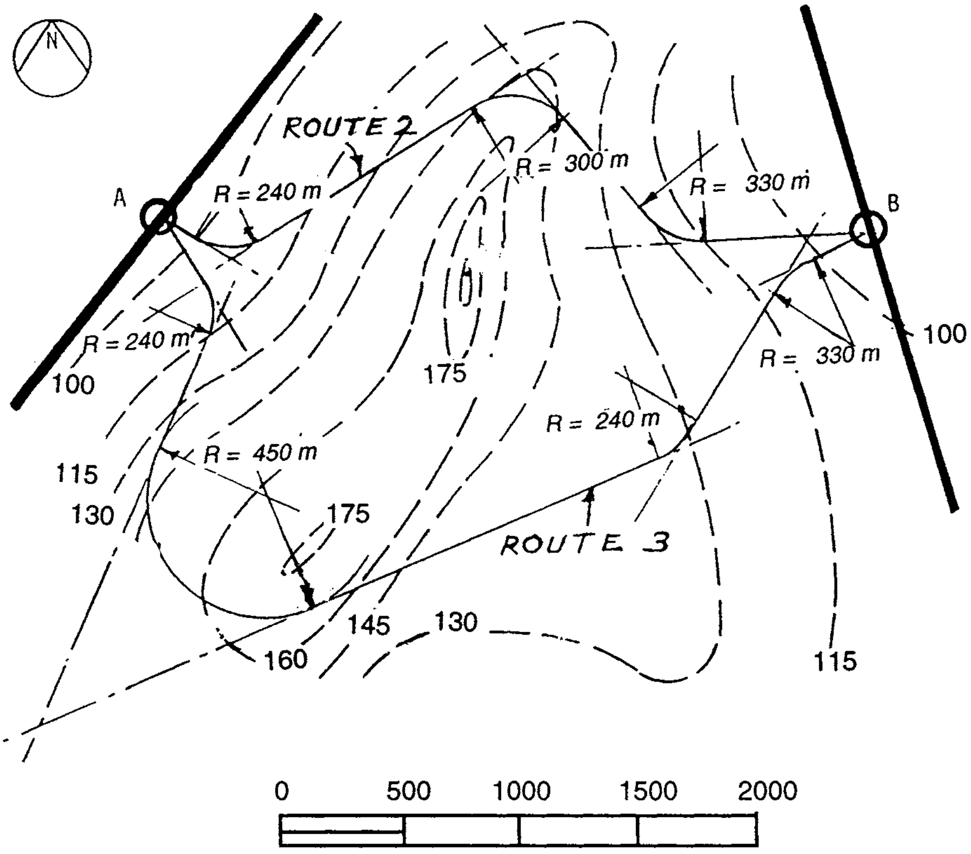
2. Check for the minimum allowable radius based upon design speed and superelevation.

3. Check for intersection angle with existing road (within 15° of right angle).

4. Construct the existing grade profile.

5. Establish a vertical alignment with a maximum grade of 6% and maximum height of cut and fill of 6 m, and within specified grade limits at intersections.

Judging by the design controls established earlier, it can be seen from Figures 3-5A and 3-5B that Route 2 is a technically feasible alternative. Also, the cuts and fills appear to balance fairly well. The horizontal and vertical alignment could, of course, be adjusted slightly and each engineer will arrive at a slightly different geometric design, at least from these preliminary efforts.



Note: Tangents and curves are sketched to show approximate route alinements only.

FIGURE 3-4

INITIAL DEVELOPMENT SKETCHES OF ROUTES 2 AND 3 RESULTING FROM EXAMINATION OF ROUTE 1

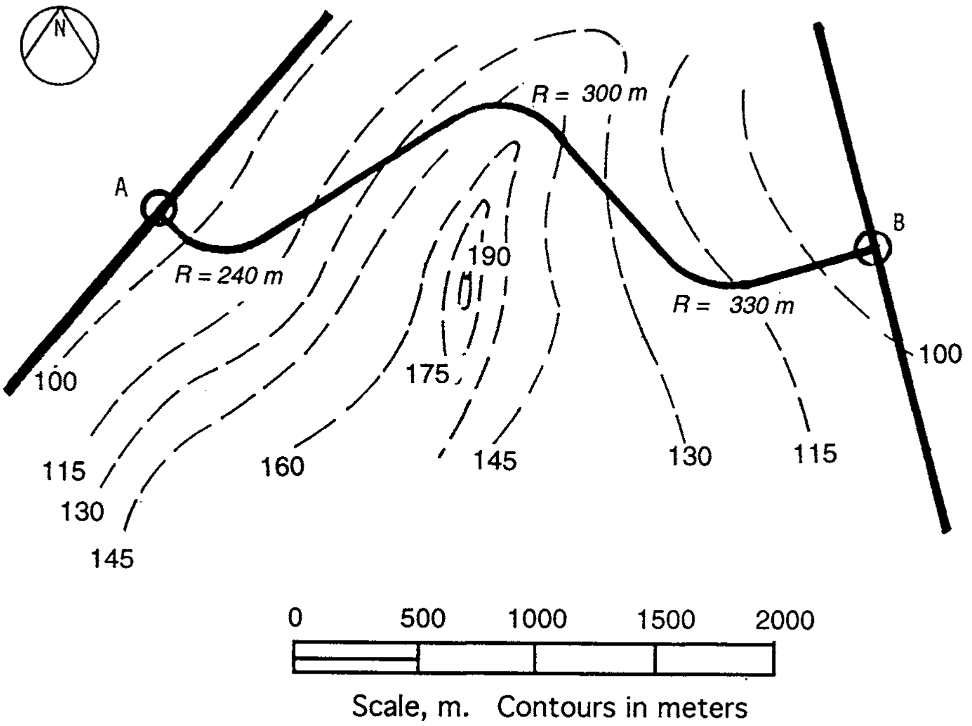


FIGURE 3 -5A

PLAN OF ROUTE 2

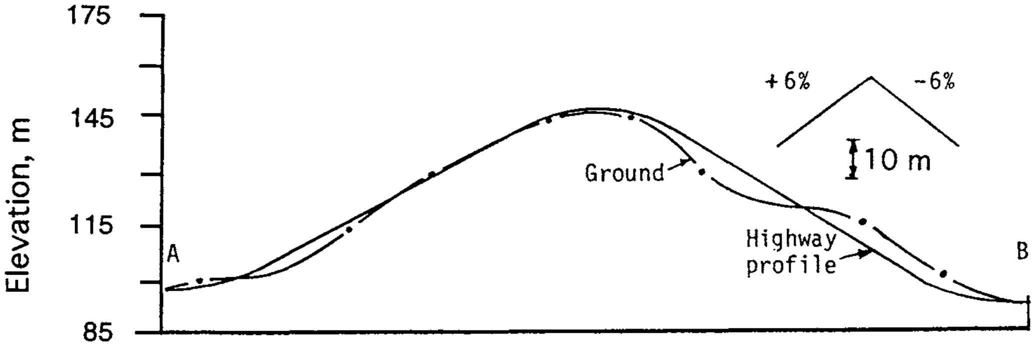


FIGURE 3-5B

PROFILE ALONG ROUTE 2

Route 3. Using the same approach as that used for Route 2, an alignment for Route 3 is developed from the initial sketch. The procedure for developing Route 3 is shown in Figures 3-6A and 3-6B, indicating that Route 3 is a technically feasible route also.

Screening and Selection of Routes for Preliminary Design -- Both Routes 2 and 3 appear to be technically feasible, based upon the allowable grade, cut and fill depths, and horizontal and vertical alignments, while Route 1 clearly is inadequate. It is often useful to screen the proposed routes at this point in order to summarize in concise form the reasons why one or another route should be considered further. Table 3-1 lists a number of major criteria and comments on how each route meets each criterion. The conclusion, as indicated above, is that both Routes 2 and 3 are technically feasible and that a preliminary design and economic analysis should be conducted as a basis for determining the prefered alternative. The three routes investigated are depicted in Figure 3-7.

Highway Centerline Traverse -- At the current stage of the design (i.e., development of a preliminary alignment), the intersecting angles and centerline dimensions may be scaled, but the traverse should "close" at least approximately so that the data given to a field survey party will be adequate for performing a more detailed ground survey. The centerline dimensions and intersecting angles, together, provide a check on the traverse angles and distances to ensure that "closure" occurs, (i.e., that the beginning and end points coincide within a reasonable degree of accuracy). This process is described in basic texts on surveying and is not discussed further here.

Important Note: Particularly when maximum depths of cut and height of fill are specified, it may not be possible to obtain an alignment which conforms to the design designation and controls. In these cases, the designer must decide if bridges or tunnels will be permitted or if controls on grade, design speed, or other determinants of the alignment can be relaxed.

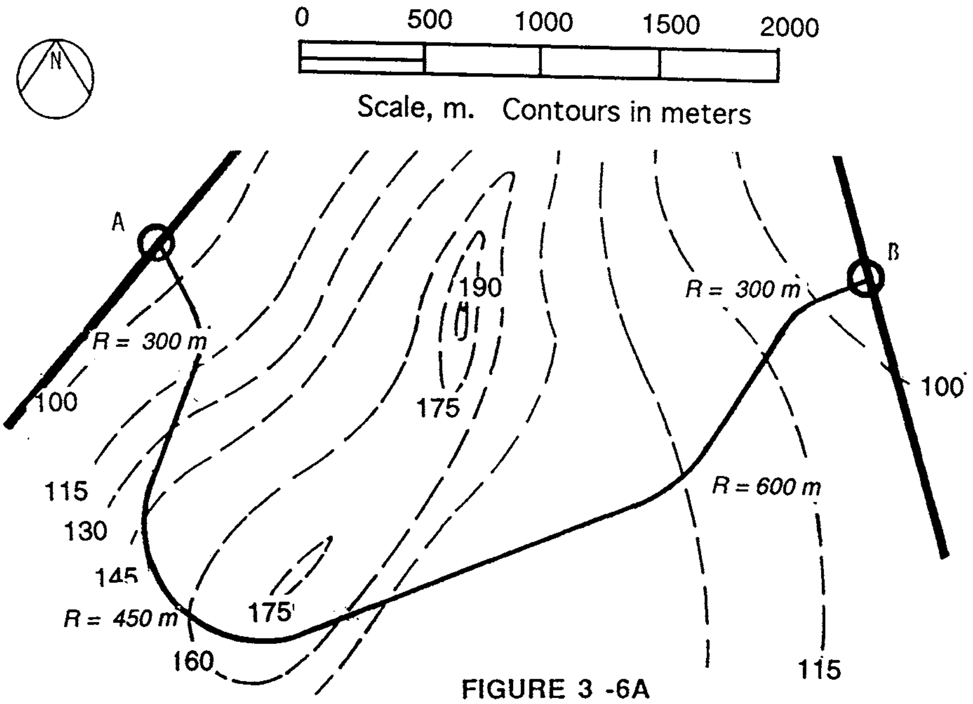


FIGURE 3 -6A

PLAN OF ROUTE 3

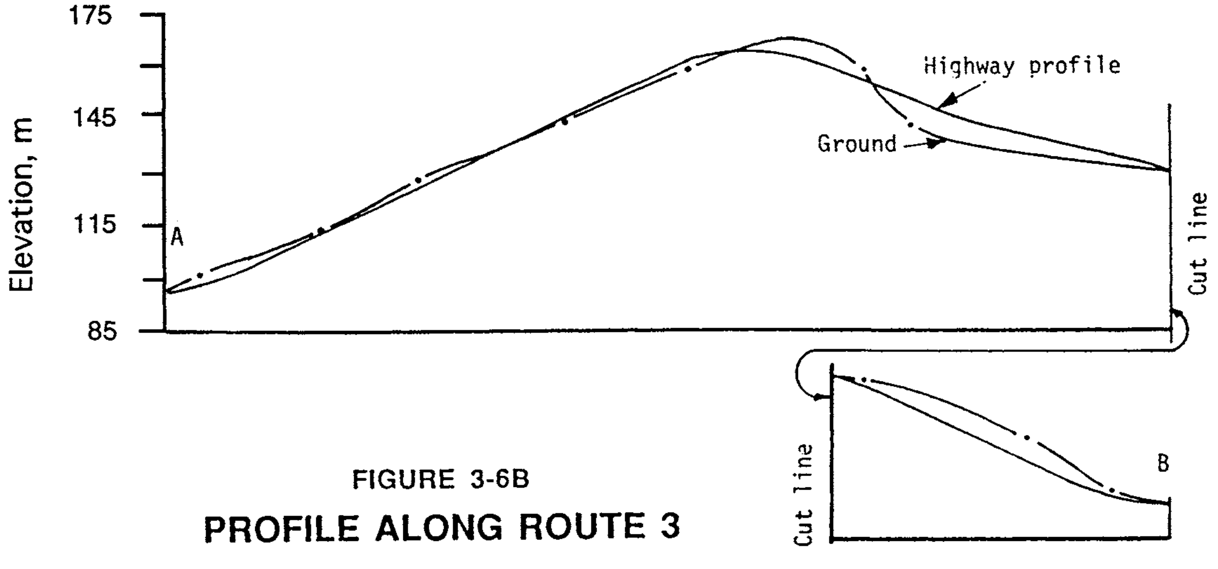


FIGURE 3-6B

PROFILE ALONG ROUTE 3

CRITERIA	SCREENING EVALUATION		
	ROUTE 1	ROUTE 2	ROUTE 3
Length of route (approximate)	*3030 m*	*3540 m*	*4180 m*
Conformance with design controls	*Not possible with specified grade control*	*Acceptable*	*Acceptable*
Cut and fill balance	*Excessive cut required to comply with design controls*	*Acceptable*	*Acceptable*
Need for bridges or other special structures	*None*	*None*	*None*
Environmental impacts	*Excessive cuts and associated slopes*	*No essential difference between Routes 2 and 3*	
Potential high cost items	*Excessive cuts and fills*	*None evident*	*None evident*
Minimize total cut and fill and minimize uphill haul	*Some uphill haul is likely with each alternative*		
Conclusion: *Route 1 is unacceptable due to the need for excessive excavation required to attain the specified grade control. Routes 2 and 3 appear technically feasible and should be further investigatedby means of an initial economic analysis before a detailed design is undertaken*			

TABLE 3-1

SCREENING EVALUATION OF ALTERNATIVES

FIGURE 3-7

OBLIQUE VIEW OF
ALTERNATIVE ROUTES 1, 2 AND 3

NON-STANDARD SITUATIONS

Particularly in mountainous terrain, it may often be the case that an acceptable alignment that conforms to the specified controls is difficult to attain without extreme measures such as deep cuts, use of bridges or even tunnels, particularly where the highway must traverse a number of valleys. Usually the solution entails either provision of horizontal curves with radii less than the allowable, and associated speed restrictions, or the provision of bridges. In cases where these design alternatives exist, a more detailed analysis must be carried out, yet the principles described earlier apply. An example of how a bridge may provide a better solution than a horizontal curve of substandard radius is shown in Figure 3-8. Again, the final decision will rest upon construction, maintenance, and user cost estimates and comparisons.

DRAINAGE PROVISIONS

An initial drainage design indicating the main locations of catchment areas, ditches, culverts, and bridges is an important part of the preliminary highway design because the alignment may have to be changed if the road cannot be adequately drained, or if it adversely affects existing drainage patterns.

The identification of runoff areas likely to affect the highway geometric design (particularly the horizontal and vertical alignments) is of crucial importance for a satisfactory design. The highway, as well as being affected by the characteristics of the watershed such as slope and ground conditions, will itself affect the flow of surface and, perhaps, subsurface drainage in its vicinity. The provision of adequate drainage ditches, culverts, and bridges is therefore of vital importance.See the bibliography in Chapter 1 for a selection of drainage-related guidelines

One way of conducting a preliminary drainage design is to define the characteristics of the major precipitation catchment areas; estimate quantities of runoff; locate ditches, culverts, and bridges; check several "worst case" ditch, culvert, and bridge dimensions; and ensure that adjacent drainage patterns of the surrounding topography are not adversely affected by changes in flow patterns. This process may be complex, depending on the location, topography, ground conditions, and environmental factors. The reader should consult the appropriate texts and manuals and, wherever possible, obtain first-hand knowledge of local practices and conditions. A preliminary drainage design may be made, however, to the extent necessary to define the basic configuration, dimensions, and construction costs and to indicate where a field survey crew should examine various features in greater detail. An example of this approach is included in the project described in Chapter 4, and examples of typical drainage facilities related to terrain and highway characteristics are shown in Figure 3-9.

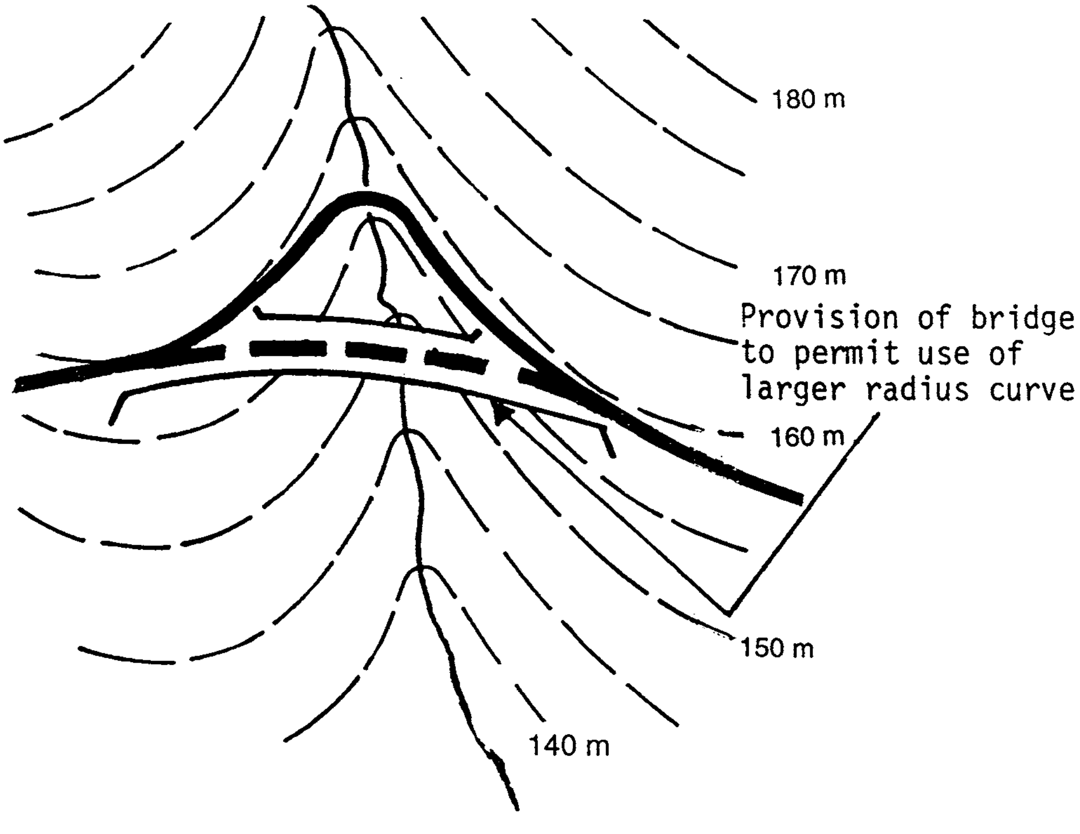
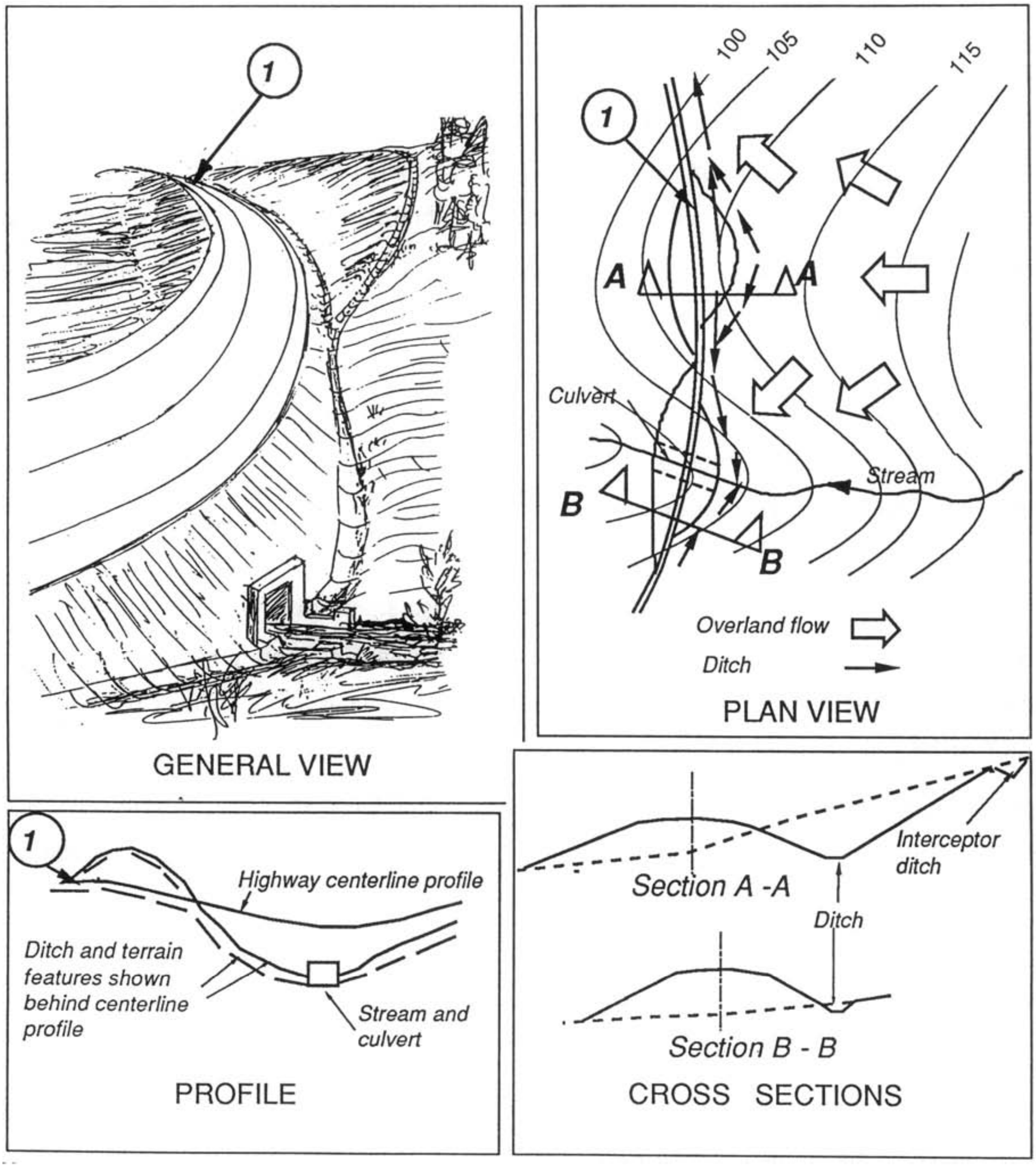


FIGURE 3-8

EXAMPLE OF WHERE A BRIDGE MAY HELP TO IMPROVE GEOMETRICS



GENERAL VIEW

PLAN VIEW

PROFILE

CROSS SECTIONS

Note: Guardrail and other features are not shown in these diagrams.
Diagrams are not to scale.

FIGURE 3 -9

EXAMPLES OF DRAINAGE FEATURES - DIAGRAMMATIC

CONSTRUCTION COST ESTIMATE

For most preliminary engineering designs, and as indicated in Chapter 1, an approximate cost estimate will be required. This estimate will be based upon the quantities of materials, labor, equipment, overhead, and profit required to construct the proposed highway. While the quantities may be estimated in the appropriate units from the preliminary design, the unit cost rates may be obtained from previous records of the agency concerned. Another source of information of unit rates may be commercial sources of construction rates which are updated and published periodically.

It must be emphasized that at this stage of the design, the cost estimate is not final, nor is it a bid estimate, which is submitted when the design has been finalized and the project has been advertised for bids from potential contractors.

Because a fully detailed estimate involves considerable time and effort to produce, the preliminary estimate may take an abbreviated form, where many items of a like nature are "compressed" into a much smaller number of items. This is the form of the estimate shown in the project described in Chapter 4. The listing of the items is self-explanatory, and it should be noted that the unit cost rates must be updated to reflect current prices by means of appropriate indices. See the bibliography in Chapter 1 for the appropriate texts.

ECONOMIC COST

Although estimates of the economic cost of the highway are somewhat beyond the main scope of this book, an economic analysis will be necessary to estimate the cost of vehicle operations and of vehicle occupants' travel time, in addition to the capital and maintenance costs of the highway. As indicated earlier, a project may be technically feasible but not economically justifiable, and this book focuses on the former concern.

The usual method of conducting the economic cost analysis is by means of the benefit-cost and present value techniques described in the AASHTO "Red Book" (see bibliography, Chapter 1). Using this method can be time consuming. However, a simplified means of comparing the relative costs of various alignments can be made in order to illustrate the principles involved, and to assist in a basic economic comparison between projects. The main features of the method were described in Chapter 2, and a simplified economic cost estimate to permit comparisons between projects is described as a part of the project in Chapter 4.

ENVIRONMENTAL IMPACT ANALYSIS

In addition to the wider issues associated with the presence of the highway within the overall transportation system, its detailed locational features must be sensitive to local and adjacent features likely to be impacted. This may require modifications to the alignment to avoid wetlands, habitats of endangered species, and other natural or man-made features of social or cultural significance.

Therefore, in selecting and formalizing the alignment, the curvature and grades outlined in earlier examples in this chapter may have required additional constraints if environmentally sensitive areas had been present nearby. Examples of the relationship of environmental features adjacent to a proposed route are shown in Figures 3-10 and 3-11. The examples also include the written description for the specific items mentioned.

Although a detailed environmental report as indicated in Chapter 2 requires considerable detailed information, the design shown in Chapter 4 mentions the key points and mitigation features only. This is intended to provide an initial alert to the environmental planners to the more salient items of which the highway engineer is aware.

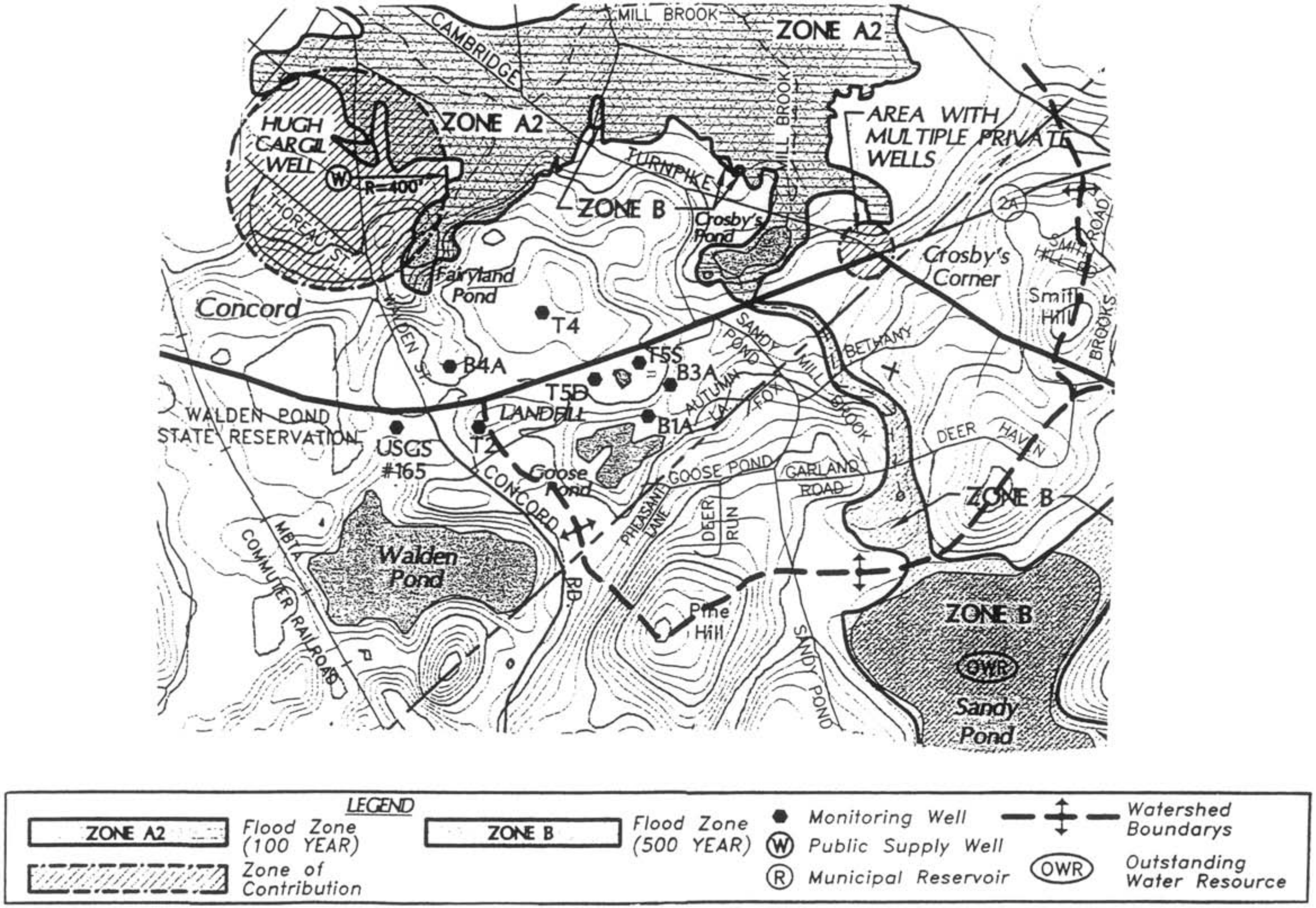
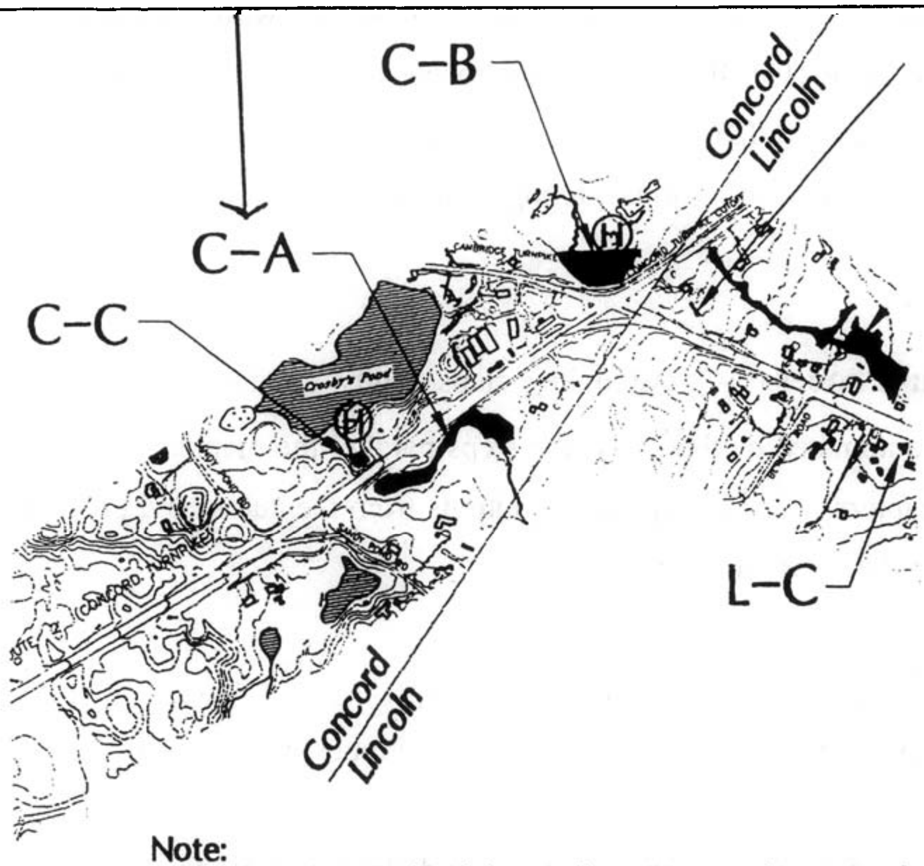


FIGURE 3-10

EXAMPLE OF WETLAND LOCATIONS AND CATEGORIES
(SOURCE: DRAFT ENVIRONMENTAL IMPACT REPORT/ENVIRONMENTAL ASSESSMENT AND SECTION 4(f) EVALUATION, ROUTE 2 CROSBY'S CORNER, MASSACHUSETTS HIGHWAY DEPARTMENT, OCTOBER, 1998)

Wetland C-A: Wetland C-A is a bordering vegetated wetland adjacent to Mill Brook, a tributary stream to Crosby's Pond south of the eastbound lane of Route 2, across from the MassHighway garage. The stream enters the project area from the south and parallels the existing Route 2 for approximately 800 meters (0.5 mile) before passing through a culvert under Route 2 to the pond. The canopy of this wetland is dominated by red maples. The understory vegetation in Wetland C-A consists of highbush blueberry, spicebush, arrowwood, and swamp azalea. Ground cover is predominately skunk cabbage, with areas of poison ivy. The stream in this wetland receives direct stormwater discharge from Route 2.



Note:
C Designates wetland located in Town of Concord
L Designates wetland located in Town of Lincoln
Ⓗ Mystic Valley amphipod (Crangonyx aberrans) habitat

FIGURE 3-11

EXAMPLE OF WETLAND DETAILED DESCRIPTION
(SOURCE: DRAFT ENVIRONMENTAL IMPACT REPORT/ENVIRONMENTAL ASSESSMENT AND SECTION 4(f) EVALUATION, ROUTE 2 CROSBY'S CORNER, MASSACHUSETTS HIGHWAY DEPARTMENT, OCTOBER, 1998)

AUTOMATED GEOMETRIC DESIGN

Current Status of Automated Geometric Design -- Determination of an appropriate route in accordance with the necessary design specifications and controls have been the subject of mostly proprietary automated methods of design since the 1980's. Most methods take advantage of, and may be embedded within, various computer-aided design and drafting (CADD) design approaches. Also, the inclusion of geographic information systems (GIS) information storage and retrieval methods often plays an extensive role in establishing initial topographic features along the highway corridor and its environs.

Design Process -- Several key steps typify conduct of a highway geometric design using automated methods. These steps parallel the manual steps described in this and earlier chapters. Selected inputs and outputs from the automated process are shown in Figure 3-12. The steps include:

1. Construction of Digital Terrain Model (DTM)

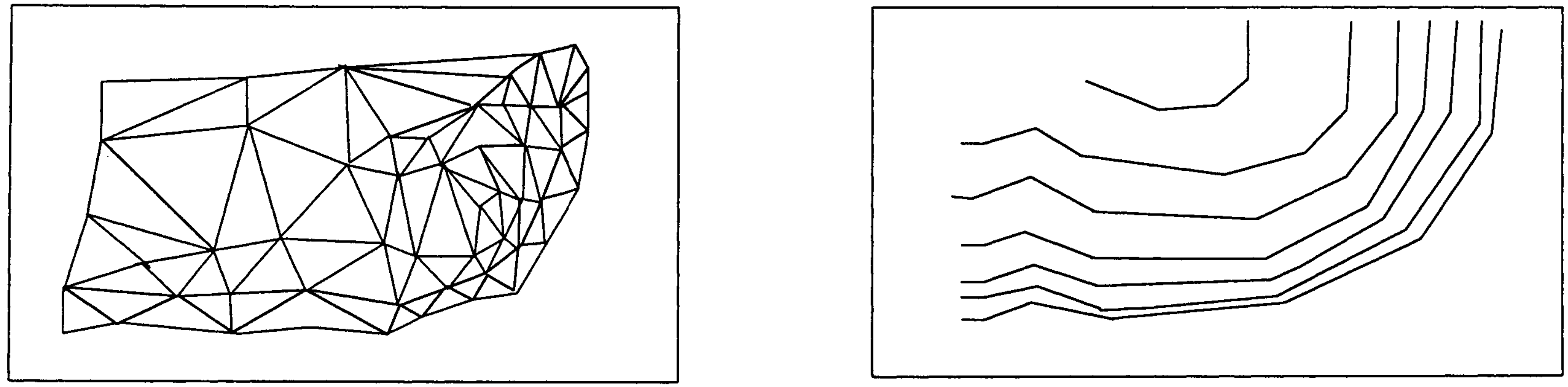
- Input of survey data records and updates – for inputs to the map of the road corridor

- Completion of maps at various scales and details, including relevant surface and subsurface information if required.

- Construction of digital terrain model (DTM) showing all vertically and horizontally defined features, including contours. The DTM is linked to a triangulated irregular network (TIN). The DTM model can be portrayed in three dimensions.

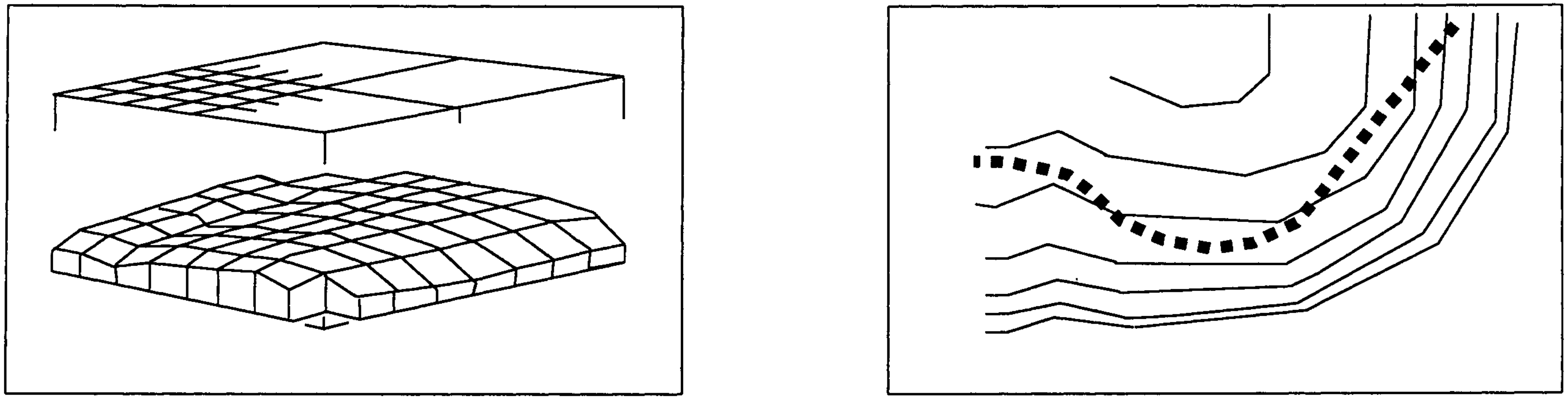
2. Plotting Alternative Routes

- Input of standard features such as cross sections templates, fill slopes, and design constraints such as maximum grades, depths of fill, minimum curvature, and related features.



1. A triangulated irregular network (TIN) is prepared to establish corridor-wide control points

2. ...contours are defined



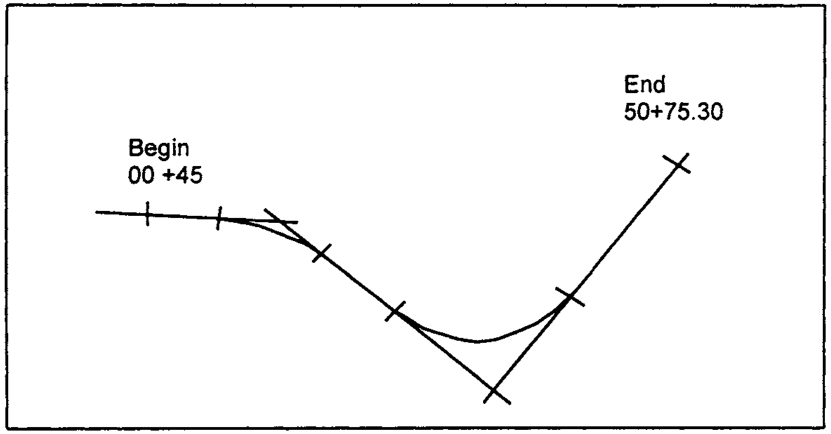
3. ....a 3-dimensional grid is established

4. ...an initial route is selected based upon results of step 3, and on geometric design controls and environmental factors

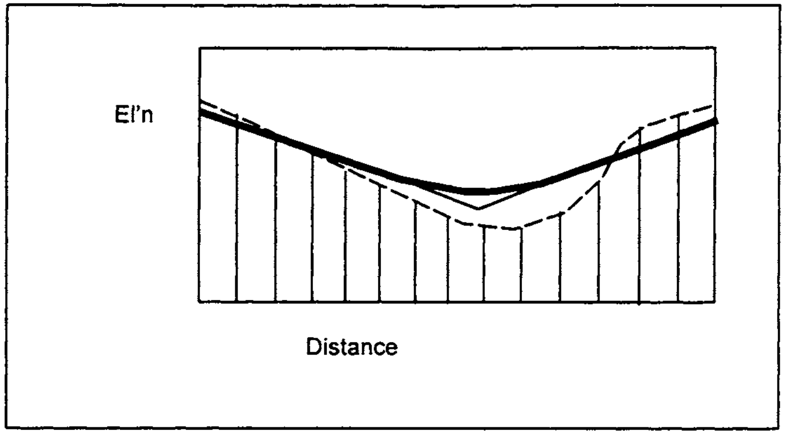
FIGURE 3-12

DIAGRAMMATIC EXAMPLES OF ITERARATIVE STEPS IN AUTOMATED ROUTE DESIGN

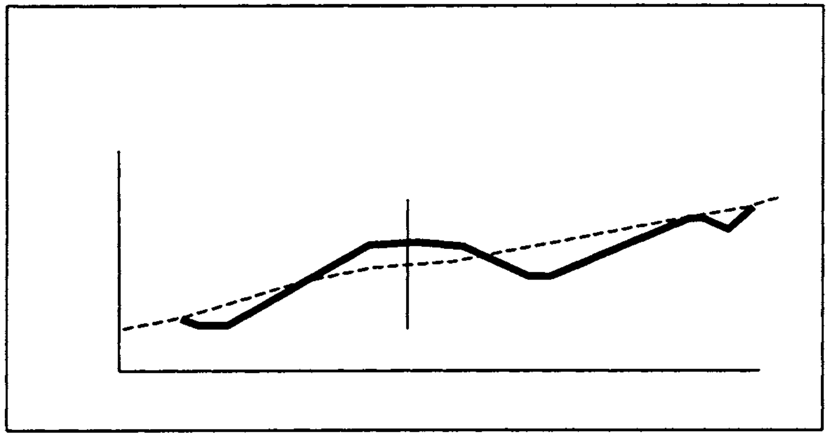
Continued.....



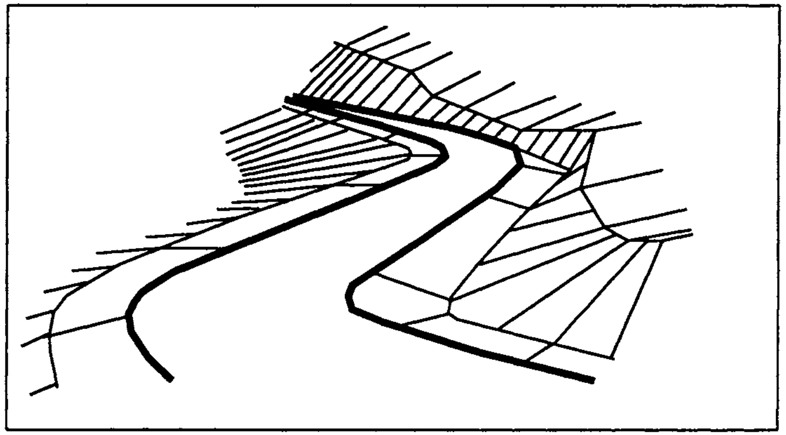
5. ...a dimensioned horizontal alignment is established



6. ...an acceptable profile is determined



7. ...cross sections are detailed based upon the profile and terrain features



8. ....an oblique digitised route representation is created to assist in investigating alternative routes based upon cost and environmental factors

....continued, FIGURE 3-12

DIAGRAMMATIC EXAMPLES OF ITERATIVE STEPS IN AUTOMATED ROUTE DESIGN

- Automated estimation of alternative horizontal alignment, profile, earthwork quantities, and major geometric features, to enable interactive editing and re-design until acceptable alternatives have been identified.

- Generation of 3-D, oblique, and "drive-thro" portrayals of selected views of the route to assist better understanding of the route's impacts and essential construction mitigation measures. These graphical portrayals can assist considerably in understanding the implications of the project – particularly by lay people and decisionmakers.

- Generation of design drawings for approval, bids, and construction.

At present, use of automated design features continues to be relatively expensive, both in terms of the equipment used, its connection with GIS systems, and the needed expertise to employ it efficiently. Consequently, many states do not have sufficient projects to justify these costs and much of the work is carried out by consulting firms. As costs decrease, greater use of these methods is likely. Yet it must be remembered that although their use can considerably speed the design process, the basic principles of design remain, and any outputs of the automated systems must be evaluated critically in terms of desirable practice.