420 FIELD RECONNAISSANCE

421 INTRODUCTION

421.1 DEFINITION. By reconnaissance is meant the reconnoitering of the terrain in the field to determine a road route or to check a projected route. It includes all the field work preceding the preliminary or location survey in which angles or bearings are measured, distances taped and stakes set. Reconnaissance implies thorough investigation and analysis. The reconnaissance is completed when the final route has been determined, within narrow limits, and the grade line marked between control points. The major decisions affecting the route have been made and only minor adjustments may be required during the survey. The reconnaissance generally is made in two stages:

1. The extensive reconnaissance. This is a reconnaissance of area and major controls, embracing a relatively wide belt of land. The extent of the extensive reconnaissance will depend upon how much reliable information is available from maps and aerial photos.

2. The intensive reconnaissance. This is a reconnaissance of a selected route and minor control points. It embraces a narrow belt of land and establishes the line for the road survey.

421.2 OBJECTIVE OF THE RECONNAISSANCE. The objective of the extensive reconnaissance is to eliminate unfeasible routes and to decide upon the best route. The best route is the most economical route which serves the purposes for which the road is to be built. It is the route which will result in a road neither above or below the standards established for the class of road. If the route has been projected on large scale maps or aerial photos the initial reconnaissance will check the validity of the projected route. Control points may be encountered which did not show on the map or photo, necessitating changes in the projected route. Finding gravel deposits or pit-run rock for surfacing is another objective of the extensive reconnaissance.

The objective of the intensive reconnaissance is to mark on the ground the line which the survey is to follow. Usually a tagged or flagged grade line is run between control points.

421.3 IMPORTANCE OF THE RECONNAISSANCE. The importance of the reconnaissance cannot be overemphasized. It is during the reconnaissance that the major decisions should be made. The construction and maintenance costs, the transportation costs and the utility of the road are all affected by the reconnaissance. Good reconnaissance will avoid changes having to be made during the location survey, at greater cost than if made during the reconnaissance. Mistakes made during the reconnaissance are often difficult and expensive to correct later on.

Reconnaissance is hard work. The successful forest road engineer does not "give up" easily. He does not accept the first and most obvious route as "good enough" and fail to investigate all possible alternate routes. There is not substitute for "leg work" on reconnaissance.

Experienced forest engineers generally consider the reconnaissance to be the most important part of their work. The subsequent survey and design is viewed as relatively routine.

Ample time should be scheduled for the reconnaissance. Saving reconnaissance expense is unimportant compared with the savings in road costs and vehicle operating costs obtainable by allowing enough time to determine the best route.

421.4 SEASONS FOR RECONNAISSANCE. Weather conditions permitting, the best seasons of the year to make the reconnaissance are late autumn, after the deciduous leaves have fallen, winter, and early spring before the brush is in leaf. Visibility is greater and a wider belt of terrain can be seen. Tag lines can be run more efficiently as longer Abney sights can be taken and less time is wasted trying to find the sighting mark.

A background of experience in road location and construction is highly desirable for the reconnaissance engineer. Such experience will enable him better to visualize the constructed road along the route and avoid mistakes. The ideal program for the forest road engineer would be to spend the late spring, summer and early autumn on location and construction engineering, the periods of winter when weather precludes field work on route projection, and the other seasons on reconnaissance.

422 RECONNAISSANCE FOR UNPROJECTED ROUTE

422.1 EXTENSIVE RECONNAISSANCE. When the road route has not been first projected on large scale maps or aerial photos, an extensive reconnaissance precedes the intensive reconnaissance. Prior to going into the field, assemble all available small scale maps such as U.S.G.S. topographic quadrangles, and geological maps, and such maps of adjacent or intermingled private lands as are obtainable. Study these maps and the aerial photos of the reconnaissance area to find possible routes to investigate, and to plan the field work.

Plan the extensive reconnaissance so as to cover the belt of land embracing the possible routes in a systematic manner. Take the map and photos into the field. Whenever an identifiable section line is crossed, run a hand compass and pacing tie to a corner to fix your position. Keep track of direction by hand compass, of distances by pacing, and of elevations at identifiable points or at possible control points by aneroid barometer or altimeter. Mark them on the photos. Do not depend upon memory to compare alternative routes. Keep notes on the left hand pages of Field Book Form 301 and strip map sketch with form lines on the right hand pages. It is helpful in making the decision on the route for the intensive reconnaissance to build up a sketch map on 10 x 10 cross-section paper.

The high cost of surfacing of roads in some districts points to the desirability of keeping a sharp lookout for rock suitable for surfacing.

If the reconnaissance is for timber sale roads, keep the logging plan in mind. The road reconnaissance must be correlated with the logging planning.

422.2 JEEP ROADS. In planning the reconnaissance the possibilities of jeep roads into the area should be considered. If the reconnaissance requires walking long distances, the jeep road pays by saving travel time, allowing more time for productive work; by having the crew arrive at their starting point unfatigued; and eliminating back-packing to side camps. If the reconnaissance is for an access road, the savings in travel time of the Bureau of Public Roads location crew will more than pay for the jeep road. Jeep roads are also desirable in enabling the contractors who are prospective bidders to get out on the road location. The more they see of the survey the closer they can bid.

Jeep road grades depend on the soil, with a maximum of 25% under favorable conditions on sandy or gravelly soils where the jeep can get traction. The location and construction of a jeep road is an intermediate step between the extensive and the intensive reconnaissance for the unprojected route. It precedes the intensive reconnaissance for the projected route.

When the best route has been determined from the extensive reconnaissance, the intensive reconnaissance follows. This subject is covered under Section 423, "Reconnaissance for Projected Route," since Bureau of Land Management roads will generally be projected on large scale maps or aerial photos before the reconnaissance.

423 RECONNAISSANCE FOR PROJECTED ROUTE

423.1 FIELD CHECK. While projecting routes on large scale maps or aerial photos saves time by eliminating the extensive reconnaissance, it is still essential to check the projection on the ground. Conditions affecting the road location may be hidden by dense forest cover. The large scale maps, being made from aerial photos, may also be affected by dense cover.

Take a print of the map and the stereo-pairs of photos on which the route has been projected, and a pocket stereoscope, into the field. Follow the projected route, identifying successive control points on the ground, and check their validity. Check elevations on the ground with aneroid or altimeter. Pace distances between control points. If elevations or distances differ appreciably from the projection, calculate the apparent grade between control points, and run a trial line back.

Watch for soft or wet ground or rock ledges which were obscured on the photos. Check the suitability of projected landings, if they are control points. Check projected stream crossings and investigate the possibility of better crossings upstream or downstream which can be reached within grade limitations. Make certain that the projected route is feasible before starting the intensive reconnaissance.

Even if a map-projected route is followed, it is desirable to take the aerial photos covering the route into the field. Correlating conditions on the ground with their appearance on the photos will improve the observer's photo-interpretive ability.

423.2 INTENSIVE RECONNAISSANCE. The control points having been identified and checked, and the grade between them computed, the tag line is run down-grade. The reason for running down is that the terrain is widening out and opening up giving more leeway for the tag line. If a tag line is run up-grade the narrowing valleys restrict the line.

Because of the grade limitations on Bureau of Land Management roads, and the elevations to be reached, the tag line will often be run at or near the maximum permissable grade. The grade line on the ground is analogous to the "grade contour" stepped off with dividers on the topographic map. If the grade line hits above or below the lower control point, obtain the difference in elevations with the Abney and compute the corrected grade percent. Tag the corrected grade line back. Remove the tags or flagging tape on the abandoned line.

Two types of tag lines are run by forest engineers. The tag line of one type represents the center line of the road. On steep side slopes where heavy cuts on center line are required, the tag line is adjusted up-hill and the preliminary or direct location survey approximately coincides with the tag line. This type is best adapted to rolling terrain or moderate side slopes.

The other type of tag line represents the grade of the constructed subgrade and the location survey is run parallel to and above the tagged grade line to get the required cut on center line. This type is best adapted to steep side slopes where much of the subgrade is to be benched.

In tagging a grade line keep the road alignment in mind. Alignment is just as important as grade. Do not turn an angle more than half the maximum degree of curve per station from or to a tangent, nor more than the degree of curve per station from the chord of a curve. Use the hand compass to turn angles. In running to maximum grade guard against the tendency to concentrate on the grade and forget the alignment.

423.3 RUNNING GRADE LINE. Following is recommended procedure for a two-man party: The Abney man notes the point on the helper's face or hat which is the same height as his "H.I." or eye height. The Abney man walks ahead and, with his Abney set at the percent grade being run, sights back on the helper who stands at the last grade point. (The Abney man can place himself on grade more quickly than he can direct a helper to move up or down hill to get on grade). A bright aluminum safety hat makes a good sighting mark under ordinary conditions. In brushy ground cover or on dark or rainy days the helper holds a flashlight at H.I.

When the Abney man finds his grade point, he kicks a spot on the ground clear with his feet, to mark where he stood, and places a red tag or piece of flagging tape on the nearest tree. Some engineers prefer to set the tag at H.I. above the ground. He takes a grade sight with the Abney ahead along the slope to get his direction, and walks ahead. The helper comes ahead, tagging the line as he goes. Arriving at the tag set by the Abney man he looks for the spot cleared by the Abney man and occupies it. By this time the Abney man has reached the vicinity of the next grade point, and repeats the above procedure. The tag interval will depend upon the density of the ground cover. The tags should be intervisible. Avoid short Abney shots which tend to make the grade line longer than the location line with consequent increase in location grade. As about the same amount of time is taken by each shot, the longer the shots the more line a party can run per day. However, shots which are too long waste time in trying to find the sighting mark.

In running a grade line without a helper, the Abney man sets a tag at his H.I., sights ahead along the slope, and sets tags as he goes ahead. When he has gone as far as he can see the tag set at his last grade point, he sights back on the tag and sets a new grade point.

The more experience the Abney man has in road location and construction the better job he can do on reconnaissance. He should visualize the alignment and profile of the constructed road along the grade line.

423.4 RUNNING GRADE LINE FOR CURVES. A mistake commonly made in running a grade line around a sharp-nosed ridge, or a narrow valley, is in tagging a line longer than the length of the curve which will be located. This results in a steeper grade on the located curve than was intended. When tagging to a maximum grade this may result in the location exceeding the allowable maximum. The inexperienced man tends to tag around the semi-tangents of the curve rather than the curve. (Figure. 423-1)

The experienced engineer will estimate the degree and length of the curve and reduce the grade on the tag line to compensate for the difference in length between the tag line and the final located curve. By reading the intersection angle with the hand compass, and estimating the appropriate degree of curve, the length is calculated from $L = 100\Delta/D$ running a grade line on the maximum allowable grade for the class of road, setting the Abney arc at ½ or 1 percent under the maximum grade will help to insure that the maximum grade is not exceeded on the location. The grade line tends to follow minor curves on the ground which are eliminated by tangents on the location. Following are methods by which the less experienced man may do a better job of tagging the grade line for sharp curves:

1. Tagging around a sharp ridge. Run grade line to nose of ridge. Take hand compass bearing back along the tag line and forward parallel to the grade on the forward tangent. Compute the intersection angle Δ. Estimate the degree of curve required (usually the maximum allowable) and calculate the semi-tangent. Pace back to the S. T. distance to the P.C. Then either

   a. Read the percent up to the crest of the ridge in the direction of the long chord. (Deflection angle of $LC = \Delta/2$). Pace the distance. Take an Abney shot the same percent down and pace the same distance. This will put you on the same elevation as the P.C.

b. With the Abney set at 0 percent, run level around the ridge to the approximate P.T. opposite the P.C.

Compute the length of curve L and the difference in elevation between P.C. on P.T. on the desired grade for the curve. Lay off this difference from the approximate P.T. point. Continue tagging the grade line along the next tangent.

Example: Running maximum 10 percent favorable grade line grade for class III road. Hand compass bearing of tangents from nose of ridge N 50° E and S 70° E. Δ = 120°. From "Calders' Forest Road Engineering Tables", Table 11, LC and ST = 9924 conditions indicate maximum 75° curve ST = 9924/75 = 132 ft. L = 100 Δ/0 = 12,000/75 = 160 ft. 160 x 10% = 16 ft. difference in elevation between P.C. and P.T. Distance via STs = 132 x 2 = 264 ft. grade via STs = 16/264 = 6%. Direction of LC = deflection angle 60° from S 50°W = S 10° E Length of LC = 9924/75 = 132 ft. (Fig. 423-1)

2. Tagging across a narrow valley. The method given above for ridges may be used in valleys by running the grade line to the PI at the creek. However, since the PC and PT are usually intervisible, it may be more convenient to work from the long chord. Take a back bearing along the tangent, shoot a level shot across the valley in the estimated direction of the L.C. and pace the distance. Take a forward bearing along the forward tangent grade percent and compute the Δ. Compute the degree of curve from LC_1°/LC. Compute the difference in elevation between P.C. and P.T. for curve L and desired grade. If the tangents are nearly parallel, as in a box canyon, select the points for the P.C. and P.T., pace the L.C. between them and compute radius of curve from LC/2. This method is also useful in tagging switch-backs.

Example 1: Backing bearing from assumed P I N 70° W. Length of approximate LC = 160 ft. Forward bearing S 30° W. Δ = 100° LC from Calders' Table 11 = 8778. Degree of curve = 8778/160 = 55° L = 10,000/55 = 182 ft. 182 x 10% = 18 ft. difference in elevation between PC and PT. Grade along LC = 18/160 = 11% Bearing of LC = S 70°E - 50° = S 20° E. Run S 20° E 160 ft. on 11% to P.T. Then proceed on 10% grade in direction of forward tangent. (Fig. 423-1)

Example 2: Box Canyon, tangents to curve approximately parallel. LC paced 190 ft. Radius of curve = 190/2 = 95 ft. Degree of curve = 60° L = 18,000/60 = 300 ft. Abney reading between PC and PT 12% difference in elevation 12 x 190 = 23 ft. Grade on curve 23/300 = 7.7%.

Where a curve is a critical part of the tagged line, it may be tagged by turning deflection angles with the hand compass (from PC or PT

FIGURE 423-1 PLAN

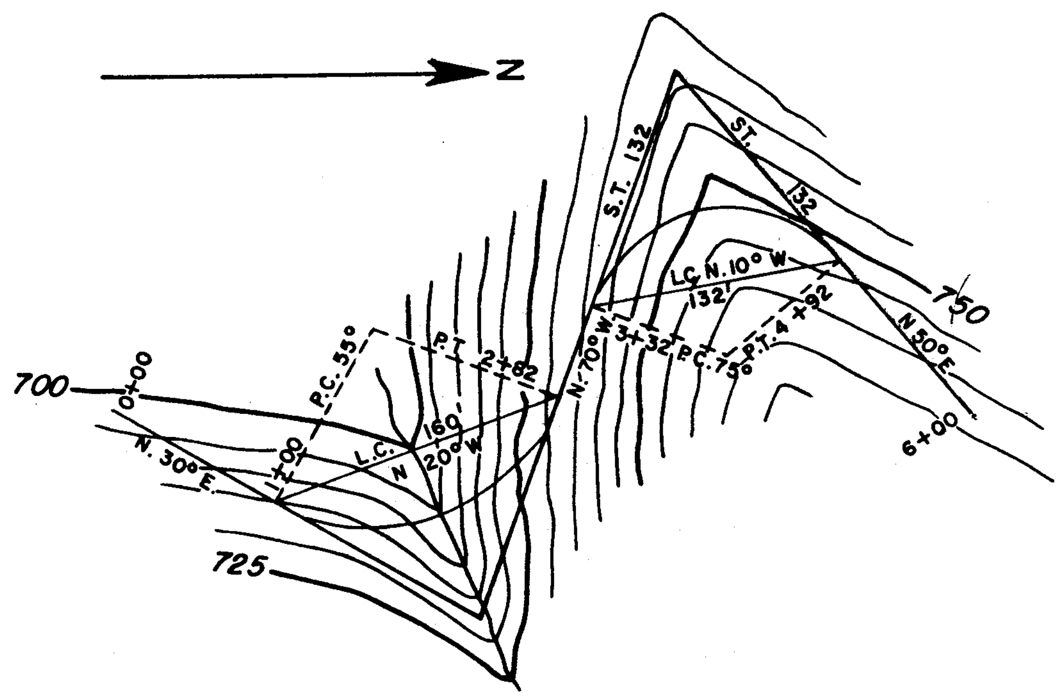
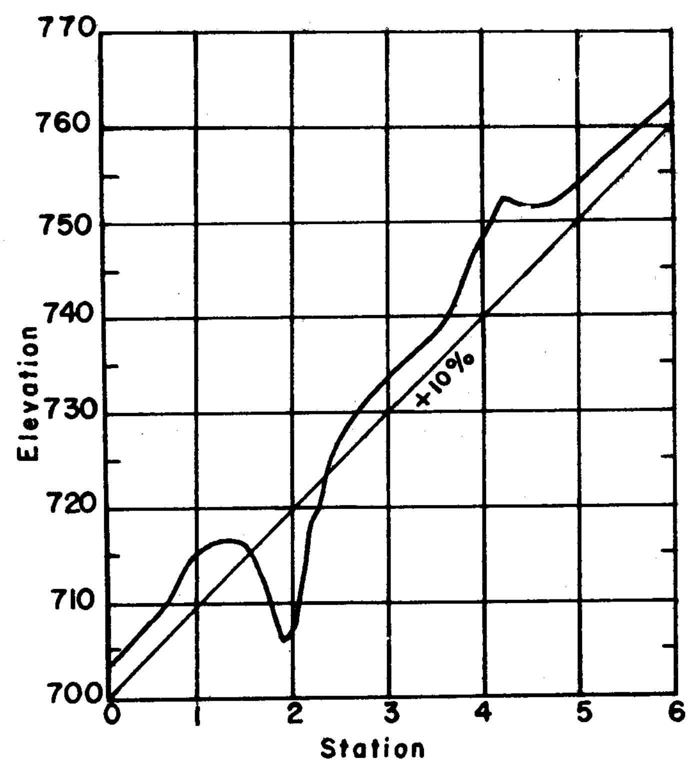


FIGURE 423-1 PROFILE



deflection for 100 ft. = one-half the degree of curve) and pacing stations, or by estimating middle ordinate distances.

423.5 GRADE SEPARATION AND VERTICAL CURVES. Other common mistakes in running grade lines are (a) branching off too abruptly from another road and not allowing enough room for grade separation, and (b) not allowing enough room for a vertical curve at grade breaks such as reducing grade for a landing. The grade on a spur road branching off of a main road must coincide with the grade of the main road until the center lines of the two roads are separated by the sum of the half-widths at the two road sub-grades.

Example: Class III spur with a half-base on the outside of the center line of 10 ft. to take off on a 25° curve on a 300 ft. vertical curve leading to a + 10% maximum grade, from a class II main road with a half-base on the ditch side of 13 ft. on a + 2% grade. Reference to Calders' Table 7, "Tangent Offsets," grade separation for a little less than 23 ft. will take place at Station 1 + 03 (actually at 1 + 02). Reference to Calders' Table 10 "Vertical Curve Offsets" shows that the offset at the vertex of the vertical curve for a change in grade of 8% is 3 ft. Therefore, start the grade line at the elevation of the main road subgrade 103 ft. from the selected P.C. Rise in 150 ft. to PVC at 2% = 3 ft. + 3 ft. offset = 6 ft. 6/150 = 4%. Run + 4% for 150 ft. to the middle of the vertical curve. Rise in 150 ft. from vertex at 10% = 15 ft. - 3 ft. offset = 12 ft. 12/150 = 8%. Run + 8% 150 ft. to the end of the vertical curve, thence run + 10%. (Fig. 423-2) If the 10% grade line were started at the P.C. 0 + 00 it would be 20.3 ft. too high at station 4 + 03; if started at 1 + 03 it would be 10 ft. too high at 4 + 03.

In running a grade line into a landing where the grade must be reduced, care must be taken to allow room for a vertical curve.

Example: Spar tree and landing at Station 12 + 50, + 3% grade wanted from 12 + 00 to 13 + 00. Approaching on a + 10% grade, reduction in grade for a 200 ft. vertical curve must begin at Station 10 + 00. From Calders' Table 10, offset at 11 + 00 is 1.75 ft. Grade from 10 + 00 to 11 + 00 = 10 - 1.75 = 8.25%. Grade from 11 + 00 to 12 + 00 = 3 + 1.75 = 4.75%. Thence run 3%. If the grade break from 10% to 3% were made at Station 12 + 00, when the road was constructed with a 200 ft. vertical curve, the grade from 12 + 00 to 12 + 50 would be 5.6% and from 12 + 50 to 13 + 00 3.9%. (Fig. 423-3)

When changing to a steep grade, reduce the preceding grade 1 or 2 percent for a station to facilitate gear shifting.

FIGURE 423-2 GRADE SEPARATION PROFILE

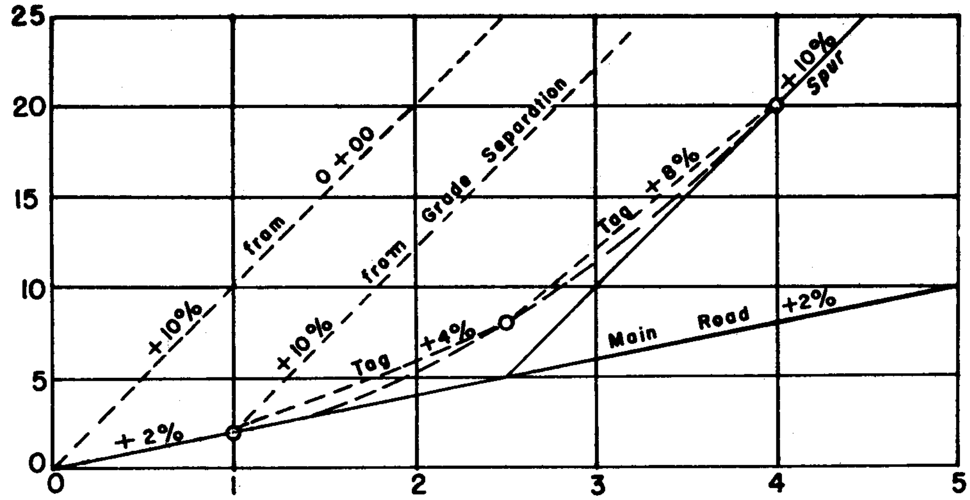


FIGURE 423-2 PLAN

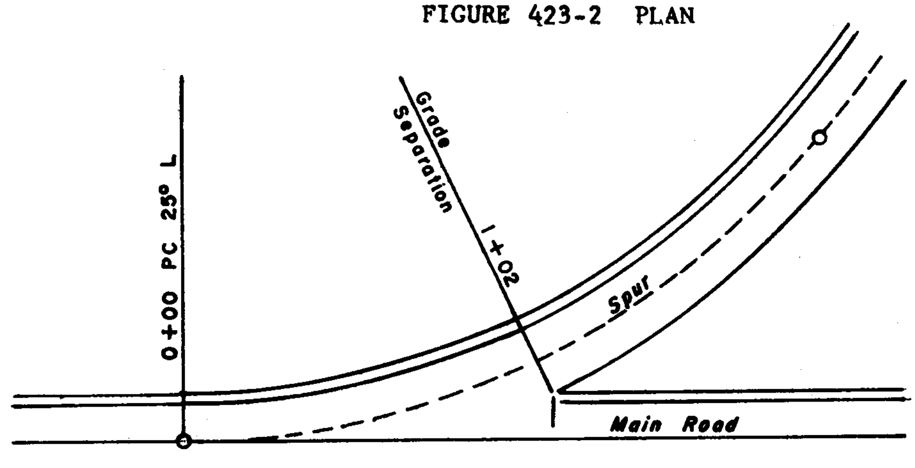


FIGURE 423-3 LANDING PROFILE