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MANUAL OF INSTRUCTIONS FOR SURVEYS AND INVESTIGATIONS

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CHAPTER I

GENERAL

1.0 Responsibility. The Road Commission organization has developed to the status where more realization of the possibilities in the field of surveys and plans is appreciated by the individuals comprising its personnel. The service to be rendered the Territory by the Road Commission is largely dependent upon provisions made when plans are prepared. Errors in establishing proper standards and practical routing become disadvantages borne by the settlers who have faith in the future of Alaska as well as the traveling public. To correct these errors in planning is sometimes impossible but always an economic loss.

We cannot overlook the opportunity given us in this expanded highway program of the Territory to more correctly anticipate the future as well as the present requirements of highway service and to justify the responsibility placed upon us by making our efforts in surveys and final plans produce the best results. Our organization is fortunate in having personnel trained in the practice and theory of the profession. Funds are available for an extensive program of recruitment of recent graduates and it is our responsibility to train new personnel so that they will become a vital part of our expanding organization. Therefore, it is essential that a comprehensive manual of instructions should be available so that all activities of the Alaska Road Commission will work to one common result.

It is evident that one person or a few persons cannot exert perfect control or give all the necessary instructions in view of the increasingly complex nature of conditions we are called upon to meet. Coordinated effort must extend throughout the organization. Each one must analyze his own problems from a standpoint of their relation to the general workability of the entire system as well as their application to the immediate assignment. This call for assistance, loyalty, patience and endeavor is made regardless of position and authority.

1.1 Status of Organization. The Road Commission has been resolved into a number of departmental activities, coordinated through administrative control, so that specialized duties are conducive to a comprehensive whole. Each district office, with an organization for Engineering, Construction, Maintenance and other functions, complete within the district, has as one of its principal corps an engineering force which prosecutes surveys, investigations and preparation of preliminary plans.

1.2 Purpose of Survey. One of the fundamental operations in road building is the location survey which becomes, through construction, a permanent monument. A satisfactory survey, complete in all details, will be proof of an endeavor well executed.

The purpose of the survey must be carefully considered. It cannot be efficiently and economically executed without all concerned having a clear conception of what the result should portray. First there should be a reconnaissance supplying information for determination of the routing and practicability of the proposed undertaking; secondly a preliminary study of comparative costs and standards; third and finally a location survey embodying all the essentials for construction plans. The importance of the proposed project should be the concern of the Locating Engineer. The service it will render and the traffic it will carry are governing factors in determining alignment, grades and standards to be used. The above determinations originate at Headquarters. However, if these values are given careful consideration by the Locator, the type of survey he should perform is clearly outlined.

In order that the Locator may define and assign to each member of his party a particular duty, the District Engineer must instruct him in the requirements for each project, whether for Force-Account or Contract. The District Engineer must delegate authority for supervision and outline methods of procedure as well as the essential route and standard of work to be executed. Upon the District Offices and Juneau Headquarters rests the responsibility of conveying administrative desires to the Locator, defining standards consistent with the Road Commission's policies, and approving the final layouts for the construction plans. A system of coordinated effort from all concerned throughout the steps of making a location and preparing final plans will produce a well-engineered project.

1.3 Economy in Survey Costs. Having defined the purpose for which the survey is intended and the results for which the plans must provide, the next concern is obtaining data for design by the most efficient and economical method. Organization and orderly conduct of survey follows general principles which uniform practice has demonstrated to be sound. Originality in applying general practices is desired when it promotes economy and efficiency and broadens the capabilities of the field personnel. Certain phases of our work require increasing attention to terrain, ground conditions, potential farming areas, property developments, etc. These all complicate working uniformity in plans for our vast Territory with its widely varied topographic and climatic conditions and permanently frozen ground. Survey and plan work should be performed by methods which will obtain at minimum expense the desired results consistent with adopted standards. Survey cost within each district should be comparable with those of similar quality in private

practice and in other organizations within the area. Camp operations on surveys are as much a part of the Locator's responsibility as other phases of the work. The camp should be carefully organized and operated as economically as the rest of the survey, observing all safety and sanitation rules of the Territory.

1.4 Purpose of Manual. The intention of these instructions is to bring about uniformity of methods and results, to establish standard requirements, and prescribe methods relative to making surveys for the preparations of final plans with the minimum amount of discrepancies. Standard recognized practice for detailed operations of surveying shall be used. The ultimate result to be obtained is the final location where the roadway may be efficiently and economically built.

It is obvious that this instruction cannot direct in detail each of the operations involved in the study. The instructions are not intended to solve all field and office problems nor are they to be used for the instruction of engineers in the rudiments of Highway Engineering. It is assumed that the field engineer has the education, experience and ability to discharge satisfactorily the duties of these positions. It is a part of his duty to visualize the needs and develop the methods which will supply quickly and economically the necessary information.

1.5 Administration of the Survey. The proper handling of a survey requires a high quality of leadership on the part of the Locating Engineer in charge. The success of the survey depends, in large part, on how well the work is planned. The survey should be based on a thoroughly planned system; complete organization of the party including its maintenance and transportation; and accurate knowledge of the information desired. The Locator should assemble all supporting maps and reports to determine the methods by which various phases of the survey can be accomplished. Inadequate planning of a survey invariably results in wasted time and expenditures reflecting discredit on those in charge.

1.6 Locating Engineers' Qualifications: The Locating Engineer must be fitted by education and experience to represent the Alaska Road Commission creditably in the discharge of administrative, supervisory, and technical duties. He is required to direct subordinates in technical work, perform personnel duties and assume authority which will qualify him for further professional advancement.

To control all phases of the survey, he must have an intimate knowledge of locating methods and construction practices and must acquaint himself with the abilities of each of his subordinates. He must familiarize himself with the experience and qualifications of his personnel and train them for greater usefulness.

He should encourage them to self-improvement which will surely lead to advancement with the Road Commission.

The Locator must devote sufficient time to the main location of the survey so that it will be placed in the optimum position with the least expense and detail. Thorough reconnaissance promotes the confidence of the party in the Locator's ability which is reflected in the character of the work performed and the enthusiasm with which it is accomplished.

The projection should have the Locator's personal attention which is necessary for a satisfactory design. He must be familiar with all projection and not overload himself with details that can be performed by subordinates.

As a responsible officer of the Alaska Road Commission, the Locator holds a position of trust and prestige that demands good public relations, judgment and tact in addition to technical and administrative ability. To carry out these essentials, he must consider his conduct and the conduct of his subordinates so as to avoid any reflections on the organization he is representing.

1.7 Classification of Surveys. Surveys are divided into the following classifications for discussion in the Manual: Reconnaissance Surveys, Preliminary Surveys, Location Surveys, and Special Surveys.

The nature of the project, whether new construction or reconstruction, heavy or light work, mountainous, frozen, swampy and brushy, heavily timbered or open, will determine the methods necessary to secure the final location. The location may involve all the steps including reconnaissance, or may eliminate some of the preliminary steps.

In open country, valleys, and along existing roadways, controls are easily discernible and the engineer can readily indicate points determining the alignment. On this class of survey, the work can be accomplished with a smaller number of men in the survey party than is necessary on more difficult locations. It is, of course, apparent that the greatest economy effected and the least delay is occasioned when one survey accomplishes our objective. Therefore, the District Engineer should give thorough consideration to all classes of survey before making the decision as to how to proceed with the work.

1.8 Authorization for Survey. An engineering work order shall be given the district by the Chief Engineer. This order will outline the proposed route to follow and a financial allotment to cover wages and purchases to initiate the survey.

1.9 Designation of Route. The designation of route will

be studied by all interested parties and final designation made by the Chief Engineer.

2.0 Determination of Roadway Cross Sections. The proposed project will be reviewed by Headquarters and the roadway cross section determined by the Chief Engineer.

2.1 Right of Way. Rights of way shall be considered and data collected in two different ways:

First, when the location traverses private land such as homesteads, patented ground, etc., all ties should be made to property lines or permanent corners with sufficient information to plot right of way maps to be submitted by the District to Headquarters for final action with the owners.

Second, when the location traverses public domain no right of way should be obtained from the Land Office until construction has been completed and the "as-built drawings" completed. Then the right of way shall be established and application for same made to the Land Office by Headquarters. However, complete ties should be made to all BLM survey corners at the time the location survey is run.

Use permits such as quarries, gravel pits and borrow pits shall be initiated by the District Offices unless it is certain that such areas will be required for permanent installations.

2.2 Care and Adjustment of Instruments. All persons using survey instruments will be responsible for their care and condition. Cases for instruments should be used when transporting them to and from work by motor vehicles. Then they should be placed in the vehicle to receive the minimum vibration.

Survey instruments will be kept in adjustment at all times and checked daily when in use. The checking and possible adjustments should not require more than a few minutes of a competent instrumentman's time. In addition, all measurements shall be taken in such a way that instrumental errors will cancel. Failure to follow this procedure may result in serious errors and much wasted time. If an instrument should give undue annoyance the matter should promptly be reported so repairs or replacement can be made.

2.3 Survey Notes. Not enough emphasis can be placed on note keeping. Completion of adequate plans and the speed in which they are prepared depend largely upon accuracy and clearness of the field notes submitted. Each recorder will be held accountable for legibility, neatness and preservation of any field data. Notes should not be crowded on a page and ample space should be used to detail all topography. All notes shall be original and any office copies thereof should be carefully marked. All transit notes should begin at the

bottom of the page with stationing carried forward up the page. All other notes except those containing sketches of roadside topography should begin at the top of the page with stationing carried forward down the page. Loose leaf notes shall not be used on any original survey. All notes shall be carefully indexed on the first page of the book. On the cover, clearly marked, shall be the project and phase of survey so that when filed no difficulty will be experienced in identifying or finding any portion or type of records which they cover.

2.4 Meridian Determination. All surveys shall be referred to true meridian and checked by magnetic bearings at each transit point. True meridian may be determined by solar observations at least every ten (10) miles. All data relative to meridian determinations shall be entered in the field book opposite that portion of line where observation is taken. Ties shall also be made to USC and GS triangulation stations wherever possible for determination of true bearing.

2.5 Coordinate Plotting. The use of coordinates for plotting and calculating preliminary and location traverses shall be standard practice. These coordinate notes shall be made a part of all permanent records.

RECONNAISSANCE SURVEY

3.0 Reconnaissance Survey. When a general investigation of a route is authorized, a reconnaissance should be made by the District Engineer, Locating Engineer and a representative of the Headquarters Survey and Road Design Branch. They should devote as much time as may be warranted by the importance of the project and the difficulties encountered to a thorough study and investigation of the proposed route prior to the more detailed survey work.

The reconnaissance should be intensive and thorough and the resulting information sufficient to make a decision where a possible choice of routes presents itself.

Great importance is attached to the reconnaissance investigation and the economy and speed of the later surveying work will be proportionate to the knowledge the Locating Engineer has acquired of the existing conditions.

3.1 Reconnaissance Data. The information obtained on the reconnaissance survey should include the general rise and fall of the country; possible governing and maximum grades which may be obtained by use of compass, by pacing, scaling or estimating from available maps; cross sections taken sufficiently often to determine the general slope of the side hills; classification of materials; drainage; glacial and snow conditions; character of clearing; development of country; service to communities, etc. This information should be

acquired by usual methods employed in reconnaissance work, including the study of U. S. Geological Survey maps when available.

The data obtained from the reconnaissance survey should indicate the general location of the route and established controls. All information should be furnished for the determination of standards of alignment, grade and typical roadway section.

3.2 Reconnaissance Report. The reconnaissance report should be a complete record, with cost estimates, maps and photographs appended, of all collected information useful in administrative circles and in the conduct of future surveys. It should conclude with a discussion of economic factors and a brief summary of comparisons and recommendations.

The following topical outline is supplied as to subject matter covered in a preliminary report. The outline may be rearranged to present topics in whatever sequence is most advantageous in the development of the particular project.

I - INTRODUCTION

1. Subject or designation
2. Origin of investigation
   a. Authorization or request
   b. Necessity for survey or program

II - PROCEDURE OF RECONNAISSANCE

1. When made
2. Personnel - authorities consulted
3. Method
   a. Plans - Maps
   b. Field Investigation
   c. Other sources of information

III - DESCRIPTION OF ROUTING AND ALTERNATES

1. Log of route - course, distances, profile, slopes, difficulties, contacts
2. Conditions, vegetation, soils, drainage, obstacles

3. Road Standard Practice; alignment, grade, width, type, right-of-way problems

4. Estimated Costs - Construction

5. Maintenance Costs

6. Construction facilities, source of supply, labor market, working conditions

IV - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

V - MAPS, PROFILES, CHARTS AND PHOTOGRAPHS

PRELIMINARY SURVEYS

4.0 Preliminary Surveys. Before starting a party on preliminary surveys, the Locator should be well informed by maps, data and instructions emanating from the previous route or reconnaissance study. He should be familiar with the area or be given time to make an intelligent study so that the entire party will not be delayed in the field initiating the survey. It should be his endeavor to place the line as close as possible to the final location.

The organization and method of procedure will be determined in the district office. Ordinarily, the personnel will include: Locating Engineer, Chief of Party, Instrumentman, Chainmen, Stakeman, Levelman, Rodman, Axemen, Cook and Tractor Operator. Preliminary lines should be marked "P" and alternates marked P1, P2, etc. Survey stationing should be from south to north and west to east where possible.

4.1 Staking. On preliminary surveys the base line should be tangent courses and angle points. A series of short tangents can be used approximating the curve when it is apparent that a curve will be required. Stakes will be placed at 100-foot station and intermediate stations at all prominent breaks in profile which will facilitate taking profile levels and topography for projections.

The accuracy in preliminary base lines should be equal to that used on final location in order that calculated traverses will check and an identical coordinate system will apply to both preliminary and location data. Transit points on tangents and angle points should be set by reversing or double centering. This method insures accuracy by providing a constant check on the adjustment of the instrument. With ordinary care, chaining should not exceed the allowable error of one foot in five thousand. Slope chaining in broken country is quick and accurate and should be common practice where the topography warrants.

If the preliminary is carefully chained, it can be used with reliability in later running out the final locations. Chainmen and

stakemen should be particularly cautioned not to skip a station and thereby throw the mapping into error before the level party detects the error in staking.

4.2 Bench Levels. Independent line of bench levels shall be run, based on U. S. Coast and Geodetic Survey data, and permanent bench marks shall be placed at intervals of approximately 1,000'. Benches should be established at all existing bridges and at proposed bridge locations. The recommended party for this phase of the work is one levelman and one rodman. The levelman should be capable of keeping notes as well as running instrument. Bench marks should be set upon some permanent object and in a way which will insure their remaining undisturbed during future construction. They should be numbered consecutively and fully described as to location, distance from centerline, etc. All bench marks should be checked by a complete circuit with allowable errors equal to the square root of the distance in miles times .05 of a foot. Each bench mark should be a turning point, keeping all notes in a separate book. It is sometimes desirable on long surveys for the rodman to keep a peg book noting all turns as the levels proceed. The profile elevations shall be taken on all preliminary stations and at permanent breaks along the profile, recording stations of transit points accurately. When running profile levels, checks should be made on bench marks and corrected to agree with the profile notes. The allowable error on bench levels which have been previously checked shall not be more than .1 of a foot for 1,000' intervals. In many cases, the profile level line can serve as a check on the bench levels, in which case the degree of accuracy for bench level survey must be maintained. The Locator should make an effort to have the level computations checked each night so that an accumulated error will not result.

4.3 Preliminary Mapping. Preliminary lines should be plotted by coordinates. Maps should be made on hard shell manila as recommended in A.R.C. Memorandum No. 68 covering paper requirements. Working maps should be in lengths convenient for handling in field and office. All drafting necessary for and during the preliminary survey shall be done by a competent member of the party. When the accuracy of scaling consistent with the accuracy of the notes and of projection permits use of the scale 1" = 100', this scale should be used on working maps so that they may contain all of the project's location and closing line, and the controlling topography for use throughout the location stages. With care in accuracy and neatness, such maps can be traced on the final layout sheets without duplicating the drafting. The scale of 1" = 20' should be used for bridge sites. It may be used rarely when the survey is in particularly rough country requiring short radiuses or many trial projection lines. This scale may be advantageous in rough country to permit reconstruction of preliminary cross sections from irregular contours.

4.4 Contours. Contours can be plotted on the alignment where the topography indicates extensive study. The common method of taking

contours is by hand level, rod and tape, locating the contours on the ground. If contours are plotted from slopes or cross section notes, care must be exercised in recording notes to indicate essential breaks or changes in contours which are not on uniform slopes. In irregular country, the most reliable results are secured by plotting contours in the field whereby they may be accurately joined and peculiar features properly located. Unless this is done, the finished contour map should be taken into the field and visually checked. The topographer should be experienced in knowledge of what constitutes controlling contour features.

4.5 Cross Section Method of Projection. Complete cross sections from the preliminary line showing all breaks in the ground surface are often necessary in connection with contour plotting or in lieu of contour projection. When used for projection in lieu of contours, the proposed road templet is superimposed on each cross section on some predetermined trial grade line. It is preferable that location notes be offset from base line at a point spotted on the projection map. The alignment projection is adjusted to pass through these points as nearly as possible. By trial with revised grade and alignment, the final projection is accomplished. When both contours and cross sections are plotted, a trial projection of contour projection is a check on the cross section plates for minor adjustments. Inaccuracy in preliminary cross sections and contours in difficult country leads to incorrect projections and subsequent revision of the located line. Emphasis should be made on taking cross sections at right angles to the centerline as many errors are effected by carelessness in taking cross sections.

4.6 Approval of the Projection. Close supervision by the District Engineer or his assistant is necessary during projection of the final location. The projection should be reviewed on the ground and approved before the final line is staked. Review of the projection by representatives from Headquarters as well as the district office is anticipated on practically all projects. The design that is approved before location is staked should be free from costly line revisions. Headquarters will cooperate with the districts in the solution of important problems that arise and should be kept informed on progress of the survey in order that they may be available when the projection is ready for review. The best results are obtained when projection and design is done by the Locating Engineer in the field where it can be reviewed and checked on the ground. This is generally not possible on most of our remote projects. The District Engineer should by field review acquaint himself with details which later study in design requires. If the design is handled in the district office, the Locating Engineer should have tentative projection of alignment and grade indicated on preliminary plans and profiles and supporting data for controlling features.

4.7 Outline of Preliminary Report.

1. Description of Project

   (a) Location and relation to Community System or Main Highway System, with reference to a vicinity map.
   (b) Economic importance, mineral, agriculture development, etc.
   (c) Scenic value or recreation development.
   (d) Length and termini; recommended width of roadway maximum curvature and grades; datum used.

2. History

   (a) Date Preliminary Investigations requested.
   (b) Date Preliminary Investigations or Reconnaissance Survey reported; with estimates.
   (c) Date of location.
   (d) Brief history of previous construction (if survey is relocation).

3. General Characteristics of Proposed Work Difficulties

   (a) Distance from rail point, seaport or supply point, transportation facilities; rates; cost.
   (b) Clearing and Grubbing.
      (i) Virgin; heavy; light; second growth; approximate acreage of each.
      (ii) Recommended method of handling.
   (c) Excavation.
      (i) Classification; ledge rock; boulders, gravel deposits, permafrost; muskeg or tundra; quantities of each probable waste; select borrow; overhaul.
      (ii) Subgrade conditions.
      (iii) Recommended construction procedure; equipment required, etc.
   (d) Structures.
      (i) Bridges; recommended type and length; material or aggregates available, etc.; probable costs.
      (ii) Culverts; recommended type and size; material corrugated metal, timber, etc.
   (e) Surfacing.
      (i) Recommended type, plant mix; prime and seal; crushed gravel; or pit run gravel, etc.
      (ii) Material — source of supply.
      (iii) Recommended method of handling and equipment required.

4. Conclusion

(a) Peculiar features encountered on survey; alignment, grade, topography, etc.; how handled.
(b) Peculiar situations to be encountered on construction and suggested methods of handling.

5. Exhibits

(a) Vicinity Map.
(b) Photographs.

LOCATION SURVEYS

5.0 Location to be Staked. The location survey will be considered complete when the projection alignment is staked on the ground, adjusted in detail, and cross sectioned. Staking location and projection should precede preparation of final plans just prior to construction. The projection is essentially a trial line, subject to revisions which the location will disclose. The stakes are necessary for review of the projection by construction forces or prospective bidders.

Relocation surveys for reconstruction of existing roads, and pioneer surveys when terrain and brush conditions permit, should be fully field-located, including staking of curves. If the Locating Engineer exercises care and judgment, few office projected lines will be required during the period of final office design, and most of the located line will become the final line without further revision.

5.1 Location Survey Party. The personnel for a location survey shall include the Locating Engineer, chief of party, instrumentman, two chainmen, a levelman, stakeman, rodman, computer-draftsmen, and necessary axemen.

5.2 Description of Located Lines. Located lines shall be marked with the letter "L" and any alternate lines shall be identified by the letters "A, B, C," etc. The use of the letter "O" shall be reserved for identification of office projections. On the location surveys, the stationing, where possible, is to increase from the south to north, or from west to east.

5.3 Method of Staking. The projected line shall not be staked by offsets from the preliminary line, but by a continuous transit line based on traverses of calculated and scaled ties to the preliminary line. By this means the staked line will pass through or follow at a desired distance from the control points noted on the projection. It should accordingly fit the ground, except where inaccuracies in preliminary data are discovered. At such places, it

will have to be adjusted by revisions and these revisions should be made by the location party as they become evident. Minor inequalities in fitting the ground may be made by grade changes rather than changes in alignment. It is not to be expected that a projection can be made which would not be subject to some advantageous changes during location. The method of running in a projection and reaching a final adjustment on the ground will depend upon the individual practice of the Locating Engineer. All locations should be accomplished by a skilled chief of party who is qualified to apply the calculated projection notes and traverses in the field. He must follow the accuracy with which the centerline fits the ground and make revisions or adjustments in the field as the survey proceeds. It is necessary that profile levels be carried close on the transit party so that elevations and cross section control can readily be determined. The complete alignment and curve data notes are made up as the survey progresses. In order to eliminate frequent backing up and re-running courses or curves, the chief of party must also investigate the accuracy of the projection ahead of the survey crew.

The Locating Engineer depends upon the accuracy of the preliminary data to the extent that the projection can be run by a qualified instrumentman and survey party and not be subject to numerous readjustments requiring his constant attention to the party. To do this, he should review their designed alignment by a "projection-in-hand" inspection of the ground and, if necessary, have important control point data or cross sections checked from the preliminary line. Traverses of preliminary and final line being on a common coordinate system are easily calculated and measured. Sketches of the traverse and pre-calculated location and alignment notes can be checked by the transit party. At each field tie, the calculated relation of the located line to the preliminary line is checked and proper change substituted in the traverse notes of the succeeding course to bring it back to the calculated position.

5.4 Closure and Allowable Error. Closures from the location survey to the preliminary line shall be made at frequent intervals. Allowable error of closures is 1' in 5000' of located centerline.

5.5 Centerline Stakes. The centerline of the locations survey shall be marked by stakes approximately 1 x 2 at least 14" long, driven at 100 foot stations on tangents, 50 feet apart on curves up to 16 degrees, and 25 feet apart on curves greater than 16 degrees. Where the location follows a traveled road, a nail with a small piece of red cloth tied to it shall be driven on centerline and the stake placed on an offset where it is least liable to be disturbed with the offset distance to the centerline marked on the side opposite the station number.

5.6 Transit Points. Transit points shall be marked by the center tacks in 2 x 2 hubs driven flush with the ground. Where the point falls on rock or an obstruction that prevents driving a hub, it

should be indelibly marked, as by a chisel cut in rock. Mark the beginning of curves as P.C. with the direction of the curve right or left. The end of the curves should be marked P.T. The intersection of semi-tangent shall be marked P.I. and points on tangent marked P.O.T. and points on curves P.C.C. On long tangents, transit points should be set at not more than 1,000' intervals.

5.7 Reference Points. Reference points must be placed so that the present centerline can be reliably replaced if lost or obliterated. Beginning and end of curve points, intersection of tangents and all transit points on tangents should be referenced. Occasionally it will be more convenient to leave a point on tangent near the point of curve rather than the curve point if the latter is difficult to reference. Reference points should be set with permanent hubs and markers or by nails and washers in adjacent permanent trees, building, poles, etc. A single reference line with accurate measurement to the nearest reference hub and a long sight to the distant reference point beyond the precise angular deflection is one of the quickest methods for referencing the original hub. The distance to the second hub need only be approximate to locate the reference point, placing the reference line with hubs on opposite sides of centerline with angle deflection and distances will also prove convenient. P.I.'s and points on semi-tangents outside the area of disturbance from the construction are usually effective. In difficult country, more points or more reference lines should be placed in case loss of reference points would cause difficulty in re-tracing the line between the remaining ties.

5.8 Topography. Topography shall consist of ties to property and land lines and corners and to all man-made objects such as houses, buildings, fences, gates, power poles, power lines, trees, culverts, bridges, ditches, railroad tracks, and all utilities within or near the proposed right-of-way. Similar ties should be made to prominent natural features such as streams, water courses, bluff and cliff lines and base lines of hills or mountains. Generally speaking, objects 600' each side of the centerline should be sufficient. Topography should be taken in conjunction with the centerline survey except in special cases such as bridge site surveys and channel changes. The topography notes should be made an integral part of the transit notes. Topography is often taken on the preliminary survey although any or all of it may be referenced to the final location if desirable. The use of identical coordinate system on preliminary and all location surveys will make it possible to apply preliminary topography ties to the located centerline.

5.9 Property Lines and Section Corners. The station and direction of all intersection property section lines shall be extended and the names of all property owners, section numbers and township numbers recorded. Ties shall be made to these corners and any other monuments to insure their definite location for the purpose of preparing right-of-way descriptions. These ties shall be made by accurate

chaining and measured angles in reference to the centerline of the location, noting of stations where such lines intercept the centerline. All noted improvements along the course of the survey shall be located and described. The station of intersection, width, direction and ties of improvement of all intersecting roads shall be determined. This is also true in the case of entrances to property, such as permanent driveways. All cross drainages shall also be noted and recommendations made for replacement.

6.0 Streams and Water Courses. The width, distance and meanderings of intersecting streams or creeks for a distance of 600' each side of centerline shall be taken. The Locating Engineer must use his judgment as to what this distance shall be, bearing in mind that the object of taking it is to obtain all of the data which might have influence on the planning and size of the structure. A separate A.R.C. form number for bridge crossings shall be completed with all the pertinent information by the Locating Engineer.

6.1 Existing Structures. Special attention shall be given to existing structures, such as bridges, culverts, retaining walls, etc. Special sketches shall be made of same, and entered in notebook together with a description of the material, serviceability and general condition, together with elevations of decks, flow lines, and high water.

6.2 Railroad Crossings. When railroad tracks are intersected, complete details of the vicinity should be gathered. Station and angle of intersection, the railroad stationing or mileage or mile, alignment and profile for at least 500' in each direction, track layout, railroad right-of-way, station ground and all important details. Railroad crossing sites are generally features requiring special attention and report. In every case, an easement must be obtained, requiring an accurate plot of the crossing.

6.3 Levels. Profile elevations of the centerline are to be taken at each station and at all definite ground breaks, recording to the nearest tenth of a foot. Location levels are to be checked on bench marks established as previously provided and the elevation of these bench marks adopted where a difference is found. If the error exceeds the allowable maximum, location levels shall be run and new elevations established. If any bench marks set during bench level survey will be interfered with by construction operations, permanent bench marks shall be re-set during location and properly described. Great care should be taken in transferring bench marks. Use the new bench mark as a turning point from which to check the maximum bench mark.

6.4 Cross Sections. The staked location shall be completely cross sectioned. On the basis of these cross sections and a detailed study of the ground, the alignment and grade are adjusted to final design and grade quantities can be accurately computed. It is important that sufficient sections and readings be taken to reproduce

the ground line in all directions over the area that may be used during construction, and should take in probable slides, borrow or widening. Readings at small breaks in the ground line of rough country complicates the notes and delays field and office progress and should be averaged. However, discretion must be used so that all low drainage points are shown correctly, and so that any averaging will not result in incorrect earthwork computation. In areas where office line changes are anticipated, particularly where the roadway section is wide, or the drainage problem intricate, it is especially important that cross sections be taken exactly at right angles to the center-line. Special emphasis must be placed on this phase of the work.

6.5 Miscellaneous Cross Section Data. At crossings of waterways, readings up and down the stream should be extended a sufficient distance to obtain data for designing structures and establishing proper grade lines for the flow of water. Elevations should be obtained at each end of openings which are already in place. High water mark elevation should be taken and may be marked on the ground by a stake on some permanent object.

At all intersecting roads, cross sections should be extended for a distance of 500' or more so as to furnish information for the establishing of grades and connections at such points. At railroad crossings, cross sections should be taken very fully as to detail. Top of rail elevation and grade rates in both directions should be obtained. During the process of taking location cross section data for some topography items may be noted to supplement notes taken separately under topography. Readings at fence lines can be clearly marked and irregular ditch mark can be indicated.

6.6 Cross Section Methods. In open and rolling country, cross sections are usually taken with the Engineer's level, rod and tape at the time the profile levels are obtained. Readings beyond the scope of the instrument can be extended by hand level method.

In rocky or bushy country, much time will be saved by taking cross sections as a separate operation after the centerline has been run. In place of the Engineer's level, the hand level or cross sectioning devices such as the Rhodes arc may be used, all readings being booked in relation to centerline and true data elevation previously reduced. The Rhodes arc is an instrument with a simple arrangement of scales combined with an arc mounted on a staff with which vertical and horizontal distances from a point of known elevation to any other point can be readily determined. The principle of its operation is that of measuring slope angles and slope distances. Its advantages over a transit are that it is lighter, more portable and eliminates calculations.

Original methods may be carefully employed to advantage such as running an auxiliary temporary base line for the levels at

the foot or over a cliff lowering by a line the weighted end of a tape to accessible points for slope chaining, etc.

6.7 Slope Stakes. The setting of slope stakes for construction is a construction engineering item and shall not be done under survey and plan authorization unless specifically ordered and approved by the engineering work order. Cases may arise where the grade line of location is not subject to change and construction slope stakes may be efficiently set at the time the location is cross sectioned. This procedure will not be used unless specifically authorized.

6.8 Transit Notes. Transit notes shall be recorded as a separate set of notes and as shown on samples which have been distributed to the District Engineering Divisions.

6.9 Field Computations. Field computations of instrumentmen should be checked by a second member of the party. Certain computations, such as triangulations and slope measuring reductions should be preserved for checking by the field office. Such computations shall be submitted with the field notes.

7.0 Topography Notes. Topography notes will be made a part of the transit notes as shown on the samples distributed to the District Engineering Divisions.

7.1 Level Notes. Level notes should be as shown in the level note form distributed in the following order in the columns on the left hand page.

(1) Stationing from top to bottom of page.
(2) Plus rods. (Turns and benches)
(3) Height of Instrument.
(4) Minus rods. (Turns, benches and profile)
(5) Elevations along profile
(6) Elevations of benches.

Bench marks are always to be described as turning points and should be fully described in level notes. (see Sample Page appended)

7.2 Cross Section Notes. When cross section notes are taken with an Engineer's level at the time profile levels are taken, cross sections should be recorded in the level book. When cross sections are taken as a separate operation, as with hand level readings from centerline elevations, it may be advantageous to keep a separate sheet of cross section notes.

The left hand page should contain stationing and centerline elevations. This method is particularly applicable where

many intermediate plusses are expected, and stationing must be made up as the work progresses to avoid crowding the notes.

On the right hand page of level or cross section notes, the cross sections shall be entered in the form of a fraction, the numerator designating the rod reading, vertical distance or elevation, the denominator the distance from centerline. Leave sufficient room from each section so that elevation reductions can be entered above rod readings. Notes should plainly indicate whether rod readings are from height of instrument or are sights above or below centerline elevation. (See sample pages attached)

7.3 Construction Notes. Location engineers should familiarize themselves with details and methods of construction, the units in which quantities are estimated, and the basis of payment as provided for in the standard specifications so that they may have a better understanding of the information that is required for an estimate. Often items are overlooked in preparing estimates, because location data did not present the necessary information. The Locating Engineer or his chief of party is expected to take all notes concerning construction data, such as clearing and grubbing, classification of material, drainage and other miscellaneous data. Notes of this character may be kept separately, properly indexed, or may be recorded in a uniform manner in one of the sets of notes of levels, topography, or cross sections.

Clearing and grubbing is often included in the grading cost, and it may easily reach such dimensions that a separate item should therefore be made. In all events, such notes should be made regarding this class of work to allow an estimate to cover the cost. Make particular note of grubbing or stump removal where it will affect embankment or excavation quantities. Type of clearing should specify kind, density and size between limiting stations.

7.4 Classification of Materials. Proper classification of materials is especially important in determining excavation and embankment slopes, probable swell, subsidence and the unit cost of excavation. However, field sampling of soils and the detailed classification of soil types are properly functions of the Materials Branch and should not be attempted by the Locating Engineer. Only such general notes as may be made from observations during the progress of the location survey should be made by the location party.

7.5 Testing Materials. On all projects involving portions of the roadway crossing muskeg, swamps or glacial conditions or other types of ground where the roadway is liable to subside or have excessive settlement and where shrinkage factors are unusually large and uncertain, the project survey shall include, in cooperation with the Materials Engineer, complete soundings and subsoil investigation for the purpose of establishing the nature of the subsoil. This is extremely important when the program survey calls for a hard finish roadway.

The results of these soundings should be noted in the preliminary report. In all such cases, complete information should be incorporated on the profile and noted on the plans as to comprehensive soil classifications so that they can be reviewed by the Headquarters office before any construction work is started.

It is necessary that all materials be tested, and test holes drilled where all major structures on the project are contemplated.

7.6 Drainage. A proper drainage system should be carefully worked out. The position, size and condition of the existing culverts, and other structures should be noted, including notes as to whether they are to be replaced by larger sizes or shall be extended. Location, kind and size of new culverts or structures shall be shown as well as necessary outlet and inlet ditches. Elevations of high water of streams or rivers shall be noted and inquiries made as to previous floods and conditions of the streams.

Comprehensive notes shall be taken and maps or sketches prepared on special situations such as ditches, channel changes, slide treatments, glacial conditions, surface ditching, and drainage and developed areas. In the latter cases, drainage will control relation of grade to the adjacent land, and may at times decide subgrade treatment due to existence of undrained subsoils. In the design of pipes, culverts, channel changes, protection work, etc., consideration should be given to their location for practicability, economy, and future widening of the roadway.

7.7 Drainage Areas. In determining the size and type of drainage structure, the Locating Engineer should obtain all data and observations available. He should confer with the District Engineer, in cooperation with the bridge section at Headquarters where large structures are involved. Tables showing relation between character and quantity of rainfall, drainage area, and size of opening should not be relied upon without verifying the conditions in the field. Existing structures or culverts often furnish important data for design, and an accurate location of all such drainage structures must be made during the location survey. High water cross sections should be taken at points near the proposed structure. Drainage areas may be obtained from maps, if available, or by traverse made by pacing, and the use of a compass or such other means. Each district should compile a drainage and run-off map for all new projects and file same for their future use.

7.8 Walls, Riprap, Etc. Where retaining walls, riprap or similar construction becomes necessary, careful examination of foundations should be made and reported with sufficient data to make a close estimate. Consideration should be given to all future widening of roadway in design of such permanent structures. Locate

source of materials for such structures, and describe or sample the quality of same.

7.9 Miscellaneous Data. Location of rock, sand and gravel deposit quarries and pits suitable for road building material should be handled with the assistance of the Materials Section.

8.0 Special Surveys. Special surveys may be required to furnish special and detailed information in addition to or aside from that obtained on the location survey. These may include surveys for rights-of-way, railroad and highway intersections, reconstruction data and detailed bridge site data. Proper instructions will be issued in cases where special surveys are required. The Locating Engineer and the District Engineer should call attention to the necessity for such surveys.

8.1 Large Structures. Small structures up to 25' spans can generally be selected from the standard designs for small structures. Large structures, culverts under highway fills or short span bridges with exceptional height will be special designs prepared by the Bridge Section at Headquarters. Location at such sites must be made as soon as practicable during the survey of the project in order that the Bridge Section may have site plans in time to design the structures.

When surveys for large structures are not authorized as a separate project, the regular location survey on a project will establish the line and grade at all bridges and provide for the approaches thereto. Site plans for the proposed structure shall be prepared in accordance with instructions issued by the Bridge Design Branch and shall show all the data necessary for the Bridge Department to determine a preliminary design of the structure. The plan and profile shall give all the location data for alignment, grade, profile roadway sections, etc. The site plans shall be made to scale suitable for showing essential details of a preliminary nature. Contours shall be shown at 5' intervals on steep slopes and 2' intervals in flat country. All the pertinent data for structure information must be filled out on ARC Form No. 124 (Revised January 2, 1951) for bridge surveys.

8.2 Typical Field Notes. The following typical field notes may be obtained either from the District Offices or from the Headquarters Office:

J-GEN-79, "Typical Transit Notes (1)"
J-GEN-80, "Typical Transit Notes (2)"
J-GEN-81, "Typical Transit Notes (3)"
J-GEN-82, "Typical Bench Level Notes"
J-GEN-83, "Typical X-Section Notes (1)"
J-GEN-84, "Typical X-Section Notes (2)"
J-GEN-85, "Typical Profile Level Notes"