Forest Service Handbook
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Forest Service Handbook 7709.56 – Road Preconstruction Handbook
Chapter 30 - Engineering Survey

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Superseded Directive: 7709.56_3, Amendment No. 1, May 1987

Approved by: James M. Pena, Associate Deputy Chief, NFS

Date approved: July 7, 2011

Responsible Staff:

Explanation of changes: Following is an explanation of the changes throughout the directive by section.

30: Revises entire chapter and makes minor technical and editorial changes throughout chapter. Revises coding from 1-digit to recommended 2-digit coding.

31: Adds direction that preparation of a job hazard analysis is a requirement for administration of contract surveys.

32.2: Adds direction that trees containing merchantable logs should not be felled during clearing of survey lines.

33.1: Revises cross-reference for requirements for rights of way surveys from FSM 7152.6 to FSM 7153. Adds "Witness trees" to the list of features requiring coordination with cadastral surveyors when the features might be destroyed during construction.

33.4: Establishes code and caption "Stream channel" and sets forth new direction for surveying of a stream channel. Adds direction for including the concept of "Bankfull Width," which is determined by trained specialists, as a consideration in collecting data for stream crossings.

34.1: Adds direction for including the Global Positioning System (GPS) as a tool for conducting low-order surveys.

36: Recodes to this section direction previously set out in section 2.23 on materials source surveys.

38: Removes obsolete direction for highlight data items to be extracted for automated processing.

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This chapter provides guidance for conducting a road preconstruction engineering survey.

30.2 - Objective

The objectives of a road preconstruction engineering survey are to:

1. Measure the ground form and conditions (along the located line or across the site).

2. Identify topographic features and other physical factors that affect design of the planned facility.

The data that is gathered includes numeric data (elevation, bearing, and distance) and nonnumeric data (drainage, materials, and resource). The amount, detail, and accuracy of the data should be commensurate with the standard of the road, value of access to resources, and risks associated with the project. The activities on the Field Location Checklist (sec. 22.9) should be completed prior to beginning work.

30.6 - Standards and Calibration

Make measurements to the selected engineering survey accuracy standards (sec. 39, ex. 01, *Guidelines for Engineering Survey Accuracy*). See FSM 7152 for standards for surveys for the location and marking of property boundaries and FSM 7153 for standards for surveys for acquisition of road rights-of-way.

Calibrate surveying equipment before use and check it periodically to obtain and maintain the accuracy required.

30.7 - Contract Surveys

Consider the following factors when determining whether to survey by force account or contract:

1. Size and complexity of projects.

2. Crew support requirements.

3. Availability of Forest Service personnel and potential contractors.

4. Lead time available.

5. Ability to define the required work.

6. Capability of Forest Service and contractor's personnel.

7. Relative costs.

Select qualification requirements for contractor’s personnel considering State and local laws and regulations and the technical and professional factors of the job. For example, a contract requiring only topographic measurement might not require performance by a professional

engineer, whereas a contract requiring professional judgments, such as complete classification of construction materials and recommendations regarding final design, requires the services of a professional engineer. Determine the specific type of survey contract and contract specifications by consulting with engineering staff, acquisition management, and affected resource staffs.

It may be advantageous to contract part of a survey project and do the remainder by force account. An example is clearing of the survey line by contract while using a force account crew to gather numeric survey data. This approach may result in less investment in equipment (power saws and hand cutting tools), a reduction in job hazards for force account crews, and better use of skilled personnel.

30.8 - Data Recording

Data may be recorded by various means, including standard field notebooks, electronic data recording equipment, programmed calculators, and voice recorders. Record data in the format and to the precision required for the planned design method. The manner of recording must provide for retention of data in accordance with previously determined requirements (sec. 31).

Record topographic features identified along the survey route. Note information about vegetation and drainage, and reference it by engineer's station or section number. Drainage data should include sketches and notation of significant characteristics, such as grade control features, high water marks, and stream channel width. See section 33.4 regarding collection of this data.

Much of the data normally recorded are nonnumeric, such as comments, descriptions, and sketches. This information can often be numerically coded for electronic recording as long as significant details are not omitted. Digital cameras with video capability may be useful. Electronic recording of data should not preclude additional handwritten comments in a companion field notebook.

31 - Preparation for Surveys

Review the project file to identify the purpose of the survey, the proposed survey method(s), and any survey control information. Verify that the proposed survey method and accuracy standards are appropriate for the intended design methods and are consistent with legal requirements and onsite constraints. Ensure that written permission has been obtained to survey on non-national forest land.

Select the data recording method. Determine and document long-term field data retention requirements.

The following guidance applies to force account surveys:

1. Prepare the Job Hazard Analysis (JHA), including hazards associated with transportation, equipment, terrain, climate, insects, flora, fauna, hygiene, and field activities. (Note: A JHA is also a requirement for administration of contract surveys.)

2. Schedule the survey crew, equipment, and transportation. Check all equipment for serviceability. Arrange for survey materials, camp needs, and vehicles.

3. Brief the survey crew. As a minimum, discuss the work to be completed, survey methods to be used, schedules to be followed, the JHA, safety plan, fire prevention, and planned logistics.

32 - Pre-Traverse Field Work

32.1 - Establishing Ground Control

1. Survey Line. Set controls commensurate with the selected survey accuracy standards before beginning the survey. Identify changes in direction of the proposed line. Include intermediate marking to ensure visibility and identify special sites.

2. Special Sites. Sites on or adjacent to the road centerline often require additional survey data and controls marked on the ground to indicate the limits of a site survey.

3. Photogrammetric Survey. When using photogrammetric survey methods, consult with geometronics personnel to determine the specific targeting and control survey requirements.

32.2 - Clearing

Clear area of trees and other potential hazards sufficiently to allow the visibility needed between points of intersection of tangents (PI) or reasonably spaced points on tangents (POT) for traversing and to permit safe and reasonable passage of personnel and equipment. Trees which will make merchantable logs should not be felled. Retain ground control markings required for traverse work. Replace markings destroyed during clearing operations to maintain the original spacing and intervisibility. Special clearing restrictions may be needed when crossing lands other than national forest and specially designated National Forest System lands.

33 - Traverse, Profile, and Cross Sections

The survey data gathered varies with the selected design method. Horizontal and vertical alignment calculations may not be needed for all design methods. For low-standard roads, collect sufficient data to allow the determination of curve widening, design speed, and design standards (sec. 42.5 of this handbook) as well as calculation of construction quantities to estimate costs.

33.1 - Horizontal Traverse

Mark and set control stations and points of intersection as appropriate to the complexity of the project. Run the survey line through the designated control points established during the location phase.

Mark and set intermediate stations at significant ground breaks along the located line or within the cross section limits. The degree of significance varies with accuracy standards and the anticipated construction tolerances. Surveyors should set stations at intervals not exceeding 100 feet or that distance identified in the field location report (FLR) (sec. 22.7 of this handbook).

The line of the horizontal traverse should not vary from the located line more than the limits defined in the FLR.

Set reference stakes as required by the survey accuracy standard (sec. 39). Set offset stakes when a survey line stake cannot be driven at the desired survey point or when the survey line stake is likely to be disturbed. Reference and offset stakes should be set perpendicular to the survey line along tangents and on the angle bisectors at point of intersections (PIs). Set all stakes firmly and mark with appropriate station or section number data.

Measure and record bearings, deflection angles, and distances between stations to the selected survey accuracy standard using appropriate methods to minimize errors.

Reference and record the location of existing roads, trails, fences, other physical improvements, property boundaries, and monuments that intersect or are sufficiently close to the traverse to be affected by construction.

Tie the traverse to designated property corners. Ties between the traverse and property corners must be made to the minimum accuracy requirements for rights-of-way surveys (FSM 7153), when appropriate, and also must not be less accurate than the overall traverse survey. Coordinate with cadastral surveyors to identify and reference land survey corners, witness trees, and other land survey monuments that might be destroyed during construction.

33.2 - Profile Survey

Set benchmarks and reference points in accordance with established standards. Locate them on permanent fixed objects outside the anticipated construction limits. Establish elevations to the same accuracy standard as the road survey. Describe benchmarks and reference them to the horizontal traverse by distance and bearing. Establish benchmarks on both sides of drainages where a major structure is planned.

Measure and record the profile, including each established station, along the horizontal traverse to the selected survey accuracy standard. Turns should be made through each established benchmark to check elevations.

33.3 - Cross Sections

Cross sections, appropriate for the design method, must be measured and recorded at selected stations along the horizontal traverse to the selected survey accuracy standard. Cross sections should be long enough to provide sufficient information should a need to move centerline occur during the design process. Cross sections should be extended when necessary to adequately depict adjacent or cross drainages. Take cross sections on each side of the traverse. Cross sections must be perpendicular to the traverse on tangent sections and located on the angle bisector at PIs. Measure and record all significant breaks in topography along the cross section. Significant topographic features must be referenced to the traverse. The length of cross sections may vary. Cross sections should be longer in steep terrain than in flat terrain.

33.4 - Stream Channel

Measure and record stream data sufficient to determine channel cross section, water surface profile, grade control, geomorphic features of interest, and channel shape variations. This may require survey 500 feet or more up and downstream. If photos are taken, tie the photo points into the survey data. Involve specialists as appropriate to assure adequate survey and identify special data requirements when aquatic species passage is a design criterion. This special data includes determination of "Bankfull Width," which is the width of the channel established at the elevation of the water during a stream flow event that occurs on average once every 1.5 years. The preferred method of establishing Bankfull Width is visual inspection of the stream channel by properly trained specialists.

34 - Reconstruction Survey

34.1 - Minor Reconstruction

Reconstruction projects involving little or no earthwork or having very low resource damage potential may require only a low-order survey method. This includes using an odometer (milepost), cloth tape, distance measuring wheel, satellite global positioning device (GPS), or other distance measuring instruments for centerline stationing. Because little or no location marking may have been done before survey, many items normally documented during location, such as identification of materials sources, special design considerations, and specific work sites, may have to be done during the survey process. Establish reference stakes that identify the termini of the work locations and temporary bench marks to establish relative elevations.

34.2 - Major Reconstruction

Surveys for reconstruction projects requiring greater construction effort than that described in section 34.1 should use the methods described in section 33.

35 - Site Survey

Conduct a site survey when more specific data is needed than normally obtained during a routine route survey. The need for a site survey is usually identified during project planning or location. Site surveys are most commonly required at the following locations:

1. Bridge and major culvert sites.
2. Terminal facilities (FSM 7705).
3. Earth-retaining structures.
4. Material borrow sites and waste areas.
5. Special earthwork situations.
6. Critical log landings.

Perform bridge site surveys in accordance with FSH 7709.56b.

36 - Investigation and Classification of Construction Materials

Investigation and classification of construction materials refers to the gathering and analysis of rock and soils data to determine the effect work items such as clearing, excavation, and drainage have on designs and on construction costs.

Potential materials sources for aggregates and borrow adjacent to the road corridor, that could be used for construction, may have been identified in road location or may be identified during surveys. Locate and survey needed access roads and site boundaries of approved sources. Materials sources must be referenced to the survey line.

In consultation with appropriate specialists, determine the location, type, and extent of sampling and testing required. Where necessary, conduct field expedient tests (visual classification) or obtain, label, and submit samples for formal laboratory testing. American Society for Testing and Materials (ASTM) D2488 outlines field expedient tests. Base the timing and extent of investigation and specific nature of the classification on local conditions and facility or system requirements. Survey crews or others may perform investigations, but they must use a degree of materials expertise consistent with the project requirements.

Include test results and recommendations in the project file so that they are available during the design and construction phase. Recommendations and results should include:

1. Slope ratios.

2. Classification of construction materials.

3. Areas for special consideration or further investigation.

4. Estimated quantities.

FSH 7709.56b discusses bridge foundation investigations.

37 - Alternative Survey Methods

Unusual data requirements, project economics, available technology, and project timing may require using alternative methods to best obtain sufficient data for design. Examples of these methods include the following:

1. Aerial and close-range photography (including standard resource photography) and photogrammetric measurements to obtain road or site design data when anticipated construction standards and tolerances, topography, and vegetation allow.

2. Specialized, site-specific information such as hydrologic and hydrographic data for design of a marine facility.

3. Non-photographic remote sensing data such as data derived by aerial or satellite survey to obtain road or site design data.

Be alert for available or potential new processes and equipment, as well as for potential modifications and new uses for existing technology.

38 - Verification of Survey Data

Review field survey data and subsequent calculations, whether performed by force-account or by contract, for clarity, completeness, accuracy, and omissions. Field verify when appropriate. Determine the need for supplemental or corrective work, and arrange for completion of that work. Note where survey methods used would not be appropriate for similar future applications.

39 - Engineering Survey Accuracy Standards

Conduct surveys to accuracy standards consistent with the final construction tolerances and with the planned design method. Exhibit 01, "Guidelines for Engineering Survey Accuracy," illustrates typical survey accuracy associated with construction tolerances, design methods, and representative survey equipment. Use the information in exhibit 01 for guidance, but do not substitute it for sound professional judgment in relating methods, accuracy standards, and design criteria.

39 - Exhibit 01

Guidelines for Engineering Survey Accuracy

Accuracy Class	Construction Tolerance [1]/	Distance Accuracy	Elevation Accuracy	Benchmarks	Reference to Traverse	Cross-Section Accuracy	Deflection Angles
High	A &B	1/5000 or better	Nearest 0.01 ft each reading	Start, end, and every 1000 ft.	Two adjacent PI's every 1000 ft.	All breaks 1 ft. or more	30 degrees or less
Medium	C & D	1/1000	Nearest 0.1 ft each reading	Start of project and every 2000 ft.	Two adjacent PI's every 1000 ft.	All breaks of 2 ft. or more; slope breaks of 5 percent or more	30 degrees or less
Low	Usually E & F	1/100	Nearest 0.2 ft or 1 percent grade each reading	Start of project	Two adjacent PI's every 1000 ft.	All breaks of 2 ft. or more: slope breaks of 5 percent or more	30 degrees or less
Flag Line	Usually F	1/30	Nearest 1 percent grade each reading	N/A	N/A	Average cross slope	N/A
Condition Survey	[2]/	[2]/	[2]/	[2]/	At each work location	[2]/	[2]/

[1]/ Refer to the Construction Tolerance Table in FHWA FP-09 Specifications, or latest revision thereof, Table 152-1, and currently used Forest Service supplemental specifications.

[2]/ Determine based on local requirements.

NOTE: See FSM 7152 and 7153 for rights-of-way and easement survey methods and precisions.