3-02.1 PROCEDURE. The sequence followed in making a survey is: (1) establish horizontal and vertical controls; if required, the centerline may be established and staked, (2) obtain topographic (3D) and planimetric (2D) features, (3) complete miscellaneous surveys for railroads crossings, interchanges, grade separations, bridges, etc. Some of the operations may be performed concurrently.

With the use of electronic data recorders and CEAL software in our surveying procedures it is advisable for the designer and the surveyor to conduct a pre-survey meeting. This meeting is used to communicate the limits and scope of the project to the surveyor, who needs an understanding of the information the designer is requesting. The designer and the surveyor may need to review the project in the field.

In some cases a post-survey meeting will prove beneficial as the surveyor may have obtained information that was overlooked or not evident without being on the actual job site.

It is preferable for the surveyor should provide the designer with an edited digital map model (fname.dmm) after the survey is complete.

3-02.2 ACCURACY

3-02.2 (1) GENERAL. Measurements are made to the best possible accuracy consistent with the equipment used and necessary speed of completing the work. The standard specifications provide for the payment of plan quantities for many contract items which are measured and computed from survey data. This fact dictates that all survey information be carefully and accurately measured and recorded.

3-02.2 (2) TOLERANCES. The required degree of accuracy for conventional surveys is shown in Table 3-02.1. The survey party is responsible for obtaining at least this degree of accuracy, through the proper adjustment and care of instruments and equipment and the method of making measurements.

TABLE 3-02.1
SURVEY ACCURACY

MEASUREMENT	ALLOWABLE ERROR
Distance	1:10,000
Angular	6 Seconds
Levels	0.012021 m x Sq. Root Dist. (km)
	0.05 ft. x Sq. Root Dist. (miles)

3-02.2 (3) RECORDING ACCURACY. Single measurements are recorded to the accuracy shown in Table 3-02.2.

TABLE 3-02.2
SURVEY RECORDING ACCURACY

MEASUREMENT	ACCURACY
Distance	0.003 m (0.01 ft)
Angular	5 Seconds
Levels	0.005 m (0.01 ft) Bench Levels, Turns, etc.
	0.005 m (0.01 ft) On Concrete
	0.03 m (0.1 ft) All Others

3-02.2 (4) TAPING. Taping accuracy requires proper tension on the tape, the use of hand levels or other devices to insure level taping, and particular care in setting and measuring to and from taping points. The tape is kept in

good condition, free of splices and kinks. Proper tension is used on the tape. The tape is unsupported between the ends and is kept free of weeds, underbrush, and low-hanging tree limbs.

3-02.2 (5) ANGLES. Angular accuracy requires care in sighting and a compensation for instrument error. The instrument error can be compensated for by a direct reading of the angle and by reversing the instrument for a duplicate reading of the angle. Line projections on tangents are double-centered to insure against introducing slight angles on tangents caused by instrument error.

3-02.2 (6) LEVELS. Bench leveling accuracy requires unyielding turning points, a level in proper adjustment, balancing the length of backsights and foresights, and care in maintaining the level rod plumb when taking readings.

3-02.3 EQUIPMENT. The 10 second repeating type theodolite or electronic distance measuring device (EDM) commonly available in the districts is suitable for this order of work.

A 30 meter (100 foot) steel tape free of kinks and splices, and checked against a calibrated tape is satisfactory. The headquarters office will furnish a calibrated tape if none is available in the district.

An accurate thermometer which can be read to the nearest degree, and which is quickly influenced by changes in temperature is necessary.

A minimum of two FM radios are needed for two-way communication between survey crew members.

A gauge to determine the proper tension on the tape is necessary. This is purchased locally or through any supplier of surveying equipment. It is of a size easily handled in the field and must register up to 15 kilograms (35 pounds). It is calibrated before being put into use, and periodically thereafter.

In addition to the above, normal survey equipment in good condition includes: two range poles; three tripods; two plumb bobs with heavy cords; a tape clamp; two prism poles; two single mirrors; one triple mirror; two hand levels; tribrachs; reflectors; and adaptors.

3-02.4 HIGHER ACCURACY SURVEYS. Survey accuracy and recording accuracy considerably better than that indicated may be necessary on particular surveys such as alignment control base lines for photogrammetric surveys and resulting centerline survey. Specific instructions and equipment are available for such surveys.

3-02.5 ALIGNMENT. Refer to Subsection 4-04.3 for horizontal alignment considerations.

3-02.5 (1) ESTABLISHING LOCATION. The first step in proceeding with a survey is to "hub" the preliminary line following as closely as possible the approved location. When the line has been "hubbed" the survey party chief advises the district design engineer, and they or designated assistants inspect the survey location in the field prior to proceeding further with the survey. At this time any justifiable adjustments of the location can be made without waste of survey work.

3-02.5 (2) ALIGNMENT REFERENCED POINTS. After the location has been inspected by the district design engineer or a designated assistant, the survey party chief is free to proceed with establishing referenced points, staking the alignment, and completing the survey. Referenced points are established at not more than 300 meter (1000 foot) intervals. In addition, a referenced point is set near each end of all proposed bridges, preferably near the top of the stream banks. Referenced points on tangents are always located by double-centering to insure that no slight angle is introduced in tangent lines. The referenced point is a steel rod or large nail driven approximately 150 millimeters (0.5 feet) below the surface of the natural ground and 300 millimeters (1.0 feet) or more below the ground surface in cultivated fields. This point is referenced to at least three identifiable features such as trees, fence posts, utility poles, etc. The references are preferably separated by 120 degrees. Referenced points are recorded in sequential station order as the first item in the field notebook similar to the illustration on Figure 3-01.2. The stations and pluses for the referenced points are

recorded on these pages as the line is staked. Where slope measurements are used for reference points it is so indicated in the field notebook.

3-02.5 (3) IDENTIFYING LOCATION. Sometime during the survey the final location is plainly marked by painting trees, fence posts, etc., so that the alignment can be followed at a later date after the location has become overgrown with brush and weeds and the stakes have deteriorated. This is particularly important in the vicinity of bridge surveys. This is, of course, not applicable in urban areas or in the vicinity of rural improvements where the painting would be unsightly and objectionable.

3-02.5 (4) STAKING. The alignment is staked at station intervals. Each station is marked with a nail and a stake that will not deteriorate rapidly. The nail and stake are both tied with red plastic ribbon. Each stake is marked with a black permanent marker showing station, offset, etc.

3-02.5 (5) CURVATURE

3-02.5 (5) (a) METRIC DEFINITION OF CURVATURE. All metric horizontal curve data will be defined by its radius. New horizontal curves should be in five meter increments. Existing alinement shall be soft converted to metric units using the U.S. Survey Foot (0.304800609601219 meters per foot).

3-02.5 (5) (b) ENGLISH DEFINITION OF CURVATURE. For English curves, the arc definition of degree of curve, which simplifies computing curve data, is preferred for use to determine the radius for all curves. The radius of a one degree arc curve is set at 5729.57795 feet, as used by the computer. This radius gives an arc length of 100.00000 feet for the one degree change in direction.

3-02.5 (5) (c) STAKING CURVES. Curves should be located and staked by coordinates. These coordinates may be obtained from the designer in the form of an interface file which can be imported into an electronic data recorder and used to stake the curve. In most cases it will only be necessary to stake main curve control points (PC, PT, midpoint, PI, etc.) to chekc geometrics.

When staking a curve by the deflection angle method, use the following formulas:

- Metric: $\text{Deflection Angle} = \dfrac{L \bullet (90°)}{\text{pi} \bullet R}$
- English: $\text{Deflection Angle} = \dfrac{L \bullet D}{200}$

where L is the length of arc in meters or feet
R is the radius in meters
D is the degree of curvature

3-02.6 LEVELING

3-02.6 (1) BENCH MARKS AND BENCH LEVELS. USGS or NGS Datum to be used is furnished the survey party chief by the designer. Permanent bench marks are established at approximately 300 meter (1000 foot) intervals along the survey centerline. The bench marks are numbered consecutively in the direction of the survey including the last two digits of the year they are established. See Figure 3-02.3. The bench levels are turned through each bench mark. Bench levels are run and adjusted as necessary to establish bench mark elevations prior to attempting to secure other elevation data such as profiles and cross sections. Acceptable examples for recording bench levels and their adjustment are illustrated on Figures 3-02.1, 3-02.2, and 3-02.3. Target elevations are obtained along with the bench levels on photogrammetric surveys and may be used as temporary bench marks when obtaining vertical control.

3-02.6 (2) PROFILES, CROSS SECTIONS, AND CULVERT SECTIONS. After the bench levels have been adjusted and the elevations set, the survey party is ready to proceed with profiles, cross sections, and culvert sections. On photogrammetric surveys, only culvert sections are necessary. On conventional surveys the cross sections and culvert sections are taken along with the profile. Profile elevations are obtained at all stations, P.C.'s, P.T.'s, and breaks in the natural ground line. Profile elevations are obtained at hilltops at sufficient intervals to properly represent the terrain. The profile elevations at sharp hill crests are spaced at not more than 7 meter (25 foot) intervals. The spacing can be increased at flatter hill crests. Cross sections are taken at all equations and at all breaks in the natural ground line as will be necessary to obtain a reasonably accurate calculation of the earthwork involved in grading the improvement. Cross sections are not necessarily taken at even stations, particularly in rough terrain since such terrain will require variations of the cross section locations as required to properly represent the terrain. In flat terrain, cross sections are taken with a maximum spacing of 60 meters (200 feet). Special care is exercised to make sure that cross sections are taken at right angles to the centerline. A right angle prism or other device is used to establish right angles. The cross section includes the elevation of all breaks in the natural ground. Profiles and cross sections for interchanges, intersections, crossroads, and any necessary connecting roads are obtained along with the survey centerline profile and cross sections. When the project begins or ends on an existing roadway, profiles are taken 300 meters (1000 feet) beyond the project limits for strip map purposes.

3-02.6 (3) CULVERT SECTIONS. Culvert sections are also obtained along with the profile and cross sections. A theodolite or EDM is used to establish and measure the skew angles for the base line for the proposed culvert. The skew angle is turned to the nearest 5 degrees. Skew angles for culvert base lines on curves are turned from the local tangent to the curve. The culvert base line cross section follows the line of the existing ditch as near as possible. Elevations are obtained at all natural ground break points along the base line. Transverse sections are taken along the culvert base line, back and ahead to adequately show the flow line of the existing ditch and the terrain on either side of it. If adequate transverse sections are taken additional field information will not be necessary as the design proceeds.

3-02.6 (4) NOTEKEEPING EXAMPLES. Acceptable examples for recording profiles and cross sections are illustrated on Figure 3-02.4. Cross section notes are recorded exactly as illustrated to simplify interpretation by office personnel. Examples for recording culvert base lines and transverse cross sections are illustrated on Figures 3-02.5 and 3-02.6. The use of electronic field notebooks can be utilized when available.

3-02.7 MAN-MADE FEATURES

3-02.7 (1) EXTENT. On conventional surveys all features are accurately located to at least 30 meters (100 feet) beyond proposed right of way limits along crossroads, connecting roads, and in interchange areas. These features include buildings, building projections, outbuildings, sidewalks, paved areas, wells, etc. The notes include a description of the foundation of all buildings, and the dimensions of concrete floors. In addition, all such items beyond the above limits in a unit of improvements are located and described. The survey includes shrubbery and trees in the vicinity of improvements. Notes covering the location are complete, including dimensions of the items located. The survey party keeps in mind the fact that the person who plots the information from the notes is not necessarily familiar with the items being plotted.

3-02.7 (2) UTILITIES. On conventional surveys all utilities, above and below ground, are located along with other features. At all overhead crossings at least one pole each side of the centerline is located, the skew angle is measured, and the clearance of the overhead facility above natural ground at the survey centerline is obtained. If these poles are within the limits of proposed right of way, additional poles are located to at least one pole beyond proposed right of way limits on each side. The elevation is obtained for all underground utilities within the limits of proposed right of way or to the nearest manhole outside the right of way limits. Quite often the utility company will assist the survey party on the location of underground utilities. On photogrammetric surveys only underground utilities are located since surface utilities are located and shown on the photogrammetric manuscript. On post flight surveys this must necessarily be deferred until after the

photogrammetric manuscripts have been compiled and the centerline is being established. The names of the owners of all utilities are obtained and recorded.

3-02.7 (3) NOTEKEEPING EXAMPLES. Acceptable examples for recording notes are illustrated on Figure 3-02.7. The use of electronic field notebooks can be utilized when available.

3-02.8 LAND SURVEY TIES

3-02.8 (1) GENERAL. The survey includes ties between the survey tangent line and legal land survey corner monuments. A legal land survey corner is defined as one that is witnessed or monumented by the county surveyor or registered land surveyor (normally an original U.S. Public Land Survey Corner). Plats, with certification and seal, of these witnessed or monumented corners and reference ties, are to be filed with the county recorder of deeds. Where possible, the corner selected should be outside the proposed right of way. The appropriate state land surveyor form is also to be completed by the surveyor and submitted to the headquarters office for submitting to the state land surveyor.

At least one tie is made between the survey tangent line and a legal land survey corner monument in each section through which the survey passes; preferably, the corner monuments to be tied should be either a section corner or a quarter-section corner. The ties between the survey tangent line and the land survey corner monument include the station and angle at the tangent line, and the distance to the monument. Bound notebooks are used for recording the field notes. The assistance of the photogrammetry survey party may be requested to obtain the ties or coordinates of corner monuments. The description of the land survey corner monuments must be complete and definite; [e.g., 100 mm x 100 mm (4" x 4") Limestone, 12 mm ($^1/_2$") Steel Pin, 25 mm (1") Axle] S 1/4 cor. of Sec. 6, T56N, R14W. The district design engineer is advised early in the survey concerning the corner monuments which need to be re-established or witnessed, so that this work can be completed and the information added to the plans prior to submittal to the Right of Way Division.

3-02.8 (2) SUBDIVISION OR LOT TIES. The survey includes ties between the survey tangent line, and the legal land survey corner monuments which may be recorded subdivision or lot corner monuments. At least two ties are required in each subdivision or lot. The best ties are to the subdivision corner monuments nearest the highway survey line. The ties are measured and recorded in bound notebooks, similar to the requirements for land survey corner monuments. The ties include a complete and definite description of the monument being tied. The district design engineer is advised early in the survey concerning the corner monuments which need to be re-established or witnessed, so that this work can be completed and the information added to the plans prior to submittal to the Right of Way Division.

3-02.8 (3) RE-ESTABLISHING CORNER MONUMENTS. Survey corner monuments may be re-established in one of the following ways: county surveyor or registered land surveyors may be used to witness or re-establish survey corner monuments. The re-establishment of a corner monument may be done by our own personnel, when witnessed, platted and certified to by the county surveyor or registered land surveyor.

3-02.9 BEARINGS. A celestial observation is made to obtain the true azimuth for use in establishing state plane coordinates and bearings. State plane bearings are shown on the plans, obtained from the computer output. A note on the first plan sheet will show that the bearings are state plane and the zone to which they apply. On projects where state plane information is not computed, previous project bearing datum may be used.

3-02.10 RAILROADS

3-02.10 (1) RAILROAD CROSSINGS. The extent of surveys for railroad crossings will vary considerably, depending upon the effects of the road work on the railroad facility. At all crossings the railroad alignment is located precisely in relation to the survey centerline for a minimum distance of 150 meters (500 feet) each side of the centerline, and top of rail profiles are obtained for the same minimum distance. A survey along the railroad is made the same minimum distance each side of the centerline. The survey includes an accurate tie to a railroad milepost alignment and to railroad drainage structures within the survey limits. If the railroad facility is

affected beyond the 150 meter (500 feet) limits, the survey extends to beyond the limits that will be affected. Surveys for railroad grade separations are in addition to the above and are explained elsewhere, along with other grade separation structures. The above data, except the rail profiles and the milepost locations, are obtained by photogrammetry on photogrammetric surveys.

3-02.10 (2) PARALLELING RAILROADS. Where railroads parallel the survey close enough that a common right of way line will be used, or where there is a possibility of encroaching upon the railroad right of way, each milepost is accurately located. In addition, a culture survey is made between the proposed alignment and the railroad. The railroad is located and the railroad is accurately tied to the survey centerline at all railroad and survey centerline curve points. Railroad curve data is obtained, if available.

3-02.11 INTERCHANGES. On conventional surveys, diamond-type interchanges are usually surveyed by extending the roadway cross sections to beyond the ramps without surveying the ramp base lines, and by extending the crossroad cross sections between the ramp terminals. This will usually apply to surveys for all other types of interchanges if this data is supplemented by profiles and cross sections on base lines extending into the areas of the interchange some distance from the centerlines of the crossroads. This procedure is better than attempting to survey along ramp base lines because it is difficult and impractical to establish interchange geometrics until after the survey has been completed. If ramp base lines are surveyed, the location of the ramp base lines, ramp identification, and the stationing of the base lines are consistent with the examples illustrated in Section 2-03 and Section 4-06. None of this is necessary for photogrammetric surveys since the manuscripts will include contours and/or cross sections covering the interchange area.

3-02.12 GRADE SEPARATIONS. Surveys for grade separation structures, both railroad and highway, include offset profiles to beyond structure limits along the centerline on which the structure is to be constructed. This is in addition to profiles and cross sections along the survey centerline and the centerline of the crossroad. Other requirements for offset profiles are given elsewhere. Surveys at railroads include a profile of the top of rail or rails to at least 50 meters (200 feet) from the survey centerline measured normal to the survey centerline. Top of rail profile elevations are obtained at not more than 10 meter (50 foot) intervals. Profiles are required for each railroad track at multiple track crossings. Profiles are required for each rail where the top of rail elevation differs. Where structures are to cross existing pavements, the survey includes profiles along the existing pavement at the centerline and at the pavement edges to at least 20 meters (50 feet) outside the structure. Profile elevations are obtained at not more than 10 meter (25 foot) intervals. Cross sections at not more than 10 meter (25 foot) intervals along the existing pavement may be obtained in lieu of the profiles. Contours are required for grade separation structures only where the natural ground elevation differs by more than 5 meters (10 feet) within the limits of the proposed structure and the bridge skew angle exceeds 50 degrees. Where contours are required they extend radially approximately 150 meters (500 feet) from the point of intersection. Contours and/or cross sections are obtained by photogrammetry on photogrammetric surveys. All other information is obtained by field methods.

3-02.13 BRIDGE SURVEYS

3-02.13 (1) INFORMATION REQUIRED. Bridge surveys for other than grade separations require the following minimum information: (1) stream meander, man-made features, and contours (where required) extending at least 300 meters (1000 feet) up and down the valley from the proposed bridge location, (2) 10 meter (30 feet) offset profiles right and left in addition to the centerline profile; (3) stream bed profile; (4) two valley sections; (5) two typical channel sections; (6) description of and section under existing bridges; (7) extreme high water elevation, date of occurrence, and estimated frequency; (8) ordinary high water elevation; (9) extreme low water elevation; (10) a survey for any necessary channel changes or channel cleanouts; and (11) miscellaneous field information necessary to complete pages 1, 2, and 3 of Form BR 105. Refer to Section 5, Bridge Reports and Layouts.

3-02.13 (2) USE OF PHOTOGRAMMETRY. On conventional surveys all of this information is obtained in the field. On photogrammetric surveys all of this information is obtained in the field except man-made features, stream meander, contours, narrow valley sections and channel change surveys.

Photogrammetric methods may be utilized to obtain bridge survey data. A contour interval of 1.0 meter (2 feet) will provide adequate accuracy for hydraulic design.

If water is present in the stream when aerial photographs are taken conventional survey methods must be used to obtain the streambed profile and portions of channel sections below the water surface.

Prior to aerial photography, the district will determine the locations of controlling valley sections from topographic maps. The valley sections are to be located on suitable maps to aid in obtaining sufficient aerial photographic coverage of the location.

3-02.13 (3) WHEN REQUIRED. Bridge surveys are required for all drainage areas exceeding 4 square kilometers (1000 acres). Contours are required to the specified limits on bridge surveys for drainage areas exceeding 10 square kilometers (5 square miles).

3-02.13 (4) FIELD DRAWINGS AND NOTES. A plat sheet is drawn in the field to a scale of 1:1000 (1" = 100'). The alignment, stream meander, man-made features including any buildings near extreme high water elevation, valley sections, and contours (where required) are drawn on this sheet in the field. A complete set of notes containing the data plotted on this sheet is included in the field notebooks. If an electronic data collector is used, the field drawing and manual notes are not required.

3-02.13 (5) REFERENCED POINTS. Referenced points are set near each end of proposed bridges, preferably near the top of the stream bank.

3-02.13 (6) BENCH MARKS. A bench mark is also set on each side of the proposed structure, preferably one on the downstream side on one side of the proposed structure and one on the upstream side on the other side of the proposed structure.

3-02.13 (7) STREAM MEANDER. The stream meander is accurately located. Where the stream has both a high bank and a low bank, both banks are located and indicated on the plat sheet, preferably using a solid line legend for the high bank and a dashed line legend for the low bank. Since the stream meander sets the structure location the stream meander is carefully and accurately located.

3-02.13 (8) CONTOURS

3-02.13 (8) (a) EXTENT OF CONTOURS. Where contours are required, the contour interval is 1 meter (2 feet)and extends to at least 300 meters (1000 feet) up and down the valley, and to 2 meters (5 feet) above extreme high water elevation. The distance to which contours are taken up and down the valley is measured along the valley and not along the stream meander.

3-02.13 (8) (b) METHODS. Generally it is more economical to use photogrammetric methods to obtain contours, stream meander, man-made features and narrow valley sections. Typical channel sections, profiles, water elevations and sections under an existing structure must be acquired in the field. If methods of photogrammetry can not be used, the use of a theodolite and stadia or a total station EDM may be used. Theodolite stations necessary for the theodolite and stadia method are established from the survey centerline to eliminate accumulative errors and to simplify checking notes. All angles are turned in a clockwise direction from the backsight. A complete set of notes is necessary to provide a complete record of the bridge survey, and for checking if checking becomes necessary.

3-02.13 (8) (c) PROCEDURE. Plan to obtain all required field data for the bridge survey with one trip to the job site, if possible. This will include vertical control elevations for photogrammetry, streambed profile, high water elevations, offset profiles, sections under existing structures, channel sections and any other field data that may be required.

3-02.13 (9) OFFSET PROFILES. Offset profiles extending to beyond the limits of the proposed structure are obtained 10 meters (30 feet) right and 10 meters (30 feet) left of the centerline of the structure if this distance furnishes representative profiles. If not, the distance is varied or additional offset profiles are obtained as necessary to obtain a true representation of the terrain features. Profiles in ditches are not representative without supplemental profiles. Where the centerline of the structure does not coincide with the survey centerline, such as surveys along the centerline of the median for divided lane facilities, an offset profile is required along the centerline of the structure. Where dual structures for divided lane facilities are separated by more than 18 meters (64 feet), offset profiles are obtained on each side of each structure. These profiles cannot be taken from cross sections.

3-02.13 (10) STREAM BED PROFILE. Stream bed profiles extend to at least 300 meters (1000 feet) upstream and 300 meters (1000 feet) downstream from the proposed crossing. If there is a change in the slope of the stream bed profile in the vicinity of 300 meters (1000 feet) upstream or downstream, the profile is extended to beyond this distance. The profile is taken along the thread of the stream. The distance is measured along the general centerline of the stream. The stream bed profile is equated to the survey centerline and extends from station 0+000 (0+00) upstream and downstream. Care is exercised to avoid a discrepancy in elevation between the survey centerline profile, offset profiles, and the stream bed profile at the survey centerline. In the case of a flowing stream, the profile of the water surface should also be indicated since it provides a more accurate hydraulic gradient.

3-02.13 (11) VALLEY SECTIONS. Two valley sections are always required, preferably one upstream and one downstream from the proposed structure. Valley sections are taken at narrow sections of the valley. For each valley section obtain the distance along the channel meander upstream or downstream from the roadway centerline. The valley sections are tied to the survey centerline and extend to at least 2 meters (5 feet) above the extreme high water elevation. The valley sections are located in such a manner as to provide, as nearly as possible, a typical section of both valley and channel as near right angles as possible to both the valley and channel. Where it is not possible to obtain a valley section at right angles to both the valley and channel, the valley controls the location of the valley section. The stationing along the valley section is established in the same direction across the valley as the survey centerline stationing. The type of ground cover should be indicated to assist office personnel establish Manning's "n" value.

3-02.13 (12) TYPICAL CHANNEL SECTIONS. Typical channel sections are obtained within 100 meters (300 feet) of the survey centerline both upstream and downstream. These sections are not precisely tied to the survey centerline but the survey field book indicates the approximate distance from the survey centerline to where the sections are taken. The stationing for the typical channel sections is established in the direction of the stationing on the survey centerline beginning at station 0+000 (0+00). The typical channel sections extend to the top of the high bank of the stream or, in the case where the stream bank is also the side of the valley, the sections extend to 2 meters (5 feet) above extreme high water.

3-02.13 (13) EXISTING BRIDGES. In addition to the other required sections, a section under all existing structures crossing the stream being surveyed is required if such structures are within 300 meters ($^1/_2$ mile) of the proposed crossing. A complete detail section is taken under the existing structure or structures, and a general description of the existing structure or structures is required, along with the elevation of extreme high water at the existing structure. Refer to Chapter V, Bridge Reports and Layouts.

3-02.13 (14) HIGH WATER ELEVATION. An extreme high water elevation is obtained either by observation of visible high water marks or by conferring with maintenance personnel or local residents. The location and elevation of the high water elevations are included in the survey notes. The location is given in relation to the survey centerline or base lines. The best procedure is to obtain information from local residents and then confirm this information by observation. Quite often local residents are prone to exaggerate, or the high water elevation remembered by them will be far beyond the flood frequency to which the structure is to be designed. Particular care is exercised in obtaining this information since it is always used as a basis for laying out the proposed structure. Survey personnel are encouraged to mark and record, for future reference, high water elevations for at least all major streams during or immediately after floods.

3-02.13 (15) ORDINARY HIGH WATER ELEVATION. An ordinary high water elevation is obtained for each bridge survey. The ordinary high water elevation is defined by the Corps of Engineers as follows: The line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas.

3-02.13 (16) LOW WATER ELEVATION. A low water elevation is necessary for streams that are generally never dry. The low water elevation is defined as the lowest water elevation during a year of normal rainfall. This information is used to establish the datum for structure excavation, and including this data with the bridge survey is never overlooked.

3-02.13 (17) CHANNEL SURVEYS. Proposed channel change surveys are always included for each bridge survey. The channel change survey consists of alignment, profile, and cross sections. On photogrammetric surveys the channel change profile and cross sections and/or contours are furnished by photogrammetry. If no channel change is necessary, the existing channel is surveyed, including cross sections 100 meters (300 feet) upstream and 100 meters (300 feet) downstream for use in computing earthwork quantities for any necessary cleanout of the existing channel.

3-02.13 (18) COORDINATION OF SURVEY. Care is exercised to insure that the valley sections, profiles, and channel change surveys do not conflict with the stream meander survey, contours, and other survey data.

3-02.13 (19) FORM BR 105R. Pages 1, 2, and 3 of Form BR 105R are partially completed in the field to supplement the bridge survey. Certain information included on this form cannot be obtained in the office, such as a complete, accurate description of the stream channel and valley as required to describe their hydraulic characteristics. This information is used for the hydraulic calculations for the bridge survey report and receives careful consideration, both in the field and in the office.

3-02.13 (20) EXAMPLES. An example for completing Form BR 105R is illustrated in Section 5, Bridge Reports and Layouts. Survey notes for bridge surveys are recorded in accordance with the requirements for other survey notes.

3-02.14 TRIANGULATION AT LARGE STREAMS. Triangulation may be necessary to project the survey centerline across larger streams where it is not practical to make a direct measurement across the stream. Since the distance across the stream and, in turn, the length of structure is determined by the triangulation, the base lines are surveyed and the angles measured to at least the same accuracy as required for the survey centerline. A better accuracy for the base line survey may be required for large streams and where the length of the base line is short in relation to the distance across the stream. The base line is established in relation to the survey centerline and to a length that will cause the interior angles of the triangle to be as near to 60 degrees as possible. Base lines are established on both sides of the stream, and the triangulation is computed from both directions as a check on all surveys. The survey field book includes notes for the base line survey, a record of the angles, and the computations for the triangulation. Electronic distance measuring equipment can be used for direct measurement of stream crossing distances.

3-02.15 MAJOR STREAMS. Major streams are defined as those handling drainage areas exceeding 250 square kilometers (100 square miles). Such streams will usually require more extensive bridge survey information than that required for smaller streams. The extent of the additional information cannot be determined until a study of the hydraulics has been started; therefore, bridge surveys for major streams are initially made to the extent and with the same information as that required for small streams. After the Bridge Division has proceeded with their study of the crossing, the district is advised of the extent and type of additional information necessary to complete the hydraulics study.

3-02.16 WIDENING EXISTING BRIDGES. Bridge surveys for widening existing bridges include the same survey information as that required for new stream crossings. In addition, certain information regarding the existing structure is required. If the existing structure was not constructed by the state, the bridge survey includes complete details of the existing structure to the extent required to structurally analyze its loading capacity. If the existing structure was constructed by the state, these details are not necessary. The bridge survey for widening the existing structure includes accurate ties to the existing bridge from the survey centerline. For multiple box culverts classified as bridges, the bridge survey includes the flow line elevation and the top slab elevation for the existing structure. For span type structures, the bridge survey includes elevations along the existing bridge floor at 2 meter (5 feet) intervals along the centerline and curb lines on each side, along with elevations of the bridge seats at all bents, and, if practical, the elevation of the top of the footings. Where deck replacement is necessary on steel beam or girder bridges, bottom of top flange elevations for each stringer or girder of each substructure unit are required. Locations where elevations are taken on existing bridges must be clearly described on the bridge survey sheets. Stationing at existing bridge ends and at the centerline of each intermediate bent or pier is required.

3-02.17 MONUMENTING RIGHT OF WAY. To reduce the need for multiple staking of the right of way line, permanent markers will normally be set by the design survey party prior to or at the time of condemnation. See Figures 3-02.8 and 3-02.9 for the type of marker and markings to be used.