
**Rules of
Department of Natural Resources
Division 30—Land Survey
Chapter 4—First and Second Order Horizontal
and Vertical Control**

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Title 10—DEPARTMENT OF NATURAL RESOURCES

**Division 30—Land Survey
Chapter 4—First and Second Order Horizontal and Vertical Control**

10 CSR 30-4.010 Definitions

PURPOSE: This rule defines technical terms used in Chapter 4.

- (1) Positional accuracy of a station is the accuracy of the station related to the reference stations that are held fixed National Geodetic Survey (NGS) or other higher order stations in the process of the adjustment. Positional accuracy of a station is computed from the constrained, correctly weighted, least squares adjustment at the ninety-five percent (95%) confidence level.
- (2) Relative accuracy is the relative position of one station with respect to another station. It is computed for all directly connected stations from the minimally constrained and the constrained correctly weighted, least squares adjustment at the ninety-five percent (95%) confidence level.
- (3) Rural area—For purposes of this chapter, a rural area is any second, third or fourth class county according to 48.020, RSMo.
- (4) Urban area—For purposes of this chapter, an urban area is any first class county according to 48.020, RSMo.

*Auth: sections 60.451.3. and 60.461, RSMo (1986). * Original rule filed March 1, 1978, effective July 15, 1978. Rescinded and readopted: Filed May 3, 1994, effective Dec. 30, 1994.*

**Original authority 1984.*

10 CSR 30-4.020 Horizontal Control Classification

PURPOSE: This rule describes the classes of horizontal control.

- (1) First Order Horizontal Control Classification. The purpose of this class of survey is to establish the primary horizontal control station of the Missouri Geographic Reference System or the National Geodetic Reference System.
- (2) Second Order Horizontal Control Classification. The purpose of this class of survey is to establish secondary and supplemental horizontal control stations of the Missouri

Geographic Reference System or the National Geodetic Reference System.

- (3) Both first and second order stations are dependent stations constrained to the existing first and second order stations of the Missouri Geographic Reference System and/or the National Geodetic Reference System. These stations are to be used to meet the needs of mapping, land information systems, property boundaries, and engineering surveys.

*Auth: sections 60.451.3. and 60.461, RSMo (1986). * Original rule filed May 3, 1994, effective Dec. 30, 1994.*

**Original authority 1984.*

10 CSR 30-4.030 Accuracy of Horizontal Control

PURPOSE: This rule prescribes the acceptable accuracy of first and second order control.

- (1) The accuracy of a horizontal control station is classified according to constrained and unconstrained relative accuracy of the distance between the stations and the positional accuracy of the station relative to the known stations. The failure to meet any of the three criteria shall cause the station to not meet the classification.

- (2) First Order Horizontal Control.
 - (A) The relative accuracy of the distance between directly connected adjacent points shall be equal to or less than twelve millimeters (12 mm) for distances equal or less than one kilometer (1 km) and ten parts per million (10 ppm) for distances greater than one kilometer (1 km).
 - (B) The positional accuracy of a station shall be thirty millimeters (30 mm) in urban areas and sixty millimeters (60 mm) in rural areas.

- (3) Second Order Horizontal Control.
 - (A) The relative accuracy of the distance between directly connected adjacent points shall be equal to or less than twenty-five millimeters (25 mm) for distances equal to or less than one kilometer (1 km) and twenty parts per million (20 ppm) for distances greater than one kilometer (1 km).
 - (B) The positional accuracy of a station shall be sixty millimeters (60 mm) in urban areas and one hundred (100) mm in rural areas.

- (3) To fully qualify as a first or second order control station, the station must be accepted and published by the Missouri Department of

Natural Resources or the United States Coast and Geodetic Survey.

*Auth: section 60.451.3. and 60.461, RSMo (1986). * Original rule filed May 3, 1994, effective Dec. 30, 1994.*

**Original authority 1984.*

10 CSR 30-4.040 Acceptance and Publication by DNR

PURPOSE: This rule designates the procedures for determining which control will be a part of the Missouri Geographic Reference System.

- (1) The following information will be submitted for each control survey that is to be evaluated for inclusion into the Missouri Geographic Reference System (MO GRS) as a first or second order station.

(A) A sketch will be submitted showing all stations occupied during the control survey. In addition to occupied stations, the sketch should show other existing horizontal or vertical stations located within or near the project area.

(B) A legend on the sketch should show the following information:

- Project Name
- General Locality
- Name of organization performing observations

Date of project start and completion
(C) A north arrow and graphic scale should appear on the sketch. All station symbols should be labeled with the station name with an inset used when stations are spaced too closely together to be clearly depicted on the network sketch.

(2) A report shall be submitted for each project and shall be signed and sealed by the surveyor or engineer in responsible charge. The report shall be the main source of information for judging whether or not the stations should be accepted as MO GRS stations. It shall be the responsibility of the surveyor or engineer to supply sufficient information in the report to facilitate inclusion of the stations in the MO GRS.

(3) The report shall contain a clear description of the survey procedures and equipment used in the field. This includes, but is not limited to the information entered into the field log and auxiliary information such as logistics, preanalysis and satellite selection results (if Global Positioning System (GPS) survey), personnel involved, and difficulties encountered.



(4) In the report there shall be a clear description of the procedures used in the office. This includes, but is not limited to, computer software and hardware used to process observations, options used (if any), data editing performed, source of orbital data (if GPS survey), parameters adjusted and held fixed, results of self-validation and any difficulties encountered.

(5) The following shall be included for GPS surveys. The version number and date of the GPS software used must be reported. For GPS surveys, the surveyor must also specifically report the baselines rejected for the project. All parameters used for any coordinate transformations shall be presented and any scaling of the covariance matrix by the surveyor must be described in detail. If the covariance matrix has been scaled, the scale factor used must also be presented. These results must be reported for all single base line and network solutions. Statistical testing of the survey results from the network solution, including analysis of variance factors, semi-major axis of 2-d (horizontal) or 3-d ninety-five percent (95%) relative confidence regions between all directly connected pairs of points, residuals and residual outliers shall be provided. In addition, the results of any self-validation checks must be reported, including but not limited to, comparisons of any repeated single base line solutions.

(6) For traverse surveys, all field data used to determine directions, distances, azimuths and elevations, the adjustment calculations shall be submitted along with the name of the software used in the adjustment. The data submitted shall show the final results of the adjustment and the error analysis.

(7) Only those stations meeting the requirements of 10 CSR 30-4.030, 10 CSR 30-4.040, 10 CSR 30-4.050 and 10 CSR 30-4.060 will be accepted for publication in the MO GRS.

*Auth: sections 60.451.3. and 60.461, RSMo (1986). * Original rule filed May 3, 1994, effective Dec. 30, 1994.*

**Original authority 1984.*

10 CSR 30-4.050 GPS Survey Guidelines

PURPOSE: *This rule prescribes the minimum procedures for first or second order Global Positioning System surveys.*

(1) Direct connections must be made to any adjacent observable National Geographic Reference System (NGRS) and/or Missouri Geographic Reference System (MO GRS) station located five kilometers (5 km) or less from any new station.

(2) At least three (3) existing higher or equal order control points must be included in any proposed Global Positioning System (GPS) survey. Whenever possible these should be three (3) 3-d control points. Otherwise two (2) sets of three (3) points (three (3) 2-d horizontal points and three (3) vertical control points) must be used. These control points should be chosen to be roughly equidistant on the periphery of the network so that they enclose as much of the proposed network as possible.

(3) Each new point to be established by the proposed GPS survey must be occupied at least two (2) separate times to enable proper checking of blunders (for example, incorrect point, setup errors, incorrect antenna heights). A separate occupation is one where the antenna has been taken down and set up again and the receiver restarted.

(4) Each point must be connected by simultaneous occupations (that is, base line) to at least three (3) other points in the network after outlier base lines have been rejected from the adjustment. Because it is generally easier to resolve the integer phase ambiguities over shorter base line, adjacent points should be connected wherever possible.

(5) At least two (2) receivers must be used for relative positioning, although three (3) or more may be used for more efficient operation and increased station reoccupation and base line repeatability.

(6) A preanalysis should be performed to determine the minimum occupation time required to achieve the required standard of accuracy. In addition, the most appropriate satellites to observe at each site should also be selected for receivers unable to track all of the "visible" satellites. The preanalysis should be specific for carrier phase relative positioning.

(7) In order to meet second order accuracies, the carrier beat phase must be observed together with a time tag for each observation. Pseudo-range observations are not precise enough for control surveys and cannot be used.

(8) A detailed field log must be kept during observation taken at each station. At the very least the following information must be recorded:

(A) Universal Time Correction (UTC) date of observations;

(B) Station identification (name and number);

(C) Session identification;

(D) Serial numbers of receiver, antenna, and data logger;

(E) Receiver operator;

(F) Antenna height and offset from monument, if any to one millimeter (1 mm). Note should be made of any deviation from standard method of measuring HI;

(G) Diagram illustrating stamping on the monument;

(H) Other stations observed during session;

(I) Starting and ending time (UTC) of observations;

(J) Satellites observed (including time of changes); and

(K) Completed field log data forms for each station occupation will be submitted either using those provided by the Department of Natural Resources (DNR) or some other type containing all necessary information found on the DNR forms.

(9) The raw data files for all station occupations must be submitted. Each file, called an R-file, will consist of one (1) set of raw observations for each station occupation session. For example, four (4) receivers operating during each of five (5) sessions will produce twenty (20) R-files. An example of a raw data file would be the DAT, ION, MES, and EPH files produced by a Trimble receiver during a station occupation.

(10) The unadjusted base line vector solution files for all observed base lines, non-trivial and trivial, will be submitted. These files are produced by post-processing software such as the OPT or FIX, FLT, and TRP files produced by Trimvec post-processing software.

(11) If station description information is not provided by DNR it must be submitted for each station occupied. Station descriptions must include station name, county, township, range, section, United States Geological Survey (USGS) 7.5' quad. name, date monumented, date of observations, complete descriptions of the station, azimuth and all reference monuments, a current "to reach" description, and any special information such as property owner name, address, and phone number. A sketch depicting the station and reference marks with dimensions and directions shown should accompany all narrative data. Examples of complete station description information may be obtained from DNR.

(12) If the GPS survey project includes any surveys using conventional or terrestrial horizontal surveying techniques, copies of all field notes and associated data must be submitted. This would include eccentric point

establishment and reduction. Polaris, solar, or direct observational data to establish azimuth marks shall also be submitted.

(13) When the GPS survey project includes surveys performed using conventional differential leveling techniques, copies of all field notes and associated data must be submitted. An example of this would be a vertical tie from a nonoccupied bench mark to a GPS station.

(14) A tabulation of the results of the repeat base line comparisons will be included in the project report.

(15) A minimally constrained (free) least squares, three dimensional (3-d) adjustment will be submitted in the form of the input and output files.

*Auth: sections 60.451.3. and 60.461, RSMo (1986). * Original rule filed May 3, 1994, effective Dec. 30, 1994.*

**Original authority 1984.*

10 CSR 30-4.060 Traverse Survey Guidelines

PURPOSE: This rule prescribes the minimum procedures for first or second order traverse surveys.

(1) First Order Traverse Procedure.

(A) The location of first order traverse lines and monumented stations shall be determined by a thorough field reconnaissance. The traverse point spacing shall not be less than six hundred meters (600m).

(B) All first order traverse lines shall start from, and close upon, first order stations of the Missouri Geographic Reference System (MO GRS) or National Geographic Reference System (GRS) in accordance with these procedures.

(C) Properly maintained theodolites with a least count of one second (1") or a din rating of one and one-half seconds (1.5") or better shall be used to observe directions and azimuths. At least four (4) positions or repetitions of the angles shall be observed. The theodolite and targets should be centered to within two millimeters (2 mm) over the survey station or traverse point.

(D) Electronic distance measuring instruments shall be used to measure all distances. Electronic Distance Meter (EDM) instruments shall be tested on a DNR base line at the start and on the completion of any first or second order traverse. Copies of the EDM calibrations shall be provided to the department in the survey report. Barometric pressure to five millimeters (5 mm) and temperature to one

degree Celsius (1°C) shall be recorded for each measurement.

(E) Each traverse shall be tied to a minimum of two (2) bench marks. Trig. or spirit leveling will be observed along all traverse lines. All HI's, HO's and zenith angles shall be recorded and submitted.

(F) The traverse shall be controlled by an astronomic azimuth at each end of the traverse line and at not more than every six (6) segments along the line. Astronomic azimuths shall have a standard deviation of one and one-half seconds (1.5") or better.

(G) All field data shall be submitted to Department of Natural Resources (DNR) in a format acceptable to the department. This shall include directions, distances, azimuth and elevations.

(2) Second Order Traverse Procedure.

(A) The location of second order traverse lines and monumented stations shall be determined by a thorough field reconnaissance. The traverse point spacing shall not be less than three hundred meters (300m).

(B) All second order traverse lines shall start from and close upon, second order or higher stations of the MO GRS or NGRS in accordance with these procedures or shall be run in closed circuits.

(C) Properly maintained theodolites with a least count of one second (1") or din of one and one-half seconds (1.5") or better shall be used to observe directions and azimuths. At least four (4) positions or repetitions of the angles shall be observed. The theodolite and targets should be centered to within two millimeters (2 mm) over the survey station or traverse point.

(D) Electronic distance measuring instruments shall be used to measure all distances. EDM instruments shall be tested on a DNR base line at the start and on the completion of any first order traverse. Copies of the EDM calibrations shall be provided to the department in the survey report. Barometric pressure to five millimeters (5 mm) and temperature to one degree Celsius (1°C) shall be recorded for each measurement.

(E) Each traverse shall be tied to a minimum of (two) 2 bench marks. Trig. or spirit leveling will be observed along all traverse lines. All HI's, HO's and zenith angles shall be recorded and submitted.

(F) The traverse shall be controlled by an astronomic azimuth at each end of the traverse line and at not more than every eight (8) segments along the line. Astronomic azimuth shall have a standard deviation of two seconds (2") or better.

(G) All field data shall be submitted to the DNR in a format acceptable to the department. This shall include directions, distances, azimuth and elevations.

*Auth: sections 60.451.3. and 60.461, RSMo (1986). * Original rule filed May 3, 1994, effective Dec. 30, 1994.*

**Original authority 1984.*

10 CSR 30-4.070 Waiver of 1 Km Limitation

PURPOSE: This rule defines conditions for which the 1 km limitation may be waived.

Coordinate values of land boundary corners presented for recording must be based upon measurements from a first or second order control station of the Missouri Geographic Reference System or the National Geographic Reference System. The one kilometer (1 km) limitation in distance from the control station may be waived if the accuracy of the coordinate values are within the accuracy values required in 10 CSR 30-2.040.

*Auth: sections 60.451.3. and 60.461, RSMo (1986). * Original rule filed May 3, 1994, effective Dec. 30, 1994.*

**Original authority 1984.*