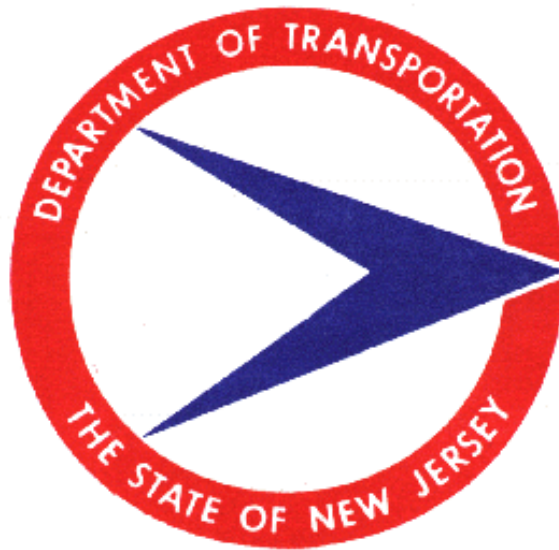


**STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION**

**SURVEY
MANUAL**



2014

Prepared by Survey Services

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Preface

Purpose

Many State Departments of Transportation have developed a survey manual. The purpose of the manual is to provide uniform guidelines for implementing survey decisions, and to assure quality and continuity in collection of survey data. The use of the survey manual is to assure appropriate execution of projects in conformity with the operational needs of the Department of Transportation, and to assure compliance with State and Federal criteria. The objective of this manual is not to serve as a general purpose text on the practice of surveying but rather as a guide to fit the special needs of the New Jersey Department of Transportation. Basic education and training in surveying require appropriate schooling, seminars and field exercises with appropriate textbook and learning kits. At the end of this manual there is a suggested reference list, including some helpful Web sites.

This manual deals with technical surveying issues. Other issues such as professional conduct and safety procedures should be in accordance with appropriate Federal and State manuals. For example, all the procedures at NJDOT with respect to safety, traffic protection, operation of tools and equipment, vehicle operation and usage, and first aid must be in accordance with the latest edition of NJDOT "safety manual". To avoid duplications and potential conflicts with existing regulations, this survey manual does not include these procedures.

Content and Format

Survey manuals of other State Department of Transportations follow one of two general conceptual models. Some manuals provide detailed instructions for surveyors, while others take the form of a more general reference guide used by DOT employees and Consultants, who are not necessarily surveyors. The purpose of the first approach is to produce a prescriptive manual to train people in surveying. The danger in such a detailed manual is that it could become easily outdated due to rapid technological developments. Such a manual may require frequent maintenance and revisions to keep it current. The second approach is more technology independent and used to educate its readers about surveying. This education provides proper understanding of surveying and improves the communication among various DOT employees. This manual follows the latter approach. The model used in developing this manual was the Ohio DOT (ODOT) survey manual.

The criteria included in this manual have been developed along the lines of various State's survey manuals, as well as in conformance with applicable Department directives, policies and procedures. The manual assures uniform guidelines for implementing survey decisions, assure quality and continuity in collection of survey data and execution of project support of operations in New Jersey, and assures compliance with Federal criteria. Consideration must also be given to submission standards adopted by city, county, or other local governments when submitting documentation under their jurisdiction.

The manual consists of eleven chapters and an appendix. The first chapter deals with general terms and definitions of surveying and surveying related terms. Chapter two describes the various survey systems. Survey systems are, to some extent, technology free concepts that serve as a foundation for different types of surveys. Chapter three

deals with survey measurements and the errors associated with them. Chapter four is a continuation of chapter three and focuses on Global Positioning Systems (GPS). GPS is the current state-of-the-art surveying technique served better with its own chapter. Chapter five discusses surveying equipment, its characteristics, and proper usage. Chapter six discusses location surveys and some field procedures. Photogrammetry is discussed in chapter seven. Photogrammetry is another surveying technique that is somewhat different compared with the traditional surveying. The special chapter serves as a means for emphasizing the applicability and the recommended utilization of photogrammetry as an integral part of the surveying tool box.

Survey Reference Documents

Barry, Austin B., *Engineering Measurement*, New York: John Wiley & Sons, 1966.

Buckner, R. B., *Surveying Measurements and Their Analysis*, Rancho Cordova: Landmark Enterprises, 1983.

Davis, Raymond E., Francis S. Foote, James M. Anderson, Edward M. Mikhail, *Surveying Theory and Practice*, 6th ed., New York: McGraw-Hill, 1981.

Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques (Federal Geodetic Control Committee, Version 5.0, May 11, 1989).

Input Formats and Specifications of the National Geodetic Survey Data Base, Volume 1, Horizontal Control Data (Federal Geodetic Control Committee, Rockville, MD, January 1989)

Input Formats and Specifications of the National Geodetic Survey Data Base, Volume 2, Vertical Control Data (Federal Geodetic Control Committee, Rockville, MD, 1980, reprinted 1982, Prepared by the National Oceanic and Atmospheric Administration as NOAA Manual NOS NGS 2).

Kissam, Philip, *Surveying for Civil Engineers*, New York: McGraw-Hill, 1956.

Standards and Specifications for Geodetic Control Networks (Federal Geodetic Control Committee, Rockville, Maryland, September 1984).

Stem James E, State Plane Coordinate System of 1983, *NOAA Manual NOS NGS 5*, 1989.

Survey Manual (State of Ohio Department of Transportation), 1995.

Specifications for GPS Surveys (State of Illinois Department of Transportation), 1996.

Location Survey Manual (State of Florida Department of Transportation), 1994.

[Work Zone Safety Set-Up Guide](#) 2005, New Jersey Department of Transportation.

User Guidelines For Single Base Real Time GNSS Positioning (National Geodetic Survey), 2014

National Geodetic Survey Guidelines for Real Time GNSS Surveys (National Geodetic Survey), 2011

RTN Field Procedures and Best Practices (National Geodetic Survey, Presentations Library), 2016