US Army Corps of Engineers®

USACE New Orleans District Minimum Survey Standards

FOR PERFORMING TOPOGRAPHIC, HYDROGRAPHIC, AND STATIC GPS CONTROL SURVEYS

EDITION 4.1

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This document and any updates or supplements thereto may be found at:
http://www.mvn.usace.army.mil/Missions/Engineering/SurveySection/SurveyingGuidelines.aspx

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Preface

In reviewing these Survey Standards and the supporting Engineering Manuals, it should be understood that the ultimate objective of a given survey task is the timely delivery of data, information that satisfies the requirements of the Scope of Work (SOW) and that the work products are complete, consistent, accurate, and properly documented.

While this document provides guidance for work performed directly for the USACE New Orleans District, and other Districts performing work in the Louisiana area on New Orleans District projects, any surveyor performing work in south Louisiana may find these standards, referenced methods, software and tools applicable to work performed for state and local agencies providing survey data to the New Orleans District. Additionally, this document serves as a supplement to the Engineering Manuals referenced in this document; all of which shall be reviewed prior to performing any survey work for the New Orleans District.

Given the variability of specific survey objectives and field conditions, as well as a technological environment that is constantly changing, no set of written procedural or technical guidelines can adequately address all possible circumstances that may be faced by land and hydrographic surveyors.

As such, the following expectations should be kept in mind when applying these Survey Guidelines. A survey contractor should provide:

Contractor Skills and Integrity:

The survey contractor is expected to possess the requisite personnel, equipment, skill, experience and integrity necessary for the timely and successful completion of a given survey task.

Clearly Defined Objectives:

The U.S. Army Corps of Engineers New Orleans District provides scopes of work (SOW) that set out clearly defined and attainable survey objectives and timelines (to help ensure this, Corps Survey Section personnel consult directly with the COE Requestor).

Thorough Preparation:

Prior to task order negotiation, the survey contractor should fully review the SOW requirements and perform all research and field investigation necessary to thoroughly discuss all technical and logistical details of the given task.

Communication and Clarity:

At a scope meeting, the survey contractor should clearly communicate any concerns or confusion regarding the requirements of the SOW. All questions and/or perceived uncertainties / ambiguities relating to the survey tasks detailed in the SOW shall be clarified and resolved to the satisfaction of both the survey contractor and the Corps.

Comprehensive Quality Control and Assurance:

The survey contractor should use the requisite equipment and personnel as well as those field and office procedures necessary to gather all specified data and to meet the tolerances and accuracy standards demanded by the SOW. It is further expected that the survey contractor shall implement all necessary QA/QC procedures and shall fully log and document the results of same (e.g., RTK check shots, hydrographic survey bar checks, etc.).

Complete and Accurate Deliverables:

The survey contractor should ensure that the form and content of all deliverables specified in the SOW are complete and accurate. All supporting data – field notes, digital files of raw data and intermediate processing results, etc. – shall be provided as well.

Of particular importance are the final Survey Report, the digital ASCII-text file of "Engineering Manual" (EM) survey coordinate data and metadata file, QA checklists, and all QC data including notes or logs of all procedures and observations.

Section A
Introduction

Purpose:
This document provides guidance to perform detailed engineering surveys of facilities and civil works projects for the New Orleans District Corps of Engineers. Technical specifications, procedural guidance, and quality control criteria are outlined for the consistent provision of surveying services in support of Corps activities. The New Orleans District Survey Section (CEMVN-ED-SS) can provide sample scopes of work and/or sample estimating spreadsheets upon request.

Applicability:
This document applies to all in-house and Architect-Engineer (A-E) contract surveying services having responsibility for the planning, engineering and design, operation, maintenance, construction, and related real estate and regulatory functions of civil works, and environmental restoration projects. It is also applicable to surveys performed or procured by local interest groups under various cooperative or cost-sharing agreements.

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Use of Manual:
This document is intended to be a reference guide for control surveying, site plan mapping, utility and infrastructure feature mapping, etc. These activities may be performed by hired-labor forces, contracted forces, or combinations thereof under the responsible charge of a Professional Land Surveyor.

Evolving Technology and Procedures:
Survey equipment operation, calibration, and procedural methods used to acquire, log, process, and plot survey data are adequately detailed in operation manuals provided by the various survey equipment manufacturers and software vendors. Since instrument and data collector operations and data processing methods are unique to each vendor, and are being constantly updated, this document will only provide a general overview of the techniques required by the New Orleans District. Other Corps regulations may dictate mandatory requirements to process, display, transfer, and archive survey data (e.g., Metadata archival). These mandatory regulations are not superseded by this document.

Survey Data Submittal:
A softcopy duplicate of all hardcopy deliverables shall be submitted to CEMVN-ED-SS, Survey Section for all survey work. Survey Section serves as the central data archive library/clearing house for the district's survey data holdings.

Section B

Survey Contractor's General Responsibilities

Overview:

The Contractor shall perform surveys and related services in accordance with specifications contained herein. The types of surveys performed for the New Orleans District include (but are not limited to): inland automated hydrographic, conventional hydrographic, and overbank surveys; topographic surveys; static GPS, Real-Time Kinematic (RTK), control surveys, etc.

The Contractor assumes responsibility for all site investigations to determine the nature and location of the work, the general and local conditions, availability of roads and boat ramps, the topography and conditions of the ground, the uncertainties of the weather, tidal action and flood stages, and the character of the equipment and facilities needed during prosecution of the work. The Contractor is also responsible for all other matters that may in any way affect the work or the cost thereof and for which information (both field and record) is reasonably available or obtainable.

Safety:

All Contractor personnel and equipment shall comply with the provisions of US Army Corps of Engineers Safety and Health Requirements Manual, EM 385-1-1, dated 15 September 2008. Additionally, Contractor's field crews shall consist of duly qualified and experienced personnel and shall be able to perform the required survey services in a manner that is satisfactory to the Contracting Officer Representative (COR). Field personnel shall be subject to particular scrutiny in regard to unsafe work practices, the lack of specified Personal Protection Equipment (PPE) and apparel, and the improper or reckless use of equipment. At least two field party members shall carry CPR and 1st Aide Certification Cards with them at all times.

The COR reserves the right to require the replacement of any work unit immediately upon his determination that the unit's performance of the required service is not in accordance with recognized standards of surveying and safety procedure.

Equipment and Personnel:

In the performance of surveys and related work, the Contractor shall furnish:

- All vehicles, boats, survey equipment, safety equipment, communications, and supplies not otherwise specified within the scope of work as Government furnished.
- All survey field books, concrete, iron rods, survey disks and all other material necessary to accomplish assigned work.
- All professional survey management personnel necessary to plan, supervise, perform, verify and certify all work.
- All field labor, transportation, fuel, materials, supplies and supervisory personnel necessary to ensure expeditious completion of services requested in each task order.
- All office equipment, software, and systems as well as properly trained technical and other personnel necessary to correctly process, compile and ensure prompt and timely delivery of all specified project data sets.

All Contractor costs in connection with the supervision, outfitting and re-supply of employees - including all equipment, safety apparel, and other miscellaneous supplies - shall be included in the contract unit prices listed in the Contractor's "Section B, Supplies or Services and Prices/Costs". Any equipment which the COR considers unsatisfactory for the accurate and expeditious performance of the requested survey services shall be replaced by the Contractor immediately upon notification by the COR.

Processing Capabilities:

The Contactor shall be competent to perform the basic and advanced survey data processing tasks demanded by the SOW. These tasks may include the following:

- Compute, compile, verify, plot, map, and otherwise construct Bentley InRoads Select CADD and ESRI Grid Analyst compatible Digital Terrain Models (DTMs).
- Construct MicroStation DGN file drawings.
- Digitize hydrographic survey chart data.
- Graphically depict onshore field and hydrographic survey data.
- Provide professional land surveyor signature and stamp on all field books, computations, hardcopy plots and/or final drawings, all survey plats and other graphic depictions of survey data.
- Process, filter, and extract airborne and terrestrial LiDAR data.
- Create LiDAR derived digital elevation models (DEMs) and associated visualization products.
- Research titles.
- Prepare abstracts for servitudes and rights-of-way.
- Prepare benchmark descriptions and survey field books, etc.

Scope of Work/Extent of Services:

Upon receipt of a formal Request for Proposal (RFP), the Contractor may schedule a Joint Field Inspection with COE field inspectors to familiarize himself with conditions on the ground at the subject project site. The Contractor may then schedule a formal Scope of Work Meeting with the COR, COE field inspectors, and other COE Survey Section personnel (as well as the Requestor, if necessary). During the SOW meeting, the COR and the Contractor's representative shall discuss each proposed assignment to develop a mutual understanding of:

- Type of work to be done.
- Existing data available.
- Specific benchmarks, datums, epochs, and elevations to be used.
- Format, content, and manner of transmission of deliverables.
- End results, plans, plots, comparative plots, computer aided design drafting (CADD) drawings, GIS products, DTMs, DEMs and other finished products, etc., expected by the COR.
- Task order completion date expected by the COR.

The Contractor shall then submit to the COR a formal time and cost proposal and detailed plans for performance of the work for each proposed assignment. Following receipt and review of the Contractor's detailed proposal, the COR will schedule a final negotiation with the Contractor. Assuming that negotiations result in mutually acceptable terms, a formal Task Order will be issued which shall serve as the Contractor's Notice to Proceed (NTP).

Deliverables:

In addition to all other specified deliverables, the Contractor shall provide all raw data, field books, all text and graphic files, and all other intermediate computations and processing output files (e.g., minimally-constrained GPS network processing results). These intermediate processing files shall be neat and orderly and presented in a form and manner such that all computations and processing procedures are easily followed.

The organization/presentation of ***all*** deliverables should lend itself to efficient, comprehensive, and meaningful quality assurance review and analysis by both the Contractor and Survey Section personnel. Final deliverables must be arranged as outlined in Appendix 7, File Index.

All detailed technical survey drawings shall be provided in MicroStation format and shall be based on the government supplied seed file with appropriate working units and subunits and utilize US Survey Feet.

Contents of all MicroStation files shall conform to the latest published MVN A/E/C CADD Standard available on the Corps' CAD/BIM

website (https://cadbim.usace.army.mil/Default.aspx) .

The Contractor shall submit PDF files of survey field books to the COR for review after the completion of fieldwork. The PDF files shall be multi-page and contain all pages of the field book. It is especially important that each field book be properly indexed, and, for projects that require three or more field books, that a master field book index of all books used on a given project is prepared and included in the PDF file. After notification of approval of the field data, the Contractor shall submit the original survey field books to the COR prior to final payment.

The Professional Land Surveyor (PLS or RLS - registered in the state that the work is being performed) shall certify that the field survey notes and computations are complete, correct and that they meet or exceed the specified project accuracy requirements prior to delivery of any derivative survey data to the COR. All survey reports, field books, plans, plots, CADD drawings, related GIS products, and other finished hardcopy products shall also be stamped and signed by the PLS as follows: "I hereby certify that the information shown hereon is true and correct to best of my knowledge and belief."

When applicable, digital and hard copy products shall comply with the Spatial Data Standards (SDSFIE) for GIS and the A/E/C CADD Standards for CADD Products (http://www.sdsfie.org/).

When applicable, the contractor shall provide a report of all significant software products and their version numbers (including any government-provided software) used to produce a final product.

The contractor may be called upon to provide products in-phases or in preliminary form, where urgency merits. These preliminary deliverables shall be organized/presented in a manner that lends itself to efficient, comprehensive, and meaningful quality assurance review and analysis by both the Contractor and Survey Section personnel.

The Contractor shall not release any data, analyses, results, conclusions or computations relative to any work performed under a USACE contract to any agency, business concern, or individual outside the government without advance express approval of the COR.

For detailed specifications regarding all deliverables, refer to “Section G” below.

Section C
Technical Survey Provisions

Survey Plan:

All A-E contract and construction top of wall, as-built, compliance, benchmark verification surveying services shall require a Survey Plan to be submitted to the USACE New Orleans District's Survey Section for technical review prior to the planned surveying activities. This requirement applies, whether the surveying activity is primary to the contract or task order or incidental to the contract or task order purpose. Technical review does not impact mobilization or initiating surveying activities; the parties engaged in data collection remain responsible for appropriate surveying approach and methodologies and as such might be required to provide clarification, adjustments to the methods and data, and recollection.

This Survey Plan should include, as a minimum, the following information:

- Job Number
- USACE Contract Number
- Approximate Lat/Long Coordinate of Project (or bounding rectangle)
- Horizontal Positioning (Datum/Epoch), Control Points, Equipment, Survey Methodology
- Vertical Positioning (Datum/Epoch), Control Points, Equipment, Survey Methodology.
- Static GPS Network Design Plan and Session Schedule (if applicable)
- USACE and A/E Points of Contact

District Datum Coordinator approval will be provided upon review.

Monumentation:

The Contractor, when required by the terms of the scope of work, shall be prepared and able to establish physical monumentation in accordance with Corps specifications. See referenced "U.S. Army Corps of Engineers Manual, EM 1110-1-1002, Survey Markers and Monumentation" for monument specifications.

The term "Permanent Monument" as used herein encompasses all published National Geodetic Survey (NGS) monuments and all monuments defined as "Permanent" in the above referenced EM 1110-1-1102. The meaning of the term "Permanent Monument" may be extended further – in certain circumstances and at the sole discretion of the District Datum Coordinator – to include other monumentation that is relatively stable, self-identifying and which incorporates, at a minimum, a stamped brass/aluminum disk set on a length of driven steel rod or which has been epoxied to a concrete foundation. Bare rods, nails (PK, 60d, etc.), railroad spikes, wooden hubs, etc., shall not be considered permanent monuments under any circumstances.

Horizontal Reference:

Acquisition of new horizontal coordinate data shall be in conformance with the Survey Plan approved by the District Datum Coordinator. All newly acquired horizontal survey data shall be connected to horizontal control points in the National Spatial Reference System (NSRS) having coordinates with respect to the most recently determined epoch of the North American Datum of 1983 (e.g., NAD83:2011, NAD83:CORS96:2002.0, etc.). The coordinate data shall be reduced and reported with respect to the Louisiana State Plane Coordinate of 1983, either North Zone (1701) or South Zone (1702) as appropriate, in U.S. Survey Feet.

On certain projects, the Government may furnish digital and/or hard-copy files of historical or legacy horizontal coordinate data (e.g., a baseline alignment file). These historical data sets were usually the result of conventional surveys (transit and tape, theodolite and EDM, electronic total station) of varying complexity, accuracy, and dependence/interconnectivity to earlier conventional surveys. Therefore, the coordinate value for a given physical monument (e.g., a baseline PI monument) as determined by prior conventional survey may be significantly different from the coordinate value of that same physical monument as recovered and surveyed via modern, precise GPS methods.

Historical/legacy coordinates are helpful as they provide a reasonable approximation of the relative positions of nearby monuments and are an aid to their recovery. The Contractor may be called upon to conduct surveys with respect to either the older historical coordinate values associated with recovered physical monuments, or to use the coordinates for those monuments as determined by current/precise GPS survey.

The contractor may also be called upon to develop a local conformal relationship between the two "systems" and provide coordinate data with respect to each. In any event, the Contractor must be extremely careful not to confuse the historical and current coordinates for any given physical location or set of physical locations. The horizontal datum and epoch of all surveys must be clearly identified in the deliverables in order to make distinctions between above mentioned "systems" (e.g. NAD83 (NA2011), NAD83 (BASELINE)). Refer to the EM File Format Specifications for more information.

On occasion, the Contractor may be required to establish additional horizontal control via conventional methods. The results of conventional control surveys shall generally conform to third-order accuracy/closure requirements as indicated in Appendix 4, Figure 1 (unless specified otherwise). Angular tolerances and azimuth closures for conventional control traverses may be found in Appendix 4, Figure 2. The Contractor shall adjust all conventional baseline surveys and may be required to use Government-furnished software to prepare and submit the associated raw traverse and adjustment files.

Vertical Reference:

Acquisition of new elevation/orthometric height data shall conform to the Survey Plan approved by the District Datum Coordinator and USACE-MVN Engineering Division Datum Policy Memo #3, "Requirements for Use of Benchmarks for USACE Projects," dated March 23, 2009.

Adherence to the above referenced Datum Policy Memo and approved Survey Plan shall ensure that all Project Benchmarks (one of which shall be designated as the Project Primary), all Secondary and Tertiary Local Vertical Control, and all other vertical survey data are properly connected to the NSRS (i.e., all elevations/orthometric heights are correct with respect to the appropriate epoch of the North American Vertical Datum of 1988 at a 95% confidence level of 0.25 feet) and that local vertical accuracy is maintained (i.e., all elevations/orthometric heights have a local or relative network accuracy of 0.15 feet at the 95% confidence level). These are the nominally acceptable vertical accuracies. More stringent or lenient NSRS and local accuracies may be specified by the District Datum Coordinator if the needs of the project dictate.

Verification Surveys of Local Vertical Control with respect to Project Control shall be done in accordance with the requirements of the previously referenced Datum Policy Memo.

The Survey Contractor shall perform and document daily and/or site-specific vertical control checks. This is done to insure that the correct local vertical control points are being utilized and that they are undisturbed. If a daily or site-specific check reveals relative height differences in excess of the specified accuracy requirements, this fact shall be documented and resolved by the Contractor in the field if possible. If not resolved in the field, the discrepancy and all relevant documentation shall be immediately reported to the COR for joint review with the District Datum Coordinator.

On certain projects, the District Datum Coordinator may require that GPS derived elevations be established in accordance with the guidelines in "NOAA Technical Memorandum NOS NGS-58" published in November 1987 (http://www.ngs.noaa.gov/PUBS_LIB/NGS-58.pdf), and Guidelines for Establishing GPS-derived Orthometric Heights. (http://www.ngs.noaa.gov/PUBS_LIB/NGS592008069FINAL2.pdf).

Section D
Topographic Surveys

General:
All topographic surveys shall follow the Control and Topographic Surveying Manual EM1110-1-1005 and relevant portion of the NAVSTAR Global Positioning System Surveying manual, EM1110-1-1003.

The elevations of all PBMs and TBMs recorded in the field book of any total station, RTK, or differential leveling survey shall be annotated with the correct Vertical Datum and Epoch.

Field notes for total station surveys shall document changes in setup, backsight, instrument height (HI), rod height (HR), cross section numbers, etc. In order to prevent the possible misidentification of occupied or backsight control points and/or to detect control point disturbances, check shots shall be performed and documented in the field book for each instrument setup. At a minimum, this shall include the occupied point number, occupied point description, measured HI, backsight point number, backsight point description, HR, difference in measured distance to the backsight and difference in measured elevation of the backsight. Additionally, a check shot should be made to the next nearest control point and the difference in distance/coordinates and elevation should be recorded.

If the measured differences for either the backsight or check shot exceed that which might reasonably be expected, additional control points shall be measured/documented and examined until the discrepancy is satisfactorily resolved. All check shot entries shall be recorded in the field book and maintained in the relevant total station data collector files.

The contractor shall submit all raw data files generated by electronic total station and/or RTK rover. All ASCII coordinate XYZ data shall be submitted in EM format (see referenced EM File Format Specifications). All RTK check shots shall be documented in the EM file (as miscellaneous shot records). In addition to supplying all specified coordinate data and metadata, the final EM file shall contain all explanatory comments relating to unique problems and/or special procedures (e.g., obstructions; etc.).

Conventional Traverses:
All conventional traverses in support of topographic surveys shall be to third-order class II specifications (see Appendix 4, Figures 1 and 2) unless otherwise specified in the scope of work. All traverse measurements shall be recorded in field books. Where short tangents (less than 800’) are required, a sub-traverse shall be run in which the angles shall close to no more than 10”/setup and the positional error shall be no more than 1:2500.

Conventional Leveling:
All differential leveling in support of topographic surveys shall be, at a minimum, to third-order loop-closure standards or higher if specified (see Appendix 4, Figure 1). The contractor shall strive to balance backsight/ foresight shot distances and in all cases limit them to less than 300 feet in order to reduce or eliminate typical instrumentation errors. The level loop shall be reviewed and initialed in the field book by a person independent of the field crew performing the level loop. In addition, each day, just before any differential leveling survey is begun, the “Two-Peg Test” should be performed and documented as follows:

- Select two TBMs “A” and “B” approximately 200 feet apart.
- Set up the level midway between the two points “A” and “B” and record the rod readings of each point and determine their difference in elevation.
- Move the level 20 feet beyond either benchmark and record the rod reading of both points again, once again determine their difference in elevation.
- If the difference in elevation measured at each setup is the same (within 0.02’), the level is in adjustment and work can proceed.

RTK Surveys:

When performing RTK surveys, raw L1/L2 data must be collected at the base station and submitted to OPUS for QA purposes. In addition, an observation log must be completed for each base station occupation and photographs documenting the occupation must be acquired. All RTK equipment must be capable of On-The-Fly ambiguity resolution/ initialization (OTF).

Field notes shall be kept to document, at a minimum: the base station setup (control point number and ID/description, antennae type, antennae reference point/ARP height, etc.); remote/rover antennae type and ARP height and any changes thereto; all check ties to established control (control point number and ID/description, observed position and elevation, difference between control and observed elevation and coordinates, time of observation, etc.); point numbers and IDs/descriptors of surveyed points and stationing of cross section ties.

As a minimum, the field procedures outlined in Section 9.22 of EM 1110-1-1003, NAVSTAR Global Positioning System Surveying and Chapter 9 of EM 1110-1-1005, Control and Topographic Surveying should be followed.

Checks to an established control point shall be done at the beginning and end of each day's work, and/or before and after each base station setup and shall be logged digitally and in a field book. RTK rovers shall have the NGS' latest published National Geoid Model (currently Geoid 12A) loaded onboard and shall be configured to properly incorporate geoid heights differences into the solution of final orthometric height values. Beta Geoid models released by NGS shall not be used unless specifically requested by the SOW or District Datum Coordinator.

Unless specified otherwise, the Rover PDOP mask should be set to 5.0 and the elevation mask at 15 degrees. Only coordinates that are the result of a "fixed" solution and have a horizontal and vertical precision (rms) of 2cm and 5cm respectively are acceptable. In addition to final coordinate data, raw data files containing quality indicators associated with each point surveyed shall be recorded and delivered (i.e., number of satellites observed, PDOP, fixed/float solution, horizontal and vertical accuracy, etc.). In setting out additional control points or making check ties to existing control, a minimum of 180 one-second epochs shall be recorded/averaged and the resultant statistics logged digitally and in a field book.

C4G RTN:

C4G Real-Time Network (RTN) is a network of Continually Operating GPS Reference Stations (CORS) that delivers real-time GPS corrections through the use of a cell phone modem. This system is operated by the LSU Center for Geoinformatics. There are presently over seventy C4G CORS distributed throughout the state of Louisiana. A subscription to this system enables end-users with a single RTK rover to conduct surveys anywhere within the state and achieve precisions that meet or exceed that attainable through classical or standard single base-station RTK methods.

To reliably achieve these precisions, all relevant guidelines in regard to standard RTK procedures are required for the use of C4G RTN (PDOP and elevation mask, fixed solution only, horizontal and vertical rms, etc.). In addition, specific calibration procedures must also be carried out in order to achieve the required accuracies. These procedures are described below.

The NGS' latest National Geoid Model (currently Geoid12A) shall be loaded onboard and properly utilized by the RTK rover/data collection system. Beta Geoid models released by NGS shall not be used unless specifically requested by the SOW or District Datum Coordinator. The proper antenna profile shall be utilized and the antenna make, model number, and L1/L2 phase-center offsets from the Antenna Reference Point (ARP) shall be noted in the project field book together with the correct ARP height (where possible, fixed height rods should be utilized).

Following system initialization at the project site, but prior to the commencement of any survey data collection session, the raw C4G RTN derived horizontal coordinates and elevation (being the average of a minimum of three minutes of one-second epoch data) of the nearest validated project or local control point shall be observed and logged, both digitally in the data collector file and in hardcopy in the project field book (with a site sketch showing sufficient descriptive detail to unambiguously identify the control station and the date and time at which it was surveyed).

The measured difference or offset between the observed and given horizontal coordinates and elevation of the control point shall then be used to calibrate or index the output of the RTK rover/data collection system to the control point. Once the RTK rover/data collection system has been calibrated or indexed, the control point shall then be re-observed to confirm that the output horizontal coordinates and elevation matches the given elevation. This re-observation shall be logged digitally and in the project field book. Once initial calibration is complete, a second validated project or local control point shall be observed with the calibrated RTK rover/data collection system and the results logged digitally and in the project field book. If the observed horizontal coordinates is within 0.10 feet and the elevation is within 0.15 feet of the given elevation of this second point, data collection may proceed; if not, contact USACE Survey Section immediately for further instruction.

In performing certain surveys (e.g., centerline profile surveys of earthen levees), motorized vehicles may be used. If a vehicular platform is used in data collection, the forward speed during collection shall at no time exceed ten miles-per-hour and the data collection epoch or interval shall be two seconds or less. Additionally, the appropriate digital feature code shall be selected and used. Great care shall be taken to ensure that the vehicular antenna mount is secure, free from obstruction, and placed so that acquisition along the levee top (highest point) is assured. A detailed sketch, showing the location of the antenna on the vehicle and the offset from natural ground to ARP, shall be included in the project field book. A note describing the general levee condition, the start and stop times of the vehicular data logging session, and a diagram of the start and stop locations (showing detail of transitions to/from wall structures, for example) shall be included in the project field book.

Surveys of the top of sheet-pile walls, I-walls, or T-walls shall be conducted on foot at a data collection interval of not more than 100 feet per survey observation and at all abrupt grade changes in excess of 0.25 feet unless otherwise specified. A detailed sketch of the wall system, the height of the wall above the adjacent ground or earthen levee, the wall thickness, and the side of the wall at which the measurement was made (protected or flood side) shall be noted in the project field book.

Bridge Sections:

All sections shall be submitted ordered from the left descending bank (LDB) to the right descending bank (RDB). When the direction of flow is undetermined, indicate the direction (North-South, East-West, etc) of the section. Shots are required at each pier station. These shots shall include centerline road profile shots, top of curb, top of guard rail, low chord or top of bent, and ground shots. These shots shall be collected at each pier and shall be perpendicular to the bridge C/L at the pier station. When the bridge is a railroad bridge, the rails shall be collected as curbs. The centerline of the stream shall be collected in every section. Bridge data shall be submitted in contiguous segments. (Bridge Section Specifications will be supplied on request as needed).

Section E
Hydrographic Surveys

General:
All hydrographic surveys shall be done in accordance with the Hydrographic Surveying Manual, EM1110-2-1003.

Gages and Benchmarks:
The elevation of the zero mark on all relevant project gages shall be determined with respect to the appropriate NAVD88 epoch in accordance with the Vertical Control Plan approved by the District Datum Coordinator. This will typically be done via conventional differential leveling ties or RTK survey techniques from nearby benchmarks that have been recovered and/or established in the vicinity of the gage. These nearby benchmarks shall be directly connected, by the contractor if necessary, to National Geodetic Reference System (NSRS) PBMs having published elevations expressed with respect to the current NAVD88 epoch (e.g., NAVD88 (2009.55), et seq.).

The Contractor shall fully document all raw gage readings and the reduction of those readings to their corresponding NAVD88 values in the field book. This shall include the location/identity of the subject gage as well as the precise time of each gage reading. The Contractor shall prepare a final report of the vertical control survey to include pictures of all vertical control monuments, descriptions, published and found elevations, network adjustments, reconnaissance notes, field notes, sketches, etc. The Contractor shall furnish pictures, descriptions and elevations of all bench marks established for vertical control.

The contractor shall utilize the government's existing gages when possible, and . shall only use gages that will allow the data to be reduced to the datum / epoch that is specificed in the SOW. The contractor shall access all PBM descriptions and elevations from NGS (http://www.ngs.noaa.gov/) or as indicated in the scope of work.

Hydrographic Survey Operations:
The Contractor shall inspect each survey site to determine if waterway obstructions such as moored barges prevent the use of automated positioning and sounding equipment for portions of ranges. At these ranges, the Contractor shall obtain the hydrographic surveys by the conventional method (e.g., the use of a distance wheel or substitute device and Fathometer or lead line) or by use of a system able to measure water depths under surface obstructions.

All soundings shall be reduced to the datum and epoch required by the SOW and tabulated to the nearest hundredth of a foot. A Differential Global Positioning System (DGPS) capable of receiving and applying correction from the USCG navigational beacon broadcast signal may typically be used for horizontal positioning of hydrographic data acquired from a survey vessel. RTK may be used if a higher accuracy is required by the scope of work.

While hydrographic surveys operations are underway, the contractor shall record and report gage readings at all relevant project gages to the nearest tenth of a foot. These readings will be recorded at that interval necessary to adequately track the tidal curve (especially at times of predicted high and low tides) and to ensure the correct determination of the water surface elevation at all times during the survey. Predicted tides can be obtained at the following web sites and shall be included in the survey report: http://tidesandcurrents.noaa.gov/

Hydrographic Surveys shall be conducted with a depth sounder able to measure not less than 10 soundings per second and make a permanent record on a scroll with a vertical scale approved by the COR. The transducer shall have a beam width of not more than five degrees. In areas of suspended sediment, a low frequency fathometer shall be used and set such that the hard bottom is digitized. To insure/confirm that the hard bottom is properly digitized, the requestor may require that additional lead-line check soundings be made. If so, the contractor shall take a minimum of three check soundings on every third range using a 13 lb. mushroom type lead.

Hydrographic survey soundings shall be taken at 20-foot intervals unless otherwise specified. Overbank elevations shall be taken at 20-foot intervals and at all abrupt changes (+/- 2') in elevation unless specified in the scope of work. Measured elevations shall have an accuracy of +/-0.20 ft or better unless specified by the scope of work.

Bar check readings shall be made twice daily (to adjust the depth sounder for water temperature and salinity); once before work commences and once at the close of each day and must be performed in the project area. When bar checks are made, the Contractor shall follow the operating procedures described in the previously referenced EM 1110-2-1003. Patch tests for multibeam surveys shall be performed prior to data collection on an as needed basis.

Hydrographic Survey Deliverables:

The Contractor shall reduce, edit, correct and combine overbank and hydrographic survey data in the EM file format as outlined in the referenced EM File Format Specifications and, if specified, the legacy file format "MVN Extended LMN830 Format (LMN830 format specifications will be provided on request).

A final hydrographic survey report shall be submitted in PDF format and shall include survey methodology, baseline computations, survey control, survey procedures, correspondence, photos, tabulation of monuments with elevations, feature descriptions, etc. All hydrographic and GPS raw data, processed vectors, network adjustments, reports, field notes, fathometer scrolls, etc. shall be submitted. All data files and photos shall be recorded on CD/DVD and submitted to the COR. The Contractor shall retain a copy of the CD/DVDs furnished to the COR until completion of the job or receipt of notification from the COR that the data was successfully read into the system.

If required, all fathometer scrolls shall be annotated with station numbers, bar check notes, job number, contract number, date, gage readings, etc and submitted to the COR along with the survey report and field data.

Section F

Static GPS Control Surveys

General:

All Static GPS Control Surveys shall be performed in accordance with the NAVSTAR Global Positioning System Surveying Manual, EM1110-1-1003. All GPS network results shall be submitted to Survey Section (CEMVN-ED-SS) for approval prior to commencement of any dependant survey operations. Any additional survey work undertaken prior to approval of the network results may not be acceptable and will be at the contractor's risk.

Acquisition of new elevation/orthometric height data shall conform to the Survey Plan approved by the District Datum Coordinator and USACE-MVN Engineering Division Datum Policy Memo #3, "Requirements for Use of Benchmarks for USACE Projects," dated March 23, 2009.

Determining Orthometric Heights using Static GPS:

When static dual-frequency differential GPS survey techniques are called for to establish a high-accuracy control network or to establish additional project or local control, there are three basic rules that need to be followed:

- Adhere to MVN's guidelines outlined in this booklet for establishing GPS-derived ellipsoid and orthometric heights when performing GPS surveys.
- Use NGS' latest National Geoid Model (at the time of publication, Geoid12A), when computing GPS-derived orthometric heights. Beta Geoid models released by NGS shall not be used unless specifically requested by the SOW or District Datum Coordinator.
- Use the latest NGS control point positions/elevations found in the NSRS Database (or as specified by the USACE): http://www.ngs.noaa.gov/cgi-bin/datasheet.prl

In some unique situations, available NGS control may be so distant and/or so sparse that full adherence to more stringent and demanding technical guidelines is required. The District Datum Coordinator will advise when/if these more demanding guidelines (NOAA Technical Memorandum NOS NGS-58, developed by the National Geodetic Survey in November 1997 titled "*Guidelines for Establishing GPS-Derived Ellipsoid Heights*", Version 4.3; NGS's "A *Guide for Establishing GPS-Derived Orthometric Heights*", Version 1.5; U.S. Army Corps of Engineers Technical Letter No. 1110-1-183 dated April 1, 1998 and titled "*Using Differential GPS Positioning for Elevation Determination*") are to be followed.

Network Design Planning:

When the use of static dual-frequency carrier-phase differential GPS is specified in the Scope of Work for a New Orleans District project, a Network Design Plan and Session Schedule must be developed. The Network Design Plan and Sessions Schedule must be submitted to the District Datum Coordinator for approval prior to commencement of any work.

The location and density of available NGS control should be carefully reviewed. The network should ordinarily incorporate a minimum of three nearby, published, and undisturbed primary NGS control monuments having valid horizontal and vertical positions expressed with respect to the current horizontal and vertical datum/epoch (e.g.., a horizontal datum/epoch of NAD83 (NA2011) or newer, and a vertical datum/ epoch of NAVD88 (2009.55) or newer). If - after the incorporation of three valid NGS vertical control points - all baseline lengths in the network are less than 15 kilometers, then no additional NGS vertical control need be included. If the network requires baseline lengths of from 15 to 40 kilometers, ties to four or more NGS vertical control points surrounding the project site may be required.

Session Planning and GPS

Scheduling:

For baselines of 15 to 40 kilometers in length, the sessions should be scheduled for a minimum common observation period of 4 hours with a minimum of 2 sessions on different days. The purpose is to ensure different atmospheric conditions (different days) and significantly different satellite geometry (different times) for the two occupation periods.

For example, if the first day occupation were made between 8:00 am to 12:00 pm, the second observation would be made on the next day anytime between 1:00 pm and 5:00 pm. If the second observation is not made for a couple of days or even a week, be sure to compensate for the daily 4-minute change in the GPS satellite constellation. It has been shown that the average ellipsoid height of repeat observations is closer to the true value, with a few exceptions, than the ellipsoid height of a single observation.

For baselines of 15 kilometers or less, the sessions should be scheduled for a minimum common observation period of 40 minutes with a minimum of 2 sessions at different times of the day and a minimum 4 hour offset, or on different days, at different times. For example, if the first occupation is made between 8:00 am to 9:00 am, the second observation could be made on the same day anytime after 1:00 pm. If the second observation is not made for a couple of days or even a week, be sure to compensate for the daily 4-minute change in the GPS satellite constellation. Make sure to work around or compensate for periods when PDOP and/or VDOP are high (> 5.0).

A Session Schedule form should be assembled showing the proposed start time and session duration time for each session. Travel times should be calculated using a road map to compute distance and travel times between set-ups. Input the GPS operator the station names of the points that will be occupied by each operator.

It is important to remember that useful data in a multi-receiver static differential GPS survey session spans only the timeframe common to all receivers, i.e., from the time that the last GPS receiver in the group starts data logging, to the time that first GPS receiver in the group terminates data logging.

GPS Equipment:

Fixed height tripods are required to be used for each set-up. Fixed height tripods provide a consistent station occupation height that can reduce the likelihood of antenna height measurement blunders. In the event that a setup cannot be performed with a fixed height tripod because of an obstruction such as a fence, then an adjustable tripod can be used. In this case make certain that the procedure for antenna height measurement on an adjustable tripod is used. In no instance is the use of a bipod acceptable unless granted prior approval by the District Datum Coordinator.

The use of dual frequency receivers can correct GPS measurements for ionosphere based range errors. This will extend the feasible baseline length and resolve integer ambiguities reliably within 40 km. Dual frequency receivers shall be used on all baselines.

Use of geodetic quality antennas with ground plane is mandatory. The use of the same geodetic antenna type for all observations is preferred. Different makes and models of GPS antennas can have different phase-center offsets. Mixing different types of antennas can cause errors in the vertical component of up to 10 cm. The use of differing antenna models will be permitted only if the processing software can account for the different phase-center offsets of the antennas, and if great care is exercised by field operators and data processors to identify, document and use the appropriate antenna phase-center offsets.

GPS Field Essentials:

GPS Log Sheets are the field notes for the static GPS survey and should be filled out in their entirety. The information on this sheet is important for field coordination and communication and is essential to proper data downloading and processing. If problems are

encountered with the raw data, the problem can often be traced back to a particular GPS receiver that may have malfunctioned or been configured incorrectly.

The data required to be logged on the GPS Log Sheets by the technician include the following: Operator, Station Name, Monument Type, Julian Date, Session Number, Receiver Serial Number, GPS Antenna Model Number, Antenna Height, Start and Stop Times, and Session Notes.

A Station Sketch with reference ties is required on the back page of the sheet for future relocation and confirmation that the correct monument was used in the survey. If you occupy an existing monument, make a note on the GPS Log Sheet as to the condition of the monument. Note if the monument may have been disturbed and report to the COR if any effort is required to re-ensure its stability.

When the use of a slip-leg or adjustable-height tripod is unavoidable, the field operator should take extreme care to measure and record the slant-height measurement of the antenna ground plane in meters on the GPS log sheet. This measurement procedure should then be repeated at 180° from previous measurement. Record the average value on the GPS Log Sheet. Now re-measure the slant-height in feet to the antenna ground plane. Record this value on GPS Log Sheet. Convert the slant-heights measured in feet to meters and compare to the slant-heights measured directly in meters.

This is your survey quality control check measurement. Make certain that the measurement is recorded properly. If the two values differ by more than 0.016 feet or 5 mm, begin the measurement procedure all over again (Note that it is the responsibility of the data processor to ensure that the slant-height measurements to the antenna ground plane as recorded in the field are properly reduced to vertical heights at the antenna reference point or ARP before processing).

If a second session is scheduled on the same GPS Station, the surveyor shall break setup and re-measure the antenna height. This will eliminate the possible use of the wrong antenna height for both sessions.

Also, field operators should be aware not to stand near and block the GPS antenna or park a vehicle nearby, blocking the antenna view to the sky.

GPS Control Survey Summary:

1) Capture critical field data and occupation information.

It is essential that all observations are logged on an appropriate GPS Observation Log form and that each station is documented with a detailed Station Location Sketch and Visibility Diagram. This documentation, which is usually accompanied with photographs of the mark and equipment set up, provides the processor and QC analyst with information about and/or confirmation of critical occupation details, especially antenna reference point height and antenna type used. (see, http://www.ngs.noaa.gov/PROJECTS/NGSforms/obslog.pdf, http://www.ngs.noaa.gov/PROJECTS/NGSforms/visibility2.pdf).

2) Confirm that all antenna reference point heights are correct and that the correct antenna phase-center offsets for each antenna type have been selected/entered. Process and evaluate individual baseline solutions, duplicates, and loop closures.

Once the processor has confirmed that all antenna heights (i.e. antenna reference point or ARP heights) and antenna types (i.e., calibrated phase-center offsets from NGS relative calibration report for given antenna types) have been correctly entered, individual baseline solutions are computed and evaluated for statistical reliability (these being usually the fixed double-differenced results). Prior to a minimally-constrained adjustment, loop closures and duplicate baselines should be evaluated to confirm that there are no large mistakes or blunders (typically, any duplicate baseline check or loop closure greater than a few centimeters in

any component ought to be cause for re-examining basic input information).

3) Perform minimally-constrained adjustment to detect remaining baseline outliers, if any, and evaluate relative height differences among control points. Incorporate the appropriate Geoid model to examine orthometric heights.

Once the apparent blunders or inadequate baseline solutions detected in the process above (if any) have been corrected or eliminated, a minimally-constrained solution may be attempted, holding the latitude, longitude, and height of a single control point fixed. At this point NGS' latest National Geoid Model needs to be incorporated (either manually deduct the geoid height from the control point orthometric height to work with ellipsoid heights directly, or enter the orthometric height of the control point and point to the appropriate geoid model if the software can handle the ellipsoid/orthometric height conversion automatically).

The minimally-constrained adjustment may further help identify and eliminate any remaining large mistakes or blunders. In the absence of any blunders, the residuals of the baseline vectors (adjusted - observed) should be small (typically less than a centimeter in easting and northing and less than two centimeters in height) and may be fairly representative of the precision of the observations themselves.

In addition, the orthometric heights of other control points in the network computed from the minimally-constrained adjustment (computed by the software if it can perform the ellipsoid/ orthometric height conversion automatically, or computed manually by adding back the Geoid height for the subject point to the computed ellipsoid height) ought to be compared to their published values. If the differences between the computed and published orthometric heights at the control points are reasonable (usually less than two centimeters), you may proceed to the constrained adjustment. If, however, there is a difference of two or more centimeters at one or more of the control points, an examination of the relative height difference among them may reveal which control point or points need to be reviewed further and possibly rejected.

4) Perform a constrained adjustment - holding to valid control points only - to generate final latitude, longitude, ellipsoid height and orthometric height values of all other points in the network.

When the focus of the network is vertical control extension, the latitude and longitude of a single control point and the orthometric heights of all valid vertical control points are usually held fixed (the validity of the selected vertical control points having been established through evaluation of the minimally-constrained adjustment).

Following the constrained adjustment, the residuals of the baseline vectors (adjusted - observed) should again be relatively small (typically less than a centimeter in easting and northing and less than two centimeters in height) and the final standard errors of all computed coordinates and elevations should be realistic (typically, less than 1.5 centimeters in easting and northing and less than 3 centimeters in local height). At this point, there should be a relatively high degree of confidence in the results. If not, further analysis and/or the re-observation of problematic baselines may be required.

5) Document and report *all* of the above as well as any final QC checks (e.g., comparisons to OPUS).

- Provide all observation logs, visibility diagrams, station location sketches, station and occupation pictures, network diagrams, etc.
- Provide all raw data in RINEX format.
- Provide a spreadsheet that shows a daily summary of the points occupied and associated ARP heights, antennas, receivers, tripods, RINEX file name, occupation start and stop time, and any additional explanatory notes.
- Provide basic vector processing, duplicate and loop closure reports.

- Provide report from minimally-constrained adjustment.
- Provide final fully-constrained adjustment report and final coordinate listing.
- Provide all final benchmark datasheets.
- Provide spreadsheet showing final-adjusted versus OPUS comparison.
- Provide narrative of scope of work, field acquisition, data processing and QC procedures, results, problems, problem resolutions, etc.

Section G
Deliverables

General:
The delivery of all raw and processed data shall be accompanied by a detailed Survey Report as described below. All project deliverables are to be submitted electronically via DVD and ftp file transfer. Upon DVD transmittal and ftp transfer, the COR should be notified immediately via e-mail.

The organization and presentation of *all* deliverables should lend itself to efficient, comprehensive, and meaningful quality assurance review and analysis by both the Contractor and Survey Section personnel.

Survey Report:
Adherence to the referenced Survey Report outline is mandatory for all contractors. *All* section and sub-section headings indicated in the outline shall be included in the Final Survey Report. Those sections and/or sub-sections that are not applicable shall be noted as "N/A". See Appendix 6 for complete Survey Report outline.

Data Submittals:
All raw, intermediate and final data sets and all intermediate and final processing results, as well as any other relevant data or information supplied and/or developed in connection with a given project or task order shall be included in the deliverables. All data and information submitted shall be organized in accordance with the file index outlined in Appendix 7.

In addition to any other deliverable format required by the SOW, all survey coordinate data shall be submitted in the "EM" or logical record format specified in the referenced EM File Format Specifications. All submitted EM files will adhere to the referenced manual for submission of data. Appropriate/ relative #T, #V, #H, and #G records will be inserted immediately before Cross Sections, Profiles, or Miscellaneous shots. The purpose is to associate a particular survey activity with the metadata describing the date, time, and control used while collecting survey data. When appropriate, certain data sets (e.g., overbank and hydrographic survey data) shall be combined or grouped logically (e.g. to form a complete cross section).

To assist Contractors with the development of properly formatted EM files, several helpful utilities are available for download from: http://www.mvn.usace.army.mil/Missions/Engineering/GeospatialSection/USACESurveyDrivers.aspx

The current release of “USACE Survey Drivers” may be downloaded from the website above and be installed locally. This utility makes available the following:

- EM File Format Specification
- LMN830 File Format Specification
- Profile Format Specification
- Survey Utilities Shell (this includes DOS executables "survey_checker.exe" that can be run against an EM file to detect format errors, and the utility "survey_to_kml.exe" that converts EM files to KML format for viewing within Google Earth) .
- If assistance is needed to use Survey Drivers please contact Survey Section.

Appendix 1
Acronyms

CADD	Computer Aided Drafting & Design
COR	Contracting Officer's Representative
CORS	Continuously Operating Reference Station
DEM	Digital Elevation Model
DTM	Digital Terrain Model
EM	Engineering Manual
FGDC	Federal Geodetic Data Committee
FTP	File Transfer Protocol
GIS	Geographic Information System
GPS	Global Positioning System
HI	Height of Instrument
MLG	Mean Low Gulf
MLLW	Mean Lower Low Water
MSL	Mean Sea Level
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NAVD88 (2004.65)	North American Vertical Datum of 1988, 2004.65 Epoch
NAVD88 (2006.81)	North American Vertical Datum of 1988, 2006.81 Epoch
NAVD88 (2009.55)	North American Vertical Datum of 1988, 2009.55 Epoch
NGS	National Geodetic Survey
NGVD29	National Geodetic Vertical Datum of 1929
NOD	New Orleans District
NTP	Notice to Proceed
NOAA	National Oceanic and Atmospheric Administration
NSRS	National Spatial reference System
OPUS	Online Positioning User Service
OTF	On The Fly
PBM	Permanent Bench Mark
PDOP	Positional Dilution of Precision
RH	Rod Height
RTK	Real Time Kinematic
SOW	Scope of Work
TBM	Temporary Bench Mark
USACE	U.S. Army Corps of Engineers
VDOP	Vertical Dilution of Precision

Appendix 2
Feature Codes

AC; TOP OF A.C. PAD
AP; ABANDONED PIPE
APR; APRON
ASP; ASPHALT
ATO; ABUTMENT TOE
ATP; ABUTMENT TOP
BAL; BALLAST
BBP; BOTTOM OF BORROW PIT
BBT; BOTTOM OF BENT
BCR; BRIDGE CORNER
BFB; BRICK FLOWER BED
BF; BRIDGE FENDER
BL; BASELINE
BM; BENCH MARK
BLD; BUILDING
BLK; BULKHEAD
BNT; BENT OF BRIDGE
BOD; BOTTOM OF DITCH
BOS; BOTTOM OF STREAM
BOT; BOTTOM
BRC; BRIDGE CONCRETE
BRF; BRIDGE FENDER
BRK; BREAKLINE
BRW; BREAK WALL
BS; BUSH
BW; BRICK WALL
CAR; CENTERLINE OF AGGREGATE ROAD
CAP; CONCRETE APRON
CA; CONCRETE ASPHALT
CB; CATCH BASIN
CBC; CABLE LINE
CBK; CONCRETE BULKHEAD
CBL; CABLE
CBT; CONCRETE BLUT TOE
CCL; CENTERLINE OF CONCRETE CULVERT
CCP; CENTERLINE OF CONCRETE PAD
CCR; CENTERLINE OF CONCRETE CURB
CDR; CONCRETE DRIVE
CFP; CORNER FLAG POLE BASE
CG; CATTLE GUARD
CH; CORNER HOUSE
CHW; CENTERLINE OF HEAD WALL
CLG; CENTERLINE GABION
CL; CENTERLINE
CLB; CENTERLINE OF BRIDGE
CLC; CENTER OF CONCRETE
CLD; CENTER OF DITCH
CLI; CENTERLINE
CLL; CENTERLINE LEVEE
CLR; CENTERLINE OF ROAD
CLW; CENTERLINE OF WALKWAY
CND; CONDUIT
CNL; CANAL
COH; CONCRETE HEAD WALL
CON; CONCRETE
COR; CORNER
CP; CRAPE MYRTLE TREE
CPG; CONCRETE PILING
CPT; CYPRESS TREE
CRD; CROWN OF DIKE
CRK; CENTERLINE ROCK
CRA; CENTERLINE OF RAIL
CRB; CURB
CR; CROWN OF LEVEE
CRN; CROWN
CRT; CROSSTIE
CRW; CONCRETE RETAINING WALL
CSP; CONCRETE AT SWIMMING POOL
CTD; CENTER OF DRAIN
CTH; CATCH BASIN
CTN; COTTONWOOD TREE
CUB; BOTTOM OF CULVERT
CUL; CULVERT
CYP; CYPRESS TREE
CYS; CYPRESS TREES
DGS; DOGWOOD TREES
DKE; DIKE
DRI; DROP INLET
DRN; DRAIN
DRV; DRIVE
EAR; EDGE OF AGGREAGATE ROAD
ECB; EDGE CONCRETE BRIDGE
EC; EDGE CONCRETE
ECC; EDGE CONCRETE CURB
ECR; EDGE CONCRETE ROAD
ECW; EDGE OF WALL
EDR; EDGE OF DIRT ROAD
EFB; EDGE OF FLOWER BED
EGL; EDGE OF GRASS LINE
ELI; EDGE OF LIMESTONE
ELM; ELM TREE
ELS; ELM TREES
EMG; EDGE OF METAL GRATING
EOA; EDGE OF ASPHALT
EOB; EDGE OF BRIDGE
EOC; EDGE OF CULVERT
EOR; EDGE OF RIP RAP
EOM; EDGE OF MEDIAN
EP; EDGE OF PLATFORM
EPL; EDGE OF PARKING LOT

ER; EDGE OF ROAD
ERF; EDGE OF ROAD FLOOD SIDE
ERP; EDGE OF ROAD PROTECTED SIDE
ESH; EDGE SHELL ROAD
ESL; EDGE OF SLAG ROAD
ESP; EDGE SHEET PILE
ESR; EDGE SHELL ROAD
EW; EDGE WOODS
FEP; FENCE POST
FC; FENCE CORNER
FIP; 4" POST
FL; FENCE LINE
FLB; FENCE LINE BRICK
FLC; FENCE LINE CHAIN LINK FENCE
FLD; FLOOD WALL
FLW; FENCE LINE WOODEN
FP; FLY POINT
FS; FLOOD SIDE LEVEE
FSC; FLOOD SIDE CROWN
FST; FLOOD SIDE TOE
FTG; FOOTING
GAC; GROUND AT CULVERT
GAP; GROUND AT PIER
GAT; GATE
GGE; GAGE
GL; GAS LINE
GM; GAS METER
GRN; GROUND
GR; GUARD RAIL
GRV; GRAVEL
GTB; GAS TEST BOX
GUY; GUY WIRE
GVL; GAS VALVE
HBK; HIGH BANK
HBS; HACKBERRY TREES
HED; HEDGES
HL; HEDGE LINE
HSE; HOUSE
HT; 10" HACKBERRY TREE
HUB; HUB
HWL; HEAD WALL
HYD; FIRE HYDRANT
INV; PIPE INVERT
IP; IRON PIPE
IRL; IRON RAIL
IR; IRON ROD
LC; LOW CORD
LPL; LIGHT POLE
LW; LOW WIRE
MB; MULLBERRY TREE
MBX; MAIL BOX
MET; METAL, TOP OF GATES
MF; MUD FLAT
MGT; MAGNOLIA TREE
MH; MANHOLE COVER
MON; MONUMENT
MSH; MARSH
MTR; METER
MTX; METER BOX
NG; NATURAL GROUND
NGP; NATURAL GROUND AT PILING
NS; NORTH SIDE
OH; OVERHEAD POWER LINES
OT; OAK TREE
OTS; OAK TREES
PC; PECAN TREE
PCS; PECAN TREES
PIC; PIPE INVERT, CONCRETE
PIM; PIPE INVERT, CMP
PIN; PIPE INVERT
PIP; PIPE INVERT, PLASTIC
PIR; PIER
PIS; PIPE INVERT, STEEL
PL; PIPELINE CROSSING
PLC; POWER LINE CROSSING
PLG; PILING
PLT; PLATFORM
POR; PORCH
PPE; PIPE
PPL; POWER POLE
PP; PICTURE POINT
PRK; PIPE RACK
PSC; PROTECTED SIDE CROWN
PST; PROTECTED SIDE TOE
PS; PROTECTED SIDE LEVEE
PT; 10" PINE TREE
PTS; PINE TREES
PVC; PVC PIPE
PWC; 4" POST WITH CABLE
PWL; POWERLINE
RAL; GUARD RAIL
RCK; ROCK
RCP; INV. RCP
RD; ROAD
RMP; RAMP
RDM; RED DAY MARKER
ROW; RIGHT OF WAY
RP; RIP RAP
RR; RAILROAD
RRP; RAILROAD POST
SCO; SEWER CLEAR OUT
SGN; SIGN
SGP; SIGN POST
SS; SOUTH SIDE
SHD; SHOULDER
SP; SHEET PILING
SHL; SHELL
SLP; SLOPE SHOT
SND; SOUNDINGS
SNG; SOUNDINGS
SOC; SLOPE ON CONCRETE
SRR; SLOPE ON RIP RAP

SPT; TOE OF SHEET PILING
SPV; SLOPE PAVING
STP; STEPS
SWK; SIDEWALK
TEP; TELEPHONE PEDESTAL
TB; TOE OF OLD RR BED
TBK; TOP OF BANK
TBL; TOE OF BALLAST
TBP; TOP OF BORROW PIT
TBR; TOE OF BERM
TBS; TOP OF BALLAST
TC; TOP CONCRETE
TCB; TOP CONCRETE BANK
TCR; TOE CURB
TCS; TOP OF CONCRETE PAVEMENT (ON SLOPE)
TCW; TOP OF CONCRETE WALL
TEC; TOP ON EDGE OF CONCRETE WALL
TED; TOP EDGE OF DITCH
THR; THRESHOLD
TIP; 3" POST
TNK; TANK
TOB; TOE OF BORROW PIT
TOC; TOE OF CONCRETE WALL
TOD; TOE OF DITCH
TOE; TOE ON NATURAL GROUND
TOL; TOP OF LEVEE
TOP; TOP ON NATURAL GROUND
TOR; TOE ROCK
TOW; TOP OF WALL
TPC; TOP CURB
TEL; TELEPHONE LINE
TP; TOP OF OLD RR BED
TPB; TOP OF BERM
TPL; TELEPHONE POLE
TPR; TOP ROCK
TPT; TOP SETTLEMENT PLATE
TPW; TOP OF CONCRETE WING WALL
TR; TREE
TRA; TOE OF GUARD RAIL
TRK; RR TRACK
TRL; TREE LINE
TRN; TRANSFORMER
TRW; TOE OF CONCRETE RETAINING WALL
TSP; TOP OF THE SHEET PILING
TWB; TOP WOOD BANK
TWR; TOWER
TWW; TOE OF CONCRETE WING WALL
UBX; UTILITY BOX
UGT; UNDERGROUND TELEPHONE LINE
UTL; UTILITIES
VAL; VALVE
WF; WATER FAUCET
WLN; WATER LINE
WBT; WOOD BANK TOE
WBK; WOOD BULKHEAD
WDP; WOOD PILING
WE; WATER EDGE
WES; WATER EDGE SURFACE
WFL; WOOD FENCE LINE
WL; WOODLINE
WLK; WALKWAY
WLS; WILLOW TREES
WM; WATER MAIN - METER
WMA; WATER MAIN HOLE
WRW; WOODEN RETAINING WALL
WS; WATER SURFACE
WSB; WISTERA BUSH
WV; WATER VALVE
WW; WING WALL
XBR; BRIDGE CROSS BR

Appendix 3
References

• EM1110-1-1005 Control and Topographic Surveying Manual
http://www.publications.usace.army.mil/USACEPublications/EngineerManuals.aspx

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• US Army Corps of Engineers Safety and Health Requirements Manual," EM 385-1-1, dated 15 September 2008.
http://publications.usace.army.mil/publications/eng-manuals/EM_385-1-1_languages/EM_385-1-1_English_2008/toc.html

• NOAA Technical Memorandum NOS NGS-58" published in November 1987 (http://www.ngs.noaa.gov/PUBS_LIB/NGS-58.pdf), and Guidelines for Establishing GPS-derived Orthometric Heights (Standards: 2 cm and 5 cm) (http://www.ngs.noaa.gov/PUBS_LIB/NGS592008069FINAL2.pdf)

• ETL 1110-1-152 - Engineering and Design, CONVERSION TO THE NORTH AMERICAN VERTICAL DATUM OF 1988

Appendix 4

Accuracy Standards

Figure 1
USACE Closure Accuracy Standards
Ref: USACE EM 1110-1-1005

Table 4-1
Minimum Closure Accuracy Standards for Engineering and Construction Surveys

USACE Classification	Closure Standard	
Engr & Const Control	Distance (Ratio)	Angle (Secs)
First-Order	1:100,000	2·√N [1]
Second Order, Class I	1:50,000	3·√N
Second Order, Class II	1:20,000	5·√N
Third Order, Class I	1:10,000	10·√N
Third Order, Class II	1: 5,000	20·√N
Engineering Construction (Fourth-Order)	1: 2,500	60·√N

[1] N = Number of angle stations

Figure 2
USACE Elevation Closure Accuracy Standards
Ref: USACE EM 1110-1-1005

Table 4-2
Minimum Elevation Closure Accuracy Standards for Engineering and Construction Surveys

USACE Classification	Elevation Closure Standard (ft)[1]	(mm)
First-Order, Class I	0.013·√M	3·√K
First-Order, Class II	0.017·√M	4·√K
Second Order, Class I	0.025·√M	6·√K
Second Order, Class II	0.035·√M	8·√K
Third Order	0.050·√M	12·√K
Construction Layout	0.100·√M	24·√K

[1] √M or √K = square root of distance in Miles or Kilometers

Appendix 5

Sample Benchmark Description Form

USACE New Orleans Benchmark Description Form

Designation: E 191

Job No. : 13-150C

Stamping: E 191 1964

NGS PID : BJ1655

Parish: St. James

Date Recovered: Jul 8, 2013

By: New Orleans District Survey Section

Condition/Stability: Good

Monument Type:

Rod Depth: **Magnetic:** (•) Yes ( ) No

GPS Suitable: (•) Yes ( ) No

Obstructions: ☐ N ☐ E ☐ S ☐ W

- Horizontal -

Datum: NAD83 (NA2011)

Local Accuracy:

NSRS Accuracy: 2'

N: 552790.191

E: 3471544.599

Lat: 30 01 07.27893

Long: 090 43 50.57444

Survey/Computation Method: Static GPS Network

- Vertical -

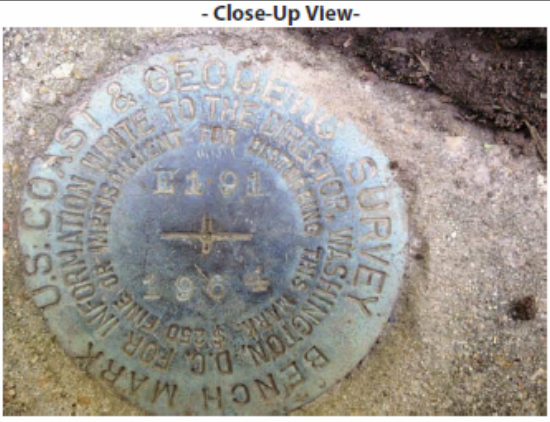
Datum: NAVD88 (2006.81)	**Datum:** NAVD88 (2004.65)	**Datum:** NAVD88 (OPUS)
Elevation Ht: 14.436 Ft	**Elevation Ht:** 14.436 Ft	**Elevation Ht:** 14.547 Ft
Ellip Ht: -71.897	**Ellip Ht:**	**Ellip Ht:** -71.785
Local Accuracy:	**Local Accuracy:**	**Local Accuracy:**
NSRS Accuracy: 0.25'	**NSRS Accuracy:** 0.25'	**NSRS Accuracy:** 0.25'
Survey/Computation Method: Static GPS Network	**Survey/Computation Method:** Static GPS Network	**Survey/Computation Method:** OPUS-DB
Date Observed: Jul 9, 2013 Geoid12	**Date Observed:** Jul 9, 2013 Geoid12	**Date Observed:** Jul 9, 2013 Geoid12

Description/Comments:

THE STATION IS LOCATED ABOUT 3.1 MILES SOUTHWEST OF GRAMERCY ON STATE HIGHWAY RIGHT OF WAY. TO REACH THE STATION FROM THE CENTER OF THE INTERSECTION OF INTERSTATE HIGHWAY 10 AND LA HIGHWAY 641 NORTH OF GRAMERCY, GO SOUTH THEN SOUTHEAST FOR 6.7 MILES ON LA 641 TO THE T-JUNCTION WITH LA HIGHWAY 44, TURN RIGHT AND GO WEST FOR 2.6 MILES ALONG LA 44 TO THE MARK ON THE RIGHT BETWEEN A UTILITY POLE AND CHAIN LINK FENCE. THE STATION IS 51.2 FEET WEST OF A FIRE HYDRANT, 40.0 FEET NORTH OF THE CENTER OF THE HIGHWAY, 4.6 FEET NORTH-NORTHWEST OF A WOODEN UTILITY POLE, 3.3 FEET SOUTH OF A CHAIN LINK FENCE, 2.9 FEET WEST OF A LDH CONCTETE RIGHT OF WAY POST, 1.3 FEET EAST OF A METAL POST WITH A METAL WITNESS SIGN ATTACHED, AND ABOUT 2.3 FEET BELOW THE LEVEL OF THE HIGHWAY. THE MARK IS A USCGS CAP STAMPED "E 191 1964".

- Horizon/Setup View -

- Close-Up View-



Appendix 6
Survey Report Outline

Title Page

- "Survey Report"
- Date
- COE Job Name
- COE Job Number
- Contractor Name
- Contractor Address
- Contractor POC Phone Number
- Contractor POC E-mail Address
- Supervising Professional Land Surveyor Stamp and Signature, attesting as follows: "I herby certify that the work described in this survey report was performed under my supervision and that the results described and/or referenced herein are complete and correct to the best of my knowledge and ability."

Table of Contents

Section 1: General Project Description

Brief and meaningful (one paragraph) overview of the project with vicinity map.

A. Project Overview

- What – Type of survey(s)
- Where – General Location
- When – Start and Stop Date
- Why – Purpose of Survey
- How – Methodology

B. Vicinity Map

- Insert vicinity map with aerial background
- Post and label key control points and area of interest outline
- Label other significant features
- North Arrow and Scale

Section 2: Project Background

All technical documentation, meeting minutes, communications, and any other descriptive detail regarding the Scope of Work, Field Reconnaissance, Scope of Work Meeting, Contract Proposal, Negotiations, and Notice to Proceed.

A. Request for Proposal/Scope of Work

- Insert SOW Document supplied by COE
- Reference: ED-SS_SOW: List SOW file name
- Reference: ED-SS_Survey_Control/Corps: List COE provided files (control data/diagrams, traverse/baselines, etc.) with short description of each file.

B. Field Reconnaissance/Joint Site Visit

- Overview of site conditions, access, etc
- Monuments recovered and their condition
- Other issues, concerns

C. SOW meeting, Contract Proposal, Negotiation Minutes, Notice to Proceed

- Insert minutes and/or summary of key points from relevant meetings
- Reference: ED-SS_Correspondence: List file name(s) containing SOW meeting minutes/correspondence, contract proposal document, negotiation minutes/correspondence, notice to proceed document, and all other clarifying documents/communication with short description of each file.

Section 3: Project Planning

All plans, schedules and other information and communications regarding project planning.

A. Survey Plan

- Insert Survey Plan approved by COE
- Reference: ED-SS_SurveyPlan: List file name of survey plan document.
- Reference: ED-SS_Correspondence: List file name(s) containing Survey Plan meeting minutes/correspondence, if any

B. Reference Systems and Survey Accuracy

Clearly restate required reference systems and accuracy requirements for survey

- Horizontal datum/epoch
- Vertical datum/epoch
- Grid System and units
- Note any unusual variances (e.g, use of a localized or "pseudo state-plane" system based upon legacy/historical coordinates of recovered monument or monuments)
- Horizontal accuracy of control points (NSRS and local or project)
- Vertical accuracy of control points (NSRS and local or project)
- Horizontal accuracy of all other plan detail
- Vertical accuracy of all other topographic/hydrographic detail

C. Proposed Field/Office QC measures

The purpose of this section is to ensure that the Contractor has given, in advance of actual survey data collection, serious thought and attention to the detection, characterization, and proper handling of all errors: random, systematic, and gross or spurious (i.e, human blunders, equipment malfunctions). In particular, procedures for the detection and mitigation of blunders (e.g., incorrect antenna reference height measurement, incorrect antenna type selected, incorrect backsight point, incorrect target height, failure to properly incorporate the appropriate geoid model in static GPS network processing, etc.) should be thoroughly reviewed with all field and data processing personnel.

- Brief narrative of general field and office QC/QA procedures
- Explain how accuracies will be confidently achieved
- Describe key field and office procedures susceptible to blunders
- Explain key blunder detection/elimination procedures

D. Key schedules/predictions (insert as required)

- Static GPS session schedules
- Anticipated PDOP/satellite visibility
- Tide predictions, etc.

E. Safety Plan

- Insert proposed safety plan

Section 4: Data Collection

Detailed narrative of all data collection activities, including but not limited to: Equipment used (make and model); tolerances, rejection thresholds and alarm settings (e.g., PDOP, rms, elevation cutoff), data collections method(s) and or techniques; control and check points used; closures; number of crews and crew personnel; survey dates; blunders detected in the field and their resolution; other problems and their resolution (provide details for each survey category below – enter N/A where appropriate):

A. Static GPS Control Surveys

Narrative overview of Static GPS survey, including:

- Annotated network diagram posted on aerial imagery
- Receiver/antenna make(s) and model(s)/ tripods (fixed-height)
- Given control points
- Points to be determined from network
- Horizontal/vertical datum/epoch
- Observation details: dates, times, elevation mask, epoch interval, etc.
- Unique problems, conditions, concerns and their resolution
- Reference: ED-SS_GPS/Static/Raw: List observation logs, occupation photos, site visibility diagrams, raw data files

B. RTK Surveys

Narrative overview of RTK survey, including

- Annotated control/check point diagram posted on aerial imagery
- Base receiver/antenna make and model/ tripod (fixed 2-meter)
- Base station static data logging interval and elevation mask
- Rover receiver(s)/antenna(s) make and model
- Rover tripod(s)/bipods/range poles
- Given control and check points
- Additional temporary control set via RTK
- Horizontal/vertical datum/epoch and Geoid model
- Observation details: dates and times; basic rover configuration (elevation mask, output coordinate system definition, geoid selected, etc.); tolerances/rejection thresholds (Minimum number of satellites, PDOP, rms, horizontal and vertical accuracy, fixed only)
- Check point closure summary
- Unique problems, conditions, concerns and their resolution (e.g., loss of lock, float solutions, etc.)
- Reference: ED-SS_GPS/RTK/Raw/Base: List base station observation logs, occupation photos, site visibility diagrams, raw data files
- Reference: ED-SS_GPS/RTK/Raw/Rover: List rover data collector files that contain configuration summary, point coordinates/elevations and descriptors/codes, HI information, data quality indicators/flags
  Reference: ED-SS_FieldBooks: List field book(s) and page ranges for rover data points

C. GulfNet VRS Surveys

Narrative overview of VRS survey, including:

- Annotated control/calibration/check point diagram posted on aerial imagery
- Rover receiver(s)/antenna(s) make and model/tripod(s)/bipods/range poles
- Given control/calibration and check points
- Additional temporary control set via VRS
- Horizontal/vertical datum/epoch and Geoid model
- Observation details: dates and times; basic rover configuration (elevation mask, output coordinate system definition, geoid selected, etc.); tolerances/rejection thresholds (Minimum number of satellites, PDOP, rms, horizontal and vertical accuracy, fixed only)
- Calibration summary
- Check point closure summary
- Unique problems, conditions, concerns and their resolution (e.g., loss of lock, float solutions, etc.)
- Reference: ED-SS_GPS/VRS/Raw/Rover: List rover data collector files that contain configuration summary, point coordinates/elevations and descriptors/codes, HI information, data quality indicators/flags
- Reference: ED-SS_FieldBooks: List field book(s) and page ranges for rover data points

D. Hydrographic Surveys

E. Conventional Traverse

F. Conventional Leveling
G. Structure Surveys
H. LiDAR Surveys

Section 5: Data Processing

Detailed narrative of all data processing activities, including but not limited to: Software used (and version); tolerances, rejection thresholds and alarm settings (e.g., PDOP, rms, elevation cutoff, data collections method(s) and or techniques; control and check points used; closures; number of crews and crew personnel; survey dates; blunders detected in the field and their resolution; other problems and their resolution (provide details for each survey category below – enter N/A where appropriate):

A. Static GPS Control Surveys
B. RTK Surveys
C. GulfNet VRS Surveys
D. Hydrographic Surveys
E. Conventional Traverse
F. Conventional Leveling
G. Structure Surveys
H. LiDAR Surveys

Section 6: Project Summary and Conclusions

Include Safety Report
Summary of safety incidents and concerns, daily safety reports, safety meetings, etc.

Section 7: Checklists

General
__ SOW reviewed
__ MVN provided data reviewed
__ Control identified and data processed
__ Correct field books (reduce levels, correct elevation, datum, epoch, etc.)
__ Intermediate CSV file created with corrected Y,X,Z, code information
__ MVN data structure implemented
__ Create EM files (import corrected Y,X,Z data)
__ All #H records included and populated in EM files
__ Field books and pages recorded in EM files as applicable
__ Date recorded in EM files as applicable
__ Equipment records included in EM files
__ LMN 830 run on EM files as necessary
__ RPT file created
__ 830 file created
__ PRO file created
__ SO file created

Horizontal Control
__ Datum correct as recorded in EM files
__ Traverse files included as necessary (T-files and J-files)
__ Primary conventional traverse adjusted (1:5000, 5”/setup) Closure:
__ Secondary conventional traverse adjusted (1:2500, 10”/setup) Closure:
__ Horizontal control included in EM files
__ Traverse stationed

Vertical Control

__ Datum correct as recorded in EM files
__ Epoch correct as recorded in EM files (average ITRF date if OPUS used)
__ Permanent benchmarks or PBMs included in EM files (#V Records)
__ Temporary benchmarks or TBMs included in EM files (#T Records)
__ Control specified by Corps was used.
__ Do levels meet accuracy requirement
__ OPUS solution averaged and shown in field book and digital files

Staff Gauge
__ Gauge readings included in EM files before each range
__ Gauge readings included before each range in Scrolls
__ Spot check of water surface interpolation performed
__ Gauges read before and after survey
__ Scrolls submitted and annotated with job information

Cross Sections
__ Spikes checked
__ Sections normal to B/L or C/L as specified
__ All sections included
__ Section lengths checked
__ Gaps checked
__ Cross sections viewed in XVIEW.exe

Miscellaneous Points
__ Descriptions, locations, etc., included in EM files (#M Records)
__ All feature located and included in EM FILES.
__ All points coded using the New Orleans CODES.dat file

GPS Control
__ Survey checked in primary processing software
__ Raw files submitted
__ Log files submitted
__ Processed files submitted (EM format)
__ Adjust report submitted
__ OPUS solutions submitted

Final Check
__ All field books scanned and legible
__ Field books stamped and signed by PLS
__ Submitted in EM and 830 formats
__ EM files reviewed in VIEW.exe
__ EM files reviewed in PUT.ma
__ DGN created with PUT.ma
__ Metadata file created
__ Job#, job name, date, contract#, and task# included on CD label
__ Transmittal letter to include each file and/or hard item submitted

Date Submitted
FTP Date:
CD Date:
Hardcopy Date:
Yes = acceptable
No = unacceptable
N/A = not applicable

Appendix 7

File Index/Submittal Folder Structure

Job YYJJJC - Title Here

ED-SS_Corrrespondence:
List on e-mail and hard copy correcpondence
ED-SS_Dgn:
List files here with short description
YYJJJ.dgn - Final map of project w/ 2' countours and breaklines
reference.dgn - Included a reference file
ED-SS_EM_Format:
YYJJJA.em - survey of riverbank (WE to FST) 123+00 to 447+00
YYJJJB.em - sections along haul road
ED-SS_FieldBooks:
060305 - pgs 1-46, control levels, sections 123+00 to 447+00
060307 - pgs 1-22, topo survey of haul road, control point descriptions
ED-SS_GPS:
YYJJJ.rpt - GPS adjustment report
*.dat - GPS raw data files
*.opus - various OPUS results
observation_logs.pdf - scanned GPS observation logs in chrological order
ED-SS_LiDAR:
list any LiDAR support files such as reports, logs, supplimental data
ED-SS_LMN830:
YYJJJA.830 - survey of riverbank (WE to FST) 123+00 to 447+00
YYJJJB.830 - sections along haul road
ED-SS_Metadata:
YYJJJ.met - metadata for job YYJJJ, Title
ED-SS_Miscellaneous:
YYJJJA.so - station and offset of topo points relativee to baseline mess.bl
codes.dat - listing of feature codes used on this job (delete the ones not used)
ED-SS_Multibeam:
List any multibeam data files here
ED-SS_Photos:
YYJJJ1.jpg - Bridge#1 looking downstream
YYJJJ2.jpg - Encroaching horse stable
ED-SS_Profile:
YYJJJ.pro - profile, centerline haul road
ED-SS_Raw_Data:
YYJJJA.rw5 - raw data for YYJJJA.em and YYJJJB.em
ED-SS_SOW:
YYJJJ_SOW.pfd - scope of work
ED-SS_Survey_Control:
YYJJJ-1.PDF - benchmnark description form for point YYJJJ-1 established this job (seperate files for each point)
T95-123.83 - ASCII traverse listing
YYJJJ.bl - reference baseline along levee C/L
T-234DS.PDF - PDF file for PBM T-234's datasheet from NGS
ED-SS_Survey_Report:
YYJJJ_Final_Report.pdf - Final report for YYJJJ, Job Title
ED-SS_Technical_Review:
List any files supporting your QA/QC process

Revision History:

Revision 2.1, 9-September-2009

Removed references to EM1110-1-1004. This manual has been incorporated into EM1110-1-1005.

Revision 3, August-2013

- Updated links throughout document
- Updated references to epochs for vertical and horizontal datums
- Updated geoid references

Revision 4, August 2014

- Licensing requirements
- Addressed NGS Beta Geoid Models
- Updated requirements for level loops
- Updated requirements for C4G RTN
- Updated requirements for Hydrographic Surveys.
- Updated Appendix 6
- Updated Appendix 7.

Revision 4.1, February 2015

- Updated horizontal and vertical epoch references
- Updated links throughout document