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SCOPE OF WORK
GEODETIC LEVELING SURVEYS

for

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY

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SCOPE OF WORK
GEODETIC LEVELING SURVEYS

1. INTRODUCTION

This Scope of Work (SOW) lists requirements for geodetic leveling surveys. Geodetic leveling is used to determine accurate orthometric height differences and extend vertical control networks. This work is administered by the National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA). Note, if Global Positioning System (GPS) surveys are required, they will be specified in separate Project Instructions and details provided in a separate SOW.

2. ADMINISTRATION

2.1 PRECIDENCE - This SOW provides general standards and specifications. In addition, the Contractor will be issued a set of Project Instructions for each survey. The Project Instructions will take precedence over this SOW since they provide detailed and often unique information. The requirements for reporting deviations, unusual circumstances, etc. described in the following paragraphs, apply to the SOW and to the Project Instructions.

2.2 CONVENTIONS - The following conventions have been adopted for these project specifications. The verb "shall" means that compliance is required. The verb "should" denotes a strong recommendation. The contraction N/A means not applicable. The term "position" means horizontal position (latitude and longitude) unless specified otherwise. The term "elevation" means the distance of a point above a specified datum, measured along the direction of gravity. The term "vertical" refers to the direction in which the force of gravity acts. The term "height" means the distance, measured along a perpendicular, between a point and a datum. See SOW Section 4. The term "Difference in Elevation" (DE) is defined as the DE between two monuments. The term "Section" means the leveling between two immediately adjacent monuments (no monument may be missed in the return run). The term "Set-up" refers to the adjustment of a leveling instrument so that it is in proper position at a point from which backsight and foresight observations are to be made. The term "Run" or "Running" is the transfer of the DE from the beginning monument to the turning point for the initial set-up and transferring the DE from the back turning point to the forward turning point for each following set-up, until the section is closed on the ending monument. The term "loop" is a continuous line of levels, a series of lines of levels, or a combination of lines or parts of lines of levels that, together with a continuous series of measured differences of elevation, forms a loop back to the starting point. The term "loop misclosure" is the amount by which two values for the elevation of the same bench mark, derived by different surveys, by the same survey made along two different routes, or by independent observations, fail to exactly equal each other.. The term "monument" is generally, any material, object, or collection of objects which indicates the location, on the ground, of a survey station or corner. Please see Attachment B for commonly used acronyms in this Scope of Work.

2.3 GENERAL REQUIREMENTS - The services to be rendered by the Contractor include all the work described in this SOW and the Project Instructions. Details not specifically described in the SOW or Project Instructions are nevertheless a firm requirement if they can be identified as an item or items commonly associated with professional grade work of a comparative nature.

2.4 MODIFICATIONS - All requests for modifications shall be submitted by the Contractor in writing to the Contracting Officer (CO) prior to making the modifications. No modifications may be made without prior written approval from the CO. Send a copy of these requests to the Points of Contact (POCs) listed in SOW Section 13.

2.5 UNUSUAL CIRCUMSTANCES - After award, the Contractor shall notify the CO and the NGS POCs of any unusual circumstances that occur during the performance of this SOW or Project Instructions, which may affect the deliverables or their quality (see SOW Sections 6 and 7). Especially note any deviation from this SOW or Project Instructions. This shall be done as soon as possible in case modifications need to be made.

2.6 ORIGINAL DATA - Observation logs and other original records generated during this project are legal records, which will be retained for data accountability and stored in the National Archives. These logs shall be original, legible, neat, clear, and fully completed in indelible black ink. Original data shall be saved, unmodified, whether in hand-written or computer-recorded form. All available spaces on the recording forms should be completed. In the original records (paper or digital), *nothing is to be erased or obliterated*. If a mistake is made on a form, draw a single line ~~through the mistake~~ and write the correction above or to the side. The person making the change shall initial all corrections. If space is too limited to permit a field correction, restart with a new log sheet, *do not recopy the form in the field or the office* in order to make a clean copy. An explanatory note should be made for all corrections to the original recorded figures. It is essential that all recorded information be neat and legible. All editing of computer recorded data shall be done on a copy of the original. Always submit the original version of the data, not a hand-made copy, a photocopy, nor a digital copy. The Geodetic Leveling Backup Sheet shall be completed in its entirety. A digital copy of this form will be provided on CD. There is a section for remarks on the backup sheets, if that is not enough room write “see back of sheet” in the remarks section and continue on the back of the backup sheet. If a section has to be restarted note the reason on the backup sheet that you started with and then use a new backup sheet for the section. Both sheets shall be submitted with the project. Any changes shall carry the initials of the individual making the change.

2.7 COMPLIANCE REQUIREMENTS – The contractor shall comply with all Federal, State, Commonwealth and local requirements.

3. GOVERNMENT SUPPLIED MATERIALS

The following items will be supplied, if applicable:

3.1 TRANSMITTAL LETTER (See Attachment L),

3.2 PROJECT INSTRUCTIONS,

3.3 EXISTING SURVEY CONTROL - Most control is accessible from the NGS web site http://www.ngs.noaa.gov by selecting "data sheets." Required and suggested connections to existing control, including data from other agencies, will be listed in the Project Instructions.

3.4 BRASS DISKS - Disks with factory standard NGS inscription.

3.5 ROD MARK SUPPLIES.

A. Logo Caps - Caps for 3D rod marks with standard NGS inscription
B. 4 foot Stainless Steel Threaded Rods
C. Connector Studs
D. Witness Posts

3.6 CD – Containing a digital copy of the NOAA Manual NOS NGS 3 "Geodetic Leveling".

See Attachment A for explanations of items listed above.

The Contractor shall acknowledge receipt of Government Supplied Items by inventorying the shipment, signing the Transmittal Letter, and FAXing the Letter to NGS. At this time contractors can not use TOMIS to acknowledge receipt of Government Supplied Items sent by the Government.

4. REFERENCE SYSTEMS

Use the following Reference Systems:

4.1 HORIZONTAL REFERENCE - The North American Datum of 1983 and year of the latest observations which is abbreviated NAD83 (currently 2002 for Puerto Rico). Note: the year of observations is on the NGS Data Sheet next to the latitude and longitude.

4.2 VERTICAL REFERENCE - Orthometric heights – NAVD 88 for the Conterminous US and PRVD 02 for Puerto Rico. Ellipsoidal heights are referenced to NAD 83 (GRS 80).

4.3 REFERENCE SYSTEM - National Spatial Reference System (NSRS). For information on NSRS see http://www.ngs.noaa.gov/INFO/OnePagers/One-Pager_NSRS.pdf and "Development of the National Spatial Reference System" http://www.ngs.noaa.gov/PUBS_LIB/develop_NSRS.html

The surveys shall be tied to the NGS vertical network. Specific tie requirements will be supplied in the Project Instructions (e.g. ties to NOAA tidal bench marks, U.S. Geological Survey (USGS) marks and/or U.S. Army Corps of Engineers (USACE) marks).

4.4 GEOID MODEL - GEOID 99, or later; use the most current version for Puerto Rico projects. GEOID 03 is available for the Conterminous United States only. For GEOID information see: http://www.ngs.noaa.gov/GEOID/GEOID99/index.html

For explanations of many of the terms in SOW Section 4, see:
http://www.ngs.noaa.gov/faq.shtml

5. REFERENCES AND GLOSSARY

REFERENCES - Note, the Contractor SHALL become thoroughly familiar with following references:

1. FGCS, "*Specifications and Procedures to Incorporate Electronic Digital/Bar-Code Leveling Systems*." Available on-line at: http://www.ngs.noaa.gov/FGCS/tech_pub/Fgcsvert.v40.specs.pdf.

2. FGCC, *Standards and Specifications for Geodetic Control Networks*, 1984. Available on-line at: http://www.ngs.noaa.gov/FGCS/tech_pub/

3. NOAA Manual NOS NGS 3, "*Geodetic Leveling*," C. Schomaker and R. M. Berry (not available on-line). A digital copy will be provided.

4. NOAA Manual NOS NGS 1 "*Geodetic Bench Marks*." Available on-line at: http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs.pdf

5. FGCC, "*Input Formats and Specifications of the National Geodetic Survey Data Base, Volume II Vertical Control*" commonly called the "Blue Book." Available on-line at: http://www.ngs.noaa.gov/FGCS/BlueBook/

6. NGS, "*Geodetic Glossary*", 1986 (not available on-line). For a printed copy contact the NGS Information Center at (301) 713-3242, or e-mail: info_center@ngs.noaa.gov.

7. D. Doyle, "*Development of the National Spatial Reference System*." Available on-line at: http://www.ngs.noaa.gov/PUBS_LIB/develop_NSRS.html

8. *Digital Leveling* by Orlando Murray (not available on-line). For a printed copy contact the NGS POC's in Section 13.

9. *Procedure's for recording Field Data for Leica DNA 03 Bar Code Level Instrument* (not available on-line). For a printed copy contact the NGS POC's in Section 13.

10. *Control Leveling*, by Charles T. Whalen. Available on-line at: http://www.ngs.noaa.gov/PUBS_LIB/TRNOS73NGS8.pdf

6. QUALITY CONTROL

The Contractor is responsible for the quality control of all data. The Contractor shall check all data to ensure that they are complete, reliable, and accurate. The Contractor's personnel shall become thoroughly familiar with the SOW and it's Attachments; the Project Instructions; the definitions of surveying terms; and with the material covered in the other references and publications, as required. See SOW Section 5 for a list of References.

QUALITY CONTROL PLAN - Prior to beginning survey work, the Contractor shall submit a written Quality Control Plan covering all work, to include at least the following requirements: a check of all manual computations (must include check marks and initials of the individual doing the computations and the individual checking the computation), a check of all manual data computer entries, a check of file formats, and a check of all reports and data submitted. The contractor shall also discuss how data will be backed-up and how it will be ensured that original data are not modified. See SOW Section 12, Deliverables.

Comments on quality control and a copy of the Quality Control Plan shall be included in the Final Project Report.

7. DATA FORMATS

7.1 ORIGINAL DATA - Original, raw digital data shall be submitted and the formats shall be documented in the Project Report. Original paper records shall also be submitted, see SOW Section 2.6.

7.2 FINAL DATA - Final project data shall be submitted in Blue Book format. All sketches, photos, project adjustments, reports, etc. shall be both paper and digital (MS Word format).

8. DATA MEDIUM AND FILE NAMING CONVENTION – All data, including photographs and reports shall be submitted on CD-ROM or DVD, with the photographs on a separate disk. Other data mediums may be acceptable with prior approval from NGS. All level lines will have an L accession number, project title, and line name assigned by NGS. Data files and description files shall have the same name with the extension determining the file type.

9. SURVEY METHODOLOGY - Differential leveling survey methodology, procedures, and equipment shall be used for the work specified in this SOW and the Project Instructions.

10. SURVEY WORK

10.1 PURPOSE - Geodetic leveling extends the vertical network. These surveys shall be tied to NSRS with PRVD 02 as its elevation reference. This vertical system provides Puerto

Rico a common, consistent set of real-time elevations. This vertical network can help provide:

A. Improved aircraft navigational aids and approach and landing procedures,

B. Advanced surface transportation control and monitoring,

C. Highly efficient fertilizer and pesticide spreading, resulting in reduced run-off water pollution,

D. More accurate modeling of storm surge and pollution trajectories,

E. Increased accuracy for improved resource management decision-making,

F. Improved disaster preparedness and earthquake detection,

G. Advanced enhancement of remote sensing applications (e.g. Light Detection and Ranging (LIDAR), photgrammetry etc.),

H. Municipalities and communities control to further densify the network,

I. An elevation model and survey points for Geographic Information System (GIS) use,

J. Technological transfer to have contractors that can provide precision leveling support in Puerto Rico,

K. FEMA and USACE a more accurate vertical (height) foundation for their mapping and survey projects.

10.2 PROJECT PHASES - The project may be divided into two phases.

A. Phase One may include:
Record research;
Mark Recovery;
Planning;
Reconnaissance;
Preparation of Survey Plan;
Preparation of Quality Control Plan;

B. Phase Two may include:
Mark setting (concrete marks, drill hole marks, and/or deep rod marks)
Note 1: Concrete Post Marks shall be set a minimal of 14 days prior to leveling, all other marks, including deep rod marks shall be set a minimal of 2 days (48 hours) prior to leveling

Note 2: Submit photos of all mark holes and completed marks prior to beginning survey observations, see Section 10.5.

Data collection;
Note: Reruns shall be completed as soon as possible after it is determined there is a mis-closed section. Reruns shall not wait until the main leveling is completed.
Data processing;
Data analysis;
Data adjustment;
Data submittal in specified formats;
Preparing reports;
If required by NGS, the contractor(s) will be issued a new task order to complete the following:
Writing manuals and other training aids explaining the work;
Providing training on how to accomplish the work;

Note: NGS may provide training in mark setting, leveling procedures, and data processing.

10.3 RECONNAISSANCE - Reconnaissance shall be performed with guidance from material in Reference 3, "*Geodetic Leveling*."

A. CONTROL STATIONS - All first, second, and third-order bench marks in or near the project area shall be considered for inclusion in this project. See Project Instructions for specific requirements and Attachment J.

B. DATABASE SEARCH:

1. VERTICAL MARKS - The NGS database shall be searched for all vertical marks (geodetic bench marks) in or near the project area using the NGS Web site at: http://www.ngs.noaa.gov/cgi-bin/datasheet.prl .

2. TIDAL BENCH MARKS – If required by the Project Instructions. Many tidal bench marks currently in use can be found at: http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Bench+Mark+Data+Sheets. The Project Instructions will contain information on additional tidal bench marks, if required.

3. HIGH ACCURACY REFERENCE NETWORK (HARN) STATIONS - Search the NGS database for all HARN (A and B-order horizontal accuracy) stations. This leveling project should include as many of these stations as possible. Special attention should be paid to including HARN stations located at airports and labeled Primary Airport Control Station (PACS) and Secondary Airport Control Station (SACS). In the Technical Proposal state the conditions for tying to each HARN and the recommendation of the contractor as to the

feasibility of that tie. See Attachment N for a complete listing of what should be included in the Technical Proposal.

4. MARK RECOVERY - The contractor shall attempt to recover all marks required by this SOW and the Project Instructions, including bench marks, Tidal Bench Marks, first or second order horizontal stations, CORS (Continuously Operating Reference Station) bench marks, and HARN stations along or within a described distance of the level line. Previously unknown marks found during the survey shall also be recovered. See Attachment I for diagrams of NOAA survey disks. The recovery of a control station includes a physical visit to the station to determine its condition, usability, etc. and the preparation of a digital recovery note in NGS format. The recovery notes could vary from one sentence to three paragraphs; see Attachment F. Station descriptions and recovery notes shall be submitted in computer-readable form using WINDESC or WDDPROC software. The WDDPROC software is available on-line at: http://www.ngs.noaa.gov/PC_PROD/DDPROC4.XX/ddproc.index.html The WINDESC software is available on-line at: http://www.ngs.noaa.gov/PC_PROD/PARTNERS/index.shtml (The basic usage instructions are built into WINDESC. You simply go under the HELP menu when you run WINDESC.).

5. POSITION - The Contractor shall obtain at least a pseudo-range GPS position for all marks recovered and/or set. Include this position in the text of recovery notes and descriptions. Data format: DDD MM SS.ss. Upon returning to the station, the contractor shall use the description to find the station and not rely strictly on GPS position.

6. MARKS OF OTHER ORGANIZATIONS - In addition, the Project Instructions may require the recovery and/or use of marks from other organizations (e.g., USGS, USACE etc.) that are not in the NGS database.

C. GPS VISIBILITY DIAGRAM - For all marks recovered, established and used, the contractor shall prepare a GPS visibility obstruction diagram using the form found at: http://www.ngs.noaa.gov/PROJECTS/FBN/ (click on Forms, then click on Visibility Obstruction Diagram).

D. DIGITAL PHOTOGRAPHS - The contractor shall take digital photographs of all marks recovered in the project as per Attachment G.

E. PROPOSED NEW STATION SITES - The contractor shall propose sites for new bench marks as necessary and propose the type of mark to be set, see SOW Section 10.4. Preliminary descriptions shall be prepared for them as well as visibility diagrams. To the extent possible and practical, station sites

should be selected to be permanent, accessible, stable, and have as clear sky visibility, see Attachment J, "Station Site Selection Guidelines". Take two photographs of proposed sites, one showing the ground in the area of the proposed mark and photo two showing the nearest satellite obstruction (or identifying feature if no obstructions).

10.4 SURVEY PLAN - After completing Phase One (reconnaissance, etc.) and prior to mark setting or observations, the contractor shall submit a Survey Plan. NGS will review the Plan as soon as possible, and will send the contractor written comments and/or approval. The contractor shall not begin mark setting or observations until the Plan is approved. The Plan shall include at least the following sections:

A. Text with summary of survey planning;
B. Requests for deviations from the SOW and Project Instructions, if any;
C. Station table (see details below);
D. Digital station recovery notes (existing stations);
E. Digital preliminary station descriptions (new stations);
F. GPS satellite visibility diagrams;
G. Project Area Sketch, to scale (include old and proposed new station locations each with different symbology);
H. Digital photographs;
I. Proposed instrumentation (instruments, rods, etc. including model, serial numbers and copies of rod calibration certificates, note: instrument type and rod shall be identified in the Technical Proposal by the Contractor;
J. Proposed Data collection and processing software;
K. Detailed leveling observation plan;

The Station Table shall include: the station designation (name), NGS Permanent Identifier (PID) provided by NGS, type (bench mark, etc.), establishing agency, order, stability (See Attachment J), condition at recovery, distance between marks, and comments/recommendations. Include proposed name and monument type of any proposed stations to be set. The series of designations will be provided by NGS in the Project Instructions. For existing stations, the name and PID shall be used exactly as listed in the NGS database, and shall be this way in all survey records.
When NGS has approved the Survey Plan, an L accession number, project title, line title, designations, and a set of Station Serial Numbers (SSNs) will be assigned by NGS for each task order.

10.5 MARK SETTING - After the Survey Plan is approved by NGS, the Contractor may begin mark setting. Marks shall be set in accordance with the approved Survey Plan and to NGS specifications for type, length, material, stability, and stamping outlined in "*Geodetic Bench Marks*" and Attachments C, D, E and O. NGS may inspect the mark setting. When mark setting is complete, and prior to beginning survey observations, submit the required photographs of each mark hole and of each completed mark, see Attachment G for detailed photographic requirements. After NGS review and approval, NGS will authorize survey operations to begin.

10.6 BENCH MARK PLOTS - The location of all marks used in the survey shall be plotted on standard USGS 7.5 minute topographic maps and each mark shall be plotted with a circle, dot and leader to the SSN.

10.7 GEODETIC LEVELING PROCEDURES - Double-run leveling (two acceptable level runs in opposite directions) preferably at different times of the day (run one direction in the morning and the opposite direction in the afternoon or one direction one day and the opposite direction on the second day and alternate the direction of the runs. For example, if you run all day in the forward direction on the first day, the second day you would run everything in the backward (opposite) direction. Then on the third day you would run in the backward direction and the forth day run in the forward (opposite) direction. This will allow for different atmospheric conditions on most runs. This will be conducted using First-Order, Class II specifications as described in Reference A, "*Standards and Specifications for Geodetic Control Networks*." All equipment shall meet first-order requirements, be in excellent condition, be properly handled and cared for, and be recently calibrated. If digital bar-code leveling systems are to be used, the model should have been previously evaluated by the Federal Geodetic Control Subcommittee (FGCS). These systems include the Leica NA3003, Leica DNA03, Topcon DL101C, Trimble DiNi 12, Zeiss DiNi 10, DiNi 11, DiNi 12 and DiNi 12T. All the above systems shall use single-piece 3-meter invar rods and rod struts. Rod calibration certificates are required in specified digital format. Use of all hardware and software shall be approved by NGS prior to performing any leveling. Reference 3, "*Geodetic Leveling*", describes the required methods and procedures including: use of instruments, rods, turning pins, how to perform a C-shot (collimation test/peg test), requirements for lengths of sights and number of setups, etc. Reference 1, "*Specifications and Procedures to Incorporate Electronic Digital/Bar-Code Leveling Systems*" contains information on these type systems.

SET UPS - An even number of set-ups is required. The only exception to this rule is a single setup section using the same rod, upon approval by NGS.

SPUR LINES - Existing marks, which were selected and approved in the Survey Plan, shall be incorporated into the level line. Spur lines may be permitted in consultation with the NGS COR. All spur lines shall be double run and no monument may be missed in the return run. The requirements for the length of spur lines will be listed in the Project Instructions.

10.8 LEVEL DATA PROCESSING - All level lines shall be checked to ensure that the standards in Reference 1 are met. Lines not meeting those standards shall be rerun as soon as possible after the misclosure is found.

10.9 LEVEL DATA ANALYSIS - Analysis will include loop closures, verifying check connection with existing leveling and concurrent leveling (New-Old computations and loop closures shall be included in the final report).

10.10 ADJUSTMENT - No network adjustment is required for submission; however, it is recommended that the contractor perform their own least squares network adjustment to ensure the integrity of the data and report the results.

10.11 LEVEL DATA SUBMITTAL - Final project data shall be submitted in the "Blue Book" format. All sketches, photos, project adjustments, reports, etc. shall be submitted on both paper and digitally (provide text documents in MS Word format). Submit all original data records (paper and digital) marked "ORIGINAL", see SOW Sections 2.7, 7.1, 12.8, and Section 12.10. All Deliverables shall be submitted through TOMIS, see Section 12 for additional information.

10.12 MANUALS AND TRAINING - If required by the Project Instructions the contractor shall produce manuals and other training aids (such as Power Point presentations) explaining portions of, or the entire geodetic leveling process. In addition, the contractor may be required to conduct training courses using the above materials.

11. FINAL PROJECT REPORT

The Final Project Report shall contain at least the following sections:

A. An overview discussion of all required work, including at least: planning, reconnaissance, mark recovery, mark setting, data collection, data processing, data error analysis, New-Old, and loop closures. This discussion shall include a summary of the results, problems encountered, conditions affecting progress, and any unusual circumstances. Include comments on any deviations from the Survey Plan, Project Instructions, or this SOW (include copies of written approvals or e-mail approvals for any deviation form the SOW or Project Instructions).

B. A written description and analysis of the quality control performed; tables showing closures, a listing and analysis of all unusual circumstances, discrepancies, and deviations; and the Quality Control Plan.

C. A listing of personnel who worked in the field or were involved with the data processing for this project.

D. A listing of the brand, model number, serial number and calibration of all instruments and rods used in the project.

E. A listing of all software, including version, used during the project.

F. A final station list: use a table format to list each station.

G. Any Loop Closures, allowable DE for each line segment, and distance and direction of the forward leveling (direction the line was run) shall be shown.

H. A final Project Diagram: update the diagram submitted with the Survey Plan (see SOW Section 10.2). Submit only a large size, readable plot (approximately 24 x 32 inches). Discuss the final layout with NGS. Note, a digital diagram may be required.

I. A list of all vertical comparisons (New-Old) to existing bench marks.

J. A list of the comparison of all repeat level lines.

K. A completed Project Submission Checklist, see Attachment H.

L. Copies of all written approvals for all modifications shall accompany the final Project Report.

M. Recommendations for future projects.

12. DELIVERABLES

The web-based Task Order Management and Information System (TOMIS) is designed to help manage geospatial services contracts for the National Ocean Service. TOMIS allows Government contractors to submit and track deliverables, as well as monitor deliverables that are upcoming or delinquent. E-mail notifications remind contractors when actions are required and contractors will be evaluated on their performance at the completion of all task orders, with a score automatically generated via TOMIS. The TOMIS system is located at https://maps.csc.noaa.gov/TOMIS/index2.jsp.

The Contractor shall submit all task order deliverables and progress reports to NGS using the TOMIS system. All progress reports shall be submitted directly to TOMIS by 2:00 pm EST every Monday, and not via email as formerly required. All deliverables smaller than 3 MB in size shall be submitted to TOMIS as an attachment. If the deliverable is over 3 MB (or hardcopy) the contractor shall submit a report to TOMIS expressly stating what the deliverable is and how the deliverable is being delivered, i.e. via FedEx, FTP, etc Once the deliverable is received by NGS, NGS will mark it as received in TOMIS and TOMIS will send an e-mail confirming receipt of the deliverable.

The contractors shall submit a deliverable tracking spreadsheet in the TOMIS format (the format will be supplied with the Project Instructions). The percentages assigned to each of the deliverables in the spreadsheet will be used as a basis for payment. The Government will not pay an invoice unless a deliverable has been received and at least partially accepted. The last 10% of payment shall be assigned to the shipment of the Government Supplied Materials back to the government. The contractor will be held accountable to the dates that are placed in the spreadsheet. If the contractor determines that they will not be able to meet a due date, it is their responsibility to request an extension.

TOMIS will track the submission dates of all deliverables, and the subsequent review comments generated when deliverables are submitted. As a last step the information within TOMIS will be used to generate a final evaluation for the project.

12.1 LABOR, EQUIPMENT, ETC. - The contractor shall provide all labor, equipment, supplies and materials to produce and deliver the products as required under this SOW, except as shown in SOW Section 3. Note, government supplied items are listed in Section 3.

12.2 GOVERNMENT SUPPLIED ITEMS - The contractor shall return to NGS all government supplied records (listed in SOW Section 3) and all unused survey marks, logo caps, stainless steel rods, and accessories.

12.3 QUALITY CONTROL PLAN - Before any fieldwork begins, the Contractor shall submit a Quality Control Plan covering all work (see SOW Section 6). NGS will review this plan as soon as possible and respond with an approval or comment letter (or e-mail) as soon as possible.

12.4 SURVEY PLAN - Before any Phase Two work begins (mark setting, observations, etc.), the Contractor shall submit a Survey Plan (see SOW Section 10.4). NGS will review this plan as soon as possible and respond with an approval or comment via TOMIS as soon as possible. Phase Two mark setting may commence after the Contractor receives the approval.

12.5 PROJECT STATUS REPORTS - After award, the Contractor shall submit project status reports via TOMIS each week, until the work is complete. Reports are due each Monday by 2:00 P.M. Eastern Time. Negative reports are required. These reports shall include a listing of where work is underway and where work is completed, with dates completed, and any unusual circumstances and/or deviations from this SOW, Project Instructions, and/or Survey Plan. See Attachment K for detailed requirements.

12.6 PROJECT DIAGRAM - Submit a diagram showing all level lines on a map background. Submit only a large size, readable plot (approximately 24 x 32 inches). Discuss the final layout with NGS. Show any/all level line junctions to illustrate that ties are being made at all line junctions. All old lines are to be connected as well as HARN and Tide Stations or connections to other agency's marks as directed by the Project Instructions that are along the route. Ties to HARN stations, other agency marks, and Tide Station marks shall be shown. Distances shall also be shown between all monuments on this diagram.

12.7 RAW DATA - Submit all original data marked "ORIGINAL" (manually recorded and automatically digitally recorded) including: GPS visibility diagrams, and digital photographs. Backup sheets (see digital copy supplied on CD) shall be used and kept by the contractor until the final adjustment is complete and accepted.

12.8 FINAL DATA - Submit paper and digital copies of all files created during data processing and adjustment. The following, as a minimal, shall be included in the submittal package:

A: Hardcopies of the INX, ABS, BOK Files, new-minus-old tabulation, loop closures, and Quad Maps;

B: A CD containing the following data files shall be attached to the folder containing the above files:

1) DSC
2) BLU
3) HGZ
4) ABS
5) BOK
6) Photographs (submit on separate CD)
7) Sketch of tidal station(s)

12.9 REPORTS - Submit a Final Project Report, see SOW Section 11. Please also see the sample Final Project Report in Attachment M.

12.10 LEVELING CHECKING PROGRAMS - Field book and field abstract software are required and are dependent on the leveling equipment used for this project. Include a listing of the equipment to be used and processing software to be used in the Survey Plan.

12.11 ORIGINAL LEVELING DATA - Submit all the original, raw data. Include an explanation of the file naming convention (there is a standard naming convention for leveling using the L accession number, See Section 8).

12.12 DESCRIPTIONS AND RECOVERY NOTES - Submit the finalized description file (D-file) from the NGS WINDESC or WDDPROC software. The contractor shall run WCHKDESC (Part of WDDPROC package) to ensure that there are no errors in the files. The descriptions will not be acceptable until this program returns no errors. The contractor shall also manually check the file because the checking program does not find all errors.

12.13 TRANSMITTAL LETTER - With the new TOMIS system, a Transmittal Letter will seldom be used for Contractor Deliverables. For Deliverables the Contractor submits to TOMIS, the system will acknowledge receipt after NGS marks the item as received. For all large digital files (greater than 3MB) and for hard copy materials that the Contractor submits outside of TOMIS, (hardcopy data being sent via express mail, regular mail, etc.) the Contractor shall submit a report to TOMIS stating the material submitted and the method of shipment. Transmittal Letters will continue to be used for items the Government ships to the Contractor. See sample Transmittal Letters in Attachment L.

12.14 BENCH MARK PLOTS - Submit USGS paper 7.5-minute topographic maps with all bench marks plotted with circle, dot and leader to designation (SSN).

13. POINTS OF CONTACT

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Contracting Officer Representative
National Geodetic Survey, NOAA
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Version 2
January 26, 2005

ATTACHMENT A
EXPLANATIONS OF GOVERNEMENT SUPPLIED MATERIALS

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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ATTACHMENT A

EXPLANATIONS OF GOVERNMENT SUPPLIED MATERIALS

1.0 TRANSMITTAL LETTER

A letter containing a list of all items shipped to the contractor for a particular survey, the date the items were shipped, and the name and address of the individual who shipped them. The contractor is responsible for verifying the receipt of all items listed and returning a signed copy of the transmittal letter to the address listed.

2.0 PROJECT INSTRUCTIONS FOR GROUND SURVEYS

A set of instructions, which is specific to a particular survey. The Project Instructions will typically contain the following sections:

2.1 Project

1. **Project Name**
2. **Geographic Limits**
3. **Project Identification Number**
4. **Size of project/ number of points**
5. **POCs**

2.2 Control

Information on all existing horizontal and vertical control points in the project area on CD-ROM.

3.0 BRASS DISKS, LOGO CAPS, STAINLESS STEEL RODS

NGS will supply standard, pre-inscribed disks with the NGS logo, pre-inscribed logo caps, stainless steel studs, and 4 ft stainless steel rod sections. These disks or logo caps shall be used by the contractor for NGS projects only. The Contractor should notify NGS of the approximate quantity required.

Version 3
February 24, 2006

ATTACHMENT B
COMMONLY USED ACRONYMS

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

ATTACHMENT B

Commonly Used Acronyms

CBN – Cooperative Base Network
CGS – U.S. Coast & Geodetic Survey (See also USC&GS)
CO -- Contracting Officer
CORS – Continuously Operating Reference Station
COR -- Contracting Officer's Representative
DE -- Difference in Elevation
FBN – Federal Base Network
FGCC -- Federal Geodetic Control Committee
FGCS -- Federal Geodetic Control Subcommittee
GIS -- Geographic Information System
GPS -- Global Positioning System
GRS80 -- Geodetic Reference System 1980
HARN -- High Accuracy Reference Network
LIDAR -- Light Detection And Ranging
NAD 83 -- North American Datum of 1983
NAVD 88 – North American Vertical Datum of 1988
NGS -- National Geodetic Survey
NOAA -- National Oceanic and Atmospheric Administration
NOS -- National Ocean Service
NSRS – National Spatial Reference System
PACS -- Primary Airport Control Station
PID -- Permanent Identifier
POC -- Point of Contact
PRVD 02 -- Puerto Rico Vertical Datum of 2002
SACS -- Secondary Airport Control Station
SOW -- Statement of Work
SSN – Station Serial Number
USACE -- U.S. Army Corps of Engineers
USC&GS – U.S. Coast and Geodetic Survey
USGS – U.S. Geological Survey

Version 3
January 27, 2005

ATTACHMENT C
CONCRETE MARKS

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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ATTACHMENT C: CONCRETE MARKS

(From NGS OPERATIONS HANDBOOK and
MANUAL OF GEODETIC TRIANGULATION, S.P. 247)

1. CONCRETE CHARACTERISTICS

1.1 GENERAL - Concrete should have properties that make it workable, strong and durable. Workability refers to the ease with which concrete can be effectively placed, consolidated, and finished, while remaining free from segregation. Workability depends on the proportions of the ingredients and the shape of the individual particles of aggregate. Strength refers to the ability to withstand external forces without rupturing. For survey monuments, high strength is not the most important property, although strong concrete usually indicates that it is durable. Durability is the ability to withstand deterioration over a long time and is primarily influenced by the watertightness of the cured concrete.

1.2 DESTRUCTIVE FORCES - Several forces can lead to the weakening or deterioration of concrete. The freezing of water in cured cement exerts great pressure against the inner walls of the pores, tending to break down the concrete. In fresh concrete, the expansion of freezing water breaks the bonds developing between solid particles, making the concrete weak and porous. Leaching and chemical attack also have detrimental effects on concrete. Leaching occurs over a long period when water slowly percolates through concrete and dissolves some of its constituents. Chemical attack is particularly common in alkali soils. Dense, impervious concrete is resistant to these destructive forces.

1.3 INGREDIENTS - The quality of the ingredients and their proportions help determine how dense and impervious the cured concrete will be. The ingredients include aggregate, cement, and water. The aggregate should be clean (free from silt and clay, harmful chemicals, and organic matter) and well-graded, i.e., it contains proportionate amounts of many particle sizes. In specifying mix proportions the aggregate is usually divided into two parts -- sand (particle size less then 2/3 cm) and gravel (particle size greater than 2/3 cm). Both parts should be well-graded. Aggregates that are porous, split easily, or are otherwise weak or permeable result in poor concrete. Examples of poor aggregates include shale, claystone, sandstone, and micaceous rocks.

Portland cement is designated by one of five types. Type I is for general use where no special properties are needed. Type III is a high-early-strength type for use when concrete will be curing during cold weather. Type V is used where the concrete will be subject to an alkali environment. Types II and IV are not suited for setting marks. Local concrete companies should be contacted to determine the best concrete type to use in the work area.

The water used in a concrete mix should be relatively free of impurities such as acids, alkalis, salts, oil, organic matter, and silt. These can decrease the strength and durability of cured concrete. As a rule, do not use water that you would not drink.

1.4 MIXING, PLACING, AND CURING - Pre-mixed concrete materials may be used. If raw materials are used, the suitable proportions (by bulk volume) of cement to sand to gravel are 1:2:3. If the gravel is made up of fragmented or angular particles, use a little less gravel and

proportionately more sand. Add only enough water to make the mix workable. About half the water added to the mix is used in the chemical reaction (hydration) that causes the paste to harden into binder. If too little water is used, however, the mix will not compact properly and spaces will be left in the mass. **A good indication of the right amount of water is that the mix neither runs nor falls off the shovel but sluggishly slides off and flattens upon hitting the ground**.

1.5 COLD WEATHER PRECAUTIONS (If Applicable)- The freezing of fresh concrete has a damaging effect because the expansion of water as it freezes separates the solid particles in the mix. This reduces the strength of the bond and makes the concrete more porous and correspondingly less durable.

Three protective measures should be taken in cold weather, either singly or in combination. First, use warm ingredients. During the first 24 hours after a mix has been placed, it develops little heat of its own to prevent freezing. After 24 hours some heat is developed as a product of the chemical reactions occurring in the mix. The use of warm ingredients is especially beneficial during the first 24 hours. Note, however, that mixing water above 165 degrees F could cause a flash set. To keep the aggregate and cement warm, store them indoors.

Second, use Type III (high-early-strength) cement or special additives that speed curing. Calcium Chloride is good for this in amounts not exceeding 2 pounds per 94-pound sack of cement. The Calcium chloride should be dissolved in the mixing water instead of mixing it with the other ingredients. Other additives include Thoroguard and Trimix. If a large number of concrete marks are being installed by mass production using a "ready-mix" contractor, fast-curing additives should not be added until the concrete is delivered on site.

Third, insulate the finished mark for a week after the concrete is poured. One method is to cover the mark with boards resting on supports. This is covered with paper or plastic, then by a layer of straw, Styrofoam, or similar insulating materials about 15 centimeters thick and finally by a layer of soil 15 to 30 centimeters thick. Pile snow loosely on top if it is available.

2. CONCRETE MONUMENTS (Note: portions of this paragraph apply to concrete collars around rod marks as well as to concrete monuments.)

2.1 STEPS:

1. Obtain property owner permission prior to proposing new mark locations.

2. Install a tall stake (lath) at each proposed site for a new mark. Write the proposed station name on the stake.

3. Obtain clearance from "MISS UTILITY" type services (underground utilities) before digging.

4. Drill or dig a 12 - 14 inch diameter hole in the ground 4.0 to 8+ feet deep. The depth depends on frost penetration in that area. The minimum depth is 4.0 feet. Keep the

sides of the hole as smooth as possible. The rounded, bottom portion of the monument must extend at least one foot below the frost line. See NOAA Manual NOS NGS1, *Geodetic Bench Marks* which contains a diagram showing average frost line depth.

5. Enlarge the bottom portion of the hole using a shovel such as a "sharp-shooter" (also called "drain spade") so that the hole is at least 2 inches larger in radius than the main shaft of the hole. This will make the bottom of the monument bell-shaped; see diagram.

6. Remove or tamp down the loose dirt at the bottom of the hole.

7. Remove any loose dirt that might fall into the hole during concrete installation. A layer of loose dirt from the sides or top of the hole, mixed with the concrete will create a fracture line (or plane) which could lead to the monument breaking, thus destroying the mark.

8. Procure a round, cardboard form 12 inches in diameter to line the top 12 - 18 inches of the hole. Test fit the form in the top of the hole. This form will help avoid any shoulders or mushrooming effect near the top of the monument which might afford purchase for frost heave. The form will also help make a neater looking monument. A cardboard, biodegradable, 12-inch diameter form is commercially available. Allow the form to protrude from the ground 2 - 6 inches.

9. Mix the concrete well before it is placed, otherwise the minute particles of cement will not be sufficiently wet and the aggregate will not be completely covered with paste. Prior to adding water, mix the ingredients well. Then, slowly add water and continue to mix. Do not make the mixture too wet.

10. Dampen the hole before concrete is added so moisture will not be drawn from the fresh concrete into the surrounding soil. In no case should it be so wet as to be muddy

11. Place concrete in the hole. Continuously tamp the mix into a compact mass so it becomes less pervious and consequently more durable. Do not contaminate the interior of the monument with dirt.

12. Place the form into the hole when the level of the concrete is approximately one foot below the surface. Continue to be careful not to allow any dirt to fall into the hole.

13. Add concrete until the top is even with or slightly below the surface of the ground. This helps ensure that the monument is not struck by lawn mowers or snow plows, etc.

14. Smooth off the top of the monument with a trowel. Create a gentle slope towards the outside so that rain water will drain off. Bevel the outside edge of the monument.

15. Stamp the disk prior to installing it in a concrete monument or a drill hole. Stamp the disk on a stamping block which has a curved surface that matches the curvature of the underside of the disk. Neatly stamp the station designation (name) above the triangle, centered below "HORIZONTAL CONTROL MARK" and then stamp the year below the triangle, centered above "THE DIRECTOR". For a “VERTICAL CONTROL MARK” stamp the designation above the cross in the center of the disk and the year below the cross centered above "THE DIRECTOR".

16. Set the disk into position in the top center of the monument with the top of the triangle below the name pointing north (so that a visitor facing north will be able to read the disk's lettering). Placing a small amount of concrete on the underside of the disk before setting helps ensure that air is not trapped under the disk. A vertical disk is set so the disk is positioned parallel to the road (level line) so that a visitor can walk up to the mark and read the stamping.

17. Press the disk into the concrete until the disk edge touches the concrete. Then tap the disk with the handle end of the trowel **until the top edge of the disk is flush with or slightly recessed into the concrete** (to the point that vandals can not get a pry bar under the disk). Do not recess the disk a greater amount because this makes a hollow that will collect rainwater and possibly shorten the life of the mark due to freezing action.

18. Clean the disk. Sprinkle some dry cement on the exposed surface of the disk, then rub it with a clean rag or short bristled brush using circular strokes. This will clean the disk, removing all excess mortar from its surface and recessed letters. Rubbing the wet mortar around the edge of the disk in the same manner is done intentionally to finish its surface and help prevent cracking. Brush away loose cement and make sure that the finished product has a neat appearance.

19. Cover the mark for at least 7 days. This prevents rain from making the mix too wet and from ruining the finished surface. It also prevents the surface from drying too rapidly, leaving too little water for complete hydration. In addition, it prevents debris from sticking to the surface of the wet concrete. A 12 inch diameter lid is available that fits on the 12 inch cylindrical form. This lid will also keep out the dirt during the next step and final clean-up.

20. Replace dirt around the form and tamp into place. At the surface, replace dirt and sod around the form and tamp into place.

21. Rake the area until neat and remove excess materials. Do not leave any construction or other materials at the site. Leave the area as neat as or neater than when you arrived. Note: the protruding form and lid shall be removed later during survey observations.

22. Remove excess dirt and dispose of it properly. In some rural areas there may be a logical spot to dump the extra soil where no one will notice. If the mark is in an area

consisting of groomed lawns, the dirt shall be removed from the site.

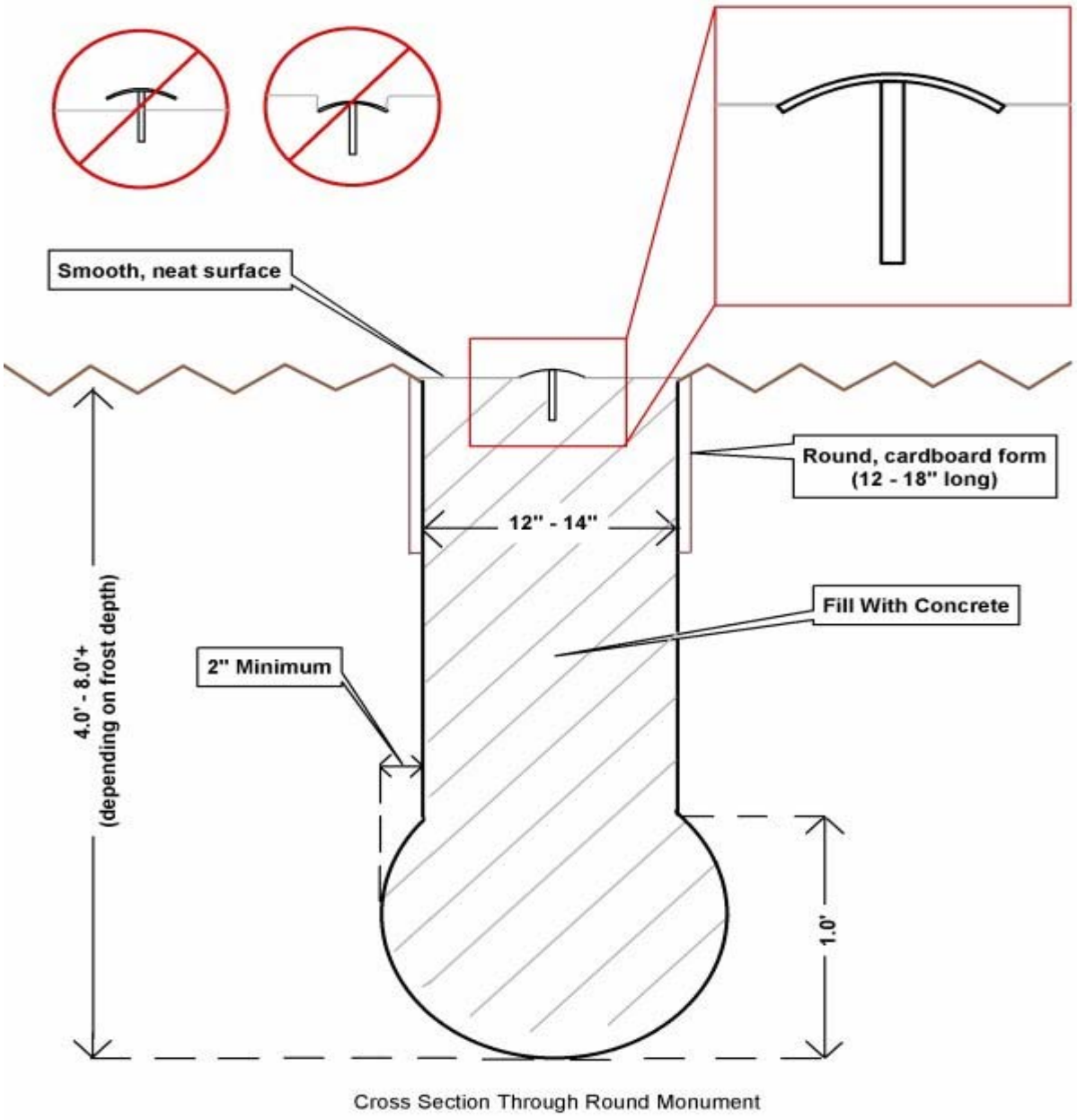
23. Remove excess concrete from the site. Proper planning should minimize excess concrete. Any excess shall not be dumped on-site.

24. Installation of NGS Witness Posts is at the option of the firm. Generally do not use Witness Posts in areas of high population density nor on airports. They are very useful to future surveyors in more remote areas and should be used in these areas. Also, if a mark is set on private property the contractor shall get permission before setting a witness post.

25. Do not add magnetic materials to the monument. (Note: A magnet or magnetic material may be placed on the North side of the monument in the dirt and noted in the description, with distance from the center of the disk to the magnet, so it can be removed for gravity observations. There is a ¾ inch diameter by 3 inch length magnet that can be purchased from several survey supply firms.

26. Concrete monuments shall be set at least 14 days before levels can be run on them.

Standard NGS Concrete Monument



Cross Section Through Round Monument

Version 2
January 26, 2005

ATTACHMENT D
SETTING A SURVEY DISK IN BEDROCK

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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ATTACHMENT D: SETTING A SURVEY DISK IN BEDROCK OR A STRUCTURE

From NOAA Manual NOS, NGS 1, *Geodetic Bench Marks*

1. GENERAL

Sound bedrock is the most desirable setting for geodetic survey control points. Besides the ease and cost effectiveness with which a disk can be installed in bedrock, it provides the most stable setting that can be used in terms of both underground activity and disturbances inflicted by people. Always use bedrock when a suitable outcrop exits. As a rule of thumb, the bedrock is considered potentially good if the distance between joints and fissures is greater than 1 meter. The National Geodetic Survey geodetic control disks are made of brass or bronze. They are about 9 centimeters in diameter and have a spherical surface to support the foot of a leveling rod and a center point for plumbing survey equipment. Information is imprinted on this surface to identify the monument and to aid the user in obtaining data on it. This logo is recessed so that it does not interfere with the leveling rod or other survey equipment. A deformed shank, about 7.5 centimeters long, is silver-soldered or otherwise attached to the bottom surface of the disk to help prevent the disk from being dislodged.

2. SETTING DISKS IN BEDROCK

2.1 STEPS:

The step-by-step procedure for setting the disk in bedrock utilizing cement is as follows:

1. Stamp the station designation and setting year on the top surface of the disk using 4.75 millimeter (3/16- inch) alpha-numeric steel dies.

2. Pick a fairly level and accessible spot on the outcrop that is intact with the bulk of the rock. A simple test can be performed to help determine the condition and integrity of the rock by placing ones hand in the area that the disk will be set, then striking the outcrop with a moderately heavy hammer and feeling for vibration. Sound outcrop will force the hammer to rebound with each impact and vibration through the rock should be minimal at best.

3. Drill a 2.5 centimeter diameter hole about 10 centimeters into the bedrock and recess the area around the top of the hole to a diameter slightly larger than that of the disk. When the installation is completed, the top of the surface of the disk should sit level and slightly below the surface of the surrounding rock. Chisel a drain channel through the low edge of the drilled recess to allow water to drain from around the finished mark. *Caution*: Safety goggles should be worn when drilling into bedrock or masonry. Note: There are drill bits available that will drill the 10 centimeter hole and cut or drill the counter sink to place the disk in. This saves a lot of time and makes setting of the mark easier and look better.

4. Remove the rock powder from the hole and recessed area, flush and fill the hole with clean water, then pour pure cement into it. Mixing of the ingredients is done right in the hole. By adding more water and cement, make enough mortar so that an extra amount is available to place on the underside of the disk. When the mortar is completely mixed, it should be thick but still workable, like heavy mashed potatoes. Mix the pure cement in the hole and build up the center of the hole so when the stem of the disk is pushed into the hole the cement will spread evenly from the center of the hole and to the outside edge of the disk.

5. Clean the disk by wetting then rubbing all surfaces with cement to remove unwanted oils; rinse. Fill the depression on the underside of the disk with mortar using a trowel. Hold the disk loosely upside-down by the end of the shank then gently tap the domed surface of the disk from below with the handle of the trowel several times to allow the mortar to settle and trapped air to escape. This is very important because it will prevent the existence of highly undesirable voids under the disk once it is in place.

6. Place the shank (Do not cut the shank from the disk and try to cement on top of or just under the top portion of the concrete. If the hole is not deep enough drill it deeper.) of the disk into the drilled hole and press the mark firmly into place. A slight rotation of the disk back-and-forth and gentle tapping with the end of the trowel handle helps settle the disk completely and evenly into the drilled recess in the bedrock. The disk is considered set when the slight back-and-forth movement stops and the disk sets firmly in place. Work excess mortar around the outer edge of the disk, making sure that it is smooth and slightly overlapping the top outside edges of the disk for security. An exposed edge of the disk would provide an area which could be used by someone or the elements to dislodge it. Fresh mortar on the upper surface of the disk can be easily cleaned off and out of any stamping.

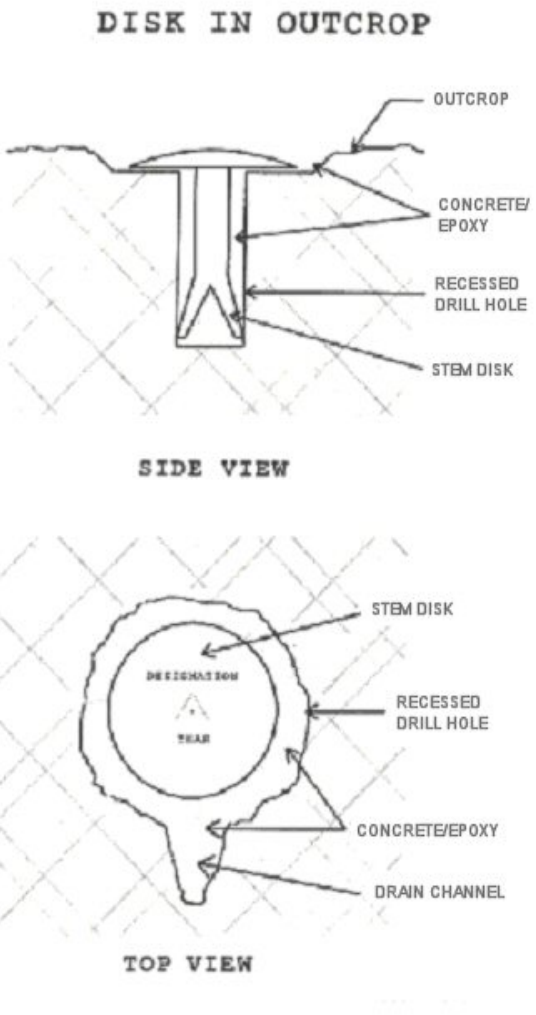
7. Sprinkle some dry cement on the exposed surface of the disk and then rub it with a clean rag or short bristled brush using circular strokes. This will clean the disk very nicely, removing all excess mortar from its surface and recessed letters. Rubbing the wet mortar around the edge of the disk in the same manner is done intentionally to finish its surface and help prevent cracking. Brush away loose cement and make sure that the finished product has a neat appearance.

8. While the mortar is still wet, it must be covered to prevent heavy rains or other foreign debris from ruining its surface and to conceal the disk from people who might tamper with it. A piece of wood, cardboard, heavy paper or similar biodegradable item will suffice.

9. The installation is complete when all accumulated trash has been picked up. Leave the site clean and in good order.

Highway grade epoxy may be used in place of cement if it meets ultraviolet standards and will hold up to all weather conditions. The setting procedures are similar to those described previously except that the drilled hole, though needing to be extremely clean, cannot be wet.

ANNEX 1: DISK IN OUTCROP
DIAGRAM



Version 2
January 27, 2005

ATTACHMENT E
SETTING AN NGS 3D MONUMENT

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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ATTACHMENT E: SETTING AN NGS 3-D MONUMENT

Based on "Revised NGS 3-Dimensional (3-D) Rod Mark" [Draft Version] by:
Curtis L. Smith
National Geodetic Survey
July, 1996

1. DISCLAIMER

This document is intended only for the purpose of providing the user with guidelines for planning and implementation of this style of survey monument. The distribution of this document or the mention of a commercial company or product contained herein does not constitute, in any way, an endorsement by the National Geodetic Survey (NGS).

2. INTRODUCTION

The extensive use and accuracies achieved by the Global Positioning System (GPS) for geodetic surveying applications have highlighted the need for increased stability in survey control point monumentation. Repeatability of accurate positions obtained through GPS require that geodetic monuments reflect this accuracy with properties of permanence and stability both horizontally and vertically.

Factors affecting the stability of survey monuments include frost heave action, changes in ground water levels and local settlement. Consult soil and geotechnical specialists about local ground conditions. Manuals, such as NOAA Manual NOS NGS 1, “Geodetic Bench Marks”, document soil types and frost penetration zones nationwide.

The recommended survey marker that produces stability for most conditions is the three-dimensional (3-D) drivable survey monument. The principal component of this monument is a 9/16-inch stainless steel rod driven into the ground, utilizing a gasoline or an electrical powered reciprocating hammer approved by the NGS COR or POC, until refusal or a reduced driving rate has been achieved (60 seconds per foot driving rate equals substantial resistances). The rounded top of the rod is the survey datum point. The upper 1 meter of the rod is encased in a 1-inch greased filled plastic extruded fin sleeve that is held horizontally stable by back-filled, washed sand. Effects of up and down ground movement during freeze/thaw (if applicable) or wet/dry conditions are removed from the anchored rod by the grease filled sleeve promoting vertical stability. A 5 or 6-inch PVC pipe with attached standard aluminum logo cap protects and identifies the top of the monument. (See documentation in this manual for specific mark setting procedures).

3. REFERENCES

NOAA Manual NOS NGS 1. Geodetic Bench Marks, by Floyd, Richard P., September 1978. Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, by Federal Geodetic Control Committee, August 1989.

4. REQUIREMENTS

4.1 RECOMMENDED EQUIPMENT FOR SETTING MONUMENTS

A. Rod Drivers and Accessories:
1- Any driver with a minimum impact force of 25 foot pounds per blow, such as Wacker Model BHB 25 (with tool kit) or Pionjar Model 120 (with tool kit) or the Electric Bosch Brute Model 11304 with 1400 blows per minute, 43 foot pounds per blow at a weight of 64 pounds (with tool kit), for driving stainless steel rods.
1- Rod Driving Insert, holds machine on rod and acts as impact point while driving rods.
1- Shovel Bit, for machine to help start and dig holes, not required but may be helpful.
1- Pint, Required Oil Type and Calibrated Container, for determining gas/oil mix.
1- Gas Containers and Gasoline, for driving machine and generator.
1- Gas Powered Generator for the Electric Driver

B. Digging the Hole:
1- Post Hole Digger, capable of digging a hole 4-feet deep.
1- Gas Powered post Hole Digger with Augurs, not required but increases productivity.
1- Digging Bar, for rocks and hard to dig holes.

C. Driving the Rod:
1- 2 lb. Hammer, to start rods, stamp designations, etc.
2- 8" Quality Pipe Wrenches (i.e. Rigid), for attaching lengths of stainless steel rods.
1- Bottle, Loctite, for cementing threads into the stainless steel rods.

D. Finishing the Rod:
1- Hack Saw with extra Quality Blades, for cutting stainless steel rod.
1- 4" or 5" Grinder (electric or battery powered), for finishing top of rod.
1- Gas Powered Electric Generator, to power grinder and/or drill.
2- Sanding Disks (medium grade), for grinder.
1- Steel File(s), for fine finishing top of rod.
1- Centering Sleeve, to help center punch mark on top of rod.
1- Center Punch, to punch plumbing point on top center of rod.
Assorted Sand Paper or Sanding Pad, for fine finish to top of rod.

E. Finishing the Monument:
1- 1/4-inch Stamping Set, for lettering and numbering station designation/date.
1- Hand Saw, for cutting 5 or 6-inch PVC pipe.
1-Bucket or Wheel Barrel, to mix cement/move unwanted dirt.
2- 5 Gallon Water containers and Water, to mix cement and clean equipment.
1- Hoe, to mix cement, can be replaced by “Sharp Shooter Shovel”.
1- Heavy Rubber Mallet, to help lower logo cap/5-inch PVC into cement.
1- Cement Finishing Trowel, to smooth top of concrete for neat appearance.
1- Stiff Vegetable Type Brush, to clean logo cap and hinges.
F. Assorted Accessories:

1- Tool Box with regular assortment of tools, for incidental repairs: slotted and Phillips Head Screw-Drivers, Pliers, Needle Nose Pliers, Wire Cutters, Assorted Wrenches, Sockets, Allen Wrenches, Wire Brush.
1- Round Nose Shovel, to help dig hole and move unwanted dirt.
1- Tile Spade ("Sharp Shooter Shovel"), to help dig hole and mix cement.
1- Roll Black Tar Paper (Felt Paper), for making a round form for top of monument.
1- 30 Meter Tape Measure, for distances in station description.
Leather or Cotton Gloves, Assorted Rags or Paper Towels.

4.2 MATERIALS REQUIRED FOR EACH MARK

Lengths of 9/16-inch Stainless Steel Rods, 4-foot sections.
1- 4 to 5-inch piece of Stainless Steel Rod, used as impact point and protection while driving rods. Stainless steel studs threaded to couple the stainless steel rods together.

Adequate supply of 3/8-inch Threaded Stainless Steel Studs.
1- Steel Spiral (fluted) Rod Entry Point, standard order.
1- Aluminum Logo Cap, standard order.
1- Schedule 40 PVC Pipe, 5 or 6-inch diameter, 24-inch length.
1- Plastic Extruded Fin sleeve, 1-inch diameter, 3-feet minimum length.
2- Plastic end Cap Alignment Bushings, center drilled to 9/16-inch (for extruded fin sleeve).
1- Pint, PVC cement, can be replaced with adequate Epoxy type.
1- Pint, PVC Cleaning Solvent, when using PVC cement.
1- 17 ounce tube, Non-Toxic, Food Grade Grease, with Applicator (i.e. grease gun).
Ready Mix Concrete (Amount depends on width and depth of hole).
2- Pounds, Portland Cement, added to enhance integrity of ready mix concrete if necessary.
0.5- Cubic feet, Washed Sand, fills bottom of hole and inside of PVC pipe around grease sleeve.

4.3 SETTING PROCEDURES

1. Ensure the monument site selection has been discussed with airport management and/or property owners, and the location meets all station siting requirements. Inquire about future construction which may affect mark longevity.

2. Contact "MISS UTILITY" type services to inquire about underground utilities before digging or driving a rod.

3. The time required to set an average mark using the following procedures and referencing the diagram on the following page is 2 to 3 hours. Several steps, such as steps 4, 5, and 7, can and should be accomplished at a maintenance shop.

4. Stamp station designation and year of establishment into the blank area on the collar of the logo cap.

5. Cut a 20-inch section of 5 or 6-inch PVC pipe. Ensure the end that will receive the logo cap is cut true and is clean. Using primer and solvent cement formulated specifically for PVC, glue the stamped aluminum logo cap to the end of the 20-inch PVC section. If this step is performed on site, allow time for the glue to set by digging the hole and driving the rod after preparing the PVC and logo cap.

6. Using a power auger or post hole digger, drill or dig a round hole in the ground 12 to 14-inches in diameter, and 22 inches deep. Extend the center of the bottom of the hole by drilling or digging a 3 to 6-inch diameter hole an additional 21 inches for a total depth of 43 inches. This extended area will be back-filled with washed sand around grease sleeve.

7. Glue both plastic end cap alignment bushings on a 3-foot section of the plastic extruded fin sleeve. Let glued ends dry completely. Pump food grade grease into capped sleeve until 3/4 full allowing for displacement by rod and completing the grease filled sleeve.

8. Using a standard 3/8-inch threaded stud coated with Loctite (Use Loctite on all *permanent* connections). Attach two 4-foot sections of stainless steel rods together. At one end of the length of rod, attach a standard spiral (fluted) rod entry point with a 3/8-inch threaded stud. On the opposite end, attach a short 4 to 5-inch piece of rod with a 3/8-inch threaded stud. Tighten all connections using two pipe wrenches a good 1/4 to 3/4 turn past the point of contact of all rod ends except the impact point which will be continually removed. This tightening requires a certain "feel" and ensures that the rod ends are seated together with greatest possible tension yet not to the point of breaking a stud. Rods tightened in this fashion should not vibrate loose when they are driven into the ground.

9. The 8-foot long connected rod is centered into the bottom of the hole and driven with a 2-pound hammer until rod is secure and as plumb as possible. A 2x4 with a 1/2" hole can be centered and braced over the hole to help guide the rod straight into the ground. Drive the section of rod to about the top of the hole with a gas powered or electric reciprocating driver such as Whacker model BHB 25, Pionjar model 120, Bosch Brute Model 11304, or another machine with an equivalent driving force.

10. Remove the short piece of rod (impact point) leaving the threaded stud section of the rod in the ground. Attach another 4-foot section of rod and, using a new threaded stud, thread on the impact point. This “cycling” of a new stud from impact point into the top of the rods in the ground insures unweakened studs at all connections. Remember to coat threads on the permanent connections with Loctite. Tighten securely utilizing pipe wrenches as described above in step 9. Always tighten rods maintaining a clockwise pressure to avoid loosening rods already in the ground. Drive the new length of rod into the ground with the reciprocating driver.

11. Repeat step 10 until the rod refuses to drive further (anchored), or until a driving rate of 60 seconds per foot is achieved. In the event that the rod will not sufficiently slow down to meet desired driving rate, terminate upon reaching 90 feet (22.5 rods). This will leave about 2 feet of

rod out of the hole. If possible, let the rod set overnight, then drive the remaining 2 feet of rod to determine whether driving rate has reduced. If rod feels secure in ground, use this depth even though minimum driving rate of 60 seconds per foot has not been met. If the rod turns freely in clockwise direction, contact NGS for a decision to drive additional rods. Sometimes, all that is necessary to achieve a well anchored rod is driving it a few more feet. In other instances an additional hundred feet may be required. Indicate in the written station description the depth of rod, and whether it was driven to refusal or met the slow driving rate. Also include a description of any unusual mark setting circumstances.

12. When refusal or prescribed driving rate is reached, cut off the rod with a hacksaw or comparable tool, always removing at least the tapped and threaded portion, leaving the top of rod about 3 inches below ground surface. Shape the top of the rod to a smooth, hemispherical surface using a portable grinding machine using a grinding attachment or sanding wheels, files, and sand paper to produce a nicely finished, rounded surface.Ragged edges or grinding marks are not acceptable on top of the finished rod.

13. The datum point must then be created by center punching a dimple on top of the rod to provide a plumbing (centering) point. Place the centering sleeve over the top of the rounded rod to facilitate locating the exact center of the rod. Punch a substantial dimple 1/16-inch deep, into the top of the rod using a punch and hammer or spring loaded center punch. Several blows may be needed to create a sufficient dimple. Remember, this is the actual survey point, so don't hesitate to spend a few extra minutes to produce a professional, finished product.

14. Insert the grease filled sleeve, produced in step 7, over the rod with the unfilled portion at the top. Upper end of the sleeve will fill as rod displaces grease from the bottom. The datum point on top of the rod should protrude through top of the sleeve about 3-inches with sleeve extending to the bottom of the hole. Clean the residual grease off the exposed top of the rod.

15. Back-fill and pack with washed sand the bottom 23 or more inches of the hole around the outside of grease sleeve. This fills the bottom of the hole and helps stabilize the sleeve.

16. Place the 5 or 6-inch PVC pipe and logo cap over and around the grease sleeve and rod in the center of the hole. The bottom of the PVC pipe should extend into the top of the sand in the bottom of the hole. Leave the top of the logo cap and PVC pipe slightly higher than the top of the ground surface until the concrete is in place. Back-fill the center of the PVC pipe with washed sand around and to within 1-inch from the top of the grease filled sleeve. The rod should be centered in the PVC pipe.

17. Mix concrete in a bucket or wheel barrel to pasty, well moistened consistency like mashed potatoes. Add Portland cement, if necessary, in sufficient quantity (1 to 2 pounds) to enhance concrete mix or dry an over moistened mixture to maintain adequate consistency. A good indication of adequate consistency is that the mix neither runs nor falls off the shovel but sluggishly slides off and flattens upon hitting the ground. Pour concrete into the hole around the logo cap and PVC pipe casing filling to slightly below the ground surface. To avoid frost heaving of the PVC collar, a round form should be used to ensure the outside walls of the concrete are vertical, and do not produce a mushroom shaped wedge at the top of the mark. Open

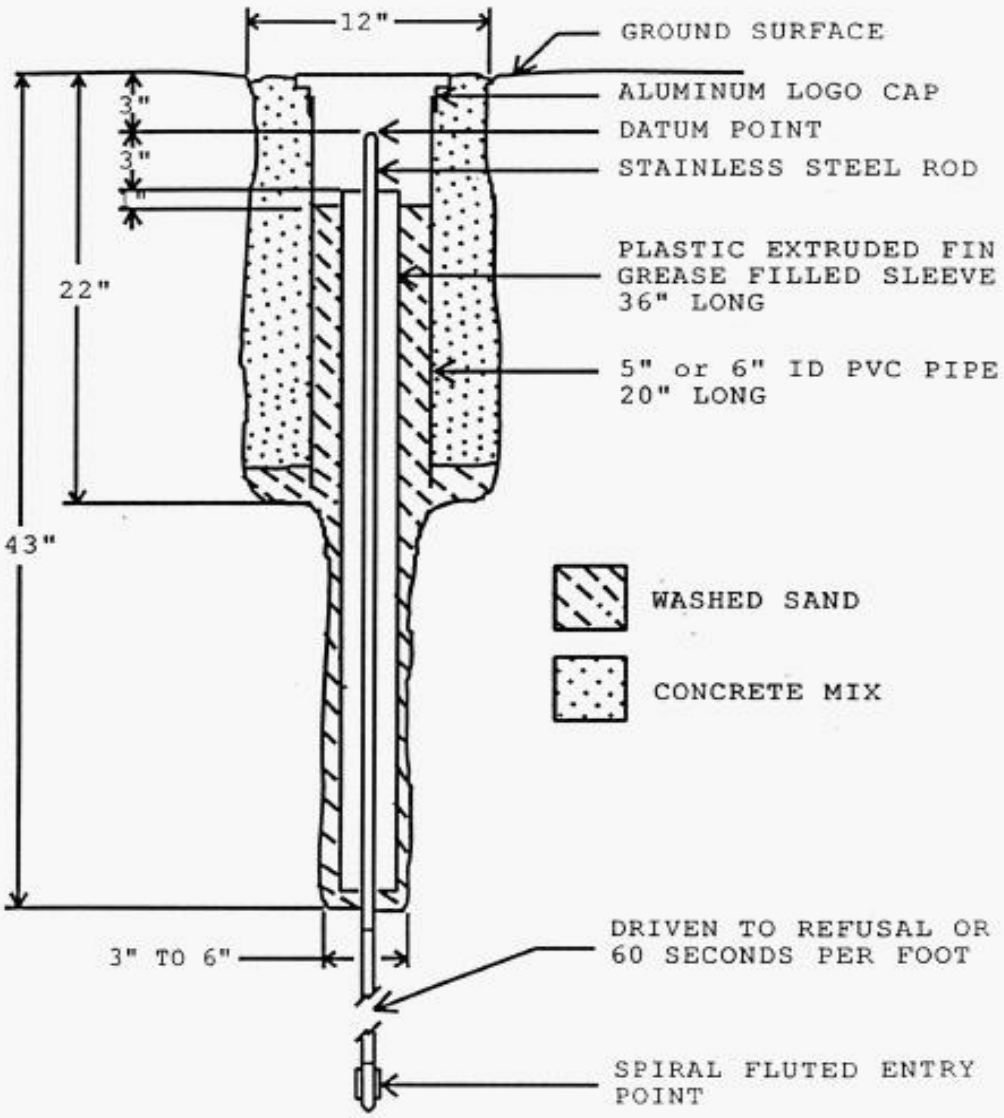
the logo cap and grasp the PVC pipe then shake to settle concrete around the pipe to fill voids. Add concrete to within 1/2-inch of the ground surface.

18. Trowel smooth the top of concrete to a fairly finished surface. Tap alternate edges of the logo cap, using a rubber mallet or hammer and wooden block, lowering it and the attached PVC pipe into the surface of the concrete. Finish the top of the concrete by troweling a smooth, finished surface, round in appearance, and sloped slightly outward to aid drainage of rain water.

19. Add sand to the inside of the PVC pipe to bring its level to within 1-inch of the top of the grease sleeve. Clean any overlapping concrete from the surface of the logo cap using the vegetable brush. The finished height of logo cap and access cover should be slightly lower than the surface of the ground. The logo cap should be approximately in the center of the top of the concrete. Datum point should be about 3-inches below the cover of the logo cap and centered in the 5 or 6-inch PVC pipe. The top of the grease filled sleeve should be about 3-inches below the datum point and the washed sand 1-inch below the top of the sleeve. Clean any cement that may have gotten onto the exposed rod or datum point.

20. Clean all equipment and remove all debris such as extra cement, excess dirt, and trash, leaving the area in the condition it was found.

ANNEX 1: DIAGRAM OF AN NGS 3-D ROD MARK



Schematic of the Revised NGS 3-D Rod Mark, Side View

5

Version 9
January 27, 2005

ATTACHMENT F
WRITING STATION DESCRIPTIONS AND RECOVERY NOTES WITH WDDPROC

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

TABLE OF CONTENTS

ATTACHMENT F: WRITING STATION DESCRIPTIONS AND RECOVERY NOTES WITH WDDPROC

Descriptions are one of the end products of surveying, along with the positions and the survey marks themselves. All three shall be of highest quality. The descriptions must be complete, accurate and in standardized format if the station is to be reliably and easily recovered for use in the future. Descriptions shall be in the standard NGS format of three paragraphs as described in Section 2 "Description Format."

1. GENERAL

1.1 DEFINITION OF DESCRIPTION VS. RECOVERY NOTE

A. A *description* details the location of a new survey mark, or one not previously in the NGS digital database.

B. A *recovery note* is an update and/or refinement to a description already in the NGS digital database, written upon a return visit to a survey mark.

1.2 LEVELS OF COMPLEXITY OF RECOVERY NOTES

A. No Changes - If an existing station's digital description is complete, accurate, and meets Blue Book requirements, the station may be recovered with a brief recovery note, such as "RECOVERED AS DESCRIBED."

B. Minor Changes - If minor changes or additions to the description are required, they may be added after the above phrase, such as "RECOVERED IN GOOD CONDITION WITH THE FOLLOWING CHANGES, EXCEPT A NEW WOODEN FENCE IS NOW 3 METERS NORTH OF THE STATION." See typical cases listed in Section 1.5 A.

C. Major Changes - Where major changes have occurred, major inaccuracies are found, or where required information is missing (in any portion of the description), a complete three-paragraph recovery note, with the same format as a new description, is required. If a measurement discrepancy is found, state that the new distance was verified, for example, by taping in both English units and metric units or by two separate measurements by two different people. See typical cases in Section 1.5 B.

1.3 SOFTWARE - Descriptions and Recovery notes must be properly encoded into a D-file by using NGS WDDPROC software. Please refer to the NGS Web site: http://www.ngs.noaa.gov/FGCS/BlueBook/, Annex P (Geodetic Control Descriptive Data), for information. Note: WDDPROC is used for both new Descriptions and for Recovery Notes.

1.4 CHECKING - Descriptions shall be written by one person and checked by another. Recovery notes should also be checked. For example, a mark setter can draft a description immediately after setting the mark, and an observer can check the description during observations. For existing marks, the reconnaissance person can draft the recovery note and the observer can check it. Descriptions and Recovery Notes should be written while at the station or immediately after visiting a station so that all details are fresh in the writer's mind.

1.5 TYPICAL RECOVERY NOTE CASES

A. A brief, one or two sentence Recovery Note is adequate:

i. When the mark is found and the description is completely accurate, sample: ("RECOVERED AS DESCRIBED"),
ii. When the mark is found and there are one or two minor changes, ("RECOVERED AS DESCRIBED EXCEPT A NEW WOODEN FENCE IS NOW 3 METERS NORTH OF THE STATION"),
iii. When the mark is not found, ("MARK NOT FOUND AFTER 3 PERSON-HOUR SEARCH"),
iv. When the mark is not found and presumed destroyed, (" MARK NOT FOUND AND PRESUMED DESTROYED. CONSTRUCTION FOREMAN STATES THAT THE MARK WAS DESTROYED YESTERDAY"),
v. When the mark is found destroyed, (" THE MARK IS DESTROYED AND THE DISK HAS BEEN SENT TO NGS"or "THE MARK IS DESTROYED AND ITS PHOTOGRAPH HAS BEEN SENT TO NGS"). Note, for a station to be considered destroyed by NGS, the disk or photograph showing the destroyed mark must be received by NGS.

B. A complete, new, three-paragraph Description/Recovery Note is required:

i. When a new mark is set,
ii. When an existing mark does not have a PID,
iii. When an existing mark does not have an NSRS digital description (i.e., description is not in the NGS database),
iv. When an existing mark has only a brief description not meeting the three-paragraph requirement (many bench marks have only short, one-paragraph descriptions),
v. When an existing mark's description is no longer accurate or complete.

2. DESCRIPTION FORMAT

The original USC&GS Special Publication No. 247, MANUAL OF GEODETIC TRIANGULATION, page 116, states, "A description must be clear, concise, and complete. It should enable one to go with certainty to the immediate vicinity of the mark, and by the measured distances to reference points and the description of the character of the mark, it should inform the searcher of the exact location of the mark and make its identification certain. It should include only essential details of a permanent character." NGS still follows these guidelines, so that a person with a minimal background in surveying and no local geographic or historical knowledge can easily find the mark by logically following the text of the description.

See also the NOAA Manual NOS NGS3 “Geodetic Leveling” for another section explaining the importance of descriptions.

2.1 FIRST PARAGRAPH - The **first paragraph** is the *description of locality.* This part of the description begins by referring to the airline distance and direction (cardinal or inter-cardinal point of the compass) from the **three** nearest well-known mapped geographic feature(s), usually the nearest cities or towns. Use three references equally spaced around the horizon, if possible. **In writing the Description, always progress from the farthest to the nearest reference point**. Distances in this part of the description shall be in kilometers (followed by miles), or meters (followed by feet), all distances to one decimal place. Detailed measurements which appear elsewhere in the description should not be repeated in this paragraph. Points of the compass should be fully spelled out. Do not use bearings or azimuths. State the name, address, and phone number of public sector property owners (however, phone numbers of private property owners are NOT included). State any advance notice and security access requirements for reaching the station. Also state any unusual transportation methods that may be required to reach the station.
Sample first paragraph:

> "STATION IS LOCATED ABOUT 12.9 KM (8.0 MILES) SOUTHWEST OF EASTON, ABOUT 6.4 KM (4.0 MILES) NORTHWEST OF CAMBRIDGE, AND ABOUT 3.6 KM (2.2 MILES) EAST OF SMITHVILLE ON PROPERTY OWNED BY MR. H.P. LAYTON, AND KNOWN AS OLD GOVERNOR JACKSONS ESTATE."

2.2 SECOND PARAGRAPH - The **second paragraph** contains the *directions **to reach** the station.* This section is one of the most useful parts of a description. It usually enables a stranger to go directly to a station without a delay due to a detailed study of maps or of making local inquiries. It is a route description which should start from a definite point, such as (a) the nearest intersection of named or numbered **main** highways (ideally Interstate and U.S. highways, or at least those which are shown on commonly used road maps), and approximately where that intersection is, or (b) some definite and well-known geographical feature (e.g. main post office or county courthouse) and give its name and general location. Odometer distances shall be given to tenths of kilometers (followed by tenths of miles). For roads with names and numbers, give both in the first occurrence.

A. The format for the first leg of the "To Reach" is:
   i. FROM THE MAIN POST OFFICE IN DOWNTOWN SMITHVILLE, or FROM THE INTERSECTION OF INTERSTATE XX AND STATE HIGHWAY YY, ABOUT 4.8 KM (3 MILES) NORTH OF SMITHVILLE;
   ii. GO A DIRECTION (north, northeast, northerly, northeasterly, etc.);
   iii. ON A ROAD (name or number of road or highway);
   iv. FOR A DISTANCE (km followed by miles in parentheses);
   v. TO SOMETHING (intersection, or fork in road, or T-road left or T-road right).

B. The format for all other legs:

i. TURN LEFT OR RIGHT, OR TAKE RIGHT OR LEFT FORK, OR CONTINUE STRAIGHT AHEAD;
ii.GO A DIRECTION (north, northeast, northerly, northeasterly, etc.),
iii. ON ROAD (name of road or highway);
iv. FOR A DISTANCE (km followed by miles in parentheses);
v. TO SOMETHING (intersection, or fork in road, or side-road left or right, or station on left or right).

All five parts of each leg shall be included in each "To Reach".

Sample:

"TO REACH THE STATION FROM THE INTERSECTION OF INTERSTATE 300 AND MAIN STREET (STATE HIGHWAY 101) IN JONESVILLE, GO EASTERLY ON HIGHWAY 101 FOR 3.7 KM (2.3 MILES) TO AN INTERSECTION. TURN RIGHT AND GO SOUTH ON MILLER ROAD FOR 5.1 KM (3.2 MILES) TO A SIDE-ROAD RIGHT. CONTINUE SOUTH ON MILLER ROAD FOR 6.6 KM (4.1 MILES) TO AN INTERSECTION. TURN LEFT AND GO EASTERLY ON SMITH ROAD FOR 2.4 KM (1.5 MILES) TO STATION ON THE LEFT IN THE FENCE LINE."

Use the word "EAST" if the road goes due east and "EASTERLY" if the road wanders in a general easterly direction. Use intermediate references, such as Miller Road above, if the distance becomes longer than about 5 miles. The place at the end of truck travel should be mentioned. If walking is required, note the approximate time required for packing. If travel to the station is by boat, the place of landing should be stated.

2.3 THIRD PARAGRAPH - The **third paragraph** provides *details of the mark and reference measurements*. It is made up of six parts:

(A) The station mark type;
(B) How the mark is stamped;
(C) How the mark is set;
(D) Reference measurements;
(E) The handheld GPS position; and
(F) PACS or SACS designation, if appropriate.

These sections are not numbered in the description, but shall be in the stated order with the stated information.

SECTION	EXAMPLE
(A) - State what the mark is:	THE MARK IS AN NGS HORIZONTAL DISK, OR A USC&GS TRIANGULATION DISK, OR A STAINLESS STEEL ROD, OR A CHISELED "X", ETC.),
(B) - State how the mark is stamped (in dashes):	STAMPED --JONES 1952--.

(C) - State how and in what the mark is set:	THE MARK IS SET IN A DRILL HOLE IN BEDROCK, OR SET IN A SQUARE CONCRETE MONUMENT, OR IS A ROD DRIVEN TO REFUSAL, ETC. A GREASE-FILLED SLEEVE ONE M LONG WAS INSTALLED.

The description shall specify whether the rod was driven to refusal or whether it met the slow driving rate (this is specified in Attachment V, Section 4.0 as 60 seconds per foot or 90 feet). Also state if a grease-filled sleeve was installed and its length. For a rod mark, the diameter of the stainless steel rod and the diameter of the PVC pipe with the aluminum cap should be in English units, and the length of the plastic sleeve should be given in metric units only.

- State if the mark projects above the ground, is flush, or is recessed and the amount, (for a rod mark state the above for both the rod and the logo cap):	MARK PROJECTS 15 CM (5 IN), OR MARK IS FLUSH WITH THE GROUND, OR MARK IS RECESSED 20 CM (8 IN); OR LOGO CAP IS FLUSH WITH THE GROUND AND TOP OF ROD IS 10 CM (3.9 IN) BELOW THE TOP OF THE LOGO CAP,
- State the depth of the mark, if known:	CONCRETE MONUMENT, 1.2 M (4 FT) DEEP, OR, ROD DRIVEN TO REFUSAL AT 15 M (49 FT)
(D) - State reference distances and directions from three or more permanent objects in the mark's immediate vicinity (farthest to nearest)	IT IS 20.7 M (67.9 FT) SOUTHWEST OF POWER POLE #2345, 15.2 M (49.9 FT) WEST OF THE EDGE OF HIGHWAY 134, AND 3.4 M (11.1 FT) NORTH OF A FENCE LINE. (If a rod mark note that "ACCESS TO THE MARK IS HAD THROUGH THE ACCESS COVER AND TOP OF ROD IS THE MARK NOT THE ACCESS COVER")

Examples of objects used as references: existing reference marks, witness posts, center lines of roads, edges of runways, ditches, power or telephone poles, or buildings. Start with the farthest distance. Horizontal distances should be used. If slope distances were measured, that fact should be stated in the paragraph. The distances shall be in meters (followed by English measurement units in parentheses, except as noted in (C) above), and the directions shall be cardinal and inter-cardinal directions, fully spelled out, such as "NORTH", "NORTHEAST", or "NORTH-NORTHEAST". Magnetic bearings from the reference objects are recommended to assist in future recoveries.

(E) Provide a handheld GPS position for all new and recovered marks, and for all proposed mark locations. Include the handheld GPS position in both the scaled position field (in the top portion of the digital description) and in the text, described hereafter. In the text, include the position and

the accuracy code of X or W, depending on the type of receiver used. X stands for Hand-Held accuracy code 1 (differentially corrected, hand-held GPS), and W stands for Hand-Held accuracy code 2 (stand-alone, hand-held GPS), as follows:

Accuracy code 1 (X) = ± 1-3 meters
Accuracy code 2 (W) = ± 10 meters

GPS Data Formats:

CODE	LATITUDE	LONGITUDE	SECOND PLACES
X	NDDMMSS.ss	WDDDMMSS.ss	(2 places of seconds)
W	NDDMMSS.s	WDDDMMSS.s	(1 place of seconds)

Use "N" or "S" for latitude and "W" or "E" for longitude. Use three digits for the degrees of longitude.

(F) If the station is a Primary or Secondary Airport Control Station mark, the third paragraph shall end with the appropriate designation of Primary or Secondary Airport Control Station): THIS STATION IS DESIGNATED AS A PRIMARY AIRPORT CONTROL STATION.

Sample for a rod mark:

"THE STATION IS THE TOP-CENTER OF A 9/16 INCH STAINLESS STEEL ROD DRIVEN TO REFUSAL DEPTH OF 18M. THE LOGO CAP IS STAMPED --SMITH 2003--. THE LOGO CAP IS MOUNTED ON A 5 IN DIAMETER PVC PIPE. A ONE METER LONG GREASE-FILLED SLEEVE WAS INSTALLED. LOGO CAP IS FLUSH WITH THE GROUND AND TOP OF ROD IS 10 CM (3.9 IN) BELOW THE TOP OF THE LOGO CAP. THE MARK IS 32.4 METERS (101.74 FEET) NORTHEAST OF NORTHEAST CORNER OF THE HOUSE, 16.62 METERS (54.5 FEET) NORTH OF WATER PUMP ALONGSIDE OF HEDGE AROUND OLD FLOWER GARDEN, AND 4 METERS (12.96 FEET) NORTH OF NORTHEAST CORNER OF HIGH HEDGE ENCLOSING OLD FLOWER GARDEN. THE HH1 GPS IS: N304050.2, W1201020.4. NOTE: ACCESS TO THE DATUM POINT IS HAD THROUGH A5-INCH ACCESS COVER (LOGO CAP).

Sample for a concrete monument:

"THE STATION IS AN NGS HORIZONTAL DISK, STAMPED --JONES 2003-- SET IN A ROUND CONCRETE MONUMENT 1.2 M (4 FT) DEEP AND 0.3 M (12 IN) IN DIAMETER. IT IS SET FLUSH WITH THE GROUND. IT IS 32.4 METERS (101.74 FEET) NORTHEAST OF NORTHEAST CORNER OF THE HOUSE, 16.62 METERS (54.5 FEET) NORTH OF WATER PUMP ALONGSIDE OF HEDGE AROUND OLD FLOWER GARDEN, AND 4 METERS (12.96 FEET) NORTH OF NORTHEAST CORNER OF HIGH HEDGE ENCLOSING OLD FLOWER GARDEN. THE HH1 GPS IS: N304050.2, W1201020.4."

3. IMPORTANT POINTS REGARDING DESCRIPTIONS

3.1 NAMES - Use the station designation (name) and PID, exactly as listed in the NGS database, in all survey records. Do not add dates, agency acronyms, or other information to the name, nor the stamping. Note, frequently the stamping and the official station designation are not the same. For example, stampings include the year set, but designations generally do not.

3.2 TERMINOLOGY - Correct NGS survey terminology shall be used in all station descriptions and reports (see GEODETIC GLOSSARY, NGS, 1986).

3.3 DISTANCES - All measurements are assumed to be horizontal unless labeled “slope.” Distances measured from a line (e.g., the center-line of a road or a fence line) are assumed to be measured perpendicular to that line. The origin of measurements at the junction of two roads is assumed to be the intersection of center-lines of both roads. Measurements are assumed to be from the center of an object (i.e. power pole) unless stated otherwise.

3.4 REPAIR - Any work done to repair a mark shall be described completely in the updated recovery note. Note: a repair strengthens the mark but must not change its position. For example, adding concrete or epoxy around a disk where some is missing is a repair.

3.5 REFERENCE MARK NAMES - Note, reference marks are abbreviated “RM x” in descriptions, but on "Reference Mark" disks they are stamped "NO. X".

3.6 WCHKDESC - Run the digital D-file through the WCHKDESC program (field-level option), one of several programs within the WDDPROC Software Suite, to identify format and coding errors. This program is accessed by (a) running the WDDPROC program and (b) selecting the option, WCHKDESC, from the main menu.

3.7 METRIC CONVERSION – Use 3937/1200 (3.2808333333 feet) equals one meter.

3.8 ABBREVIATIONS - Meter = M, kilometer = KM, centimeter = CM, mile = MI, nautical mile = NM, feet = FT, inch = IN.

4. THE WDESC PROGRAM

4.1 GENERAL - The WDESC program, one of several programs within the WDDPROC Software Suite (available over the Web at http://www.ngs.noaa.gov/PC_PROD/DDPROC4.XX/ddproc.index.html), is used to encode descriptions and recovery notes in D-FILE format for the loading of these descriptions into the NGS database. The NGS Blue Book and the WDESC documentation contain information for properly encoding descriptions. Helpful information is contained in the following paragraphs.

4.2 BACKUP FILE - When creating a description file, a backup file is automatically created. Every time a few descriptions are entered, it would be best if they are checked with WCHKDESC and the file corrected. The backup should be renamed **before** reopening the program or it will be overwritten. Always exit from the WDESC program from the pull-down File, option Exit or from

the X at the NE corner of the window frame, never use the save option. It is recommended to save the description file as a new filename every time the program is exited; saving after each description is entered is also recommended.

4.3 GPS OBSERVATIONS - Remember to enter "Y" into the satellite usage code field in the *Header Record* if the mark is suitable for GPS observations.

4.4 SETTING CONDITION CODES - Set the *condition code* on the *Description Header* form as described in **The Description Processing Handbook, Chapter 1, D-FILE Format (for Both Microsoft Windows 95/98/NT and UNIX): The Format of a Description File (D-FILE)**, which is available on the Web by downloading dformat.htm from Section 4 of the WDDPROC page **(**http://www.ngs.noaa.gov/PC_PROD/DDPROC4.XX/ddproc.index.html).

4.5 SPACING - Three separate paragraphs are required in the descriptive text field since they make the description much easier to read. Therefore, when entering the text into the *Description Header* form using the WDESC program, separate each paragraph by pressing the [ENTER] key on the keyboard to add a blank line at the end of the first paragraph.

4.6 FLUSH, PROJECTED, RECESSED - The FPR code is a field on the *Description Header* form in the WDESC program. Set the "FPR" field in the Description Header form to "F", "P", or "R", for Flush, Projected, or Recessed, respectively. In the description, include the logo cap relationship to the ground surface (projecting above, flush with, or recessed below), and include the distance that the top of the rod is below the top of the logo cap. It is important to include information regarding the exact placement of the logo cap for future reference.

4.7 AGENCY CODES - A list of the proper agency codes for the WDDPROC Software Suite can be found on the NGS Web site in WDDPROC ANNEX C (http://www.ngs.noaa.gov/FGCS/BlueBook/annexc/annexc.index.html). The agency code to be used for marks that are set by the National Geodetic Survey is NGS. The agency code for marks set by the USC&GS is CGS. Contractors shall use the code assigned to their company. If a contractor does not have a code, a request for one should be emailed to: Burt.Smith@noaa.gov.

5. MARK TYPES

5.1 CONCRETE MARK - For a concrete mark set in accordance with the requirements of Attachment T, use a **setting code** of "07". This classifies the station with a default **vertical stability code** of "C".

5.2 ROD MARK GREATER THAN 4 METERS - For an NGS 3-D stainless steel rod mark driven to a depth of 4 meters or GREATER, use a **monumentation code** of "F" and a *setting code* of "59". This classifies the station with a default **vertical stability code** of "A". Note, if the standard one meter plastic sleeve is not used, the vertical stability code must be downgraded to "B".

5.3 ROD MARKS LESS THAN 4 METERS - **ARE GENERALLY NOT ACCEPTABLE**, see "Geodetic Bench Marks", page 27, Table 3. There are times a rod mark may be driven only 3

meters or less and hits rock. After driving the rod for several minutes with no change, the contractor may set the mark as a B monument. Also, if the rod is driven down 1, 2, or 3 meters and stops, the contractor can dig down to the rock, test it, and then drill a 1 meter hole into the rock. If the rock is broken through continue driving the rod. If the rock is not broken through pour water and pure cement in the hole you drilled, and then pound the rod into the hole until the rock is again reached. At this point take the driver and pound further on the rod locking into the rock. Pour cement in the hole and use a small stick or other item to get the cement to the bottom and fill the hole up around the rod. At this point finish the top of the rod mark as described in Attachment E. This mark can be classified as an A monument due to it being imbedded in bedrock, the same as a disk in a rock outcrop. Use the code for a deep rod mark, but note in the body of the description as to how the mark was set.

5.4 DISK IN ROCK OUTCROP - For a disk that is set in solid rock outcrop, and can be verified to be in bedrock and not a buried boulder, will be classified with a vertical stability of "A".

Check the listing of valid **monumentation codes** and **setting codes** in **The Description Processing Handbook, Chapter 1, D-FILE Format (for Both Microsoft Windows 95/98/NT and UNIX): The Format of a Description File (D-FILE),** which is available on the Web in Annex P of the blue book (http://www.ngs.noaa.gov/FGCS/BlueBook/), for the proper codes to use for other types of marks.

Again, refer to the complete directions available at the Web site for using the NGS software package WDDPROC to write the required station descriptions, and be sure to check your final product with WCHKDESC.

Version 13B
July 27, 2005

ATTACHMENT G
REQUIREMENTS FOR DIGITAL PHOTOGRAPHS OF SURVEY CONTROL

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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ATTACHMENT G - REQUIREMENTS FOR DIGITAL PHOTOGRAPHS OF SURVEY CONTROL

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1. PURPOSE - This document describes digital photographic standards for images of survey marks that will be stored in the National Geodetic Survey (NGS) database and for other reconnaissance photographs (including photo ground control). Since many of these images will be in the NGS database and available to the public, the subject matter (survey equipment, personnel, background, etc.) must be in good taste and professional in nature.

Digital photographs are useful for station (mark) reconnaissance, mark recovery, mark stability assessment, quality control, and as an aid during data processing and data verification. Some projects may require digital photographs during several stages of the project. Generally three photographs per station will be stored in the NGS database, which will make them accessible to future users. The table below summarizes the required photographs. Detailed descriptions of the photographs follow.

2. SURVEY MARK PHOTOGRAPHS - This section states the requirements for digital photographs of new and existing survey marks. For the requirements for reconnaissance photographs, including photo control points, runways, etc., see Section 3.

Take all photographs during daylight hours.

2.1. NUMBER OF SURVEY MARK PHOTOGRAPHS - At least three digital photographs are required for each mark recovered or described. This means marks for which a written, NGS format, digital description or recovery note was prepared. The three photographs are described as numbers: (1) extreme close-up, (2) eye-level (5-6 feet distant), and (3) horizontal view (approx. 10-30 feet distant). All three photographs require a digital caption and the correct file name. Photographs 2 and 3 require a **small, temporary sign** in the photograph. Use a small sign with large, clear letters (e.g. white board with dark marker). Ensure that the sign does not cover any portion of the mark, the monument, or any important feature.

REQUIRED PHOTOGRAPHS

All Marks Recovered and/or Described
1. Close-up (Taken Vertically; so stamping is legible)
2. Eye level (Taken Vertically; shows mark and area)
3. Horizontal view(s), mark in foreground, feature(s) in background

Take sufficient photographs to describe the stamping, appearance, condition, and location of the mark and points of potential interest including visibility obstructions, roads, runways, taxiways, or other dangers, any special set-up requirements, etc. Alter the orientation of the photographs as necessary to include this information in as few photographs as possible (For example, for a tall

obstruction, rotate the camera 90 degrees so that the long axis of the image is vertical). Capture the tops of nearby obstructions, if possible. If a station already has acceptable photographs in the NGS database, additional photographs are not required, unless changes have occurred or more than one year has passed. An "acceptable photograph" is defined as an image that meets the requirements of this document, is of good visual quality, and that no changes have taken place that a new photograph would help clarify.

2.2. CAPTION - The photographer shall write a caption for each photograph and add the caption to the image. The block containing the caption shall not cover any portion of the mark, the monument, or any important feature. The caption should contain the following comma-separated information:

- Station designation (name),
- Station Permanent IDentifier (PID), for existing stations in the NGS database, leave blank if new station,
- Airport Location IDentifier (LID), if on airport, leave blank if not on airport,
- Photo number with cardinal direction (N, NE, E, SE, etc) that the camera is pointing, note, only photo #3 has a direction
- Station type (PACS, SACS, FBN, CBN), otherwise leave blank
- Date photo was taken (yyyymmdd).

SAMPLE CAPTION FOR NEW MARK

JONES, 2, 20040825

SAMPLE CAPTION FOR PHOTO CONTROL POINT

PH1,2,20040825

SAMPLE CAPTION FOR EXISTING PACS ON AIRPORT

SMITH, AB1234, LAX, 3N, PACS, 20040825

Note, the cardinal direction should not be included on photographs 1 and 2 since they were taken vertically. Do not leave blank spaces for missing data, see JONES example above with no PID, no LID, no station type, and no extra "commas".

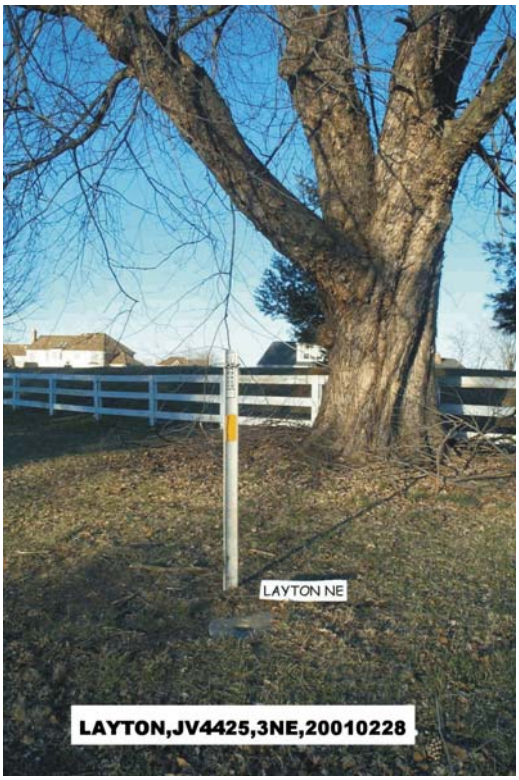
The caption may be digitally captured on the image at the time of exposure or may be inserted later, off-line. Record at least the date on-line, if possible. If caption information is added later, take careful notes at the time of exposure to help ensure that the correct caption is added. **Note, the caption shall not obstruct any pertinent aspects of the station or surroundings.** To ensure that the letters of the caption are visible, use software to "erase" a rectangular area for the caption's lettering; see samples in section 2.3 and Attachment Q.

2.3. DESCRIPTION OF PHOTOGRAPHS:

A. CLOSE-UP - For survey marks, the first photograph (photo no.1) will be a close-up, taken vertically. It will be oriented downward to show the survey mark from directly above with the disk or logo cap nearly filling the image. The tripod shall not be in place when this photograph is captured. Brush any dirt or debris off the mark to show the disk. If it has a logo cap, the logo cap should be open. The intent of this photograph is to **clearly show the mark, its condition, and all stamping on the mark or logo cap so that it is clearly legible**. Use extra care to ensure that the stamping is clear. Suggestions: set the camera to its highest quality and resolution modes; **rub a yellow crayon across the stamping to highlight the letters;** set the camera to "macro" mode, if available; consider the minium focusing distance of the camera (take test photographs to determine the minimum focusing distance and consult the camera owner's manual) ; and, if a flash is used, hold the camera above and off to the side so that the flash does not create a bright spot in the middle of the disk's image. Note, medium quality and resolution camera modes may be used for photographs other than the close-ups. If additional photographs are required, number these close-ups as 1A, 1B, etc.

B. EYE-LEVEL - For survey marks, this photograph (photo no.2) will be oriented vertically downward from eye level to show the monument from directly above and cover an area about 1 meter in radius, all around the mark. The tripod shall not be in place when this photograph is captured. Brush any dirt or debris off the mark to show the disk and the setting. If it is a concrete monument, clear off debris to the edge of the monument. If it has a logo cap, the logo cap should be open. **Include a small, temporary sign in this photograph with the station designation (name) printed so it is clearly visible in the photograph.** The intent of this photograph is to show the general condition of the mark and the immediate surrounding area. If additional photographs are required, number these eye-level photos as 2A, 2B...

C. HORIZONTAL VIEW(S) - For survey marks, take at least one additional, daylight photograph oriented near horizontal, and show the mark, with tripod and antenna (if possible), in the foreground, and the mark's identifying surroundings and any significant obstructions or possible sources of multi-path in the background. Show the top of nearby obstructions, if possible. Consider rotating the camera 90 degrees to use the long axis of the image to capture an entire obstruction. **Place a temporary sign in this photograph with the station designation (name) and the direction the camera is pointing, both printed so they are clearly visible in the photograph.** If additional photographs are taken, ideally move around the mark to locations which are 90 degrees apart (preferably cardinal directions). Name these photographs number 3XX, where the "XX" is the cardinal direction the camera is pointing, for example, 3N or 3NE.



3. RECONNAISSANCE PHOTOGRAPHS - Some, none, or all of the digital images described in this section may be required on a given project; refer to the Project Instructions. Each of these photographs requires a sign, a caption, and the correct file name. **The names for all of these files shall begin with "RE" to indicate reconnaissance.**

Required Item	Contents	Description
Sign in Photo	Name & Direction (unless vertical photo)	Place a sign in this photograph with the station designation (name) and the direction the camera is pointing, both printed so they are clearly visible in the photograph.
Digital Caption	Name, PID, LID, Number, Type, Date	See Section 2.2 above
Photo File Name	RE-Name-PID-Number-Date.jpg	See Section 4.4 below

All of the images required by this section shall be designated as reconnaissance (recon) with the letters "RE" at the beginning of their file names. Generally these recon images will not be loaded in the NGS data base but may be required for use during planning, review, etc. All reconnaissance photographs will have digital captions. These captions may be captured on the image or added later. Note, in these specifications, **"RE" stands for "REconnaissance"** and "R" stands for "Right" runway.

See the Project Instructions to determine which of the following are required:

3.1. PROPOSED LOCATIONS FOR MARKS - Take two photographs of each proposed permanent mark location. These may be one photo number 2 and one number 3, or two number 3 (3A and 3B), depending on which combination better shows the proposed mark location. Include a tripod, stake, sign, or other device showing the proposed mark location.

3.2. RUNWAY END PHOTOGRAPHS - Take at least three photographs at the end of each runway (including thresholds and stopways), as follows:

- Eye-Level (photo type #1) - photo from directly above the mark, showing about 1 meter in diameter,
- Approach (photo type #3) - photo showing tripod over mark in foreground and approach in background
- Across runway (photo type #3) - photo taken from the side of the runway looking across the end of the runway, with a tripod or arrow indicating the end point; include any features used to identify the runway end.

3.3. NAVIGATION AIDS (NAVAIDS) - Take photo(s) (type #3) of all NAVAIDS surveyed. Show the survey tripod in place to indicate the exact point surveyed, or if positioned remotely, add arrows and labels to the photograph indicating the horizontal and/or vertical point(s) surveyed.

3.4. DEPTH OF HOLE PHOTOGRAPHS - Take at least one photograph showing the hole dug or drilled for a concrete or rod mark. Place a measuring device (e.g., tape measure or level rod) in the hole, clearly showing the depth of the hole.

3.5. PHOTOGRAMMETRIC CONTROL POINTS (Paneled and photo identified) - **Take two number 3 type photographs** of all photogrammetric control points clearly showing the point. These photos will be used later as an aid in identifying the point on the aerial photographs. Show the mark in the foreground and the nearest identifiable feature in the background. The two photographs should be taken from two different directions, ideally 90 degrees apart (such as from the East and the South). It may be helpful to have the survey tripod in the photograph.

3.6. OTHER REQUIRED PHOTOGRAPHS - as may be required by other instructions.

4. GENERAL:

4.1. IMAGE SIZE - Each image should be about 800 by 1000 pixels when submitted.

4.2. FILE SIZE - Maximum file size for each image is 500 KB, typical file size should be about 50 - 100KB.

4.3. IMAGE FORMAT - Store the digital photographs in JPEG format, approximately 50% reduction.

4.4. PHOTOGRAPH FILE NAME - Use the following file naming convention: "RE" (for reconnaissance photographs only), dash, the station designator, dash, the PID, dash, the photo number (1, 1A, 2, 3N, or 3NE, etc.), dash, date, dot, jpg. For new marks, there is no PID. Use a maximum of 30 alpha-numeric characters to the left of the dot.

Sample File Names

For new stations:	SMITH-3-date.jpg
For existing stations:	JONES-AB1234-1-date.jpg
For recon/photo control photos:	RE-MILLER-3N-date.jpg
For runway end point:	RE-LAX_CL_END_RWY_12R-3-date.jpg

For the runway end point example, "RE" = reconnaissance, dash, LAX = LID, dash, "CL END RWY 12R" = runway end point designator (CL = centerline, END = end, RWY = runway, 12 = runway number, and R = right (or C = center, or L = left), dash, "3" = photo number, and date. Note, "_" (underscores) used to fill blanks. Note, in these specifications, "RE" stands for "reconnaissance" and "R" stands for "right" runway (used if there is a parallel set of runways). Also, the LID may be four characters rather than just three.

The format for the date is: "yyyymmdd", all numeric.

5. STORAGE MEDIUM - Submit all digital photos together on their own medium (CD), **not on the same medium with other types of data**. For airport work, submit all photos for a given airport in a subdirectory named for that airport.

*Acronyms:
PACS - Primary Airport Control Station
SACS - Secondary Airport Control Station
FBN - Federal Base Network
CORS - Continuously Operating Reference Station (Global Positioning System receiver)
CBN - Cooperative Base Network

ANNEX 1
INFORMATION SHEET FOR TAKING PHOTOGRAPHS OF SURVEY MARKS

EQUIPMENT REQUIRED:
CAMERA (WITH MEMORY CHIP, OR FILM FOR LATER SCANNING)
STIFF BRUSH TO CLEAN OFF MARK AND CLEAN LETTERING
SMALL SHOVEL OR SCRAPER TO CLEAN OFF MARK
YELLOW CONSTRUCTION CRAYON
WHITE BOARD WITH DARK MARKER
WEED WACKER (OR OTHER CUTTING DEVICE) TO CUT BACK GRASS AND WEEDS
COMPASS TO DETERMINE DIRECTIONS

PHOTO #1 - CLOSE-UP:
- SET CAMERA TO HIGH RESOLUTION,
- SET CAMERA TO MACRO MODE (IF AVAILABLE),
- DETERMINE MINIMUM FOCUS DISTANCE,
- SET CAPTION OR DATE INTO CAMERA, IF POSSIBLE,
- THOROUGHLY CLEAN OFF TOP OF MARK (INCL. LOGO CAP, CONCRETE, ETC.),
- THOROUGHLY CLEAN LETTERING (DISK OR LOGO CAP),
- CUT BACK GRASS AND WEEDS, AS REQUIRED,
- REMOVE SURVEY TRIPOD,
- OPEN LOGO CAP,
- RUB YELLOW CRAYON ACROSS STAMPING,
- ORIENT CAMERA VERTICALLY, AT APPROX. MINIMUM FOCUS DISTANCE,
- COMPOSE TO INCLUDE ENTIRE DISK, OR TOP OF ROD AND LOGO CAP STAMPING,
- EXPOSE PHOTOGRAPH IN MID-AM OR MID-PM, IF POSSIBLE, TO OBTAIN GOOD LIGHTING OF THE STAMPING
- NOTE, IF FLASH IS REQUIRED, MOVE CAMERA SLIGHTLY OFF CENTER TO MINIMIZE REFLECTION.

PHOTO #2 - EYE LEVEL
- SET CAMERA TO NORMAL RESOLUTION,
- SET CAMERA TO NORMAL MODE (NOT MACRO),
- SET CAPTION OR DATE INTO CAMERA (IF AVAILABLE),
- IF NOT ALREADY DONE, CLEAN OFF MARK AND STAMPING,
- CUT BACK GRASS AND WEEDS, AS REQUIRED,
- REMOVE SURVEY TRIPOD,
- WRITE STATION NAME ON SIGN AND PLACE NEAR (NOT ON) MARK,
- CLOSE LOGO CAP,
- ORIENT CAMERA VERTICALLY AT EYE LEVEL,
- COMPOSE WITH ENTIRE MONUMENT AND AREA AROUND MARK APPROX. 1 M. IN RADIUS,
- EXPOSE PHOTOGRAPH.

PHOTO #3 - HORIZONTAL VIEW(S)
- SET CAMERA TO NORMAL RESOLUTION,

- SET CAMERA TO NORMAL MODE (NOT MACRO),
- SET CAPTION OR DATE INTO CAMERA (IF AVAILABLE),
- IF NOT ALREADY DONE, CLEAN OFF MARK AND STAMPING,
- CUT BACK GRASS AND WEEDS, AS REQUIRED,
- SET-UP SURVEY TRIPOD OVER MARK,
- WRITE STATION NAME AND CAMERA DIRECTION ON SIGN AND PLACE NEAR MARK,
- CLOSE LOGO CAP,
- ORIENT CAMERA HORIZONTALLY AT EYE LEVEL,
- COMPOSE TO INCLUDE MARK, AND IDENTIFYING SURROUNDINGS, ANY OBSTRUCTIONS OR POSSIBLE SOURCES OF MULTI-PATH,
- EXPOSE PHOTOGRAPH.

Version 2
January 26, 2005

ATTACHMENT H
PROJECT SUBMISSION CHECKLIST

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

ATTACHMENT H

PROJECT SUBMISSION CHECKLIST - LEVELING PROJECTS

Project Title: _____
Accession Number: _____
Submitting Agency/Company:_____
Observing Agency/Company: _____
Level Type: _____

PACKAGE CONTENTS

Project Report and Attachments	**Required For**
( ) Project Report	All Projects
( ) Approved Reconnaissance and Project Sketch	All Projects
( ) Project Instructions or Contract Specifications	All Projects
( ) Final Station List	All Projects
( ) Loop Misclosures	Optional
( ) Free Adjustment with Analysis	All Projects
( ) Meteorological Instrument Comparison Logs	If Specified
( ) Photographs of Views from Stations	If Specified
( ) Photographs or Rubbings of Station Marks	All Projects

Digitized Data Files ( ) Diskettes ( ) Other:_____

( ) Raw Phase Data (R-files)	All Projects
( ) Descriptions or Recovery Notes (D-file)	All Projects
( ) Differential Leveling Observations (L-file)	If Applicable

LEVELING PROJECTS REQUIRE THE FOLLOWING TO BE SUBMITTED

HARD COPY OF:	**REQUIRED FOR**
( ) Project Report	All Projects
( ) Printed Station listing (.INX file)	All Projects
( ) Printed Abstract of the level run (.ABS)	All Projects
( ) Printed copy of the processed files (.BOK)	All Projects
( ) Printed copy of New-minus old tabulation	All Projects
( ) Required if any loops are closed	All Projects
( ) USGS 7.5 Quad Maps with all marks plotted	All Projects

CD CONTAINING THE FOLLOWING FILES

( ) Description file (.DSC)	All Projects

( ) Blue Book file (.BLU)	All Projects
( ) Binary File (.HGZ)	All Projects
( ) Abstract File (.ABS)	All Projects
( ) The processed blue book file (.BOK)	All Projects
( ) Photography's of all marks	All Projects
( ) A network adjustment	Optional at this time

TIDAL STATIONS IF LEVELED TOO

( ) SKETCH OF TIDAL STATION	All Projects

Comments - Enter on the reverse side of this form.

Org Code **Name** **Date**

Received by: _____

Reviewed by: _____

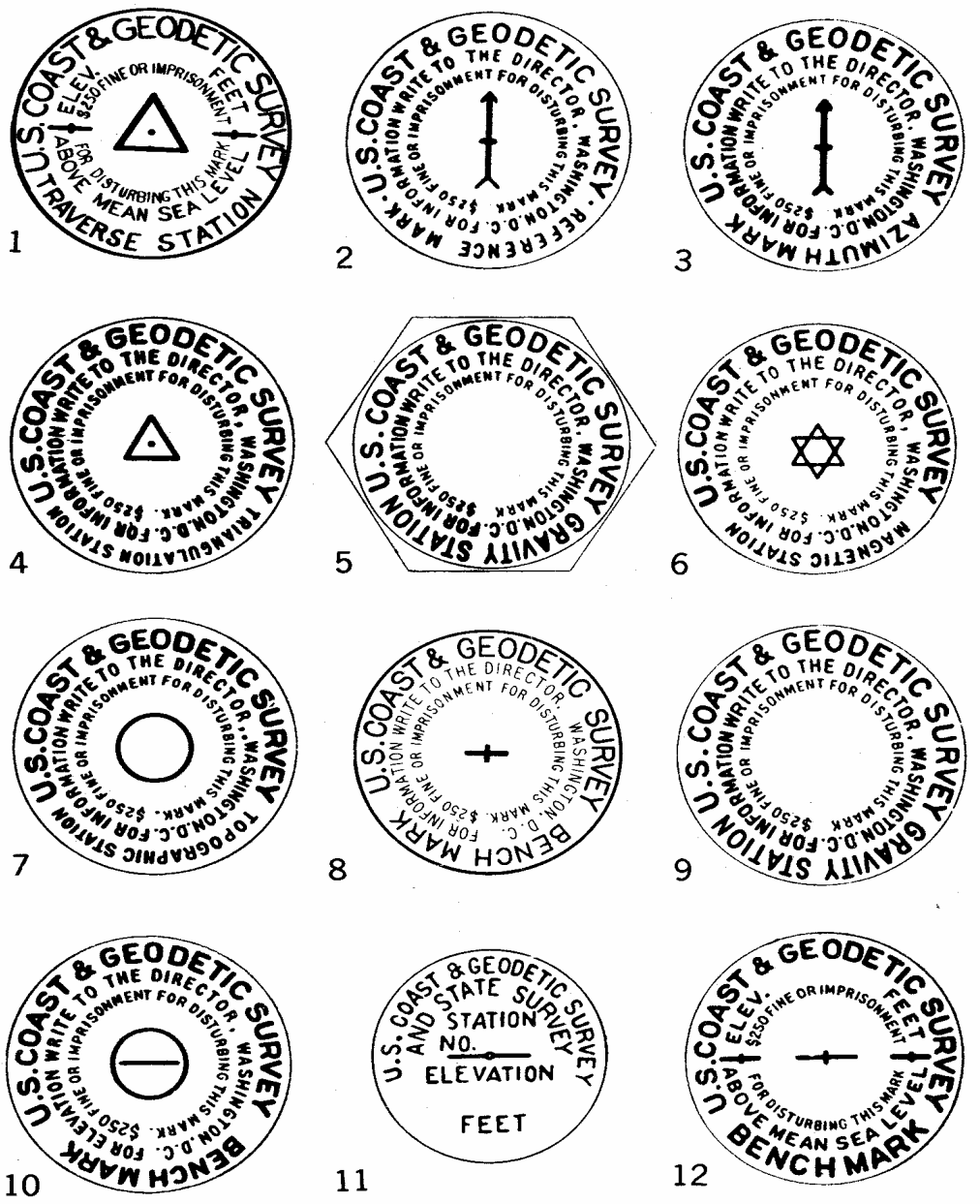
Reviewed by: _____

Version 1
September 30, 2004

ATTACHMENT I
SURVEY DISK DIAGRAMS

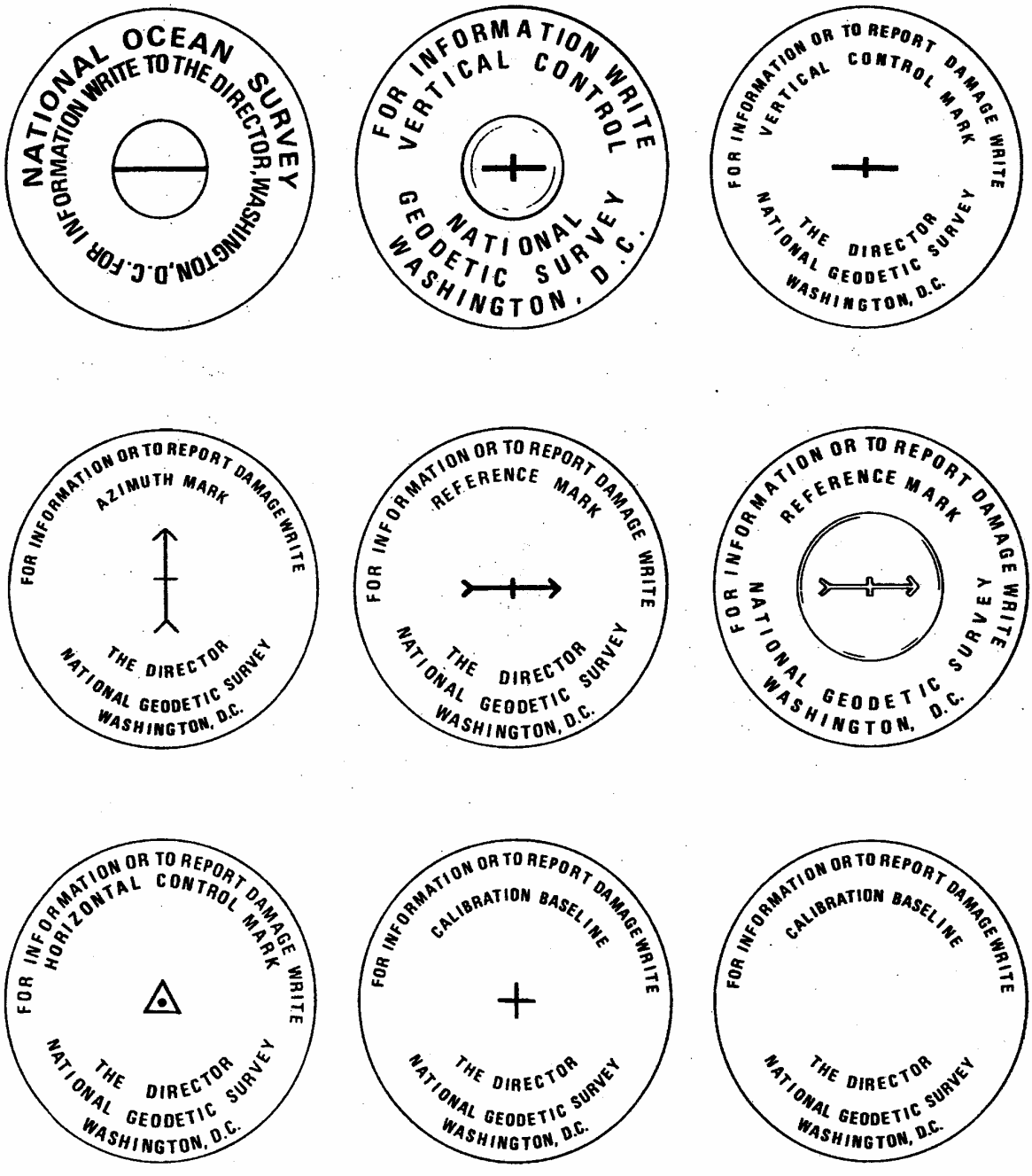
TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE



1. Traverse station mark.
2. Reference mark.
3. Azimuth mark.
4. Triangulation station mark.
5. Gravity station mark (old type).
6. Magnetic station mark.
7. Topographic station mark.
8. Geodetic bench mark (new type).
9. Gravity station mark (new type).
10. Tidal bench mark.
11. State Survey mark.
12. Geodetic bench mark (old type).

Standard marks of the U.S. Coast and Geodetic Survey



Standard marks of the National Ocean Survey/National Geodetic Survey

National Ocean Service
Tidal Bench Mark

National Ocean Service
General Usage Disk

National Geodetic Survey
New Geodetic Control Disk

Version 2
January 26, 2005

ATTACHMENT J
STATION SITE SELECTION GUIDE

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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ATTACHMENT J: STATION SELECTION GUIDELINES

1. SELECTION PRIORITIES

Station selection shall be based on the following priorities, which are given in the order of highest priority first. Within each priority category, preference should be given to selection of appropriate older stations having a known history of prior stability as indicated by previous observations.

1.1 STATIONS

A. Existing A- or B-order station, where possible,

B. Primary Airport Control Stations (PACS),

C. Existing National Spatial Reference System (NSRS) station with:
   i. 1st, 2nd, or 3rd-order elevation, and
   ii. 1st or 2nd-order horizontal,

D. Existing NSRS station with elevation, higher accuracy classification being preferred,

E. Existing NSRS station with first- or second-order horizontal coordinates, higher accuracy classification being preferred,

F. New station or existing station not in NSRS, suitable for GPS observations, set in bedrock,

G. New station or existing station not in NSRS, suitable for GPS observations, established by setting a 3D monument,

H. New stations or existing station not in NSRS, suitable for GPS observations, established by setting lesser stability mark, such as standard concrete mark.

2. STATION SPACING

Station spacing is project dependent. See project instructions.

3. MONUMENTATION AND STATION ENVIRONMENT

The following is a list of considerations for each station. The intent is to ensure that station monuments will be locally stable and remain usable indefinitely. Each of these considerations is important.

3.1 CONSIDERATIONS

A. Adequate GPS satellite visibility (unrestricted at 15 degrees and higher above the horizon). Minor obstructions may be acceptable, but must be depicted on the Visibility Obstruction Diagram.

B. Accessible by vehicle (two-wheel drive preferred),

C. Stability; bedrock mark being most preferred. (See Section 4.0 below.),

D. Permanency,

E. Ease of recovery,

F. Avoid known multi-path sources,

G. Appropriate geographic location and spacing,

H. Location allows efficient use by surveying community,

I. Accessible by public. (See Section 5.0 below.),

J. No known potential conflict with future development,

K. Open area for possible aerial-photo paneling,

L. Avoid electronic interference where possible.

4. STABILITY

Station monument stability is often difficult to assess in the field with limited resources. For existing NSRS station monumentation, the NGS database contains stability qualifiers which were assigned for the majority of marks when they were set.
Quality Codes are as follow:

4.1 QUALITY CODE A - most reliable; are expected to hold a precise elevation. Examples: rock outcrops; rock ledges; rock cuts; bedrock; massive structures with deep foundations; large structures with foundations on bedrock; or sleeved deep settings (10 ft or more) with galvanized steel pipe or galvanized steel, stainless steel, or aluminum rods.

4.2 QUALITY CODE B - will probably hold a precise elevation. Examples: unsleeved deep settings (10 ft or more) with galvanized steel pipe or galvanized steel, stainless steel, or aluminum rods; massive structures other than those listed under Quality Code A; massive retaining walls; abutments and piers of large bridges or tunnels; unspecified rods or pipe in a

sleeve less than 10 ft; or sleeved copper-clad steel rods.

4.3 QUALITY CODE C - may hold precise elevation, but subject to ground movement. Examples: metal rods with base plates less than 10 ft deep; concrete posts (3 ft or more deep); unspecified rods or pipe more than 10 ft deep; large boulders; retaining walls for culverts or small bridges; footings or foundation walls of small to medium-size structures; or foundations such as landings, platforms, or steps. See Section 4.5, below.

4.4 QUALITY CODE D - of questionable stability. Examples: generally, objects of unknown character; shallow set rods or pipe (less than 10 ft); light structures; pavements such as street, curbs, or aprons; piles and poles such as spikes in utility poles; masses of concrete; or concrete posts less than 3 ft deep. New marks shall not be set in pavements such as street, curbs, aprons, piles and poles such as spikes in utility poles, masses of concrete, concrete marks less than 3 feet deep, pipe culverts of any size, or headwalls of either round or squared culvert outlets. Only the top of wing walls of large boxed culverts can be used or the abutment of a large bridge and only if they are over 5 years of age. New disks shall never be set in the curb of concrete road portion of a bridge as they mostly lay on the forms that are attached to the abutment and pilings of the bridge.

4.5 QUALITY CODE C EXCEPTION - when selecting FBN stations, only Quality Codes A and B are recommended. However, concrete posts may be selected with a C stability if the mark is deemed stable from review of historical re-leveling, soil type, and frost depth. Final selection is subjective, and is based on local knowledge of soil and frost heave, plus knowledge of how well the mark has held its horizontal and vertical positions over the years.

5. ACCESSIBILITY

Accessible public property should be utilized where feasible. If the station is located on private property, permission must be obtained from the land owner for station accessibility. Include the name, address, and, if public ownership, the telephone number of the responsible party. Do not include telephone numbers of private property owners.

Version 2
January 23, 2008

ATTACHMENT K
STATUS REPORT FORMAT

TO
SCOPE OF WORK FOR GROUND SURVEYS

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

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ATTACHMENT K: STATUS REPORT FORMAT

1.GENERAL

1.1 Format - The Prime Contractor shall submit project status reports via TOMIS every Monday by 2:00 PM Eastern Time, from the date of a Task Order award until the work is complete and accepted by NGS. These reports shall show the status of each Deliverable in order to help track the progress. A suggested format is shown below (the percent complete and date are required).

Submit the status report to TOMIS as an attachment in MS Word, MS Excel, or PDF format. The table boxes shown below are not required, but ensure that the information is in columns so that it is more readable.

Prime Contractor Firm Name:_____

Sub-Contractor(s) Firm Name:_____

Project ID & Location Dates:	TX0401/South TX (sample)	CA0401/SF Bay Area (sample)
Date Task Order Awarded		
Date Project Due		

Project ID Project Deliverables	TX0401 (Approx. % Complete)	Date Complete or Planned Complete	CA0401 (Approx. % Complete)	Date Complete or Planned Complete
Deliverable #1	100%	1 MAR 05		
Deliverable #2	75%	1 APR 05		
Deliverable #3		1 MAY 05		
Deliverable #4		1 NOV 05		
Etc.		1 DEC 05		
Overall Completeness		15 DEC 05		

1.2 Sample percentages and dates filled in above.

1.3 Include the above information for each project underway; add 2 columns for each project.

1.4 Flag entries that have been changed from the previous week.

2. DELIVERABLES SUBMITTED - List deliverables submitted

3. FUTURE PLANS - Briefly state plans for the coming week.

4. COMMENTS - Include comments/unusual circumstances/approved modifications from this SOW or Project Instructions.

Version 1
September 30, 2004

ATTACHMENT L
TRANSMITTAL LETTER

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

NOAA FORM 61-29
(12-71)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

LETTER TRANSMITTING DATA

REFERENCE NO.

DATA AS LISTED BELOW WERE FORWARDED TO YOU BY (Check)

☐ ORDINARY MAIL ☐ AIR MAIL

☐ REGISTERED MAIL ☐ EXPRESS

☐ GBL (Give number)_____

DATE FORWARDED

NUMBER OF PACKAGES

TO:

NOTE: A separate transmittal letter is to be used for each type of data, as tidal data, seismology, geomagnetism, etc. State the number of packages and include an executed copy of the transmittal letter in each package. In addition the original and one copy of the letter should be sent under separate cover. The copy will be returned as a receipt. This form should not be used for correspondence or transmitting accounting documents.

FROM: (Signature)

RECEIVED THE ABOVE
(Name, Division, Date)

Return receipted copy to:

NOAA FORM 61-29 SUPERCEDES FORM C AND GS 413 WHICH MAY BE USED.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1988 - 554-006-61309

Reset

NOAA FORM **61-29**
(12-71)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REFERENCE NO.
Task 1

LETTER TRANSMITTING DATA

DATA AS LISTED BELOW WERE FORWARDED TO YOU BY *(Check):*

☐ ORDINARY MAIL ☐ AIR MAIL

☐ REGISTERED MAIL ☑ EXPRESS

☐ GBL *(Give number)* _____

TO:

George Leigh
Attn: N/NGS Station 8609
1315 East-West Highway
Silver Spring, MD 20910

DATE FORWARDED
17JUN04

NUMBER OF PACKAGES
2 Notebooks

NOTE: A separate transmittal letter is to be used for each type of data, as tidal data, seismology, geomagnetism, etc. State the number of packages and include an executed copy of the transmittal letter in each package. In addition the original and one copy of the letter should be sent under separate cover. The copy will be returned as a receipt. This form should not be used for correspondence or transmitting accounting documents.

This package includes the survey plan for the project area (2 three-ring notebooks are included)

Please let us know if you have any questions.

FROM: *(Signature)*
George Leigh

Return receipted copy to:

Contractor
Program Manager
Shoreline Mapping Contractor
301-713-4315

RECEIVED THE ABOVE
(Name, Company, Date)

George Leigh

National Geodetic Survey

19JUN04

NOAA FORM 61-29 SUPERSEDES FORM C & GS 413 WHICH MAY BE USED.

Version 1
January 31, 2005

ATTACHMENT M
SAMPLE FINAL PROJECT REPORT

TO
SCOPE OF WORK FOR GEODETIC LEVELING
OF PUERTO RICO

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SERVICE

NATIONAL GEODETIC SURVEY
Charles W. Challstrom
Director

PROJECT REPORT

Second Order Class I
Leveling, Mark Setting and Recovery

TASK NUMBER 8K6D4000

October 10, 2000 - October 23, 2000

George A. Sowell
Project Director - NL4130
Survey Section C

LEVEL PROJECT TITLES ARE SAME AS LINE TITLES

HGZ No. Line Title L25824

BAR HARBOR CORS SITE SURVEY 2000, MAINE

JOB CODE **G2**

CONTENTS

PROJECT REPORT
Survey Unit C

I. INTRODUCTION

A. Authority

Leveling Observations at Bar Harbor, MAINE CORS SITE (L25824) ask Number 8K6D4000. Authorized October 11, 2000, and signed for Charles W. Challstrom, Director, National Geodetic Survey.

B. Purpose

The stations established at the site provide a very accurate tie to the antenna as an aid to quickly reposition the antenna should it become necessary. The purpose of this leveling project is to establish precise NAVD 88 heights for the bench marks located near the CORS sites.

II. PROJECT AREA

A. Locality:

BAR HARBOR - The CORS Site is located in the South-southeast part of the state of Maine, from Ellsworth Maine, at the junction of U.S. Highway 1 and State Highway 3, take State Highway 3 south-southeast to State Highway 102. turn left and continue east-southeast on State Highway 3 to the CORS Site, just before reaching Bar Harbor, Maine.

B. Limits

Survey operations were roughly within the boundaries of:

North 44 deg 28 min	North Latitude
South 44 deg 28 min	North Latitude
East 068 deg 15 min	West Longitude
West 068 deg 15 min	West Longitude

C. Terrain

The terrain is flat.

III. CONDITIONS AFFECTING PROGRESS

A. Climate and Terrain

The climate was mild. The Terrain is flat.

IV. DEVIATION FROM INSTRUCTIONS

NONE

V. ORGANIZATION

A. Personnel

Permanent Employees Title

Sowell, George A. ..... Project Director-S/L
Breidenbach, Donald E. .. Marksetter/GPS,OBS./Rodperson/Utility
Palo, James A. ..... Marksetter/LV Observer/Rodperson/Utility
Palo, Richard A. ..... LWOP
Williams, John M. ..... Computer/LV Observer/Utility

Schedule A Employees

Nowlin, Jason B. .GPS OBS/Rod Person/Recorder/LV OBS, THRU 10/13/00

Contract Employees

Cochran, Cheryl L. .GPS OBS/Rod Person/Recorder/LV OBS
Nowlin, Jason B. .GPS OBS/Rod Person/Recorder/LV OBS

B. Liaison

Liaison was maintained with the Field Operations Branch, Spatial Reference System Division.

Contact for **BAR HARBOR**: Gordon Longsworth, College of the Atlantic GIS Laboratory, 105 Eden Street, Bar Harbor, ME 04609 - Phone - 207-288-2271. Fax: 207-288-4126
E-mail: gordon1@ecology.coa.edu

C. Equipment

(1) Level Instruments and serial numbers
Ni002
456574

V. ORGANIZATION (continued)

C. Equipment (continued)

(2) **Rod pairs, Unmatched Kern, Invar 1/2 CM GRAD**

Serial Numbers

352134/368781

(3) Vehicles

1 - 1 ton Chevrolet/utility bed for mark setting.
1 - 3/4 ton Chevrolet suburban equipped for conventional, Phase II leveling procedures, 2 - Honda CT-110 motorbikes for Phase II leveling.

(4) Field Equipment

2 - Data collector, programmable CMT MC-V
2 - Thermometer, Digital Doric MDL-450
1 - Computers, Dell 133 Pentium
1 - Printers - 1 Cannon BJC-240,- various hand tools, mallets, turning plates and pins for leveling and mark setting.

(5) Office Equipment

1 - Dell 133 pentium. 1 Cannon BJC-620 Printers, and 1 - XC540 Xerox Copying Machine.

VI. FIELD WORK

A. **Chronology**

L25824 BAR HARBOR CORS SITE SURVEY 2000, MAINE

3.555 kms double run
1.990 kms single run
9.100 kms total linear distance
5.545 km forward progress
Setups=201
Leveling date: 10/20/00 - 10/23/00
Bench mark recovery: (7-rec.) Marks set 0:
Mark recovery (10/10/00).

JOB CODE **G2**

VI. FIELD WORK (continued)

B. Summary for leveling

Leveling was performed using Second Order Class I standard of accuracy. The CMT MC-V system was used for field data recording and data processing. Data for the project will be released under separate cover.

C. Leveling Procedures

Motorized leveling is with the use of 1-suburban for transporting the instrument man and recorder, and 2-Honda CT110 motorcycles for transporting the rod person, and leveling rods between setups.

Conventional leveling is with all personnel being afoot.

Both leveling procedures were used as dictated by traffic, road shoulders, and other terrain features.

D. Data Formats and Handling

All data was recorded and processed as outlined by Project Instructions, the NOAA NGS Operations Manual, and the Geodetic Leveling Manual.

VII. STATISTICS

A. **Number of Days, Leveling, Marks set, and recovery**

1. **Personnel Days**

0 ---- Project Director S/L
3 ---- Computer
3 ---- Mark setting/recovery
0 ---- Maintenance
4 ---- Activity not defined
2 ---- Level Observer
2 ---- Recorder
4 ---- Rod Persons
0 ---- Travel
0 ---- Holiday
0 ---- Annual Leave
3 ---- Sick Leave
3 ---- LWOP
24 ---- Total

VII. STATISTICS (continued)

B. Marks Set and Recovery

Mark setting and recovery were performed according to project instructions, established procedures, and mark setting manuals and memorandum.

The computer printout of the **"Vertical Bench Mark and Field Statistics"** for each level line are attached.

New marks established

0 ---- Class A
0 ---- Class B
0 ---- Total

Marks recovered

3 ---- Class A
3 ---- Class B
1 ---- Class C
0 ---- Class D
7 ---- total

C. Logistics

The field computations and project support was managed from the National Geodetic Survey Field Office in Bangor, Maine.

D. Summary for levels procedure

Both leveling procedures were used as dictated by traffic, road shoulders, and other terrain features. (see Item C Page 4)

E. Attachments

Project Instructions (1-set)
Letter Transmitting Data (1-sheet)
Memo from BM Setters (1 sheets)
List of Contacts (1-sheet)
Bench Mark Statistics (1 Sheets)
Field Statistics (1 sheets)
Abstract for CORS Site Levels (6 sheets - stapled)
NEW - OLD sheet for tie marks (1 sheet)

Version 3A
January 30 2008

ATTACHMENT N
TECHNICAL PROPOSAL CONTENTS

TO
SCOPE OF WORK FOR SHORELINE MAPPING
UNDER THE
NOAA COASTAL MAPPING PROGRAM

REMOTE SENSING DIVISION
NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

TABLE OF CONTENTS

ATTACHMENT N: TECHNICAL PROPOSAL CONTENTS

1. GENERAL - Technical Proposals shall contain at least the sections and information listed below. The Technical Proposals shall not contain the SOW or the Project Instructions, but shall contain information about the methodologies and equipment selected by the contractor and reasoning/justification for these methods. In addition, the TOMIS "Deliverable Tracking Log" is required.

2. INCLUDED INFORMATION

2.1 PRIME AND SUBS - State which firm(s) will perform which portions of the project.

2.2 TIME LINE - Provide rough time-line.

2.3 PROJECT LIMITS - A brief statement showing that the contractor understands the Project area.

2.4 ACCURACY - A brief statement on the accuracy requirements and how they will be achieved.

2.5 GROUND CONTROL - Provide a map showing locations of all ground control points using different symbology for existing control, new control. State the total number of points and justify why that number is correct for the project. Discuss how these points will be marked and how they will be positioned and/or checked. State if CORS and OPUS will be used, and why or why not. Note: approximate locations are acceptable.

2.6 CALIBRATIONS - Discuss equipment calibrations.

2.7 QUALITY CONTROL (QC) - State how all work will be reviewed and how the prime will oversee their sub-contractors.

2.8 REPORTS - List the reports that will be submitted.

2.9 ADDRESS - State the NGS address where all data and invoices will be sent.

2.10 PROPOSED INSTRUMENTATION - (instruments, rods, etc. including model, serial numbers and copies of rod calibration certificates.

2.11 CONDITIONS - State the conditions for tying to each HARN and the recommendation of the contractor as to the feasibility of that tie.

2.12 TOMIS DELIVERABLE TRACKING LOG – In the format as specified in the Project Instructions.

Version 1
January 23, 2008

ATTACHMENT O
SETTING A MARK IN OR NEAR BEDROCK

TO
SCOPE OF WORK FOR GROUND SURVEYS

NATIONAL GEODETIC SURVEY
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

ATTACHMENT O - SETTING A MARK IN OR NEAR BEDROCK

CASE I – BEDROCK AT GROUND SURFACE
Set a disk in a drill hole per Attachment entitled, "**SETTING A DISK IN BEDROCK OR A STRUCTURE"**

CASE II – BEDROCK LESS THAN ~1.5 FOOT (0.5 METER) BELOW SURFACE
Same as CASE I, then, install a protective monument box, such as an iron utility well cover, plastic valve box, or PVC pipe with aluminum logo cap, surrounding and over the disk for protection and access. Surround the box or pipe with a concrete collar to hold it in place. Also consider a CASE III mark.

CASE III – BEDROCK ~1.5 - 3 FEET (0.5 - 1 METER) BELOW SURFACE
Dig out an area at least 0.5 meter in diameter and clean off the top of the bedrock removing all loose material and washing down the rock to provide a clean surface. If the bedrock is smooth, drill holes or chisel furrows to afford better anchorage for the concrete monument. Set a concrete monument on top of the bedrock with a disk on the surface.

CASE IV – BEDROCK ~ 3 – 13 FEET (1 – 4 METERS) BELOW SURFACE
Do not set a rod mark that is less than 4 meters long. If bedrock is reached less than 4 meters below the surface then either set a concrete mark (according to the Attachment entitled, "**SETTING CONCRETE MARK**S"), or move to a different location to set a rod mark (according to the Attachment "**SETTING A NGS 3-D MONUMENT**").

CASE V – BEDROCK DEEPER THAN 4 METERS
Set a rod mark or concrete monument per appropriate Attachments.

See graphic on next page.

setting a mark in bedrock

case 1: bedrock at surface	case 2: bedrock 0 - ½ m deep	case 3: bedrock ½ - 1 m deep	case 4: bedrock 1 - 4 m deep	case 5: bedrock > 4 m deep
mark in bedrock	mark in bedrock in a protective well	concrete monument affixed to bedrock	concrete monument in soil okay	rod mark okay.