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ATTACHMENT V
SETTING AN NGS 3D MONUMENT

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

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Based on "Revised NGS 3-Dimensional (3-D) Rod Mark" [Draft Version] by:
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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 requires 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" (http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs.pdf), 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 powered reciprocating hammer, until refusal or a reduced driving rate has been achieved. 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. The effects of up and down ground movement during freeze/thaw or wet/dry conditions are removed from the anchored rod by the grease filled sleeve promoting vertical stability. A 5 or 6-inch PolyVinyl Chloride (PVC) pipe with attached, standard, NGS 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, see: http://www.ngs.noaa.gov/PUBS_LIB/GeodeticBMs.pdf .

Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, by Federal Geodetic Control Committee, August 1989, see: http://www.ngs.noaa.gov/FGCS/tech_pub/GeomGeod.pdf .

4. REQUIREMENTS

4.1 RECOMMENDED EQUIPMENT FOR SETTING MONUMENTS

A. Rod Drivers and Accessories:
Safety Goggles for each worker.
1- Any driver with a minimum impact force of 25 foot pounds per blow, such as the Wacker Model BHB 25 (with tool kit) or Pionjar Model 120 (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.
2- Gas Containers and Gasoline, for driving machine and generator.

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 on 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 on Logo Cap.
1- Hand Saw, for cutting 5 or 6-inch PVC pipe.
1 - Bucket or Wheel Barrel, to mix cement/move unwanted dirt.
2- Five Gallon Water containers and clean 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, Socket-Wrench, 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) or cardboard form, 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

Sufficient lengths of 9/16-inch diameter Stainless Steel Rods, 4-foot sections.
1- Four to five-inch piece of Stainless Steel Rod, used as impact point and protection while driving rods.
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 (For photograph documentation of these steps, see: http://www.ngs.noaa.gov/AERO/Genspecs_A/Volume%20A_Attachment%2010.pdf .)

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

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

C. 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 D, E, and G, can and should be accomplished at a maintenance shop.

D. Stamp station designation and year of establishment into the blank area on the collar of the logo cap. Use 3/16 inch steel dies.

E. Cut a 20-inch section of 5 or 6-inch PVC pipe. Ensure the end that will receive the logo cap is cut true, smooth, and 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.

F. 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.

G. 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.

H. 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.

I. The 8-foot long connected rod (two sections) 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 reciprocating driver such as Whacker model BHB 25, Pionjar Model 120, or another machine with an equivalent driving force.

J. 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.

K. Repeat step 10 until the rod refuses to drive further (anchored), or until the driving rate is reduced to 60 seconds per foot. 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.

L. 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.

M. The datum point must then be created by center punching a dimple on the top-center 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.

N. 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.

O. 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.

P. 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.

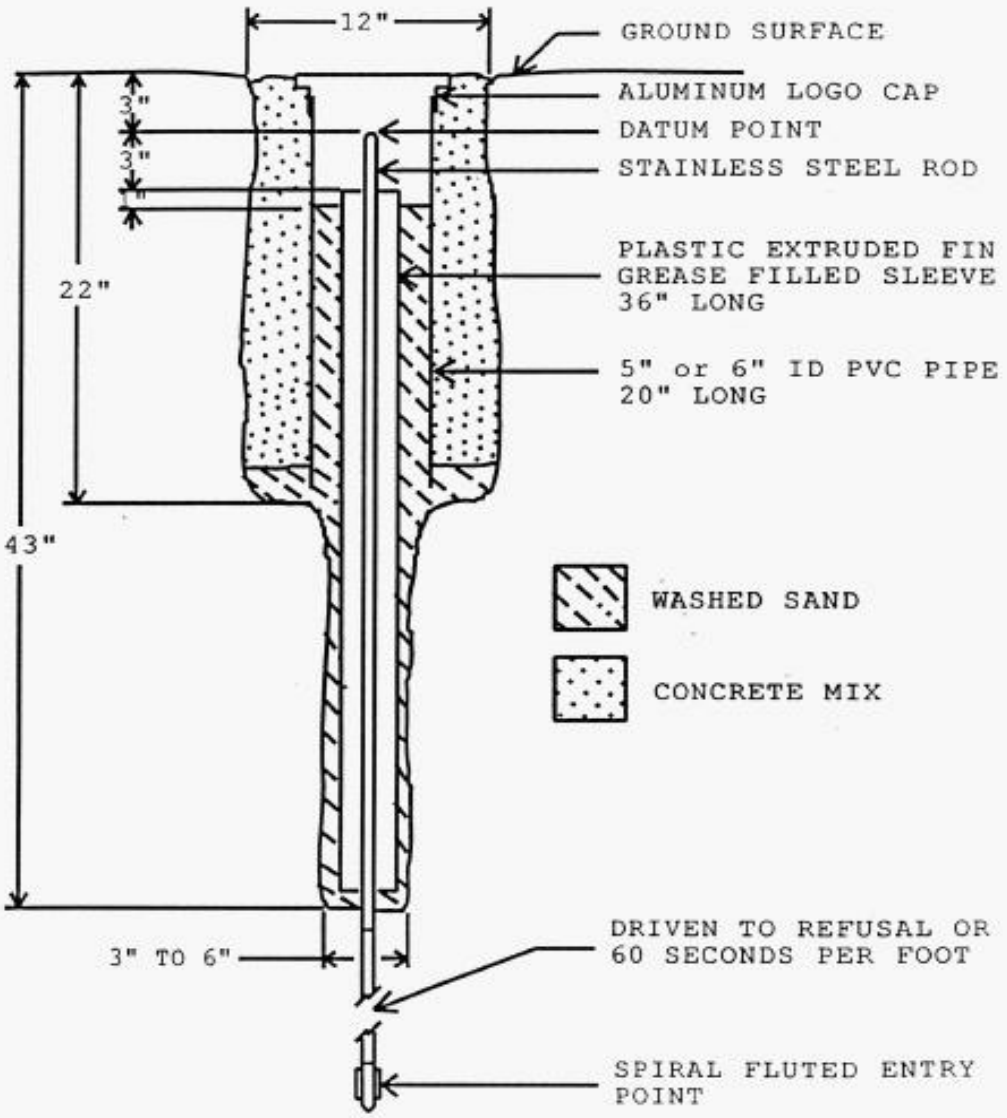
Q. Mix concrete in a bucket or wheel barrel to pasty, well moistened consistency like mashed potatoes. Add Portland cement, if necessary, in sufficient quantity (1 to 2 pounds) to enhance concrete mix or dry an over moistened mixture to maintain adequate consistency. A good indication of adequate consistency 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.

R. 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.

S. 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.

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

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



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

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