SSCL-SR-1145

No GR Nr

SUPERCONDUCTING SUPER COLLIDER

Permanent Monumentation for Horizontal and Vertical Control at the SSC Site

May 1991

RTK

a joint venture

Kaiser Engineers Inc.
Tudor Engineering Company
Keller & Gannon-Knight

1800 Harrison Street
Post Office Box 23210
Oakland, California 94623-2321
(415) 268-6000 Telex 335326

Prepared Under URA Contract SSCL-89-0006

Permanent Monumentation

for

Horizontal and Vertical Control

at the SSC Site

M. Jones, M. Riddle, D. Scapuzzi
RTK
1800 Harrison Street
Oakland, California 95612

J. Kor, J. Langan
TOWILL, INC.
301 Mission Street, Suite 300
San Francisco, California 94105

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CHAPTER 1

INTRODUCTION

1.1 Purpose

This report describes the three-year effort to provide a comprehensive system of survey monuments for the Superconducting Super Collider (SSC) site in Ellis County, Texas. The report covers the early efforts of ICF Kaiser Engineers, Inc., Tudor Engineering Co., and Keller & Gannon-Knight, A Joint Venture (RTK) and the Central Design Group (CDG) and subsequent work by RTK in support of the SSC Laboratory (SSCL) and the Texas National Research Laboratory Commission (TNRLC).

The purpose of the monument system is to provide permanent, stable monuments for horizontal and vertical control to support property acquisition, photogrammetry and mapping activities at the site during the site-specific conceptual design phase. The system will also support the design, construction, maintenance and operation of the conventional facilities over the lifetime of the project.

1.2 System Description

The monumentation system consists of 89 monuments for horizontal control (80 of which are included in the vertical control network) and 82 monuments for vertical control only, arranged as shown on Drawing CS-30 in Appendix A. The horizontal control monuments are located roughly in a circular pattern along the outline of the main ring alignment. The vertical monuments are located roughly as spokes beginning at a hub in Waxahachie and radiating out more or less northerly, easterly, southerly, and westerly to points approximately 15 mi (24 km) outside the main ring.

CHAPTER 2

BACKGROUND

2.1 December 1987 Survey Workshop

On December 7, 1987, a workshop was conducted at the RTK offices to discuss various aspects of survey control for the SSC project (1). The workshop was attended by representatives of the Department of Energy (DOE), the CDG, RTK, and Towill, Inc. (Towill), a California firm specializing in surveying and photogrammetry. Topics discussed at this workshop included "Emerging Surveying Technology," "Typical Control Networks," and "Control for Tunneling."

It was determined that advance planning for a comprehensive survey control system was necessary for the SSC project. Additionally, a primary control network of very high precision had to be established at the beginning of the project as the basis of all subsequent surveys to keep the survey control work for design and construction cost-effective and on schedule. The technology and instrumentation were available to meet that challenge.

2.2 Survey Advisory Panel

In February 1989, a meeting was held at SSCL in Dallas, Texas, attended by representatives of SSCL, RTK, TNRLC, and the Sverdrup Corporation.

Preliminary discussions involved the survey programs needed to support the following:

- Locating drill holes, trenches and other field geotechnical activities for the Geotechnical Site Characterization Program.
- Property acquisition work to be done by TNRLC.
- Aerial photogrammetry and mapping.
- Design and construction of the conventional facilities.
- Installation of the technical facilities once conventional construction is complete.

An advisory panel was created to plan the monumentation and survey control system for the SSC project. The panel was made up of members of SSCL, RTK, TNRLC, and the Sverdrup Corporation. Jim Kor of Towill was added to the panel later that summer.

Since there was an immediate need for a system of survey control to support the startup geotechnical characterization program for the SSC site, SSCL assigned RTK the responsibility to provide a system of temporary monuments with Texas State Plane Coordinates based upon the North American Datum of 1927 (NAD 27) for locating the drill holes, test pits, and rock outcroppings. This effort is described in SSCL-SR-1149, "Horizontal and Vertical Control System for the Startup Geotechnical Characterization Program at the SSC Site" (2).

2.3 Control System Planning

At the May 26, 1989 meeting of the panel, John Slonaker of TNRLC presented the first draft of criteria for control surveying associated with the land acquisition for which TNRLC was responsible. This report included the criteria for a system of baseline control, primary control, and vertical control monuments which would be used to control all land surveys associated with the land acquisition program for the project. The report was subsequently revised and is being used to support TNRLC's land surveying efforts (3).

At the same meeting, RTK presented an outline for a Preliminary Survey Program (see Appendix B) addressing location of existing control, design of a control system to support property acquisition, development of a plan for property surveys, and coordination of this work with the local surveying community.

Subsequent meetings of the panel were held during the summer of 1989 at which several reports were presented by Don Scapuzzi on draft survey control plans which would support the property acquisition plan, monument construction, and small diameter shafts which could be used for surveyor access to tunnels under construction (see Appendix B). The proposed system of monuments that resulted from these meetings is shown on Drawing CS-5 in Appendix A.

In September 1989, SSCL authorized RTK to finalize the control system details and to engage a subcontractor to construct the monuments and install a system of horizontal and vertical control.

CHAPTER 3

SYSTEM DESIGN

3.1 Criteria

The monumentation system was designed to perform the following functions.

- Provide a stable, permanent location for horizontal and/or vertical control reference.
- Include a series of a few very high-precision monuments and a larger number of monuments of lesser precision for horizontal control.
- Include a series of benchmarks to be combined with a majority of the horizontal control monuments to provide a system of vertical control.
- Provide horizontal and vertical control to support property acquisition by TNRLC.
- Provide horizontal and vertical control to support the design and construction of the conventional facilities.
- Provide horizontal and vertical control to support the maintenance and operation of the conventional facilities for the Laboratory over the expected life of the project.

3.2 Monumentation Design

The horizontal control system consists of two classes of monumentation precision: master monuments which are located to Order B specifications of the Federal Geodetic Control Committee (4) and primary control monuments which are located to First Order specifications (ibid.).

The vertical control system consists of a series of benchmarks combined with all of the master monuments and most of the primary control monuments. All vertical control was established using the specifications for First Order Levels of the Federal Geodetic Control Committee (5).

The SSC site is located in a region of highly expansive soil. Therefore, the monuments had to be anchored in the bedrock below the layer of soil subjected to movement by seasonal changes in moisture content.

The entire system of horizontal control monuments had been planned to consist of NGS 3-D monuments as shown on the drawing "Primary Control Monument (NGS 3-D Monument) Construction Details" in Appendix A and in Reference (4). Concerns by the Underground Technology Advisory Panel (UTAP), a group of geotechnical consultants under contract to SSCL, over the long-term stability of this type of monument led to additional research on monument construction in highly expansive soil, especially in the Dallas area. Consequently, monument construction details successfully used for controlling large construction projects in downtown Dallas were used for the master monuments. Details are shown on the drawing "Master Monument Construction Details" in Appendix A.

3.3 Monument Location

3.3.1 Master Monuments

A system of master monuments provides the overall horizontal control for the project. These monuments are the highest precision monuments in the system and were located horizontally using Global Positioning System (GPS) survey techniques to "Order B" specifications, or 1:1,000,000 error tolerance. The monuments were located at roughly eight-mile (13 km) intervals around the ring footprint as shown on Drawing CS-30 in Appendix A. Additionally, one monument was located inside the ring and another four approximately 15 mi (24 km) outside of the ring. All master monuments were included in the first order vertical control network. Future monuments set during the property acquisition, design, or construction phases should be horizontally referenced to these monuments.

The master monuments (as well as the primary control monuments and benchmarks) were located to ensure the highest chance of survivability. All monuments were located in public rights of way. The appropriate agencies were consulted as to future construction plans and roadway maintenance practices which might have an effect on the stability and long-term life of the monuments.

Additionally, the master monuments were placed at the highest local elevation to provide future surveyors a transit station with the greatest overview of the adjacent landscape. Each location also had to have an unobstructed view of the satellite constellation for GPS data gathering. Intervisibility between master monuments was desirable but not practical at the site due to the flat terrain. The number of monuments would have had to have been more than doubled to provide intervisibility from one master monument to another.

Existing monumentation in the area was omitted from the network because of the instability of the highly expansive soil. A tie was made to an existing monument in the area (Mustang, southeast of Waxahachie) to place the network into the Texas State Plane Coordinate system, but this monument should not be used in any future surveys for control purposes.

3.3.2 Primary Control Monuments

A system of primary control monuments was established around the ring, as shown on Drawing CS-30, to provide horizontal and vertical control in support

of surveying operations for property acquisition, final design and construction, and future maintenance of the facility. These monuments were set in intervisible pairs to function as a source of bearing in conventional survey traverse work. The paired monuments were set with an approximate interval of 2,000 ft (600 m) between them and with intervals of from 6,000 ft (1,800 m) to 10,000 ft (3,000 m) between pairs of monuments. All primary control monuments were located horizontally using GPS survey techniques to First Order specifications or 1:100,000 error tolerance and referenced to the master monuments.

The monuments were located to facilitate conventional traverse work to locate property boundaries in the immediate vicinity. Spacing between pairs of monuments was set so traverses could be started on one pair of monuments and closed on an adjacent pair without having to run the closing route an excessive distance. Most pairs of monuments are within two or three transit stations or "turns" of an adjacent pair for conventional traversing.

This spacing also supports probable design and construction activity for the conventional facilities. Any area requiring mapping is within close proximity of the network. Flight crosses can be controlled horizontally with a minimum of effort using conventional traversing or GPS techniques. The accuracy of the network is more than adequate for any reference to mapping control. Other surveys (profiles, spot elevations, cross-sections) can be undertaken efficiently with this density of monumentation.

Additional monuments will probably be needed once construction of the conventional facilities begins. No attempt was made to locate monuments in the most favorable location to support this construction, since the actual locations cannot be determined with sufficient accuracy, and monuments may be damaged or destroyed during construction activities.

Any monuments added to support construction activities should be built and surveyed using equivalent specifications to those described in this report to prevent degradation of the overall control system.

3.3.3 Vertical Control Monuments

The network of vertical control monuments includes 80 master and primary control monuments as well as 56 additional monuments (benchmarks) constructed between the four master monuments located approximately 15 mi (24 km) outside the ring as well as the ring itself (see Drawing CS-30). These additional monuments are spaced at approximately one-mile (1,600 m) intervals between each outside master monument and the nearest master or primary control monument at the ring location. Thirty-four additional monuments were constructed inside the ring to tie together the top and bottom and the sides of the ring in a crossing pattern. All monuments in this network were located vertically using procedures for First Order, Class 1 vertical control surveys.

The pattern of locating these monuments was selected to provide an accurate network of vertical benchmarks to support the stratified fee property acquisition and design and construction of the Laboratory facilities. Additionally, monuments were placed in a crossing pattern inside the ring and extended 15 mi (24 km) outside the ring in four directions to provide a means of monitoring the long-term stability of the SSC site with respect to potential ground movement from groundwater withdrawal.

3.3.4 Other Monuments

Other future monuments, such as control for aerial photography or construction staking will be constructed and controlled by the subcontractors performing that work and in accordance with specifications to be developed by the contracting agency. These monuments will be referenced to the master monuments, primary control monuments, or benchmarks, as appropriate.

3.4 Monument Construction Details

Master monuments were constructed in accordance with the details shown on the drawing "Master Monument Construction Details" in Appendix A except Master Monuments 005 and 012 which are standard three-in. (76 mm) brass disks set in existing concrete structures. Holes were drilled through the overburden soil into bedrock using truck-mounted drill rigs furnished by Mason-Johnston and Associates of Dallas, Texas. These same rigs were used to hoist the one-in. (25 mm) diameter monument bars and three-in. (76 mm) diameter pipe casings into position over the drilled hole and lower them into place. The monument bars were grouted 10 ft (3 m) into the bedrock, and the protective pipe casings were grouted into the bedrock as shown.

Primary and vertical control monuments were constructed in accordance with the details for an NGS 3-D Marker as shown on the drawing "Primary Control Monument (NGS 3-D Monument) Construction Details" in Appendix A. Thirty-three of the benchmarks were constructed by setting standard three-in. (76 mm) brass disks into existing concrete structures.

A tractor with a power takeoff/drill attachment was used to drill the 40-in. (1 m) deep hole. A device similar to a jackhammer was used to drive the 9/16-in. (14 mm) diameter stainless steel rod into bedrock or until the driving rate fell below 12 in. (30 cm) per minute. When bedrock was found within five ft (1.5 m) of the surface, the rod was grouted into a hole drilled one ft (30 cm) into the bedrock. A grease-filled tube was placed over the upper three ft (1 m) of rod to protect it from vertical stress transmitted from the surrounding soil during the wetting/drying process. A two-ft (60 cm) long section of PVC pipe was placed at the top of the monument for protection and to support the monument cap. The bottom of the augured hole was filled with sand. The top, outside of the PVC pipe, was filled with concrete.

The top of the rods for the monuments (except the brass discs set in concrete structures) were set a minimum of three in. (8 cm) below the top of the access cover. The covers were set three to 12 in. (8 to 30 cm) below the existing ground to protect them from damage by maintenance equipment or grass mowers.

CHAPTER 4

MONUMENTATION PROGRAM

4.1 Monumentation Subcontract

A contract for the monumentation work was awarded to Towill, Inc. on January 24, 1990. Following is the scope of work.

- Reconnaissance of all proposed monument field locations.
- Construction of all master monuments.
- Construction of all primary control monuments.
- Determination of the horizontal position of the master monuments using GPS techniques.
- Determination of the horizontal position of the primary control monuments using GPS techniques.
- Construction of all vertical control benchmarks.
- Determination of the vertical position of all monuments and benchmarks in the vertical control system using First Order leveling techniques.

A list of Towill subcontractors is included in Appendix C.

4.2 Local Agency Approvals

The tentative location of each monument was marked on United States Geological Survey 7.5 Minute Series Quadrangles. Towill used these maps as a guide in the field and placed 18-in. (0.5 m) long sections of half-in. (13 mm) diameter reinforcing steel (re-bar) at the chosen locations. The locations were modified to suit the requirements for access to GPS satellites, intervisibility, compatibility with existing topography, and probability of long-term life in view of future construction activities. The re-bar locations were referenced or "tied off" in two directions to "nails and shiners" driven into adjacent trees, fence posts, paving or other suitable locations, and the locations were recorded on sketches.

A review of the tentative locations was held on Tuesday, February 27, 1990 by the following:

Mike Smith and Joe Barrentine, TNRLC
Al Barton, Texas Department of Transportation (DOT)
Jimmy Reavis, Ellis County Public Works Department
Jim Kor and John Langan, Towill, Inc.
Don Scapuzzi, RTK.

During this review it became apparent that a significant number of monument locations were too close to the edge of the road, thereby making the monuments vulnerable to disturbances by road shoulder maintenance and planned road-widening construction. It was agreed that these monuments would be relocated to the backslope side of the roadside ditches and as near to the right-of-way line as practical.

Towill coordinated the selection of new monument locations with the utility companies and the State and County representatives (see listing in Appendix D) to avoid conflicting locations. This resulted in the selection of new locations for almost all monuments. Prior to monument construction, the location of each monument was again reviewed by designated representatives of the Texas DOT or the Ellis County Department of Public Works. Any monument not approved by these agencies was relocated.

4.3 Horizontal Control

4.3.1 Field Work

The baseline network viewing scheme was developed on maps showing the monument locations to scale. The network was designed to exceed National Geodetic Survey (NGS) requirements for Order B work. Of the 12 established master monuments, eight have three or more independent occupations and the remaining monuments have two each. Master Monument 005 with nine independent occupations and Master Monuments 008 and 012 each with seven independent occupations serve as fiducial stations for the project. See Table 4-1 for a tabulation of the independent occupations for the master monuments. One hundred percent of the monuments were occupied two or more times and 67% were occupied three or more times. Forms (see Figure 4-1) were designed to ensure that all information required to comply with Order B procedures would be acquired and documented at each station for each session.

Trimble geodetic antennas were used for the survey. The antennas were aligned north using the arrow on the antenna ring. Antenna height measurements were taken to the edge of the antenna ring in four quadrants using Trimble calibrated aluminum rods, and a repeat measurement was taken at the end of the session. Plumb bobs were used to verify the optical plummet and as a check against blunders in centering.

Table 4-1

MASTER MONUMENT OCCUPATIONS

		Master Monument Number											
Day	Session	001	202	003	004	005	006	007	008	011	012	013	014
100	0								x		x		
101	0					x					x		
108	1			x	x	x			x		x	x	
109	1	x	x	x		x			x		x		
111	1	x				x	x	x	x		x		
112	0	x				x				x	x	x	x
113	1	x				x	x	x	x				x
114	1				x	x	x		x		x	x	
115	1	x	x	x		x			x	x			
117	1			x	x	x							
Total Occupations		5	2	4	3	9	3	2	7	2	7	3	2

TOWILL INC. GPS SURVEY FOR THE TEXAS SUPERCONDUCTING SUPERCOLLIDER PROJECT

CLASS "B" FORM

DATE 24 APRIL 1990

POINT STAMPING MMOMS

SESSION NUMBER 1
FILE NAME 00051151
START TIME UTC 21:35 CDT
END TIME UTC 00:52 CDT
JULIAN DATE 115
RECEIVER SN 582
ANTENNA SN 92
OPERATOR J.A. GARCIA

ANTENNA HEIGHT CALCULATIONS

MEASUREMENTS ARE TO THE BOTTOM OF THE GROUND PLANE AT THE OUTER RIM (NOT SCALLOPED INDENT)

1ST QUADRANT	1.526	METERS
2ND QUADRANT	1.525	METERS
3RD QUADRANT	1.526	METERS
4TH QUADRANT	1.526	METERS
TOTAL 1 TO 4	6.103	METERS
AVERAGE OF 4	1.5253	METERS
AVG SQUARED	2.3279	METERS
MINUS	0.0582	
TOTAL	2.2697	METERS
SQUARE ROOT	1.5066	METERS
PLUS	0.0095	METERS
=VERTICAL ANT HEIGHT	1.5161	METERS

ANY QUADRANT 4.990 DEC FEET
TIMES 0.3048
= SLOPE DIST
CHECK (+-5MM) 1.5210 METERS
WAS VERT HEIGHT ENTERED (YES) NO
(IF VERT NOT CALCULATED ENTER 0.0000 AS ANTENNA HEIGHT)

BAR #1 PSYCH #2

METEOROLOGICAL INFORMATION

TAKE EACH HOUR AFTER START

TIME 21:50 CDT
TEMPERATURE F 69° C
PRESSURE (29.70 + 0.06) 29.76
HUMIDITY DRY 69° WET 65° % 83

TIME 23:00 CDT
TEMPERATURE F 69° C
PRESSURE (29.73 + 0.06) 29.79
HUMIDITY DRY 69° WET 66° % 95

TIME 00:00 CDT
TEMPERATURE F 68° C
PRESSURE (29.75 + 0.06) = 29.81
HUMIDITY DRY 68° WET 65° % 86

TIME 00:55 CDT
TEMPERATURE F 67° C
PRESSURE (29.75 + 0.06) = 29.81
HUMIDITY DRY 67° WET 66° % 90%

TIME CDT
TEMPERATURE F C
PRESSURE
HUMIDITY DRY WET %

START OF SURVEY
LATITUDE 32°14'47.60"
LONGITUDE 96°52'33.32"
HEIGHT 163.7
NUMBER OF SV TRACKED 6

END OF SURVEY
LATITUDE 32°14'45.60"
LONGITUDE 96°52'33.24"
HEIGHT -236.0
NUMBER OF SV TRACKED 4

CHECKED SETUP WITH PLUMB BOB (YES) NO

ANTENNA HEIGHT CHECK AT END OF SURVEY - 1ST QUADRANT 1.526 METERS

NOTES - INCLUDE ANY SIGNIFICANT WEATHER AND ALL OBSTRUCTIONS OVER 20 DEGREES ELEVATION WITH THE AZIMUTH TO THE EDGES OF THE OBSTRUCTION FROM MAGNETIC NORTH. USE BACK OF FORM FOR NOTES OR PERTINENT SKETCHES.

Figure 4-1

Forms similar to the Order B survey forms were used for the Order 1 survey work (see Figure 4-2). As the primary monuments were not in place at the start of the survey, the network viewing scheme was developed as the work progressed using a scaled map for compliance with requirements for First Order surveys.

Field work began on April 8, 1990 to coincide with the Texas DOT viewing schedule at selected sites around the state. Trimble 4000SST dual frequency GPS units were placed at Master Monuments 005 and 012. The session lasted five-and-one-half hours. Data from the final adjustment of the Texas DOT network was not yet available at the time of this report and could therefore not be used for baseline reductions and scale checking.

On April 9, 1990, the GPS survey crew met to review the procedures involved in both Order B and Order 1 GPS surveys. The GPS crew was comprised of three Towill and three Oceanics Inc. employees. At this time the tribrachs and other equipment used in the survey were calibrated and adjusted. Barometers and thermometers were calibrated at the Love Field Flight Service Station and checked with the Dallas International Airport control tower instrumentation. Equipment at both sites is calibrated monthly. The optical plummet tribrachs were checked for accuracy every three survey days and were found to be in adjustment throughout the survey. The meteorological instruments were again calibrated on April 17, and no change from the April 9 calibration was found.

From April 9-12, five Trimble 4000SST units were used for each viewing session. Master Monuments 005 and 012 were again observed on April 9 and 10 for a five-and-one-half hour period to coincide with the Texas DOT viewing schedule. The three remaining GPS units were used on the primary monuments as part of the Order 1 survey. From April 16 to 27, six Trimble 4000SST GPS units were used for all sessions.

Session viewing schedules were prepared for each night of surveying and distributed to all personnel. The schedules listed the point to be occupied, file name to be entered in the GPS unit, start and stop times for each session, and any pertinent comments. Order B stations were occupied for periods ranging from two hours and thirty minutes to five hours and forty minutes depending on baseline length, number of visible satellites, and configuration of the constellation. Primary monuments were occupied for periods ranging from forty-five minutes to two hours and five minutes. Sessions were arranged to provide optimum number of satellites and constellation geometry for the Order B sessions. The daily observing schedule started at approximately 1900 hours and ended at 0130. Morning sessions on primary monuments were conducted on three occasions starting at approximately 0600 and ending at 0900. Since only a portion of the available satellite viewing period was good for Order B Work, Order B work was performed during that time and First Order work during the remaining time. On April 22, only one session was completed on the lines between Master Monuments 011, 012, 013, 014, 008 and 005. Drawings of each day's GPS field data gathering sessions and the baselines calculated from that data are included in Appendix E. Drawings showing the cumulative baselines from the master monument sessions (Order B) and the primary control sessions (First Order) are also included.

TOWILL INC. GPS SURVEY FOR THE TEXAS SUPERCONDUCTING SUPERCOLLIDER PROJECT

DATE 4.12.90

POINT NUMBER PC 120

SESSION NUMBER 0
FILE NAME 0120.103.0
START TIME UTC 1950 (CDT)
END TIME UTC 2140 (CDT)
JULIAN UTC DATE 103
RECEIVER SN 0579
ANTENNA SN 00096
OPERATOR JCR

ANTENNA HEIGHT CALCULATIONS

MEASUREMENTS ARE TO THE BOTTOM OF THE GROUND PLANE AT THE OUTER RIM (NOT SCALLOPED INDENT)

1ST QUADRANT	1.714	METERS
2ND QUADRANT	1.714	METERS
3RD QUADRANT	1.714	METERS
4TH QUADRANT	1.714	METERS
TOTAL 1 TO 4	6.856	METERS
AVERAGE OF 4	1.714	METERS
AVG SQUARED	2.9378	METERS
MINUS	0.0582	
TOTAL	2.8796	METERS
SQUARE ROOT	1.6969	METERS
PLUS	0.0095	METERS
= VERTICAL ANT HEIGHT	1.7064	METERS ENTER
ANY QUADRANT	5.622	DEC FEET
TIMES	0.3048	
= SLOPE DIST CHECK (+-5MM)	1.7136	METERS ✓

WAS VERT HEIGHT ENTERED (YES) NO
(IF VERT NOT CALCULATED ENTER 0.0000 AS ANTENNA HEIGHT)

NOTES - INCLUDE ANY SIGNIFICANT WEATHER AND ALL OBSTRUCTIONS OVER 20 DEGREES ELEV WITH THE AZIMUTH TO THE EDGES OF THE OBSTRUCTION FROM MAG NORTH

NO OBSTRUCTIONS
CLEAR / HIGH CLOS
WARM

DATE 4.12.90

POINT NUMBER PC 117

SESSION NUMBER 1
FILE NAME 0117.103.1
START TIME UTC 2151 (CDT)
END TIME UTC 2255 CDT
JULIAN UTC DATE 103
RECEIVER SN 0579
ANTENNA SN 00096
OPERATOR JCR

ANTENNA HEIGHT CALCULATIONS

MEASUREMENTS ARE TO THE BOTTOM OF THE GROUND PLANE AT THE OUTER RIM (NOT SCALLOPED INDENT)

1ST QUADRANT	1.727	METERS
2ND QUADRANT	1.727	METERS
3RD QUADRANT	1.726	METERS
4TH QUADRANT	1.726	METERS
TOTAL 1 TO 4	6.906	METERS
AVERAGE OF 4	1.7265	METERS
AVG SQUARED	2.9808	METERS
MINUS	0.0582	
TOTAL	2.9226	METERS
SQUARE ROOT	1.7096	METERS
PLUS	0.0095	METERS
= VERTICAL ANT HEIGHT	1.7191	METERS
ANY QUADRANT	5.663	DEC FEET
TIMES	0.3048	
= SLOPE DIST CHECK (+-5MM)	1.7261	METERS

WAS VERT HEIGHT ENTERED (YES) NO
(IF VERT NOT CALCULATED ENTER 0.0000 AS ANTENNA HEIGHT)

NOTES - INCLUDE ANY SIGNIFICANT WEATHER AND ALL OBSTRUCTIONS OVER 20 DEGREES ELEV WITH THE AZIMUTH TO THE EDGES OF THE OBSTRUCTION FROM MAG NORTH

2 SMALL POWER LINES
O-HEAD. ONE P.P.
150' +/- DUE EAST

Figure 4-2

All personnel were given maps showing the locations of the master and primary monuments superimposed on the County road network. Since the monuments were located in the road right-of-way, safety equipment including cones with reflecting tape and reflecting triangles were distributed to the crews. The County Sheriff was given a map showing all monument locations. At the start of a nighttime survey, the dispatcher at the Sheriff's office would be apprised of the night's viewing schedule by monument numbers. Since work took place during darkness, the Sheriff's department received calls from the public about suspicious vehicles and people moving about. Notifying the department ahead of time allowed the operator to inform the callers of the surveying operation and saved them dispatching a patrol car to investigate.

Daily surveys began with a meeting at the job site to distribute GPS units and session schedules. After an examination of the work schedule and a general discussion of the night's work, individuals would visit the monuments they were to occupy. During this visit, the monument would be inspected for punch marks, damage, water inflow, or obstructions which might interfere with setting up a tripod and GPS unit over the point to avoid delays during the viewing sessions. As most of the work was conducted during darkness, mileage was clocked from monument to monument in reverse order so the survey crewman would have a detailed route to follow during the course of the survey. The route was listed by mileage from turn to turn, and a lath with reflecting tape was placed at sharp turns in the road and at monument locations. The travel time allotted from the end of a session to the logging of data at the next setup was twenty-five minutes for the primary monuments. The actual time used averaged fifteen to twenty minutes. Since the satellites are available for only a short period of time each night, short distances between setups are important to obtain the optimum number of sessions per evening. Travel time to master monuments was considerably longer. At the end of the evening, the GPS units were collected at a central meeting place and transported to the field office.

During the survey only one day of viewing was lost because of thunderstorms and heavy rains. In general, the survey progressed in an orderly manner with no planned sessions lost during the entire period.

4.3.2 Office Work

A field office was established at the Holiday Inn in DeSoto to provide support and initial checking of the GPS data. Maps with the locations of all primary and master monuments served as the tool for planning viewing schedules and keeping track of progress. The master monument locations were plotted to scale on separate sheets to track the progress of the Order B surveys.

Trimble "Trimvec" software was used for all data reduction. The software package includes a planning utility which uses the broadcast ephemeris to predict satellite locations and times of availability. Starting in April 1990, the Department of Defense (DOD) started changing the satellite orbits to optimize the constellation for navigation. The satellite orbits were changed one vehicle at a time. The satellite vehicle would be unusable for a period of time until its new orbit was stable and the orbit data could be uplinked in a new ephemeris. It was necessary to stay in contact with personnel at Falcon Air Force Base, Colorado, to ensure that the satellites required to complete a

session would in fact be available. Satellite movement and availability changed from day to day. The broadcast ephemeris did not make this apparent, and a satellite being set unhealthy during a session would normally make the session unusable as viewing times and length of sessions are determined by the number and location of visible satellites.

At the same time that the DOD was shifting orbits, selective availability was instituted. The normal condition for User Range Accuracy (URA) of a satellite is two to three meters. Selective availability using clock dithering and false orbit information changed the URA to 32 meters. The starting position for baseline reduction is normally taken from the position obtained by the GPS unit during the session. With the effect of selective availability unknown, it was necessary to establish a starting position for the reduction in another manner. The published position of USC&GS monument "Mustang" was used for this survey.

Using the latest information from the downloaded broadcast ephemeris and the information from Falcon Air Force Base, viewing schedules would be compiled for distribution to the survey crews.

After each evening's work the GPS units were returned to the field office for data dumping, and a preliminary baseline reduction was completed using the L1 frequency to ensure that valid information for the sessions had been obtained. Once the data had been checked for validity the baselines were marked on the planning and progress charts. During the field data collection period none of the baselines failed to meet the requirements. Preliminary loop closures were formed to verify the integrity of the data and check on the effects of selective availability.

When field work was completed the office functions returned to Towill's California office. The Order B survey required the use of a precise ephemeris and not the broadcast ephemeris. NGS provides a precise ephemeris to civilian users of the GPS constellation. This ephemeris is available after a two-week delay required by DOD. At the time of the survey in April, the NGS and DOD were both employing new software and hardware to calculate the ephemeris. By the end of the field work in April, DOD had delivered information to the NGS through the end of January only. The NGS was unable to get a timetable from DOD on orbit data delivery. With the ongoing delay in obtaining the precise ephemeris, SSCL directed RTK to purchase a precise ephemeris from Aero Service Corporation. The ephemeris provided by Aero Service would not run in the Trimble "Trimvec" software package, and Towill was unable to make modifications to get it to run in a timely manner. NGS provided data for weeks 14, 15, and 16 on August 8, and this was used to reduce all data for the project.

TNRLC needed coordinate information on certain monuments to start preliminary surveying. To obtain this information, SSCL directed RTK to provide information based on the broadcast ephemeris. The needed baselines were computed and when the precise ephemeris became available, final calculations were begun.

The starting point for all baseline calculations was the NAD83 geographical position of NGS monument "Mustang." Ellipsoidal height was obtained by running a direct level circuit from USC&GS BM H955 to "Mustang" and applying the ellipsoid separation value of -26.8 m given for Mustang. A preliminary run using the L1 data was used to determine geographical positions for each master

monument. A batch file was then created using these initial positions as a starting point for each baseline reduction.

To detect and fix cycle slips, Towill used an as yet unreleased software by Trimble, which they had authorized for use on the project. This software provides the highest level of data confidence and is used only where the utmost accuracy is needed. All baselines involved in the Order B survey were reduced using this program. Templates for processing data were developed and batch files were run. All graphical cycle slip fixing was done on the same computer, as the process requires handling large amounts of data in a graphic format. As the baselines became available they were run through a loop closure routine to test for errors. All baselines, trivial and non-trivial, used in both the Order 1 and Order B surveys were subjected to the loop closure test.

The final adjustment of the Order B surveys was completed using the ion-free L1, L2 solution files and "GeoLab" least squares software. The master monuments were adjusted and the values obtained were held as fixed in the final primary monument adjustment. The least squares adjustment for the Order B survey yielded a worst-case precision of 0.4 PPM in a line length of 9700 m for a closure of 1 in 2,400,000. There were three lines with a precision between 0.30 and 0.35 PPM. The remainder of the 84 baselines measured and used in the adjustment had precisions of better then 0.30 PPM. These values equated to 4 mm over the length of any line. The average closure on the master monuments around the ring would be approximately 1 in 3,000,000. A tabulation of the standard GeoLab output is included in Appendix F.

Using the values obtained from the Order B survey, the primary monuments were adjusted using GeoLab software. The Order 1 final adjustment included 355 baselines. The worst baseline had a precision of 6 PPM or 1 in 170,000. The average precision of all baselines was approximately 3 PPM, or 5 mm, for a closure of 1 in 300,000.

The final adjusted horizontal and vertical coordinates for each monument are contained in an "SSC Survey Monument Record" which also includes the latitude, longitude, and a description of how to reach the monument using the local roads. Copies of these records are included in Appendix G.

Scale checks were made using redundant master monument baseline measurements. As an additional check, Master Monuments 005 and 012 were occupied on April 8 and again on April 10, 1990, and MM008 and MM012 were occupied on April 9, 1990 to coincide with the NGS' occupation of their Eastern Strain Network Project.

Towill has transmitted the raw data for the baselines between MM005 and MM012 and between MM008 and MM012 to the NGS for reduction and inclusion in the adjustment of their ongoing surveys. After NGS completes this work and makes the adjusted baseline lengths for MM005 to MM012 and MM008 to MM012 available to Towill, RTK will transmit the results along with an analysis to SSCL.

4.3.3 Independent Analysis

An independent analysis of the SSC geodetic networks was performed by Dr. Alfred Leick of the University of Maine to compare GPS and leveling data sets

and to combine both using geoid undulations provided by Dr. Carlos Aiken of the University of Texas at Dallas. This analysis is included in Appendix H.

4.4 Vertical Control

4.4.1 Field Work

4.4.1.1 Equipment

Towill employed two types of levels on the project. The main ring and cross ties as well as portions of the spokes were surveyed using a Jena Ni002A level. This level utilizes a reversible compensator. It has a setting precision of 0.05 seconds of arc and is considered the best First Order level available. The majority of the spokes or external legs were surveyed using a Zeiss Ni-1. This level has a setting precision of 0.10 seconds of arc. The minimum required setting precision for First Order levels is 0.25 seconds of arc. Both of these instruments are equipped with one-cm parallel plate micrometers. Two sets of new, calibrated Kern three-m lovar rods were used. These rods are graduated in one-cm intervals. The rods were supported using conventional bipod rod braces. Sixteen-pound turning plates were used.

4.4.1.2 Procedures

Field work began on May 8, 1990 using the Jena Ni002A. Arrangements had been made to use a beta version of the NGS data collection software, however, it was not yet available at the start of the field work. Initially, the data was recorded manually onto pre-printed forms. Standard procedures for first order leveling were employed. These procedures include:

- Collimation or 'C' determinations performed weekly
- Rods, tripod, and tribrach checked daily
- Readings obtained in prescribed order.

During July 1990, the beta version of the NGS software became available, and on July 17, 1990 the field crew began recording data electronically. In the next weeks, updated and modified versions of this software were received which did, however, not affect the technical operation of the software. The software forces the user to comply with all requirements of First Order leveling at each instrument setup before the instrument can be moved to the next setup. Readings must be taken in the prescribed manner. The software also improves the field production rate by eliminating the need to perform check calculations.

A second leveling crew using the Zeiss Ni-1 level and a CMT MC-V computer began work on July 23, 1990. The work performed by this crew was limited to the spoke areas. The software accommodates the use of different instruments. Collimation checks are required on a daily basis when using the Zeiss Ni-1.

Work was performed under varying weather conditions. Temperatures ranged from 45°F (7°C) to 110°F (43°C). Winds varied from still to 35 knots (65 km/hr). No work was performed during high-wind days. Each crew was equipped with highway safety signs and cones. The safety equipment was deployed each day in conformance with Texas DOT standards.

Closures were made in the field and checked by the office staff. Sections that did not meet first order closure requirements were identified and re-run. In some cases this procedure was repeated several times. Evaluation of the data indicates most re-runs were precipitated by high wind.

4.4.2 Office Work

Initially, data was reduced by hand and entered onto abstracts. Electronically collected data was down-loaded in the field into a laptop computer. The file was processed using the program supplied by the NGS. The processed data was recorded on floppy disks and transferred to in-house computers. Some difficulties were encountered using the NGS office programs and a program was written to process the data into elevation differences.

Preliminary closures on the loops were computed prior to final adjustments by NGS. Preliminary elevations were transmitted to SSCL in the draft report, dated February 1991.

4.4.3 Independent Evaluation

The field data was furnished to Dr. Carlos Aiken of the University of Texas and Dr. Alfred Leick of the University of Maine. Working together, Dr. Aiken and Dr. Leick performed an independent adjustment of the data. This adjustment included the GPS and level data, as well as gravity data furnished by Dr. Aiken. A copy of the adjustment and report is included in Appendix H.

4.4.4 Final Adjustment

The leveling data was reprocessed through the field programs NEWREC and ABSTRA for the MCV data logger and submitted by Towill to the NGS for final adjustment.

The benchmark descriptions were checked and loaded into the NGS integrated data base (NGSIDB) with unique identifiers. The observation data set was corrected for systematic errors (i.e., rod scale, rod temperature, level collimation, refraction, astronomic and orthometric corrections) and reformatted by the REDUC4 program in preparation for entering the data into NGSIDB.

Further analysis and adjustment of the data followed after the data were loaded. The data were retrieved from NGSIDB and adjusted in a minimum constraint, least squares adjustment holding only one previously determined height fixed, i.e., that of BM608 which is a standard USC and GS benchmark stamped with B-389, 1946.

Differences between preliminary and final adjusted elevations on the monuments varied from 0 to 9 mm (0 to 0.031 ft).

CHAPTER 5

CONCLUSION

RTK has constructed a comprehensive system of horizontal and vertical control that will serve the needs of SSCL and TNRLC. The system is sufficiently precise for property acquisition, design and construction of conventional facilities, and maintenance of these facilities in the future.

The basis of bearings for the horizontal control is the Texas State Plane Coordinate system, North Central Zone, North American Datum of 1983 (NAD 83). Elevations are based on the National Geodetic Vertical Datum of 1929.

All monuments have been located in public rights of way and exposure to activities which might disturb the monuments has been minimized. Monument construction took place in March and April 1990, when the ground was saturated from extremely heavy and persistent rain storms. An inspection of all monuments in the system was performed in late October 1990, after the ground had dried out over the summer. Ground subsidence amounted to as much as six in. (15 cm) in the eastern portion of the ring where expansive soil, i.e., Taylor Marl, lies at the surface and on the far end of the western leg of vertical benchmarks where there is some exposed Eagle Ford Shale.

Since the monument rods were firmly anchored in bedrock, the rods had not moved. The surface ground, however, has subsided in some locations, lowering the monument covers and their concrete collar assemblies and exposing the tops of the monument rods by as much as three in. (8 cm) above the covers. At most monument locations, the top of the rod is still below the cover. The monument cover has a threaded screw to fasten the cover to the cover frame. If the screw threads had been engaged while ground subsidence took place, the cover assembly would have jarred the top of the rod, possibly disturbing the precise location of the monument. To prevent this, all screws have been removed from the monument covers.

The success of this program was enhanced by the cooperation of many of SSCL's neighbors, i.e., the Texas Department of Transportation, the Ellis County Road Commissioners and Public Works Administrators, and the Public Works departments of the affected cities. Since the State of Texas has no recording system whereby the horizontal and vertical positions of the monuments can be placed for access by the entire surveying and engineering community, RTK recommends that this report be distributed to the various State, County, City and other agencies listed in Appendix I.

REFERENCES

1. RTK. The Superconducting Super Collider Survey Control Workshop. Oakland, CA. December 1987. (Unpublished)

2. RTK. Horizontal and Vertical Control System for the Startup Geotechnical Characterization Program at the SSC Site. December 1990. SSCL-SR-1149.

3. Slonaker, J. Control Surveying for SSC Boundary Location. July 20, 1989.

4. Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Version 5.0. Federal Geodetic Control Committee. 1988.

5. Specifications to Support Classifications, Standards of Accuracy, and General Specifications of Geodetic Control Surveys. Federal Geodetic Control Committee. Revised June 1980.

APPENDIX A

DRAWINGS

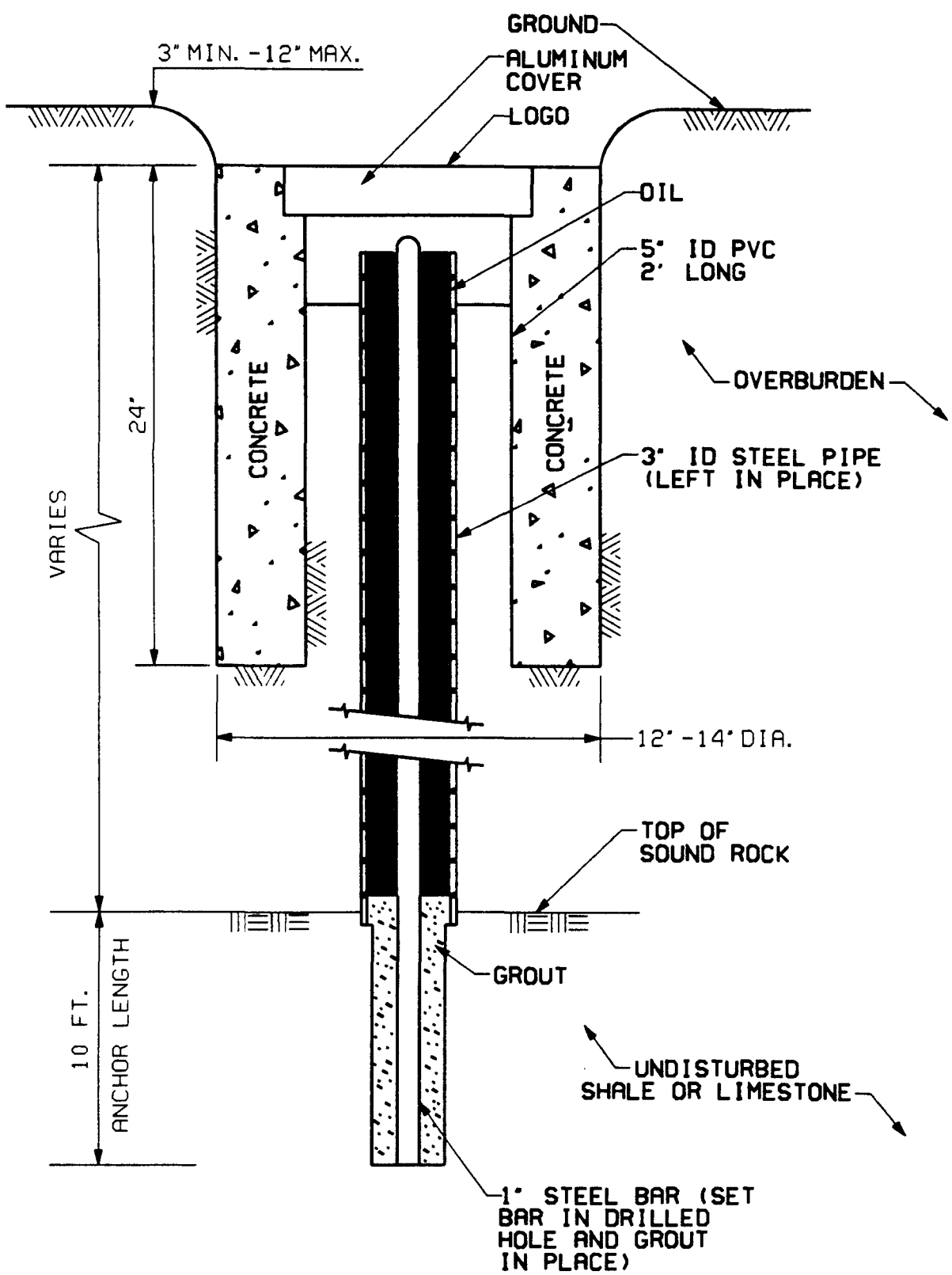
DRAWINGS

Master Monument Construction Details

Primary Control Monument (NGS 3-D Monument) Construction Details

CS-5 - Control Scheme for Property Acquisition for G-Ring Alignment - Alternative D

CS-30 - Monument Locations for Horizontal and Vertical Control



MASTER MONUMENT

CONSTRUCTION DETAILS

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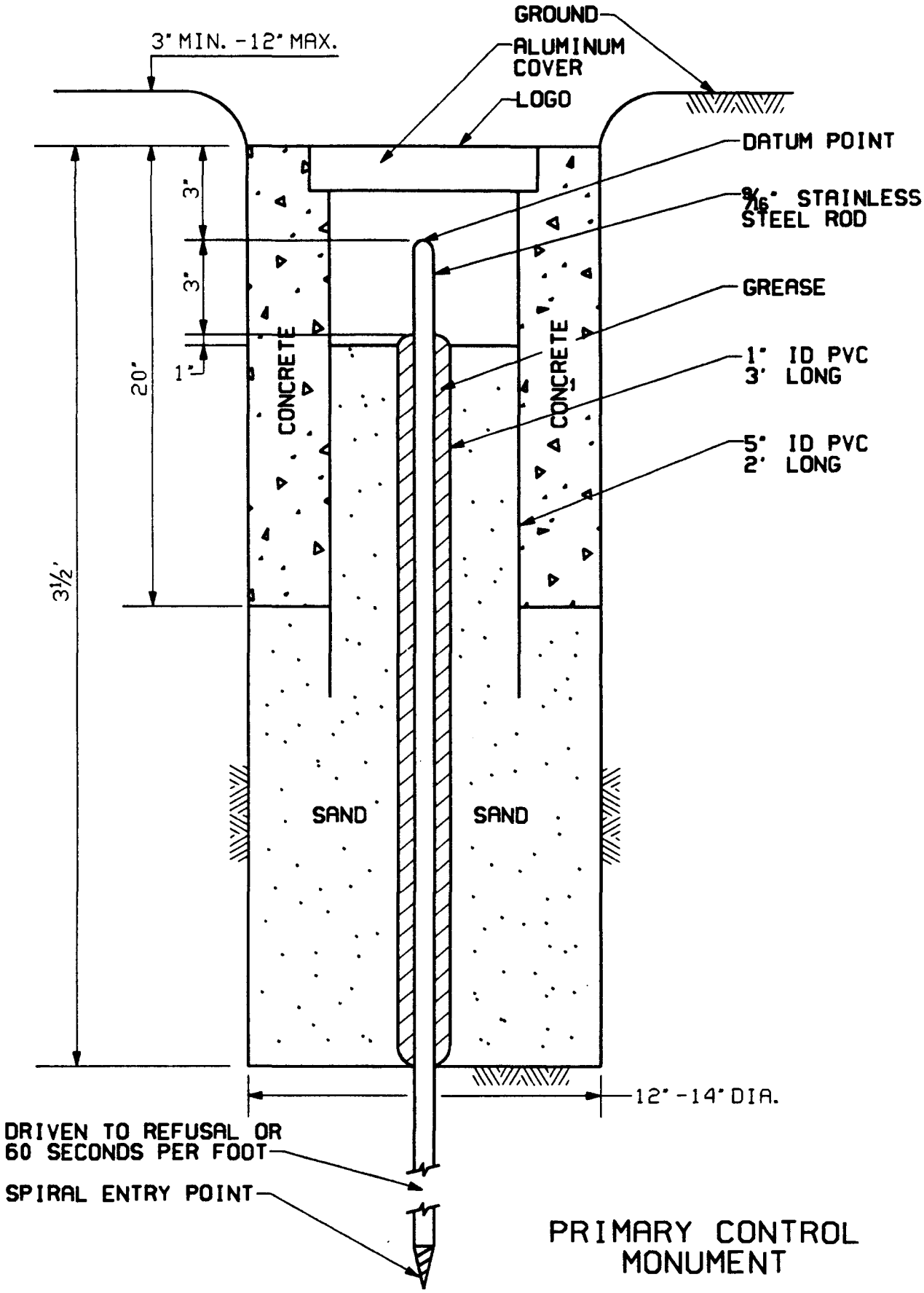


PRIMARY CONTROL MONUMENT

(NGS 3-D MONUMENT) CONSTRUCTION DETAILS

MASTMON.DGN 18-OCT-1990 15:02

APPENDIX B

RTK DOCUMENTATION

DRAFT

PRELIMINARY SURVEY PROGRAM

1. Locate Existing Horizontal Control.

   - Obtain USGS horizontal control diagram for Dallas, Texas.

   - Obtain USGS descriptions of First and Second Order control points in the area around the proposed SSC footprint.

   - Locate monuments in the field and take photographs and descriptions of monuments for the files.

2. Design Horizontal Control System To Support Property Acquisition.

   - Design a system of horizontal control to be used to support the determination of which property will be needed in fee or easement for the SSC footprint.

   - Consideration during design of the control system shall be given to using the monuments wholly or in part in conjunction with future control systems to be set up for aerial mapping, conventional facilities design, conventional systems construction, technical systems construction, and operation of the laboratory.

   - Design monumentation details consistent with USGS First and Second Order monumentation criteria and for installation and long term use in the local soil conditions.

   - Develop a schedule for implementation of the new control work consistent with the needs of the DOE.

   - Develop standards for survey methods and levels of precision for each different control network to be used.

3. Develop A Plan For Property Surveys.

- o Develop a plan and schedule for surveying the boundaries of all property in the immediate vicinity of the SSC footprint. Coverage of property included in the survey shall include all property wholly or partially within the SSC footprint as well as those parcels judged to be close enough to the footprint to be effected by small changes in it's location.

- o Investigate available methods for ability to perform the surveys within the time allotted in the schedule:

  - Transit and tape surveys

  - Total station surveys

  - GPS surveys, static and kinematic

  - Photogrammetric surveys

4. Coordination With The Local Surveying Community.

- o Maintain contact with the State Land Surveyors Association for dissemination of survey system plans and schedules as they are developed to facilitate planning of staff and equipment needs for the project by private industry.

- o Maintain contact with the State Land Surveyors Association and the local surveying academic community for development of innovative survey methods for the project.

DRAFT

June 7, 1989

CONTROL SURVEYING AND BOUNDARY LOCATION
SSC LAND ACQUISITION

RTK REPORT ON A FIRST DRAFT SURVEY CONTROL PLAN TO SUPPORT THE LAND ACQUISITION FOR THE SSC PROJECT

On May 26, 1989, a surveying meeting was held at the offices of the SSC Laboratory in Dallas, Texas with representatives from URA/CDG, Sverdrup, TNRLC and RTK in attendance. One of the agenda items was planning the land surveying activities to support property boundary location associated with land acquisition for the SSC project.

At this meeting a draft report titled "CONTROL SURVEYING AND BOUNDARY LOCATION - SSC LAND ACQUISITION" (the Report) was presented by Mr. John Slonaker of the Texas National Research Laboratory Commission (TNRLC). The stated purpose of the Report was to document the surveying and mapping requirements of the Commission during the land acquisition process.

The next step is to develop a plan for the horizontal and vertical control and the photogrammetric base maps necessary to support the land acquisition process. The criteria established in the report is:

Footprint. The SSC footprint upon which all this planning is being based is that which was published as a supplement to the Invitation for Site Proposals (ISP) entitled A Study of the ISP Footprint, by J.R. Sanford, June 1988.

Control Survey Positional Tolerance. A network of horizontal control was specified in the Report to support the boundary location surveys necessary to proceed with property acquisition. A description of this network, in ascending order, is as follows:

Horizontal Control

Tertiary Control. Survey monuments spaced at approximately 1,600 foot intervals and set with a positional error tolerance of 1:20,000, National Oceanic and Atmospheric Administration (NOAA) Second-Order, Class II standards.

Secondary Control. Survey monuments spaced at approximately 3,000-4,000 foot intervals and set with a positional error tolerance of 1:50,000, National Oceanic and Atmospheric Administration (NOAA) Second-Order, Class I standards.

Primary Control. Survey monuments spaced at approximately 6,000 - 8,000 foot intervals and set with a positional error tolerance of 1:100,000, National Oceanic and Atmospheric Administration (NOAA) First-Order standards.

Baseline Control Network. Survey monuments spaced at undetermined intervals and set with a positional error tolerance of 1:1,000,000, Federal Geodetic Committee Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Order B.

Vertical Control

No specific vertical control was specified in the Report, although NOAA Second-Order standards were mentioned in the discussion on acquisition of Stratified Fee Estate.

Photogrammetric Base Maps

A series of planimetric orthophotos covering the footprint and adjacent areas are needed to locate physical features on property effected by the SSC project. Planimetriclly correct orthophotos were specified because of their ability to provide images which can be scaled accurately for use in determining lengths and areas of improvements or other visible features. A series of "D" size drawings with a standard 22 inch by 34 inch working area was determined with the mapping scale set at 1 inch = 400 feet.

As a first draft, two alternative control plans are included in this report. Common to both plans are the Baseline Control network and the photogrammetric base map layout with its required horizontal and vertical control. A verbal requirement for mapping coverage to extend approximately 8,000 feet on each side of the footprint was set at the meeting by Mr. Slonaker.

Baseline Control Network. A network of nine points is shown for the baseline control network. Seven of the points are located around the periphery of the footprint and are separated by distances ranging from six to twelve miles. Two points are located within the circular limits of the footprint. These points should be set in conformance with the requirements of the Federal Geodetic Committee Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Order B.

Photogrammetric Base Mapping. The mapping was laid out using data presented in the "Aerial Photography and Photogrammetric Mapping Chart" printed by Western Air Maps, Inc., which was attached to the Report. The photographic model layout shown on drawings CS-1 and CS-2 is based upon the data shown for a 6" focal length camera and a negative scale of 1 inch = 2,640 feet. The coverage provided by model layout exceeds the criteria set by Mr. Slonaker because two parallel flight lines were used. The specified coverage can not be obtained with a set of single flight lines. The model layout may be optimized by further study and/or revised criteria. The current plan shows sixty-eight models and twenty-five "photogrammetric only" flight crosses. These flight crosses would require horizontal and vertical control to be established to NOAA Second-Order, Class II standards. An additional seventeen flight crosses will be required to control the photogrammerty. These can be set on other control points in the SSC network, however, Second-Order, Class II vertical control must be added to these points.

Alternative A. Alternative A shows a control scheme laid out using criteria set in the Report. To begin with, tertiary control point locations were laid out at approximately 1,600 foot to 2,000 foot intervals in the areas where the footprint overlaid existing property lines. Next, some of the tertiary points were changed to secondary points so that secondary points were separated by approximately 3,000 feet to 4,000 feet. Then, some of the secondary points were changed to primary points so that primary points were separated by approximately 6,000 feet to 8,000 feet. This results in a total of 297 control points in the network excluding baseline control and flight crosses. This breaks down to approximately 51 primary points, 66 secondary points and 180 tertiary points for a total of approximately 297 points.

Alternative B. Alternative B shows a control scheme laid out using only primary control points set in pairs approximately 2,000 feet apart with pairs being separated by approximately 5,000 feet to 10,000 feet. This more widely spaced monument pattern is justified because the property boundary surveys are very likely to be performed using modern total stations or combinations of theodolites and electronic distance meters which can cover the monument spacing in two or three shots, making the dense network in Alternative A unnecessary. The monuments are arranged in pairs to provide a second monument to use as a backsight or foresight from the first monument during traversing. This results in a total of 86 primary points.

Vertical Control. A network of vertical control benchmarks is required to control the vertical aspects of any stratified fee estates around the footprint. The required accuracy of this network has not yet been established. If elevations for these estates are required to be accurate within a few hundredths of a foot (0.01' to 0.05'), the network will have to be established using differential leveling, representing a considerable expense for a network covering the perimeter of a 53 mile ring. Significant savings could be realized if the accuracy can be reduced to a few tenths of a foot (0.1' to 0.3'). This work can be accomplished during the location of the monument network using Global Positioning Satellite (GPS) techniques.

MONUMENTATION FOR THE SSC BASELINE CONTROL NETWORK

RTK

DON SCAPUZZI

JULY 21, 1989

Attached is copy of an article on GPS surveying[1] in which reference is made to a GPS control network developed by the Tennessee Department of Transportation (TDOT).

Because of its higher degree of accuracy, this network is independent of the NGS network, although it is tied into points in the old triangulation network.

The TDOT contact for this work is Jack Lindsey, 615-594-6300. Mr. Lindsey furnished the following information regarding this work:

- The system consists of 60 to 70 points spread over the entire state.
- NGS constructed the monuments to their specifications for 3-D monuments in a cooperative agreement with TDOT. The work was accomplished well within the time scheduled. NGS also furnished written descriptions of each monument.
- The location of each monument was established by TDOT to fit their needs. No reference monuments were set. Only a few of the new monuments have azimuth marks for conventional traversing use.
- NGS had the latitude to slightly shift monument locations for ease of construction, as long as the requirements for use as a GPS station were not compromised.
- TDOT uses NAD 83 datum for the Tennessee state plane coordinate system.
- Mr. Lindsey listed Mr. Rodger Merrill, Texas Department of Transportation, Austin, as a knowledgeable resource in Texas for GPS work and "super monumentation."

[1] Collins, James. Shooting for a Full GPS Constellation. Professional Surveyor, July/August 1989.

Shooting For A Full GPS Constellation

New satellites are going up while prices for receivers come down. The combination will allow GPS to reach into new areas of application in the coming years.

by Dr. James Collins 301 - 340 - 7215

The first of the "new" Block II GPS satellites was launched into orbit in February. The satellite was carried into space from Cape Canavaral, Florida, by a U.S. Air Force Delta II rocket, and was declared operational in March.

Current plans include launching a new satellite every other month until the full constellation is in place sometime in the early 1990s. At that point, 24-hour coverage should be available worldwide. Presently, several Block I satellites in orbit are operational. They provide continuous coverage for eight-to-ten hours per day for two-dimensional surface navigation, and four-to-five hours per day for three-dimensional air navigation.

As the satellites go up, electronic manufacturers seem to have discovered the potential importance of GPS as a consumer item in the coming decades. Even now the degree of sophistication of survey receivers is increasing while the price is decreasing. Several firms have brought state-of-the-art electronic design to bear on the problem, so that instead of a two-channel, $150,000 instrument of a few years ago we have 12-channel, $30,000 instruments. It seems likely that this trend will continue (although probably at a slower pace) until, by the mid-1990s, GPS equipment will be selling for the price of total stations.

The use of GPS systems in surveying is, in fact, quite similar to that of total stations. In a sense, GPS (used differentially) does nothing more than measure the azimuth, distance and vertical angle between two points. When surveyors combine interconnecting GPS measurements in a network of lines, the resulting framework provides an excellent way to interpolate between points whose coordinates are known. Most surveyors can easily visualize how such a system can be used to interpolate between two or more horizontal control points, but they often fail to see that they must also interpolate between vertical points.

GPS will undoubtedly be used for more and more tasks in the coming decades. Some of these include the establishment of accurate coordinates on every parcel in the country, as well as determining the coordinates of all the data that goes into our state and national digital data bases. Even today, a small number of surveyors are using GPS to determine coordinates at various project sites as they perform their conventional surveys. To do this, they simply take a GPS receiver with them to the project site and set it up over one of the control points. While they are performing their normal stake-out and traversing, the GPS receiver is busy determining the state plane coordinates of the reference point.

GPS Information Sources

by Larry Hothem

GPS Satellite Clock Behavior and Related GPS Information
U.S. Naval Observatory
Washington DC 20392-5100

Dial-up on-line computer files:
Requires full duplex, seven data bits, even parity, upper case
300 or 120 baud 202/653-1079
2400 baud or CCITT.21 or CCITT.22 bis 202/653-1783.

Files of interest:
@GPS: GPS status information
@GPSTD: Constellation status
@GPSB2: Block II constellation information
@GPSSY: GPS system explanation
@GPSAC: GPS time transfer performance
@GPSPD: Detailed time steering, clock changes and system modification
@GPSXP: Directory and explanation of @GPS commands

USNO Series 4 Weekly Bulletins: Received by mail, they contain information on the status of GPS including GPS, time steering and satellite clock behavior.
Contact Ms. Christina Dise at 202/653-1525 for assistance.

Precise GPS Orbit Information

Government: Precise orbital positions and velocities based on post computations of tracking data collected from stations of the Cooperative International GPS Tracking Network (CIGNET) are available from the National Geodetic Survey. Satellite orbital data are scheduled to be available two weeks after the tracking data are collected. For a description of formats, fee schedule or to order data, contact:
National Geodetic Information Center, N/CG17
National Geodetic Survey
National Ocean Service, NOAA
Rockville MD 20852
301/443-8775

Commercial: Precise orbit data is available from the Aero Service Division, Western Atlas International, using data obtained from its tracking network stations. For a description of format, fee schedule or to order data, contact:
Jim Cain
Manager, GPS Services
Aero Service Division
Western Atlas International
3600 Briarpark Drive
PO Box 1939
Houston TX 77251-1939
713/784-5800

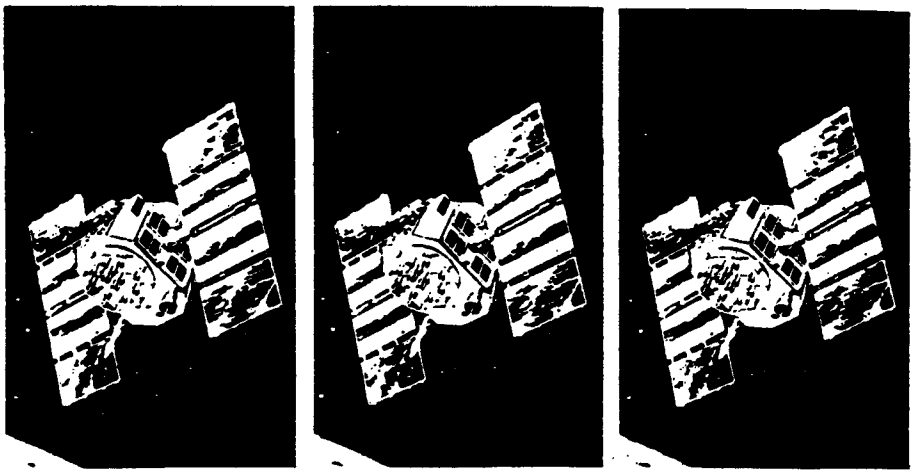
GPS Satellite Status and Health
Navstar/GPS Operational Control System
Falcon Air Force Base
Colorado Springs CO 80914-5000

Recorded daily operations report 719/550-2115
Live Mission Operations Controller 719/550-2363
(Note: Civilian access to this service will be restricted once the Civil GPS Service becomes operational sometime in 1989.)

General GPS Electronic Bulletin Board at Yuma

Operated by General Dynamics Services Company for the U.S. Air Force Space Division at Yuma. The Bulletin Board provides a daily almanac, observed range errors, comments on the satellites or Yuma Reference Station data collection and the OCS Advisories. Five days' tracking data is maintained. The nominal schedule is a five day test week during the four satellite tracking window.

Requires full duplex, eight-bit data words, no parity and one stop bit (*preferred because it supports the X-modem and Y-modem error checking block transmission*) or full duplex, seven-bit word, odd or even parity and one stop bit.
1200 (preferred) or 300 baud 602/328-3162
(military Autovon) 899-3162



Thus, at the end of the work day, the survey crew not only has a highly accurate relative site survey, but the coordinates of all points established in the national reference system as well. If all surveyors were to do this, we would soon have the precise coordinates of many thousands of points ready to place in various digital data bases.

Many more surveyors are using GPS to perform control surveys, and it is this use that makes GPS highly cost-competitive today. For example, placing accurate GPS points at regular intervals throughout a county or state or placing points along a planned road or transmission line are highly cost-effective uses of these systems. The resulting control points can be used with high confidence by surveyors to control their property and construction surveys. When a GPS survey is properly executed and the proper quality control measures are applied, it can be an almost flawless survey.

In the past year, the term "kinematic GPS" survey has become the latest buzz word. Kinematic surveys are performed by placing a pair of receivers at two known points. After a few minutes of data collection, one receiver (designated as the roving receiver) is moved to a new point, where again a few minutes of data are collected. As long as a minimum of four satellites (five or more are desirable) are continuously tracked, the surveyor can maintain accuracy to a few hundredths of a foot.

Because of the four-satellite requirement, surveyors using this technique must work in areas where they can avoid obstruction in those portions of the sky where the satellites appear. When they find sites that meet this specification, surveyors will be able to determine accurate coordinates of points with a few minutes observing time. The present satellite "window of opportunity" virtually limits the use of kinematic surveying to areas of maximum coverage, but it won't be long before increased coverage makes this technique useful everywhere.

Another similar technique being discussed today is the pseudo-kinematic method. The field technique is quite similar to the kinematic method in that satel-

Continued on page 40

Performance of GPS Satellite Survey Systems
GPS Test Coordinator
Instrument Subcommittee
Federal Geodetic Control Committee
c/o National Geodetic Survey, NOAA
N/CG14, Rockwall 306
Rockville MD 20852
301/443-8171

The Civil GPS Service

The CGS is evolving under the guidance of a steering committee representing the civil user community and the Department of Transportation. CGS will serve as a source of information and point of contact for civil users, and GPS status, and information will be disseminated by the Civil GPS Information Center. The CGIC is expected to begin operations in 1989. For information, contact:
Chairman, CGS Steering Committee
U.S. Department of Transportation
Research and Special Programs Administration
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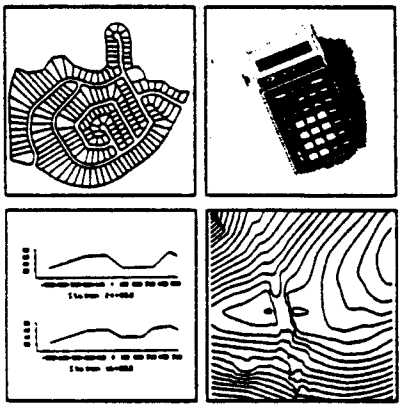
Larry Hothem is chief, Astronomy and Space Geodesy Section of the National Geodetic Service, which is responsible for the GPS satellite surveying programs within NGS.



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GPS

Continued from page 23

lites must be tracked during moves to new points. This method could also be called "pseudo-static," since the same processing technique is used for the "conventional" static technique. This method is more hardy than the pure kinematic mode, in that continuous tracking of all four satellites is not mandatory. The disadvantage, however, is that the surveyor must remain at the point for longer periods of time and must make multiple point occupations to obtain a solution.

A combination of the static, kinematic and pseudo-kinematic GPS survey methods will be used in the future for construction stake-out control, topographic surveys, boundary surveys and photo-control surveys. The cost per point surveyed can be much less using GPS than using the conventional total station approach.

For example, in clear areas an all-terrain vehicle equipped with GPS will be able to drive over an area in a designated pattern collecting digital terrain data accurate to a tenth of a foot or better. Topographic surveys using GPS will be conducted in a manner similar to the way hydrographic data are collected. Upon completion of the day's work, the surveyor will simply dump the data into a computer, where it can be computed and automatically plotted.

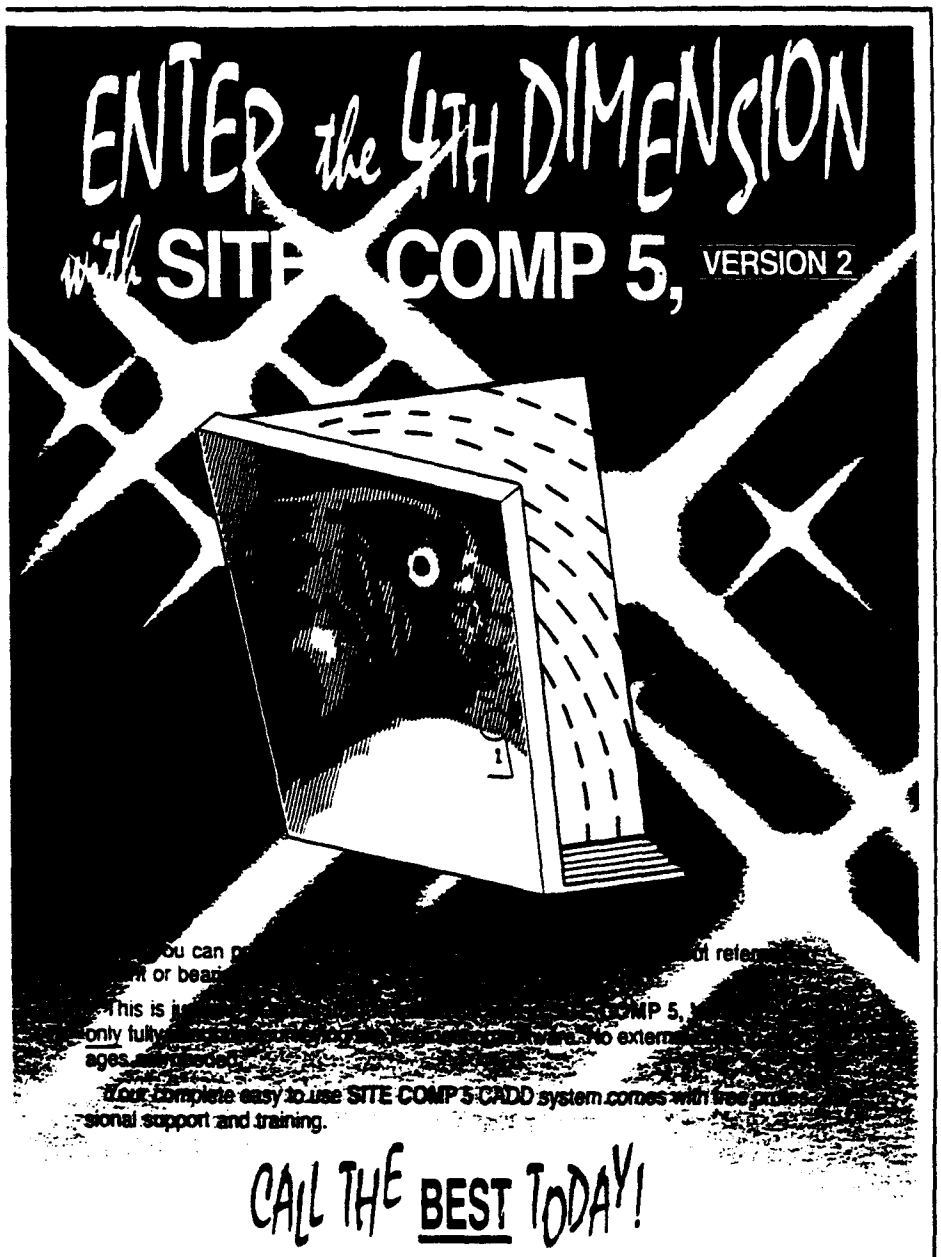
There is, however, still a prejudice among some surveyors against using GPS to determine accurate elevations of points. This prejudice stems mainly from the fact that the system has been misused by some, and uncorrected GPS elevations have been mistakenly compared to true spirit-leveled elevations.

The proper way to ensure that accurate elevations are determined using GPS is to make sure surveys are connected to three or more well spaced benchmarks. When this procedure is carefully followed, surveyors can be assured of obtaining elevations good to plus or minus a tenth of a foot. Special network adjustment programs such as GEOLAB and FILLNET perform both the horizontal and vertical interpolations automatically.

There is also some disagreement over control networks. Several states have virtually abandoned the existing national horizontal (NGS & USC&GS) control network, primarily for two reasons. First, the existing NGS network points are in difficult to reach locations which are also often unsuited for GPS occupation (surrounded by trees, for example). Since GPS surveyors are the first to systematically make use of the national horizontal network points, it is not surprising that they would prefer a different set of control reference points.

The second reason is accuracy. Today's GPS surveyors can normally obtain accuracies ranging from 1:200,000 to 1:500,000, while some parts of the national network show accuracies between adjacent points much less than this. As a result, the GPS surveyor is faced with the problem of performing control surveys at accuracies exceeding the accuracies of the control he is required to tie his work to.

This combination of problems with the national network points has led some states to develop their own GPS control network (in cooperation with NGS) with accuracies ranging up to 1:10,000,000. These



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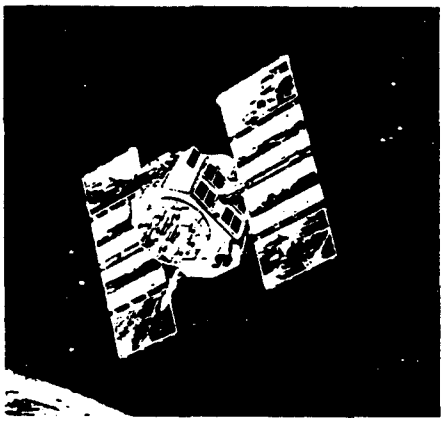
"super" control points are located in easily accessible areas that are free from obstructions and thus provide ideal points to tie in any GPS survey. An example of this type of network is the one established by the Tennessee Department of Transportation. Agencies such as the TVA have been requiring that GPS surveys performed for them be tied to this super control network, which is also tied into points in the old triangulation network.

It may sound confusing to have two reference networks in a given state, but the widespread use of GPS requires that surveys be tied to some network of higher-order points. Since the existing national system is clearly unsuited for this purpose, it appears that the trend for upgrading state networks will continue.

It should also be mentioned that the GPS super control points will have accurate published ellipsoidal heights as well as geoidal heights. The trend to determine both ellipsoidal (by GPS) and geoidal heights at control points will greatly facilitate determining the proper "corrections" to heights determined by GPS surveys, so accurate elevations can be obtained. As the control networks are further densified, and levels are run to these points, it will become possible to determine more accurate "true" elevations using the GPS system.

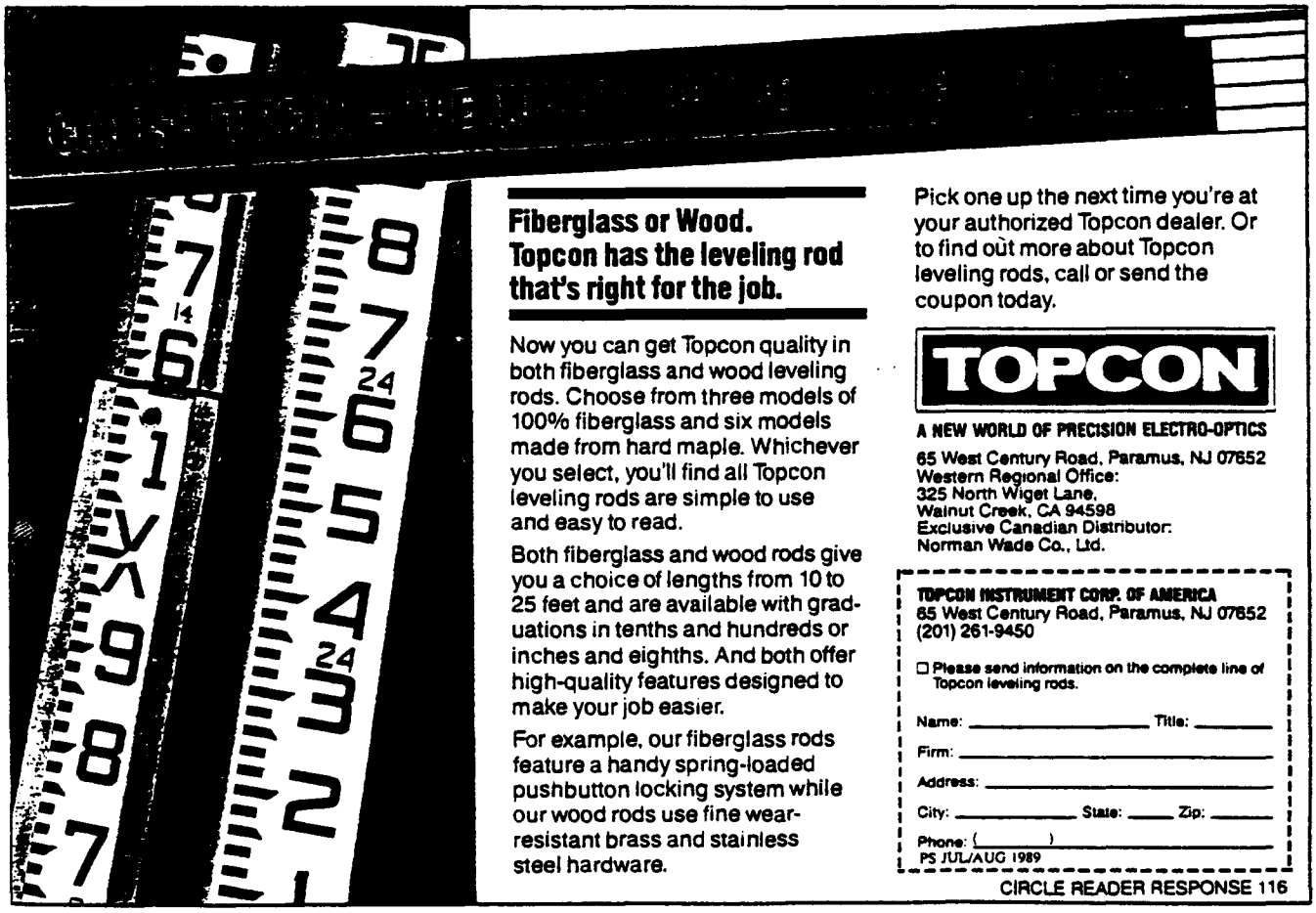


Is GPS here to stay? You bet it is. In the coming decade we will see GPS receivers in common use in automobiles, boats, trains and planes. At least one GPS surveying equipment manufacturer also produces vehicle tracking systems that are capable of showing a road map of the entire United States, or zeroing in on a city block. The future driver will be able to call up the nearest hospital, grocery store or motel on his automobile digital map display by punching in a special code. He will then be able to plot the shortest route to his destination, since GPS will give him his precise position on a continuous basis.

In 1983, when I started performing GPS surveys, information was scarce and interest was minimal. Today there are a score of seminars dealing with this subject and most state society meetings devote at least a portion of their meeting to GPS.

Like the use of electronic distance measuring equipment, GPS has the potential to revolutionize our profession. This is the year that satellites will begin going up on a regular schedule until the full constellation is up. In my opinion, next year will mark the beginning of an era in which GPS is truly popularized. **PS**

Dr. James Collins is vice president for marketing at Ashtech, Inc., in Sunnyvale, California. He is the founder and former president of GeoHydro, Inc.



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CIRCLE READER RESPONSE 116

CONTROL SURVEYING AND BOUNDARY LOCATION
SSC LAND ACQUISITION

RTK REPORT ON A SECOND DRAFT SURVEY CONTROL PLAN
TO SUPPORT THE LAND ACQUISITION FOR THE SSC PROJECT

Don Scapuzzi

August 9, 1989

Several meetings of the SSC Survey Advisory Panel have been held at the SSC Laboratory offices in Dallas, Texas. The panel is made up of representatives of staff from the SSC Laboratory, Sverdrup, TNRLC and RTK.

First and second drafts of a report titled "CONTROL SURVEYING AND BOUNDARY LOCATION - SSC LAND ACQUISITION" (the Report) have been prepared by Mr. John Slonaker of the Texas National Research Laboratory Commission (TNRLC). The stated purpose of the Report is to document the surveying and mapping requirements of the Commission during the land acquisition process for the SSC project.

The second draft of the report presents criteria for controlling the property surveys based upon a baseline control network of monuments established consistent with Order B accuracy standards as specified in Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques; Federal Geodetic Control Committee; Version 5.0, May 1988. This network is augmented by a primary control network of monuments established consistent with First Order accuracy standards and photogrammetric base mapping control monuments established with unspecified accuracy standards.

The next step is to develop a plan for the horizontal and vertical control and the photogrammetric base maps necessary to support the land acquisition process. The criteria established in the Report is:

Footprint. The SSC footprint upon which all this planning is being based is that which was published as a supplement to the Invitation for Site Proposals (ISP) entitled A Study of the ISP Footprint, by J.R. Sanford, June 1988.

Control Survey Positional Tolerance. A network of horizontal control is specified in the Second Draft Report to support the boundary location surveys necessary to proceed with property acquisition. A description of a minimum network, in ascending order, is as follows:

Horizontal Control

Secondary Control. Survey monuments spaced at approximately 3,000-4,000 foot intervals and set with a positional error tolerance of 1:50,000, National Oceanic and Atmospheric Administration (NOAA) Second-Order, Class I standards.

Primary Control. Survey monuments spaced at approximately 6,000 - 8,000 foot intervals and set with a positional error tolerance of 1:100,000, National Oceanic and Atmospheric Administration (NOAA) First-Order standards.

Baseline Control Network. Survey monuments spaced at undetermined intervals and set with a positional error tolerance of 1:1,000,000, Federal Geodetic Committee, Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Order B.

Vertical Control

No specific vertical control was listed in the Report.

Photogrammetric Base Maps

A series of planimetric orthophotos covering the footprint and adjacent areas are needed to locate physical features on property effected by the SSC project. Planimetriclly correct orthophotos were specified because of their ability to provide images which can be scaled accurately for use in determining lengths and areas of improvements or other visible features. A series of "D" size drawings with a standard 22 inch by 34 inch working area was determined with the mapping scale set at 1 inch = 400 feet.

Two alternative control plans are included in this report. Common to both plans are the Baseline Control network, the Primary Control Network and the photogrammetric base map layout with its required horizontal and vertical control. A verbal requirement for mapping coverage to extend approximately 8,000 feet on each side of the footprint has been set by Mr. Slonaker at the May 26 meeting of the SSC Survey Advisory Panel.

Baseline Control Network. A network of nine points is shown for the baseline control network. Seven of the points are located around the periphery of the footprint and are separated by distances ranging from six to twelve miles. Two points are located within the circular limits of the footprint. These points should be set in conformance with the requirements of the Federal Geodetic Committee Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Order B.

Photogrammetric Base Mapping. The mapping was laid out using data presented in the "Aerial Photography and Photogrammetric Mapping Chart" printed by Western Air Maps, Inc., which was attached to the Report. The photographic model layout shown on drawings CS-3 and CS-4 is based upon the data shown for a 6" focal length camera and a negative scale of 1 inch = 2,640 feet. The coverage provided by model layout exceeds the criteria set by Mr. Slonaker because two parallel flight lines were used. The specified coverage can not be obtained with a set of single flight lines. The model layout may be optimized by further study and/or revised criteria. The current plan shows sixty-eight models and twenty-five "photogrammetric only" flight crosses. These flight crosses would require horizontal and vertical control to be established to NOAA Second-Order, Class II standards. An additional seventeen flight crosses will be required to control the photogrammetry. These can be set on other control points in the SSC network, however, Second-Order, Class II vertical control must be added to these points.

Alternative B-2. Alternative B-2 shows a control scheme laid out using primary control points set in pairs approximately 2,000 feet apart with pairs being separated by approximately 5,000 feet to 10,000 feet. This monument pattern is adequate to control the property boundary surveys since they are very likely to be performed using modern total stations or combinations of theodolites and electronic distance meters which can cover the monument spacing in two or three turns or set-ups. The monuments are arranged in pairs to provide a second monument to use as a backsight or foresight from the first monument during traversing. This results in a total of 86 primary points.

Alternative C. Alternative C-2 shows the control scheme for Alternative B-2 with the addition of ten primary monuments at shaft locations which are located slightly away from one of a paired set of primary control points. These points would be set at a point intervisable with one of the other points in the nearest pair so an azimuth can be obtained by a transit station for use in construction staking or control. This alternative is intended to show how the control network established for property acquisition could be utilized for final design and construction.

Vertical Control. A network of vertical control benchmarks is required to control the vertical aspects of any stratified fee estates around the footprint. The required accuracy of this network has not yet been established. If elevations for these estates are required to be accurate within a few hundredths of a foot (0.01' to 0.05'), the network will have to be established using differential leveling, representing a considerable expense for a network covering the perimeter of a 53 mile ring. Significant savings could be realized if the accuracy can be reduced to a few tenths of a foot (0.1' to 0.3'). This work can be accomplished during the location of the monument network using Global Positioning Satellite (GPS) techniques to establish vertical control on the same monuments used for the Baseline Control and Primary Control networks.

Future Control System Requirements. Additional monuments for design/construction similar to the ten monuments shown on Alternative C should not be constructed until shortly prior to the start of the final design phase. This allows for last minute changes in the configuration of the conventional facilities for the project. Additionally, a complete resurvey of all base line control and primary control monuments should be accomplished prior to the start of construction to verify that none of the monuments have been disturbed or shifted from their original positions.

The monuments used to control the installation of the technical facilities after conventional construction is completed may also be the same Baseline Control and Primary Control monuments used for property acquisition, final design and construction. The actual requirements for this system have not yet been determined, but similar systems have been utilized at other laboratories.

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08/31/89
D. Scapuzzi

CONTROL SURVEYING AND BOUNDARY LOCATION
SSC LAND ACQUISITION

RTK REPORT ON A THIRD DRAFT SURVEY CONTROL PLAN TO SUPPORT THE LAND ACQUISITION FOR THE SSC PROJECT BASED UPON THE AUGUST 1989 G-RING ALIGNMENT

At the August 9, meeting of the SSC Survey Advisory Panel held at the SSC Laboratory, a request was made to prepare a site-specific control scheme for the G-ring alignment. This scheme was to include master control monuments and primary control monuments only.

The criteria for locating these monuments are described below.

Alternative D

A total of nine master control monuments were located at seven strategic locations around the outside of the ring footprint and two strategic locations within the ring. Spacing of these monuments varies between 5.1 mi and 9.5 mi; the average spacing is 7.5 mi. All monuments are located in or adjacent to public road rights-of-way. These monuments will be intervisible only through the use of towers.

Alternative D has 79 primary control monuments. Seventy-two were located in pairs at 6,000- to 12,000-ft intervals around the ring within the property areas affected by the G-ring footprint. The monuments in each pair are from 2,000 to 3,500 ft apart and should be intervisible. In addition, the seven master control monuments around the perimeter of the ring have an intervisible primary control monument located within 2,000 ft to be used for determining azimuth during conventional traversing.

For both master and primary control monuments, the latest issue of the U.S.G.S. 7.5 minute quadrangles and a set of 1986 orthophotographs were studied for locations which appear to be adequate for fixing the location using GPS and for use of the monument in triangulation or trilateration networks.

Alternative E

Alternative E represents a control scheme proposed be Dr. Michel Mayoud of the CERN high energy physics project in Geneva, Switzerland, wherein a master control monument is located adjacent to each shaft or experimental hall site. To facilitate this scheme, 17 primary control monuments in Alternative D were changed to master control monuments, resulting in 26 master control monuments and 62 primary control monuments.

Photogrammetric Base Maps

Photogrammetric base maps have been omitted from these alternatives since specific mapping needs have not been established at this time.

Control System Precision

All master station monuments shall be located horizontally in accordance with the provisions for Order B (1:1,000,000) (for primary control monuments - Order 1 (1:100,000)) geometric relative positioning accuracy standards as specified in "Geometric Geodetic Accuracy Standards and Specifications For Using GPS Relative Positioning Techniques", latest version.

All monuments in the master station and primary control systems should be located vertically in accordance with the provisions for Second Order vertical networks as specified in "Standards and Specifications for Geodetic Control Networks", latest version.

Checking

At least five of the the master stations' positions should be checked by trilateration methods using electronic distance measuring equipment calibrated so the frequency modulation is within plus or minus 3 MHz. The checking should be performed between the four monuments located in a north-to-south trending line shown on drawing SC-5 and three of the monuments located in a west-to-east trending line shown on the same drawing.

At least 20% of the primary control monuments should be checked by traversing between sets of paired monuments using first order procedures in accordance with the provisions of "Standards and Specifications for Geodetic Control Networks", latest version.

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09/15/89
Don Scapuzzi

SURVEY ADVISORY PANEL

RTK REPORT ON SMALL DIAMETER SHAFTS

The following are conceptual design details and costs for small diameter shafts which could be used for cryogenics venting during the operational phase of the SSC.

The shafts are to be located at 1,000-ft intervals along the center-line of the tunnel. The inside diameter is to be three feet. The ultimate purpose of the shaft would be for venting the cryogenics system during normal operations of the SSC machine.

The shafts would be constructed prior to the tunnel since construction after the tunnel is in place presents very difficult problems in grouting a shaft lining in place without having the grout pour into the tunnel space. A four foot diameter hole is drilled to a depth approximately one foot inside the finished tunnel diameter. A three foot diameter steel liner pipe is then hung inside the hole and suspended so the bottom of the pipe is approximately one foot above the crown of the excavated tunnel grade so as not to interfere with the tunnel boring machine (TBM) during excavation of the tunnel. The pipe is grouted in place with a week concrete. The concrete is placed so it fills the bottom of the drilled hole completely but not further up inside the steel liner than an inch or two.

The TBM will cut through the week concrete without difficulty. For the tunnels in Austin chalk, workmen will chip the week concrete from the crown of the tunnel up to inside the lining and smooth the chipped concrete surfaces with a grinder. For tunnels in Taylor marl or Eagle Ford shale, a portion of the precast segmental lining will have to be cut away prior to chipping the weak concrete. A tight connection between the segmental lining and the weak concrete will be constructed using cement mortar or a similar method.

The shafts can then be used by the TBM contractor's surveyors for checking tunnel alignment and grade or by the contractor for construction ventilation, utilities connection, concrete supply to the tunnel, etc.

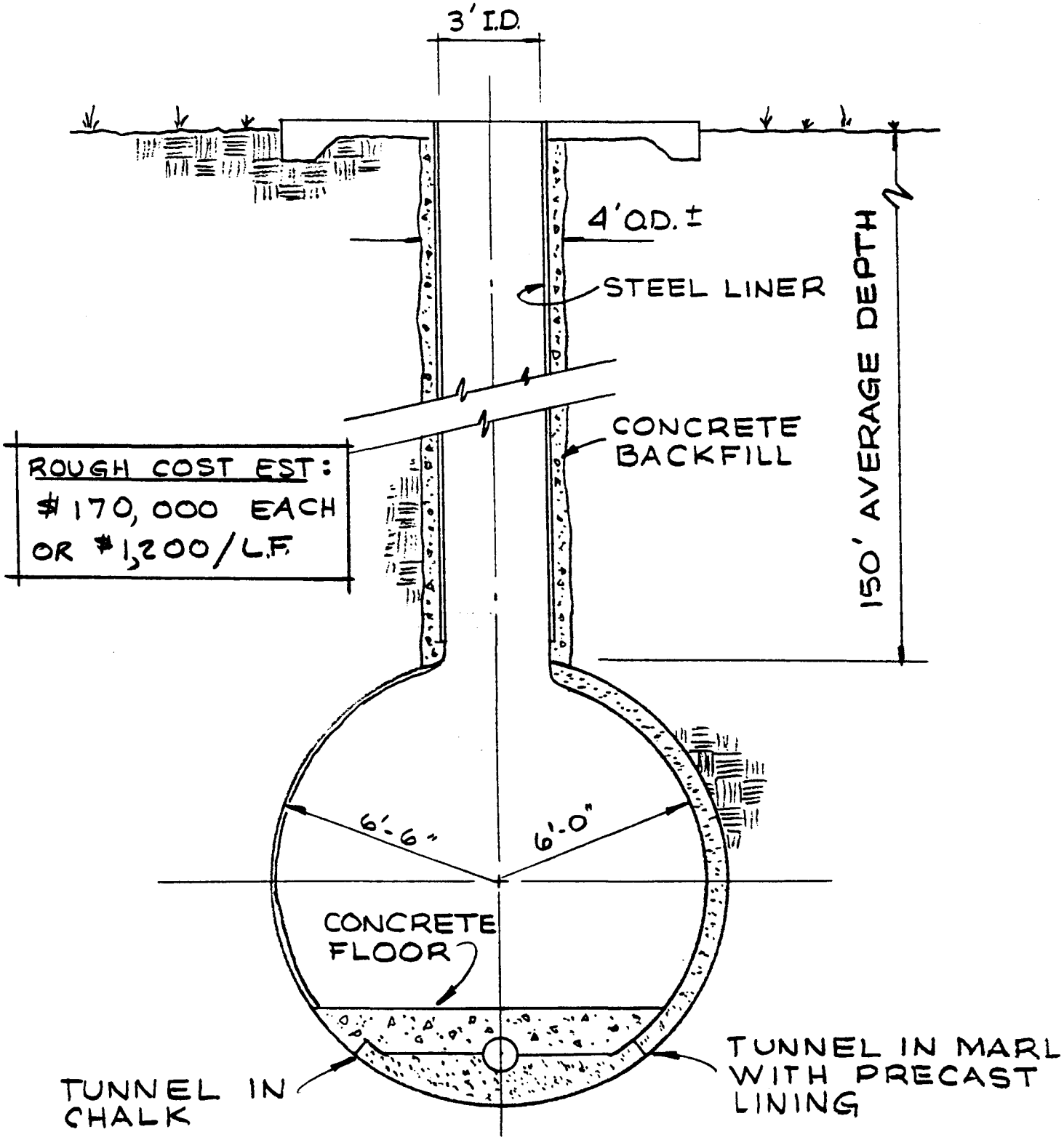
After the tunnel has been completed, the shafts can be used by the SSC Lab for transferring precise survey control from the surface to the tunnel floor to be used for locating the magnets during the magnet installation phase.

A rough-order cost estimate is as follows:

Mobilization and demobilization of drilling equipment:	$400,000
Intermobilization of drilling equipment between drill-holes: 25 ea. at $75,000 ea. =	$1,875,000
Collar holes: 26 ea., 15' deep at $750/lf =	$292,500
Drill and line holes: 26 ea. at 135' deep at $500/lf =	$1,755,000
Total for construction =	$4,322,500

For 26 shafts: $4,322,500 / 26 = $166,250 ea — USE $170,000 EA

At 150' feet average depth: $170,000 / 150' = $1,133/lf — USE $1,200/LF



TYPICAL SECTION THROUGH CRYOGENICS VENT SHAFT

SCALE: 1/4" = 1'-0"

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09/15/89
Don Scapuzzi

SURVEY ADVISORY PANEL

RTK REPORT ON A FOURTH DRAFT SURVEY CONTROL PLAN TO SUPPORT THE LAND ACQUISITION FOR THE SSC PROJECT

Background.

At the August 31 meeting of the SSC Survey Advisory Panel, held at the SSC Laboratory, the Third Draft plan for survey control (1) was presented to the Panel.

This draft consisted of Alternative D which had a total of nine master control monuments and 79 primary control monuments, and Alternative E which had a total of 26 master control monuments and 62 primary control monuments. The consensus of opinion of those present was that the scheme for Alternative D was to be implemented.

Implementation.

The next step will be to perform field reconnaissance on the proposed monument locations in Alternative D to determine if each site would be adequate for the intended use; if the site could be surveyed using Global Positioning Satellite (GPS) techniques; if the site appeared to be stable with regard to ground movement; and if the site appeared to be out of the path of construction activity for the foreseeable future. The monument locations will be marked by driving two ft. or three ft. lengths of 5/8 in diameter reinforcing steel flush with the ground. The re-bars will be "tied off" in two directions to "nails and shiners" driven in adjacent trees, fence posts, paving or other suitable locations. A sketch will be made to record the location. This will be accomplished by subcontractors to RTK in FY 1990.

After all proposed monument locations have been selected, the owners (private, Texas Department of Transportation (TXDOT), Ellis County, various cities) of the property where the monument is to be constructed will be contacted for permission to construct the monument on their property. This effort should be coordinated between the SSC Lab, the Texas National Research Laboratory Commission (TNRLC) and RTK.

Once the monument program has been selected (only the master monuments, or the master monuments and the primary control monuments combined), another subcontract will be issued by RTK for the construction and surveying work.

Monument Selection.

Two types of monument construction have been seriously considered by the Panel: concrete pedestals with a forced centering base plate cast in the top of the pedestal and the sleeved class A rod mark or NGS 3-D marker.

Since the SSC site lies wholly within an area of highly expansive soil, the monuments will have to be anchored below the depths at which changes in moisture content cause shrinking and swelling of the soil (Floyd 1978). This can result in very deep and costly pedestals. The portion of the pedestal which is located above the surface presents additional problems. Private property owners will be less likely to want such a monument sticking up in their front yards because of their unsightliness and this type of construction is more subject to vandalism than a monument installed flush with the ground.

Floyd (1978), Gatto (1987) and the FGCC (1988) recommend the exclusive use of the sleeved class A rod mark or NGS 3-D marker for all permanent benchmarks. A telephone conversation between the author and Mr. Jack Howell, TXDOT, verified his department is planning to use this type of monuments for their planned regional reference point monument system. The Tennessee Department of Transportation also used this monument, installed by the NGS in a cooperative effort, in their super control network recently constructed across their entire state (2).

Based upon the large amount of supporting information available, it is recommended that all master monuments and all primary control monuments be constructed in accordance with the requirements for sleeved class A rod marks as specified in the NOAA Manual NOS NGS 1, Geodetic Benchmarks (Floyd 1978).

Bench Mark Depth.

The following example computes the maximum depth for rod marks at the SSC site using the NOAA Manual:

1. The SSC site is plotted on Figure 10 and it lies in the highly expansive material area.

2. A Climate Factor (CF) of 1.4 for the area is determined from Figure 12.

3. From Table 2, the sleeve depth required to prevent changes in soil volume from altering the elevation of the rod is 10 meters X the CF of 1.4 = 14 meters or 46 ft.

4. The extreme depth of frost penetration for the site as shown on Figure 13 is 0.25 meters. Table 2 indicates that no sleeve is required for depths of frost penetration less than 0.5 meters.

The depth of soil at the SSC site varies from approximately three feet to more than 50 feet. When soil depths extend below the maximum sleeve depth of 46 feet, the monuments will be constructed using full length sleeves of 46 feet. When bedrock is found at shallower depths, the monument construction details will be revised according to Floyd (1978) and the bottom of the rod mark will be set in concrete in the bedrock.

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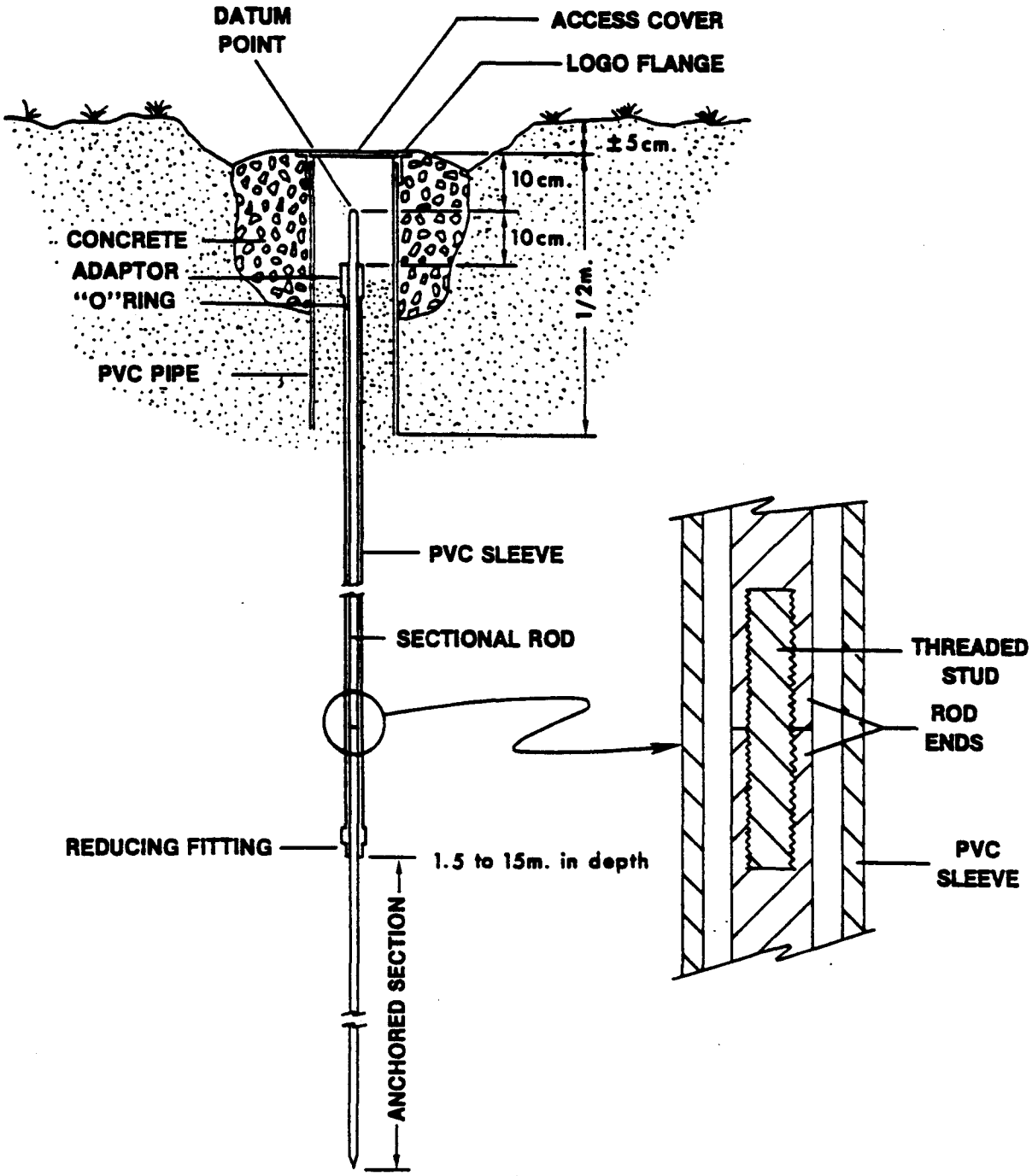


Figure 4.—Sleeved class A rod mark.

Table 2.—Sleeve depth for class A rod mark set within the continental United States

Condition	Extent of occurrence	Depth
Soil volume change[a]	nonexpansive	no sleeve required[b]
	low expansive character	6 meters × CF[c]
	medium or high expansive character	10 meters × CF[c]
Active frost penetration[d]	maximum 0.5 meter or less	no sleeve required[b]
	maximum greater than 0.5 meter	3 × max frost penetration
Permafrost[e]	any extent	10 meters

[a] Categories of expansiveness are shown on the maps in figures 7 through 11. Inability to accurately delineate category boundaries necessitates assumption of the greater expansive character when working near a boundary. A consolidated map of these figures, at a larger scale, in color, is available by writing to the USAE Waterways Experiment Station, P.O. Box 631, Attn: GEO, Vicksburg, MS 39180. It is entitled Occurrence and Distribution of Potentially Expansive Materials in the United States.

[b] Where no sleeve is required, the rod assembly shall be set to the depth at which a static load of 250 kilograms causes no movement (see footnote 7, page 18) but at least 4 meters.

[c] The Climate Factor (CF) is indicated on the map in figure 12. Use the larger value when there is doubt as to what value applies to a particular site.

[d] Depth of maximum frost penetration is indicated on the map in figure 13. Use the upper limit for each area delineated.

[e] For an excellent overview of permafrost areas, consult Ferrains (1965).

Table 3.—Minimum depth for class B rod mark[a]

Condition	Depth
Nonexpansive soils	4 meters
Soils of low expansive character	5 meters × CF
Medium or highly expansive soils	6 meters × CF
Low penetration resistance[b]	To substantial resistance[c]
Seasonal frost penetration	4 × maximum frost penetration[d]
Permafrost	2.5 × maximum depth of active frost layer

[a] Footnotes a, c, d, and e from table 2 also apply here.

[b] A static load of 250 kilograms will move the rod.

[c] Substantial resistance is indicated when a static load of 250 kilograms will not move the rod (see footnote 7, page 18).

[d] The minimum depth shall be 4 meters.

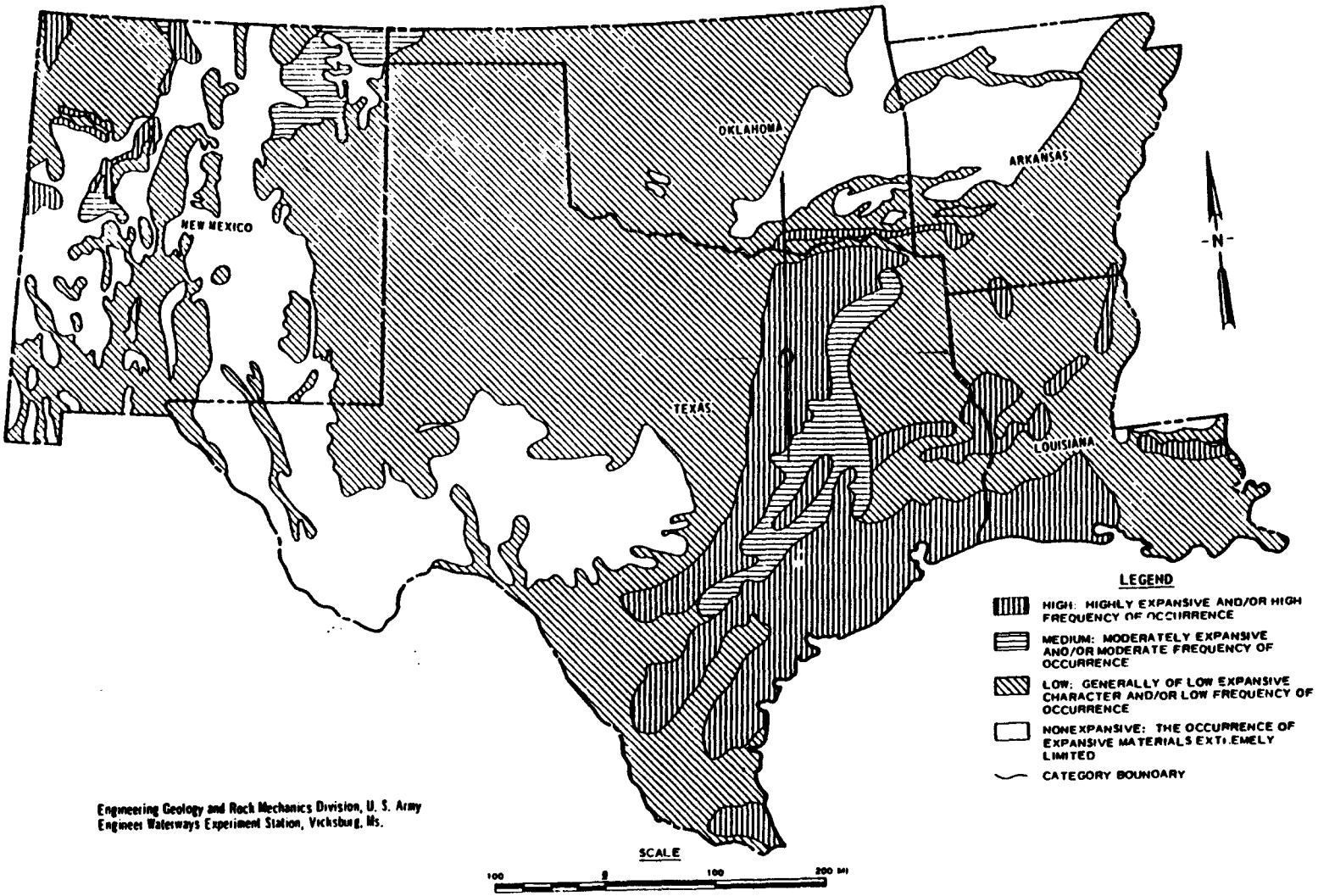


Figure 10.—Distribution of potentially expansive materials, South-Central States.

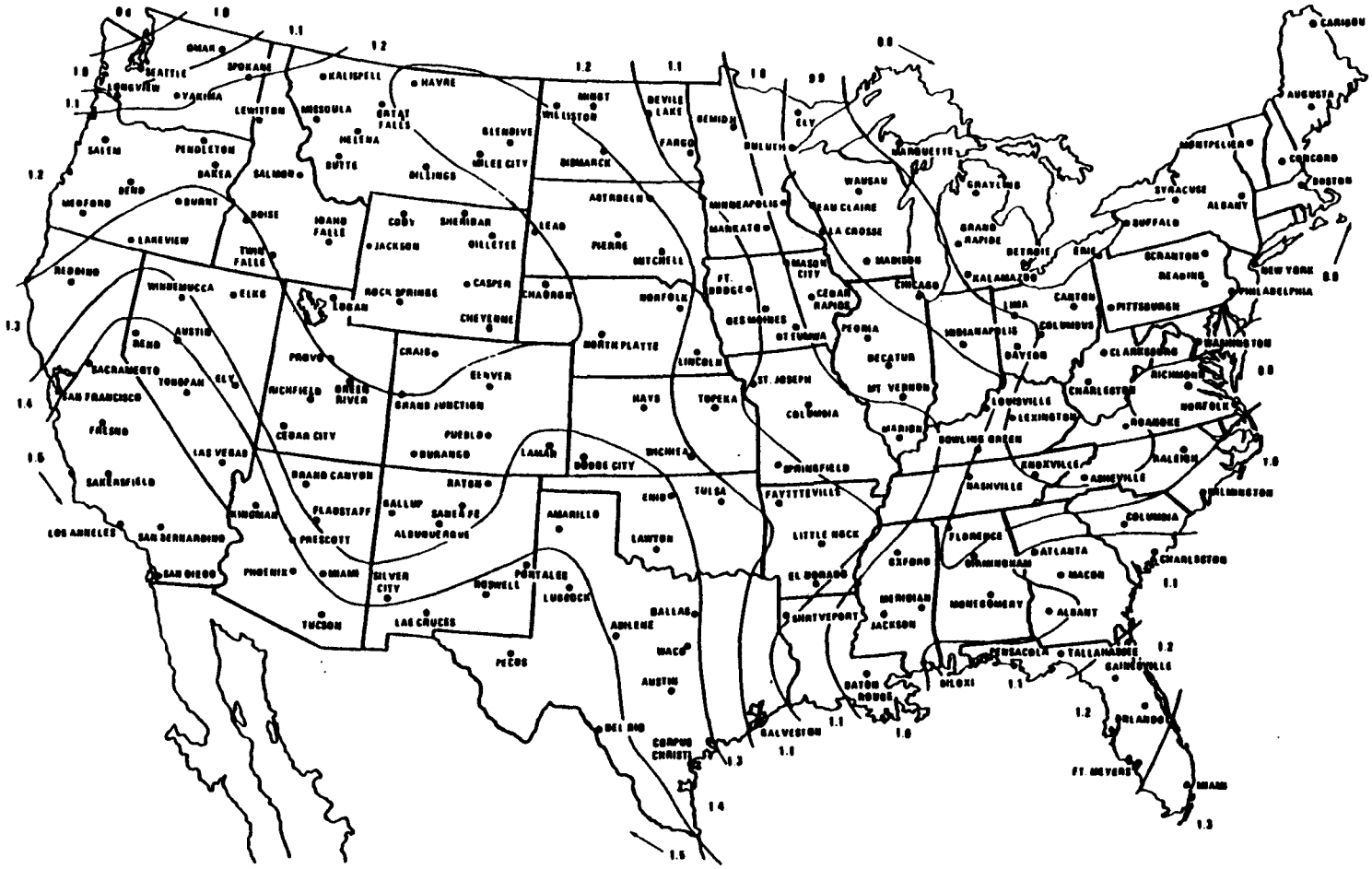


Figure 12.—Climate Factor (CF), adapted from Building Research Advisory Board (National Academy of Sciences 1968).

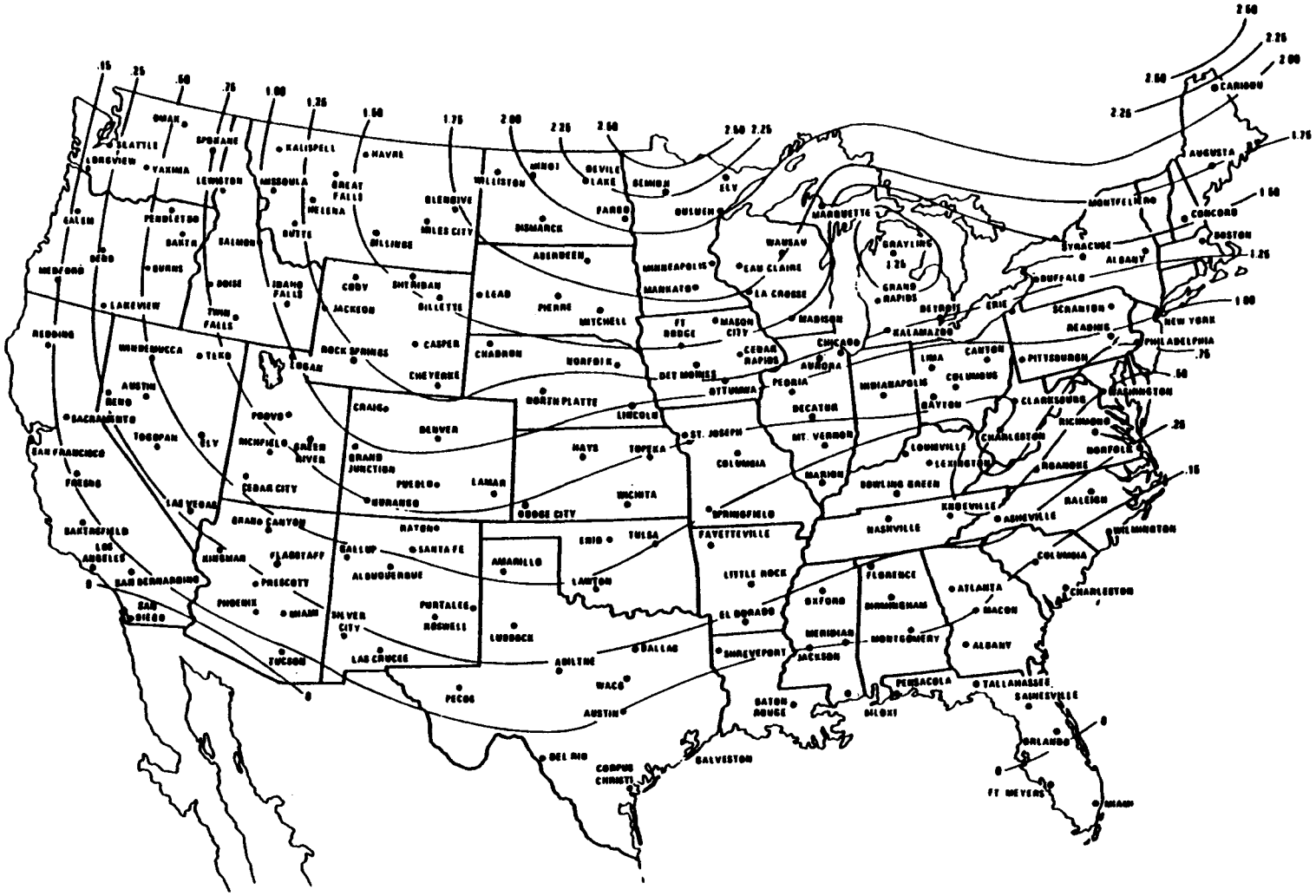


Figure 13.—Extreme depth of frost penetration (in meters).

APPENDIX C

TOWILL SUBCONTRACTORS

SUBCONTRACTOR	WORK PERFORMED
Berntsen, Inc. Madison, WI 800-356-8549 Mr. John D. Hohol	Monument Materials
Mason-Johnston and Associates Dallas, Texas 214-941-3803 Mr. Pete Henley	Master Monument Construction
Oceanics, Inc. Houston, Texas 800-525-0509 Mr. George Loy	Primary Monument Construction Benchmark Construction GPS Surveys
Ringley Surveying and Mapping Mc Kinney, Texas 214-542-1266 Mr. Lawrence Mc Kinney	Primary Monument Construction Benchmark Construction
Western Group Consultants Houston, Texas 713-972-1188 Mr. Abdool Rahaman	First Order Levels

APPENDIX D

LOCAL AGENCIES

TELEPHONE COMPANIES

Contel

	Ms. Ruth Richardson	800-849-7955
Bardwell	Mr. Charlie Jones	800-882-7870
Emhouse	Mr. Don Taylor	214-354-6800 or 354-6710
Ferris - Palmer	Mr. Dan Rock	214-544-2200

Southwest Bell

Italy - Ennis	Mr. Mike Lewis	214-875-2618
Italy	Mr. Gary Zakowski	214-483-6809
Ennis	Mr. Steve Nash	214-875-2618
Hutchins	Mr. Jerry Martin	214-944-6790
Lancaster	Mr. Larry Trewin	214-944-6863
Red Oak	Mr. Carter Vaughn	214-998-4102
	Mr. Johnny Lee	214-998-4102
Waxahachie	Mr. Bernie Cantu	214-937-1207
	Mr. Bill Tidwell	214-937-1207

Fiber Optic Line

Mr. Jim Reese
Electra Communications, Dallas, Texas

Texas Midland Phone Company

817-866-3322

GAS COMPANIES

Lonestar Gas

Dallas	Ms. Sheri Hardesty	214-2633444
Waxahachie	Mr. Luther Kirvin	214-937-1410

WATER COMPANIES

Avalon Water		
	Mr. Marc Buse	
	Mr. Clide Griffith	
Bardwell Water Company		
	Mr. Joe Betik	214-646-5410
Boyce Water Company		
	Mr. Dwight Sullivan	214-875-3243
Brandon Irene Water Company		
	Mr. Leroy Lamson	817-687-2812
Buena Vista Bethel Water Supply Company		
	Mr. Joe Buchanan	214-937-1212
	Mr. Steve Sievers	214-937-1212
	Ms. Sandy Fisher	214-937-1212
South Ellis County Water, Italy		
	Ms. Jo Beth Martin	214-483-6885
City of Ennis Water Department - Public Works		
	Mr. Billy Long	214-875-9081
Files Valley Water Company		
	Mr. Leroy Lamson	817-687-2812
City of Hutchins - Public Works		
	Mr. Earl Kendrick	214-225-3380
	Mr. David Breshears	214-225-3380
City of Lancaster Water Department - Public Works		
	Mr. Steve Seward	214-227-6050
City of Milford Public Works		
	Mr. Othel Smith	214-493-3161

Mountain Peak Water Supply Company

Ms. Thelma Crais	214-775-3765
Mr. Randy Kirk	214-775-3765
Mr. Mackey Mc Kennon	214-775-3765

Nash Forreston Water

Mr. Duane Williams	214-483-6236
Mr. Leland Calvert	214-483-6236

City of Palmer - Water Superintendent

Mr. James Gowin	214-449-3288

Rice Water Supply Company

Mr. Raymond Svehlak	214-326-5551

Rockett Water

Mr. Arthur Black	214-617-3542

Sardis - Lone Elm Water Company

Mr. Hugh Inman	214-775-8566
Mr. Scott Settlemeyer	214-775-8566

Venus

Mr. John Daniel	214-366-3348

Waxahachie Water Department

Mr. Gary Heine	214-937-7330
Mr. Pablo Benavides	214-937-7330

Texas Department of Highways

Mr. Al Barton	214-937-1570
Mr. Glynn Lloyd	214-937-1570
Ms. Shirley Smith	214-937-1570

Ellis County Road Commissioners

Precinct No. 1	Mr. James Harper	214-449-3260
Precinct No. 2	Mr. Ron Gilespie	214-875-3241
Precinct No. 3	Mr. Del McLane	214-483-7477
Precinct No. 4	Mr. Cliff Wammack	214-775-8017

Ellis County Sheriff

Mr. Ray Stewert	214-937-8620 or 937-6060

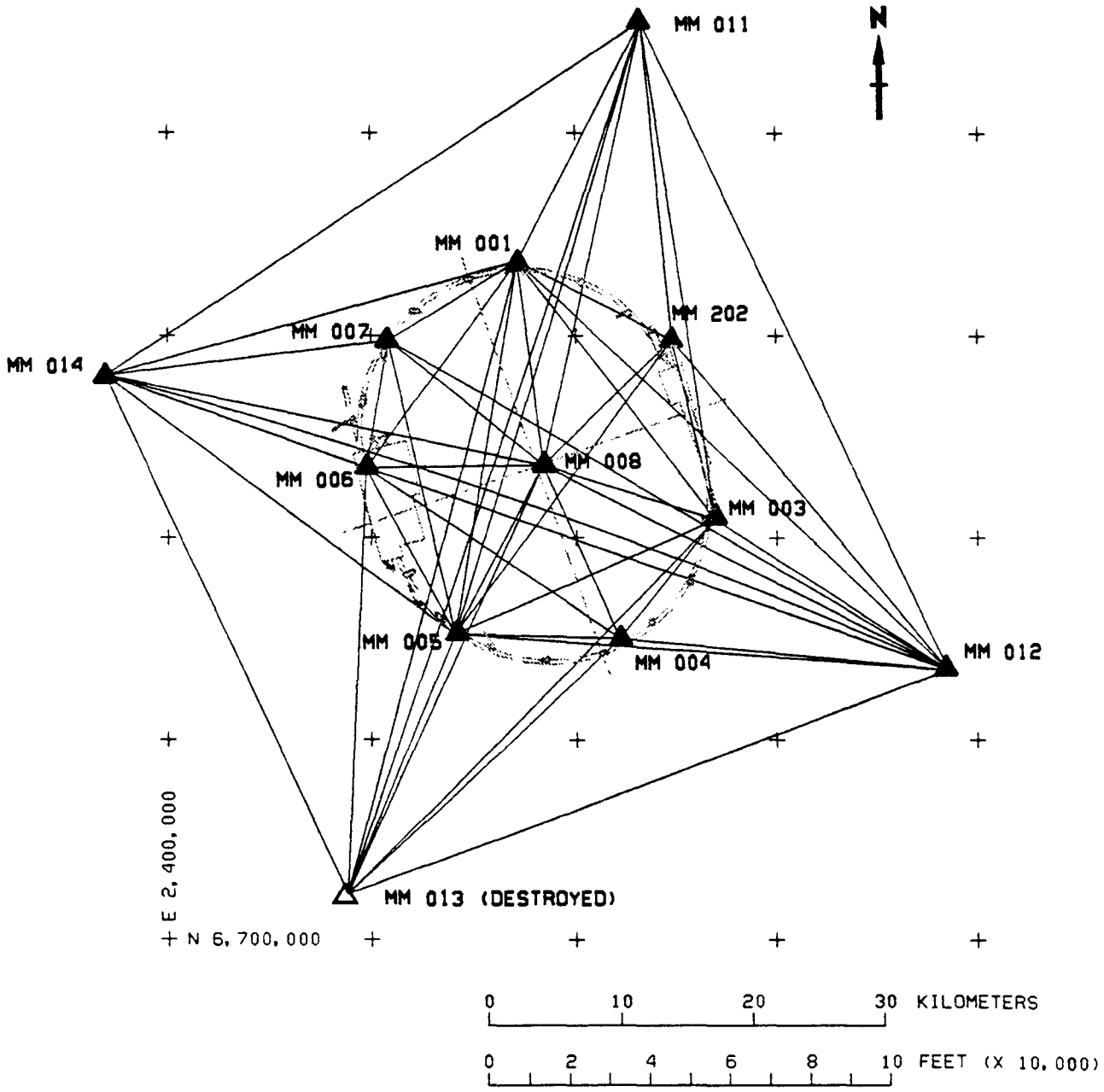
Ellis County Public Works Administrator

Mr. Jimmy Reavis	214-937-8631

APPENDIX E

GPS OBSERVATION SESSIONS

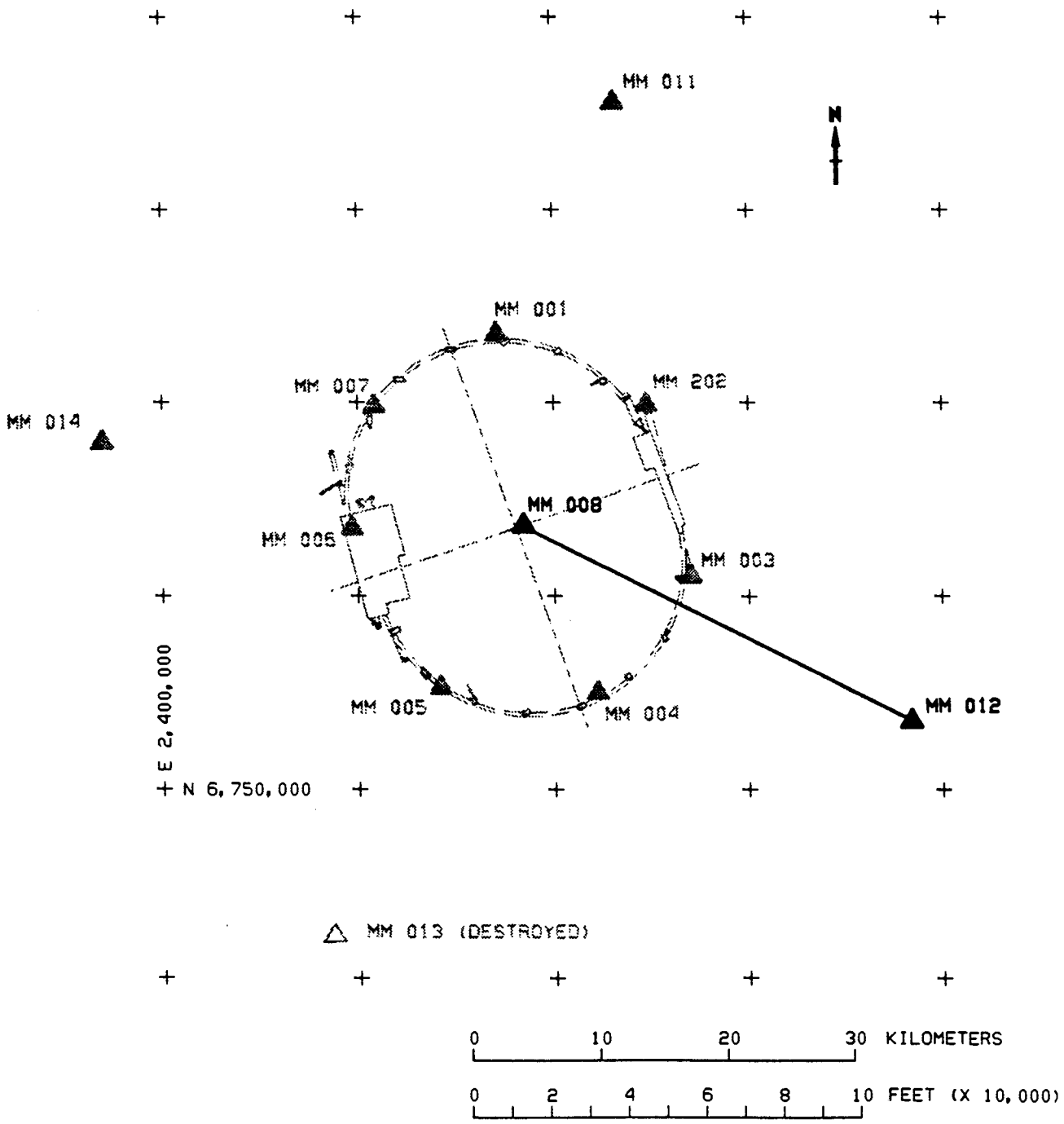
DAY	SESSION	STATIONS OCCUPIED
100	0	008, 012
101	0	005, 012
108	1	003, 004, 005, 008, 012, 013
109	1	001, 202, 003, 005, 008, 012
111	1	001, 005, 006, 007, 008, 012
112	0	001, 005, 011, 012, 013, 014
113	1	001, 005, 006, 007, 008, 014
114	1	004, 005, 006, 008, 012, 013
115	1	001, 202, 003, 005, 008, 011
117	1	003, 004, 005



CUMULATIVE BASE LINES FROM
MASTER MONUMENT SESSIONS (ORDER B)

ZG1: [102,4]MONALL.DGN

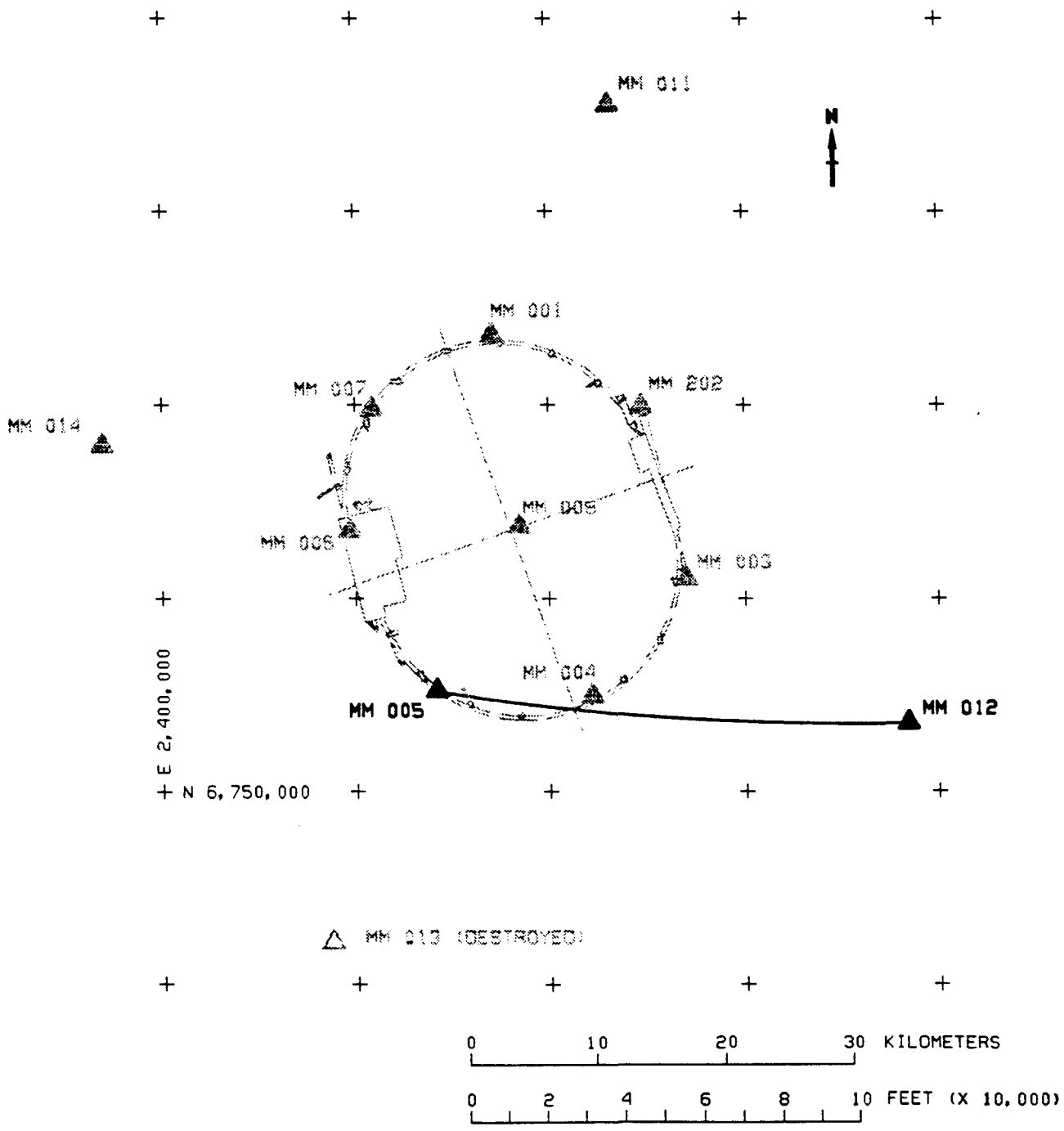
DAY	SESSION	STATIONS OCCUPIED
100	0	008, 012



DAY 100 - SESSION 0

ZG1: [102,4]MON1.DGN;1

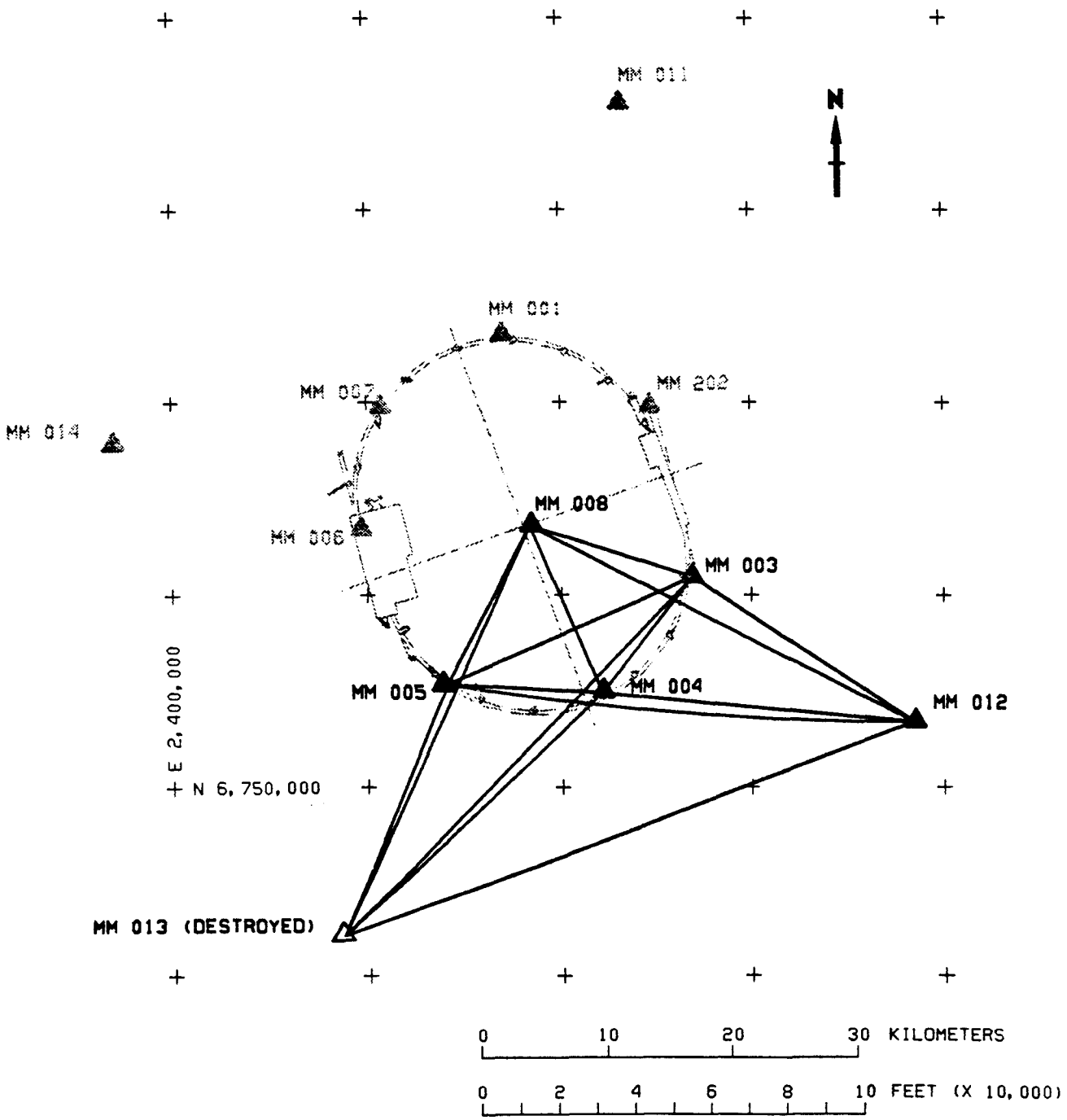
DAY	SESSION	STATIONS OCCUPIED
101	0	005, 012



DAY 101 - SESSION 0

ZG1: [102,4]MON1A.DGN

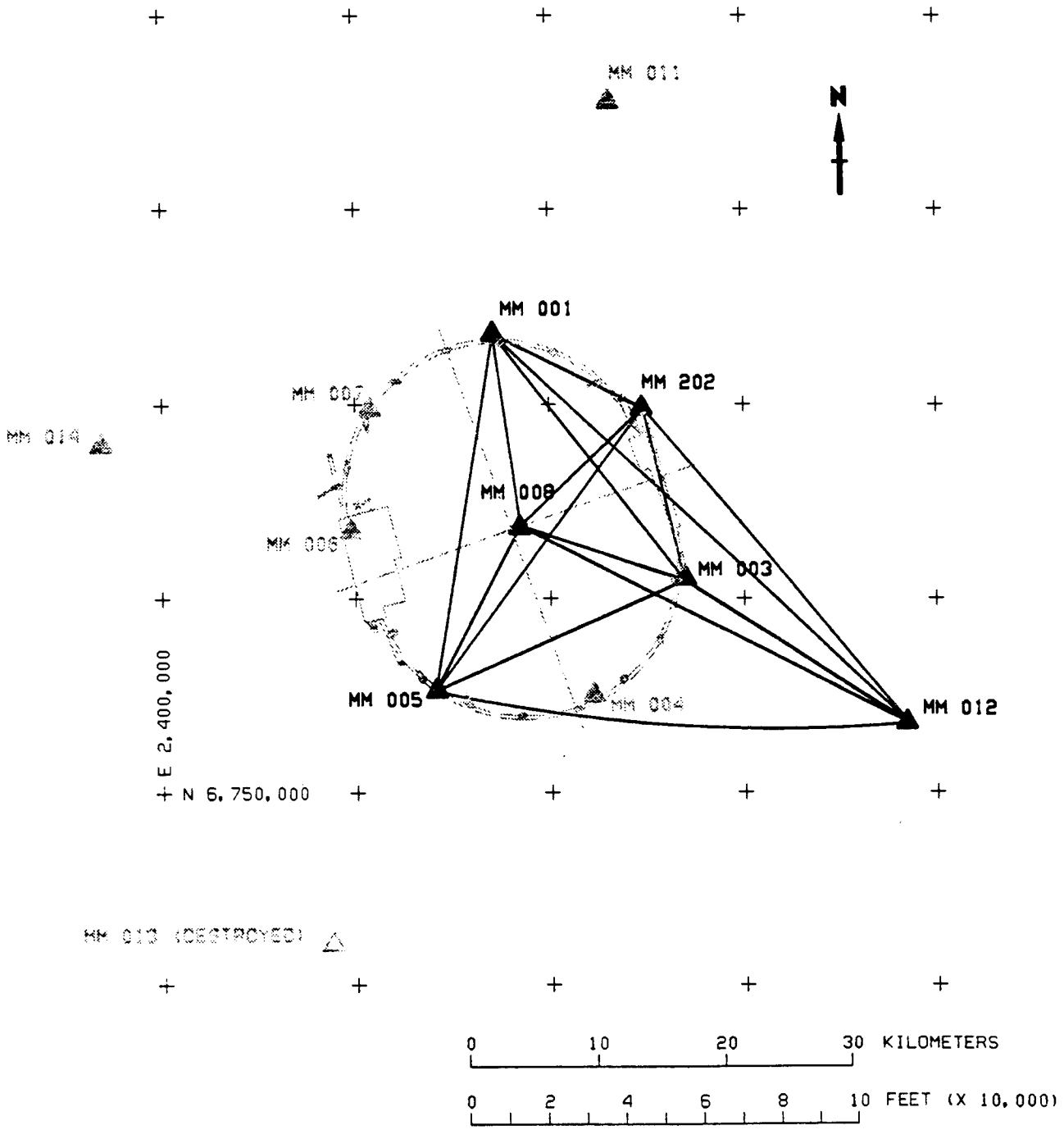
DAY	SESSION	STATIONS OCCUPIED
108	1	003, 004, 005, 008, 012, 013



DAY 108 - SESSION 1

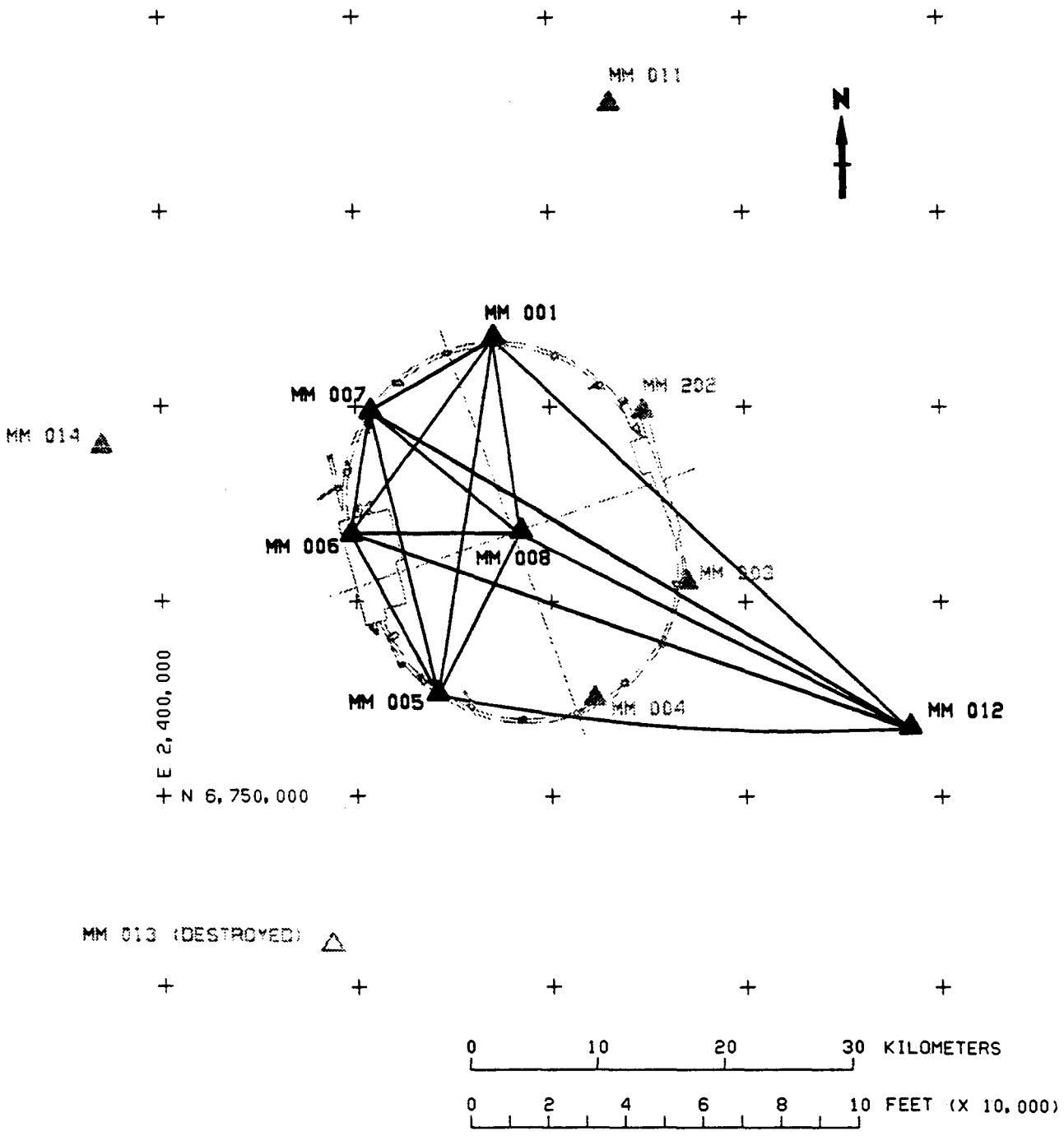
ZG1: [102,4]MON2.DGN

DAY	SESSION	STATIONS OCCUPIED
109	1	001, 202, 003, 005, 008, 012



DAY 109 - SESSION 1

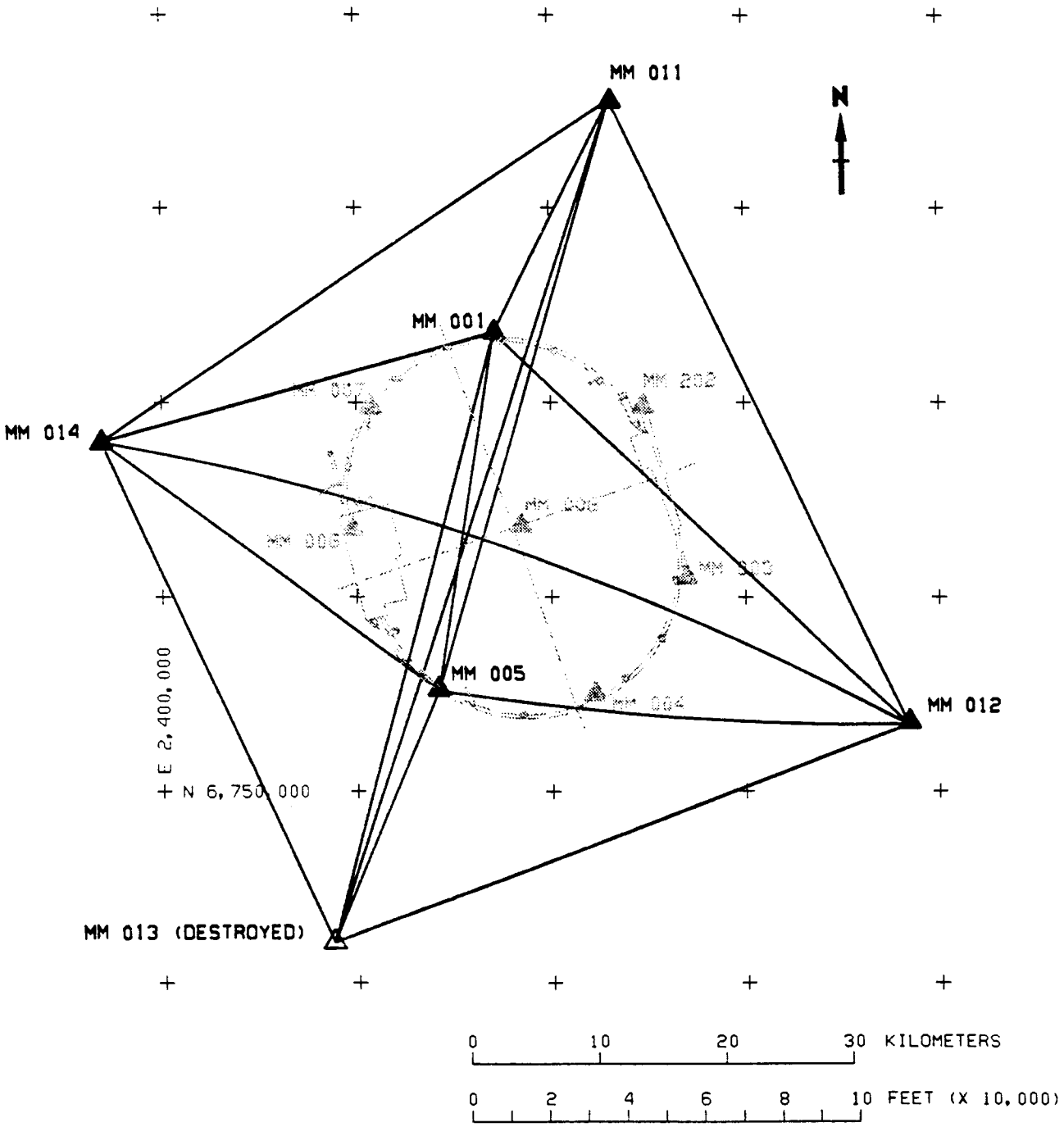
DAY	SESSION	STATIONS OCCUPIED
111	1	001, 005, 006, 007, 008, 012



DAY 111 - SESSION 1

ZG1: [102,4]MON4.DGN

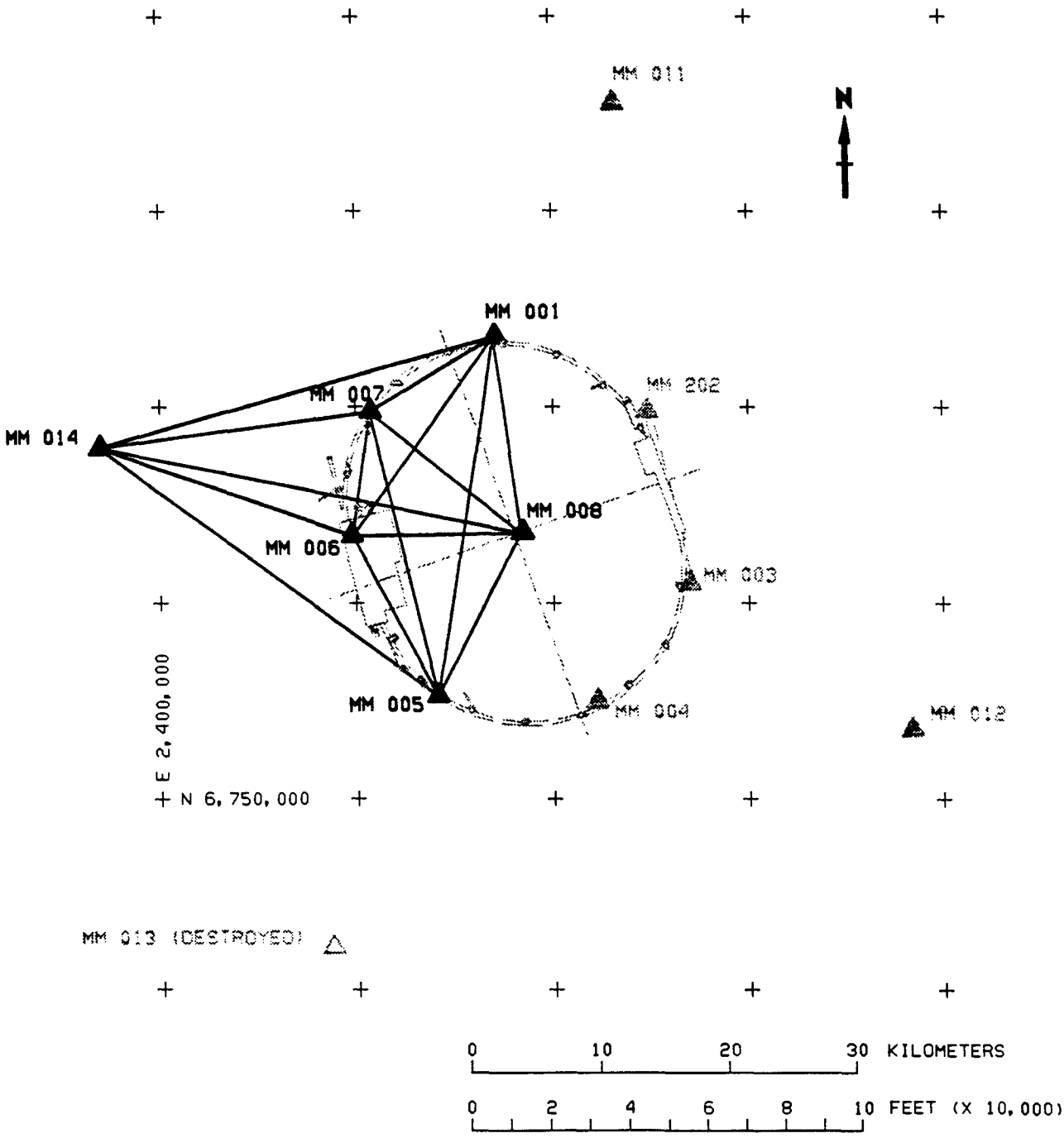
DAY	SESSION	STATIONS OCCUPIED
112	0	001, 005, 011, 012, 013, 014



DAY 112 - SESSION 0

ZG1: [102,4]MON5.DGN;1

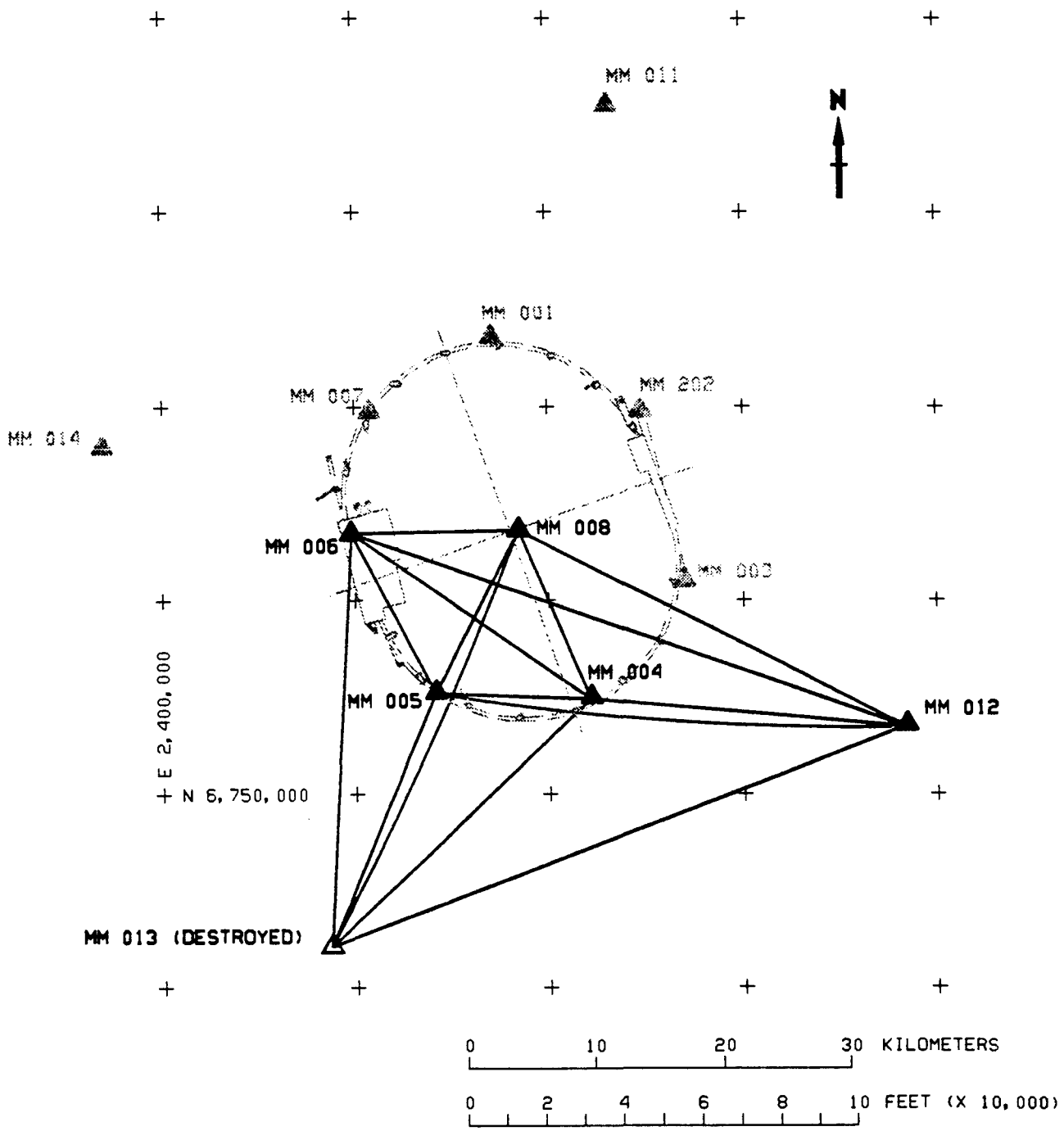
DAY	SESSION	STATIONS OCCUPIED
113	1	001, 005, 006, 007, 008, 014



DAY 113 - SESSION 1

ZG1: [102,4]MON6.DGN

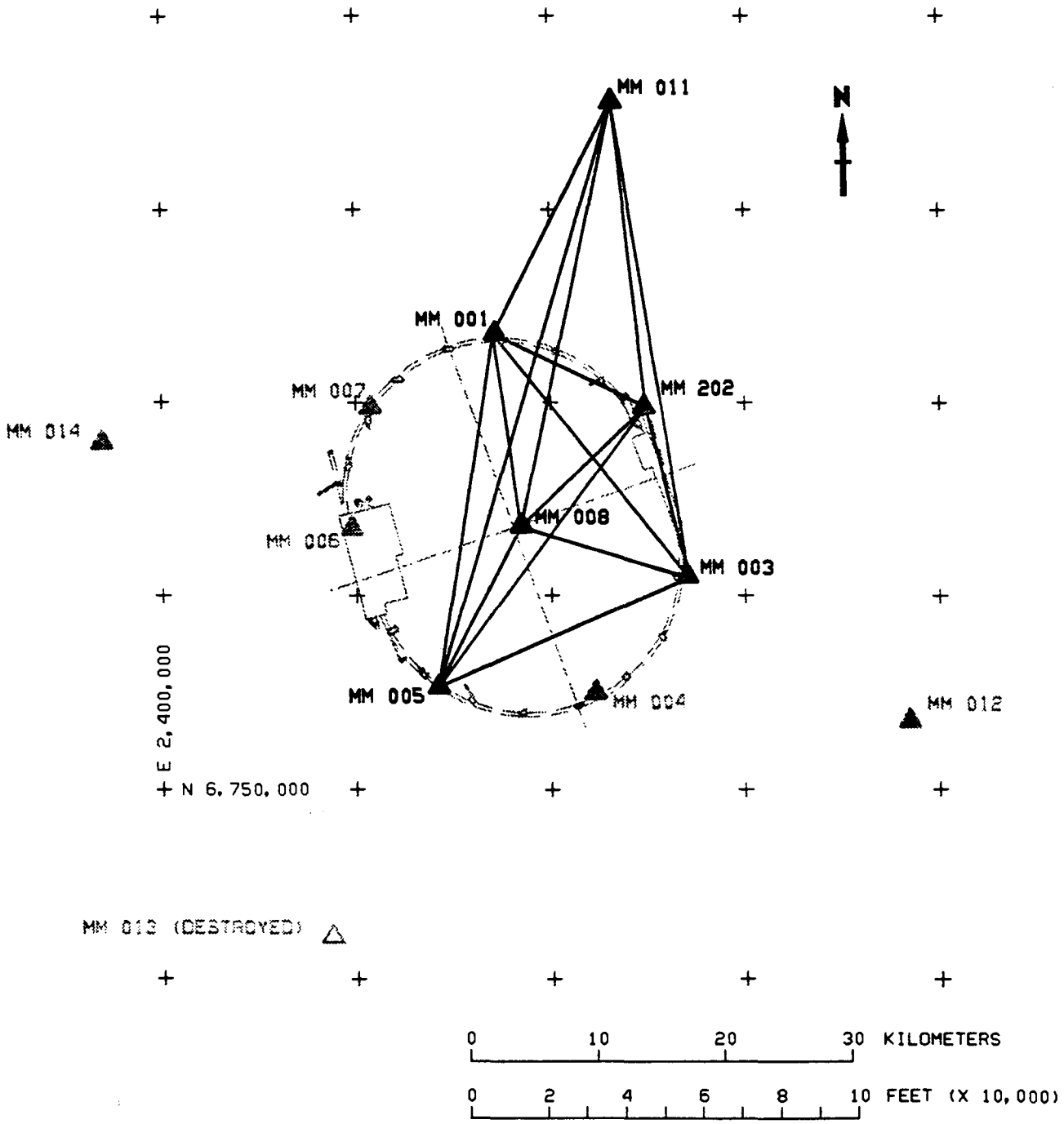
DAY	SESSION	STATIONS OCCUPIED
114	1	004, 005, 006, 008, 012, 013



DAY 114 - SESSION 1

ZG1: [102,4]MON7.DGN

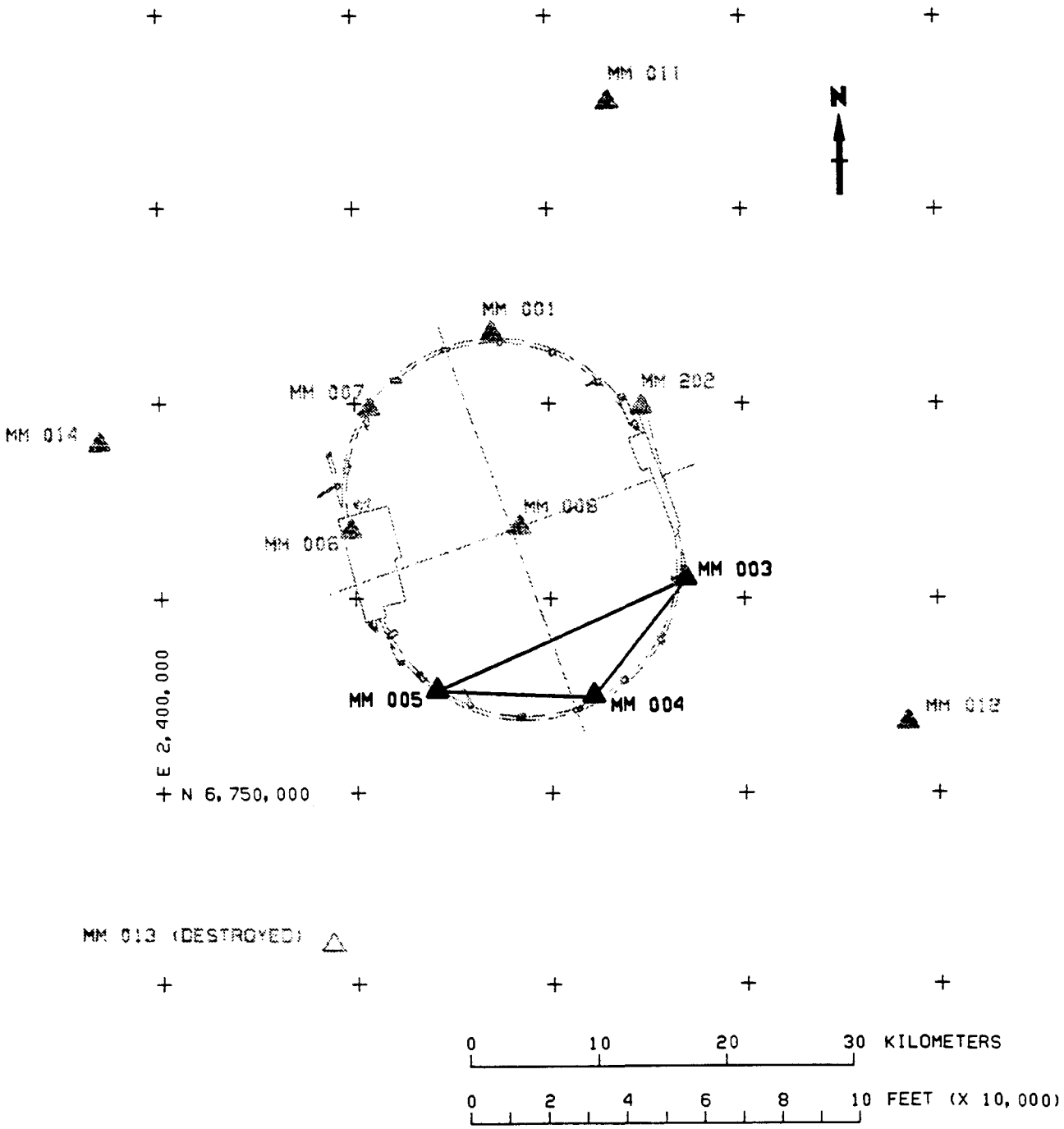
DAY	SESSION	STATIONS OCCUPIED
115	1	001, 202, 003, 005, 008, 011



DAY 115 - SESSION 1

ZG1: [102,4]MON8.DGN

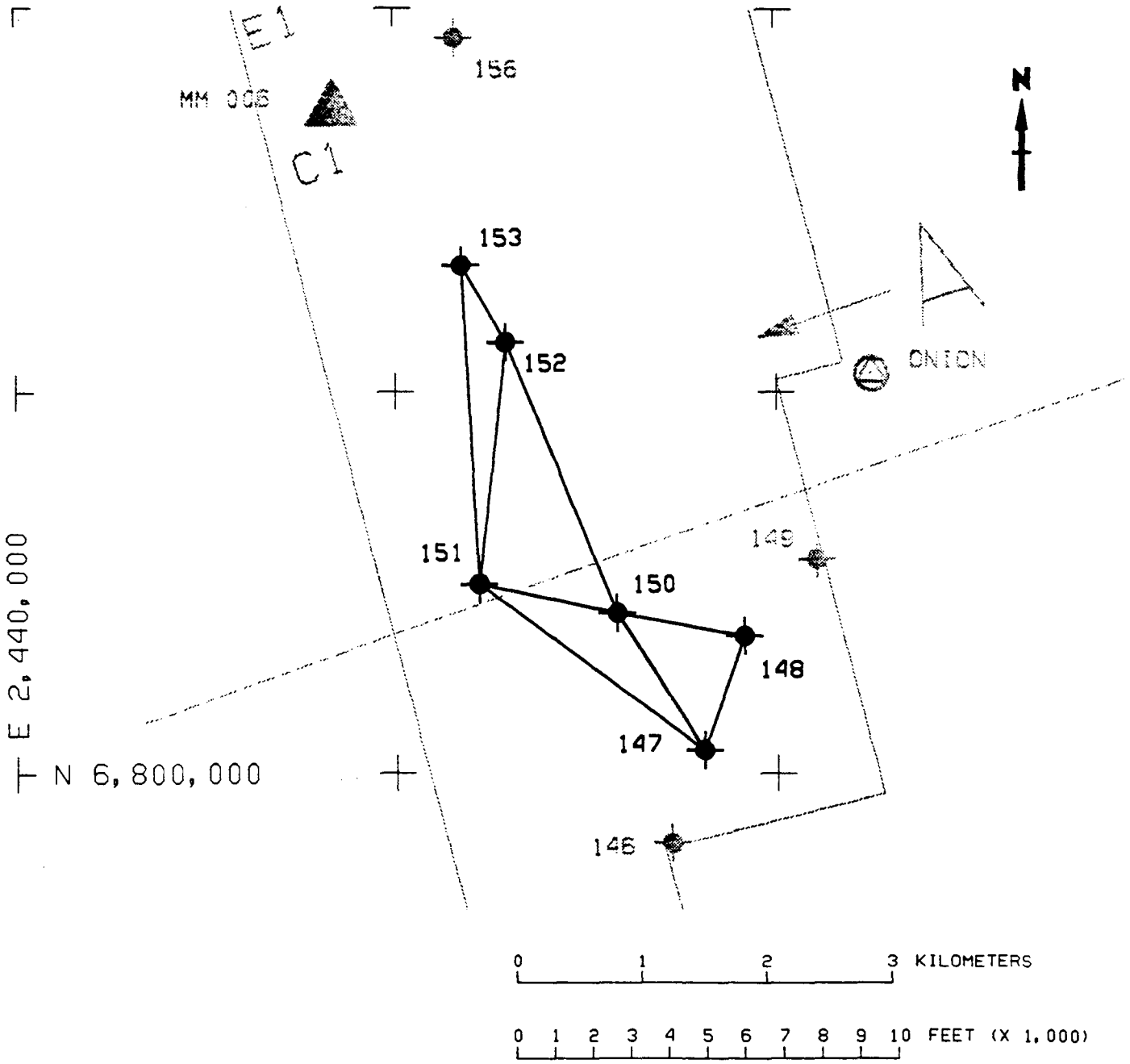
DAY	SESSION	STATIONS OCCUPIED
117	1	003, 004, 005



DAY 117 - SESSION 1

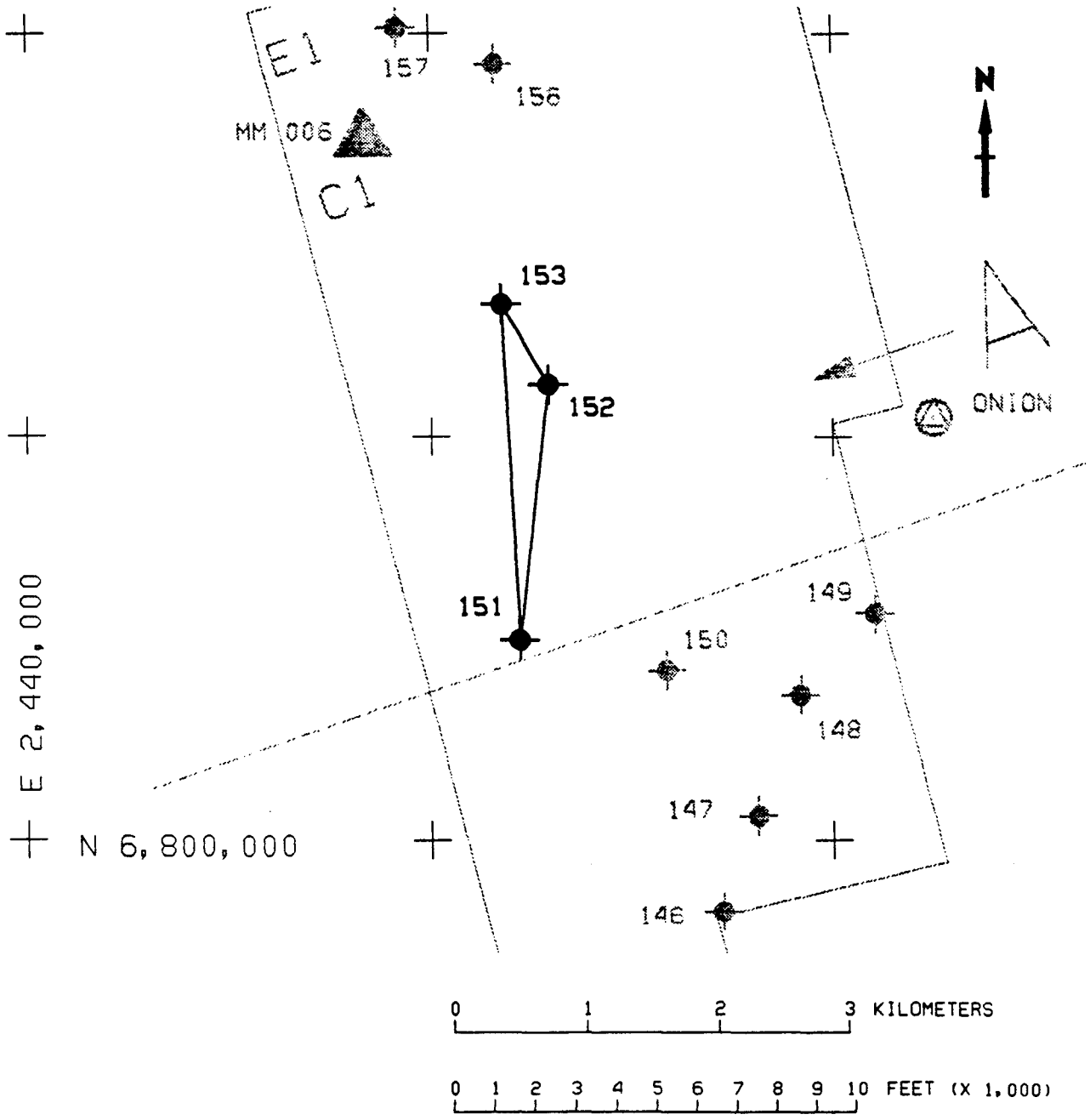
ZG1: [102,4]MON9.DGN

DAY	SESSION	STATIONS OCCUPIED
100	0	151, 152, 153
	1	150, 151, 152
	2	147, 150, 151
	3	147, 148, 150



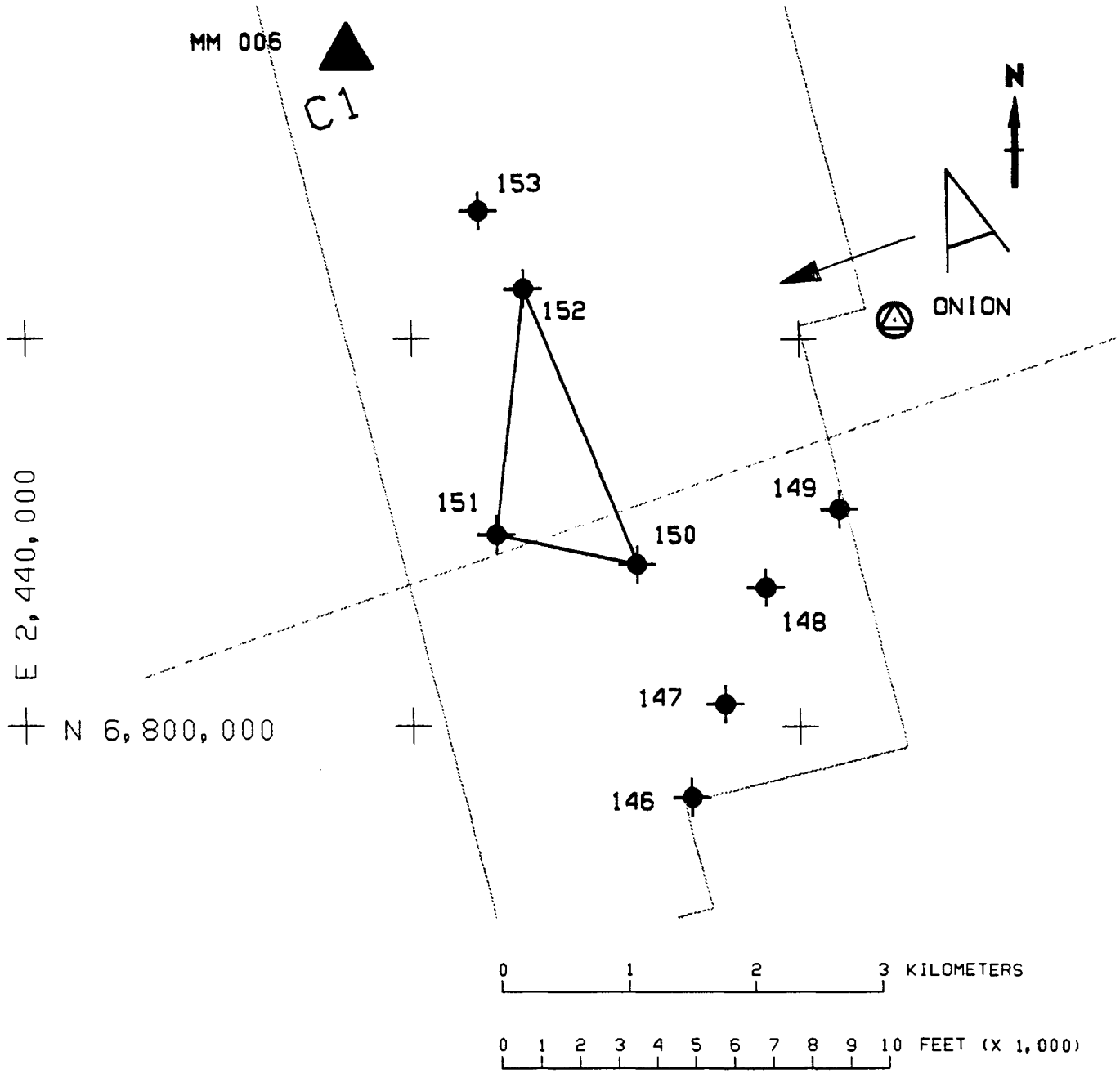
DAY 100 - SESSIONS 0, 1, 2 & 3

ZG1: [102,4]MON101.DGN;1



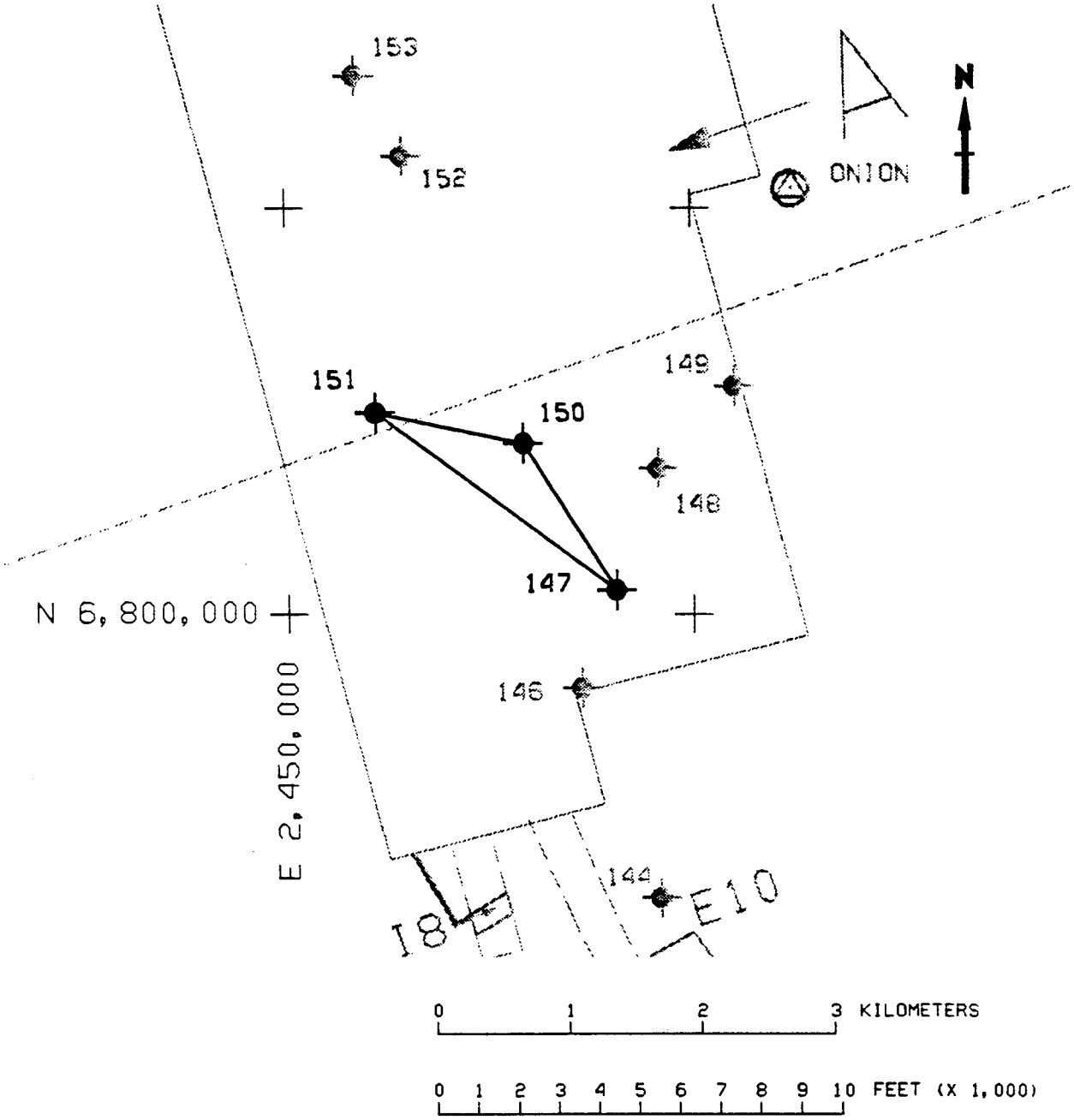
DAY 100 - SESSION 0

ZG1: [102,4]MON102.DGN;2



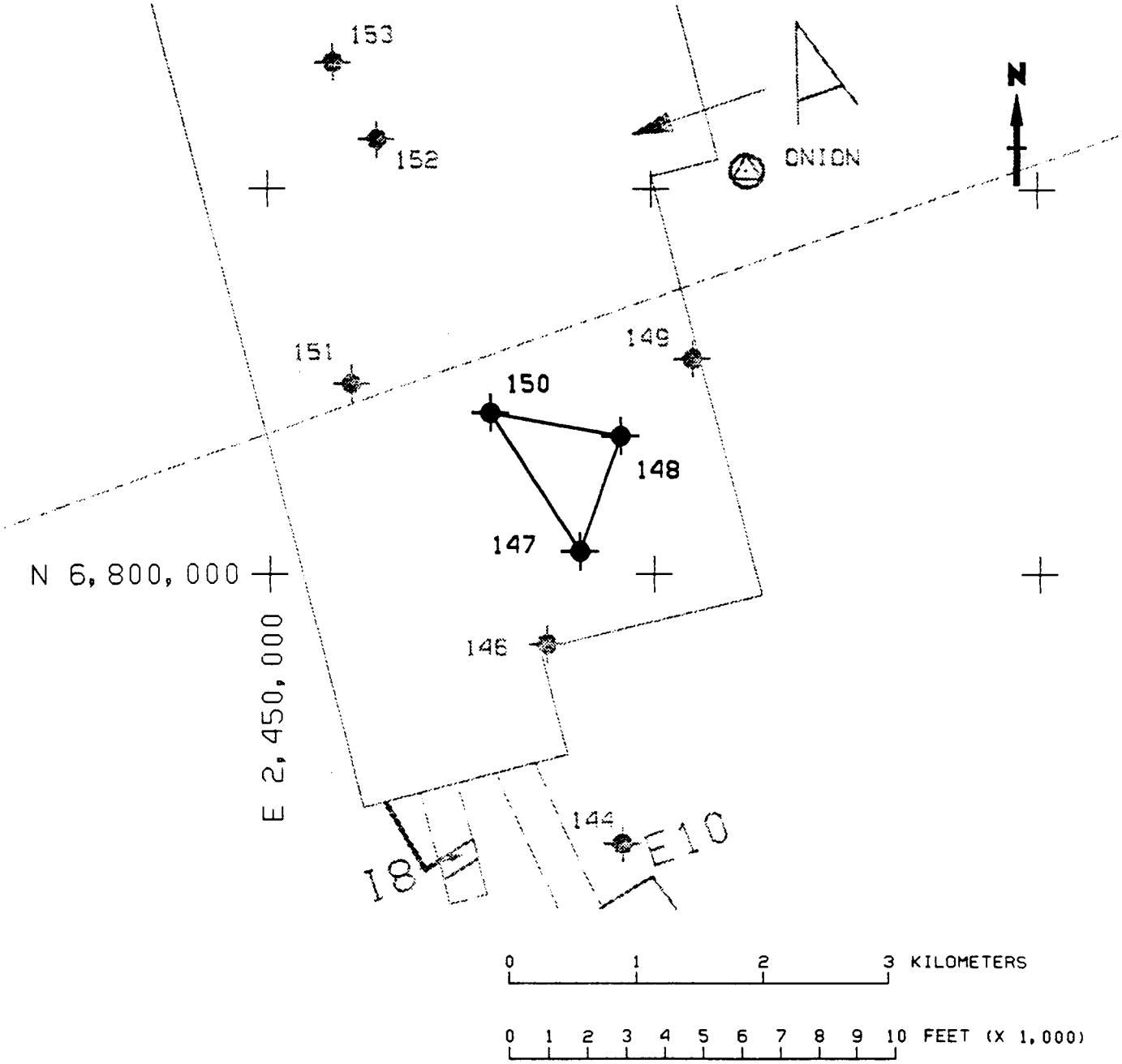
DAY 100 - SESSION 1

ZG1: [102,4]MON103.DGN



DAY 100 - SESSION 2

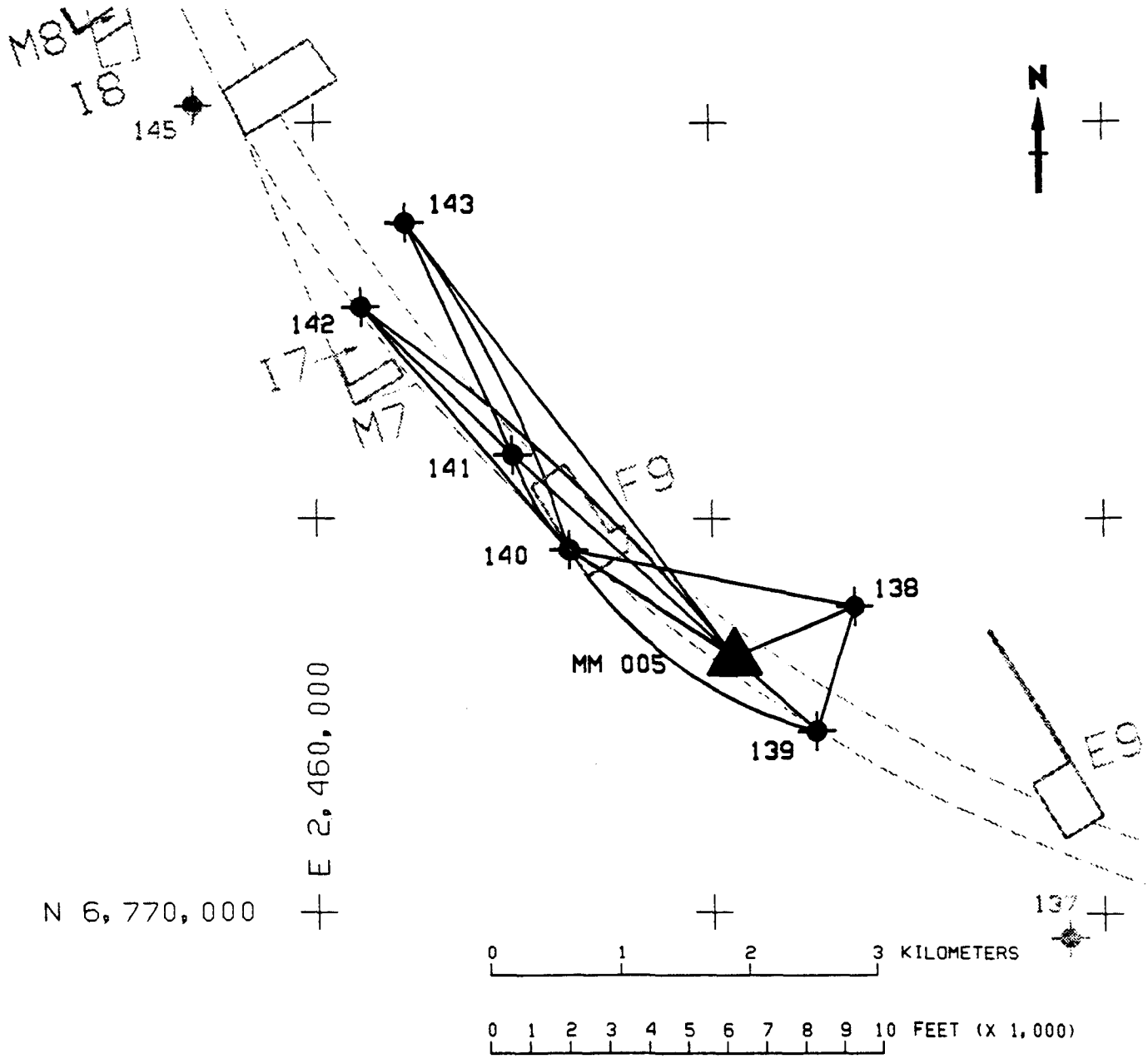
ZG1: [102,4]MON104.DGN



DAY 100 - SESSION 3

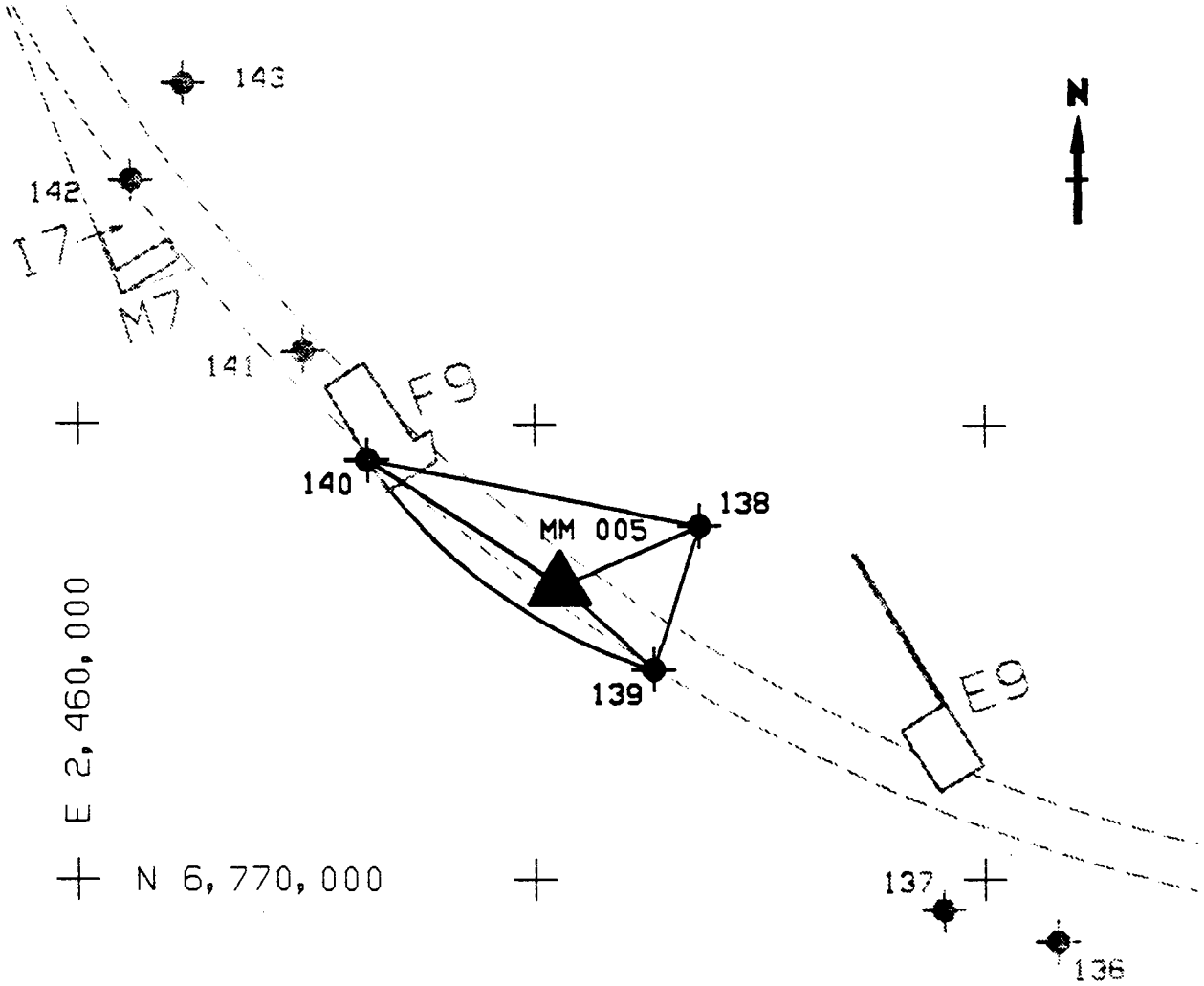
ZG1: [102,4]MON105.DGN

DAY	SESSION	STATIONS OCCUPIED
101	0	005, 138, 139, 140
	1	140, 141, 143
	2	140, 141, 142



DAY 101 - SESSIONS 0, 1 & 2

ZG1: [102,4]MON106.DGN;1

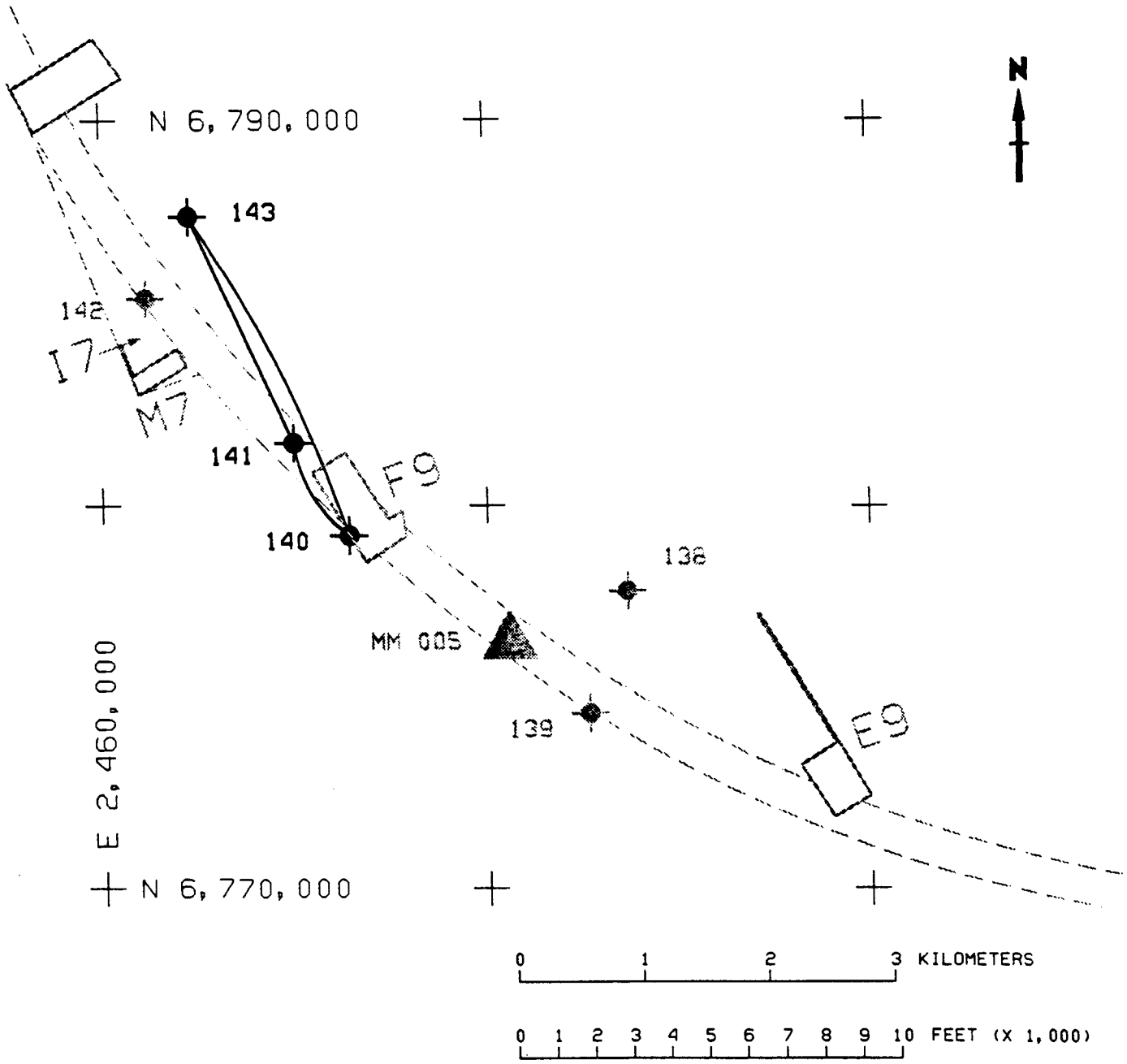


0 1 2 3 KILOMETERS

0 1 2 3 4 5 6 7 8 9 10 FEET (X 1,000)

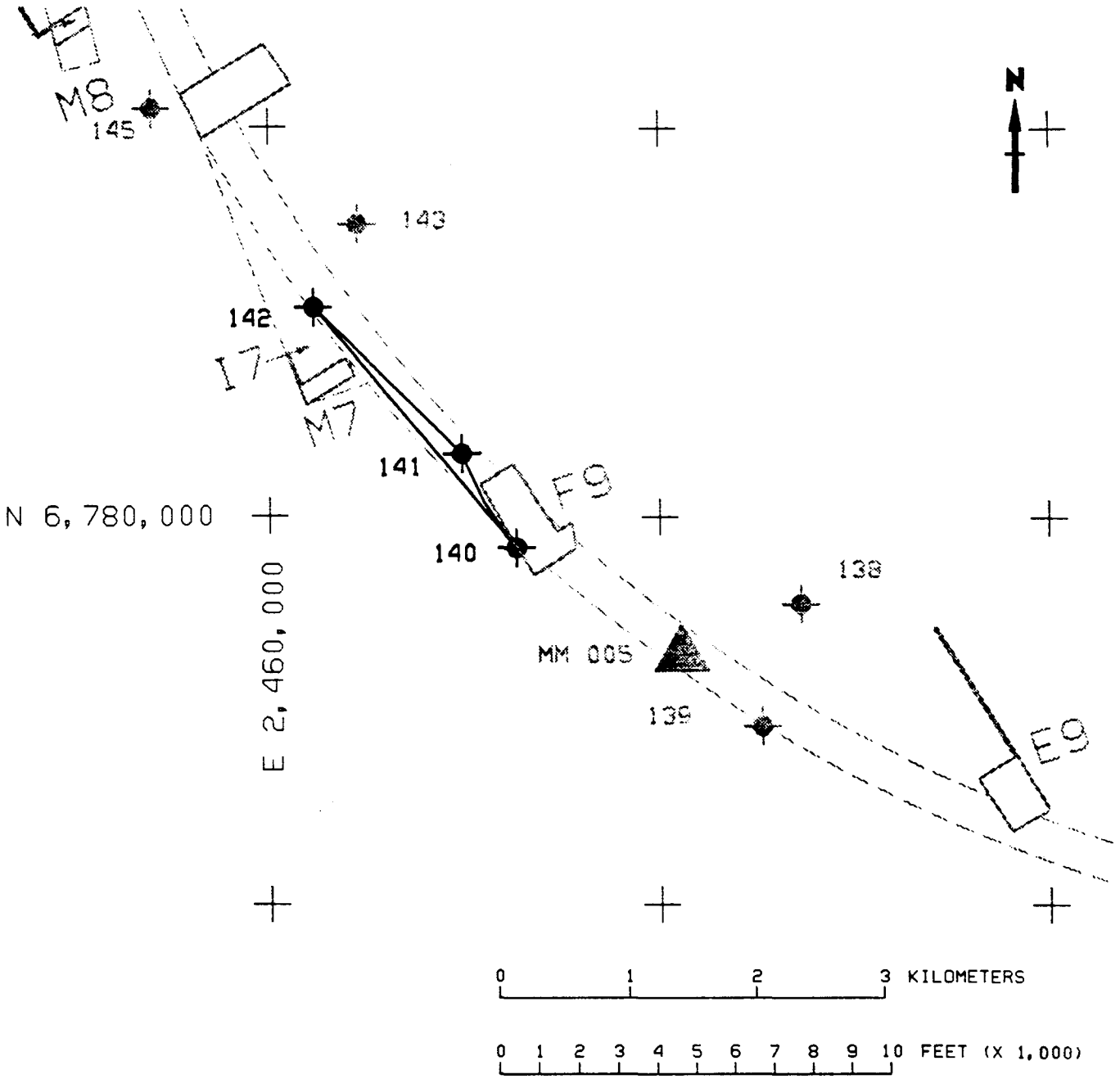
DAY 101 - SESSION 0

ZG1: [102,4]MON107.DGN



DAY 101 - SESSION 1

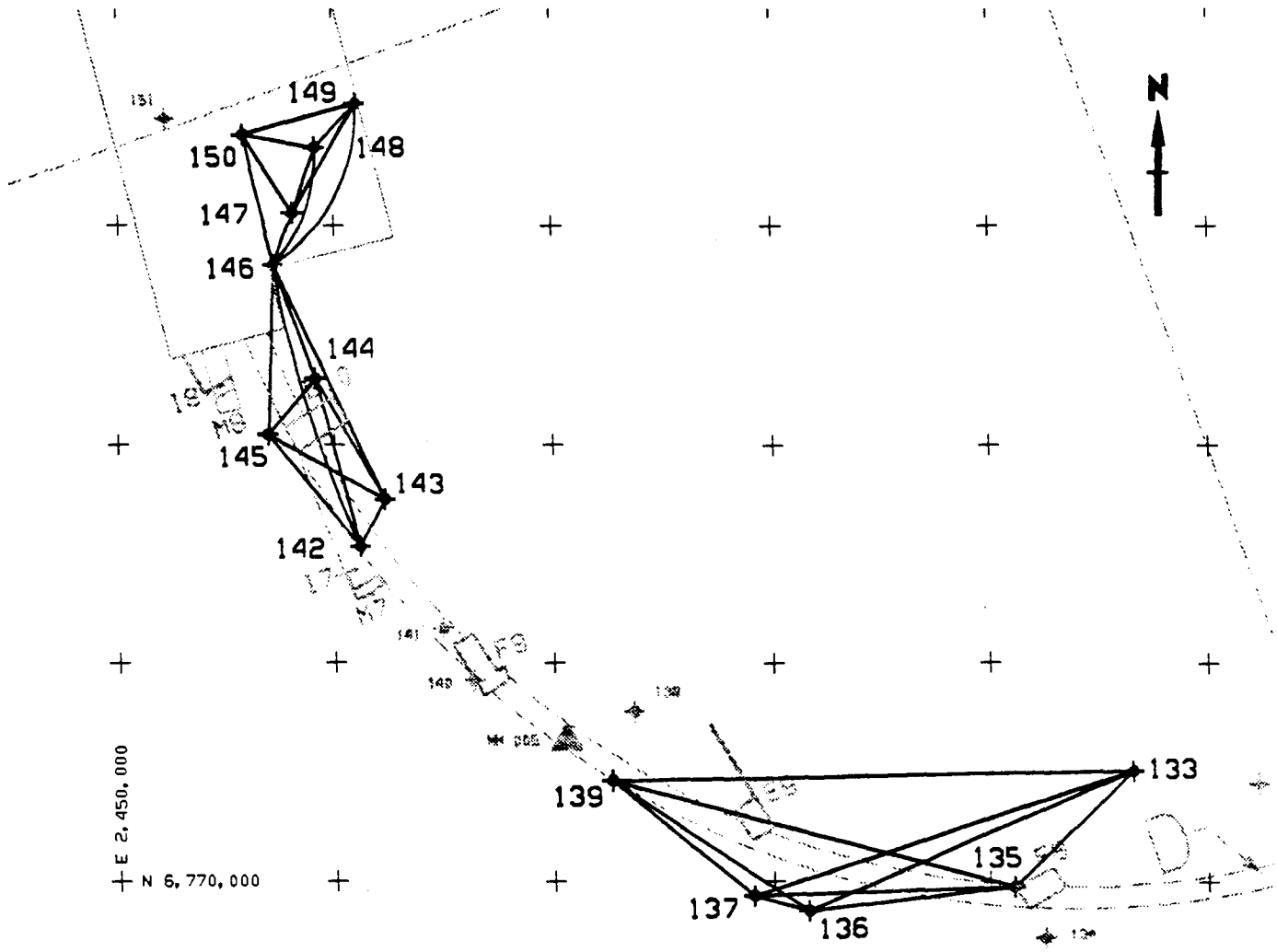
ZG1: [102,4]MON108.DGN



DAY 101 - SESSION 2

ZG1: [102,4]MON109.DGN

DAY	SESSION	STATIONS OCCUPIED
102	0	146, 147, 148, 149, 150
	1	142, 143, 144, 145, 146
	2	133, 135, 136, 137, 139

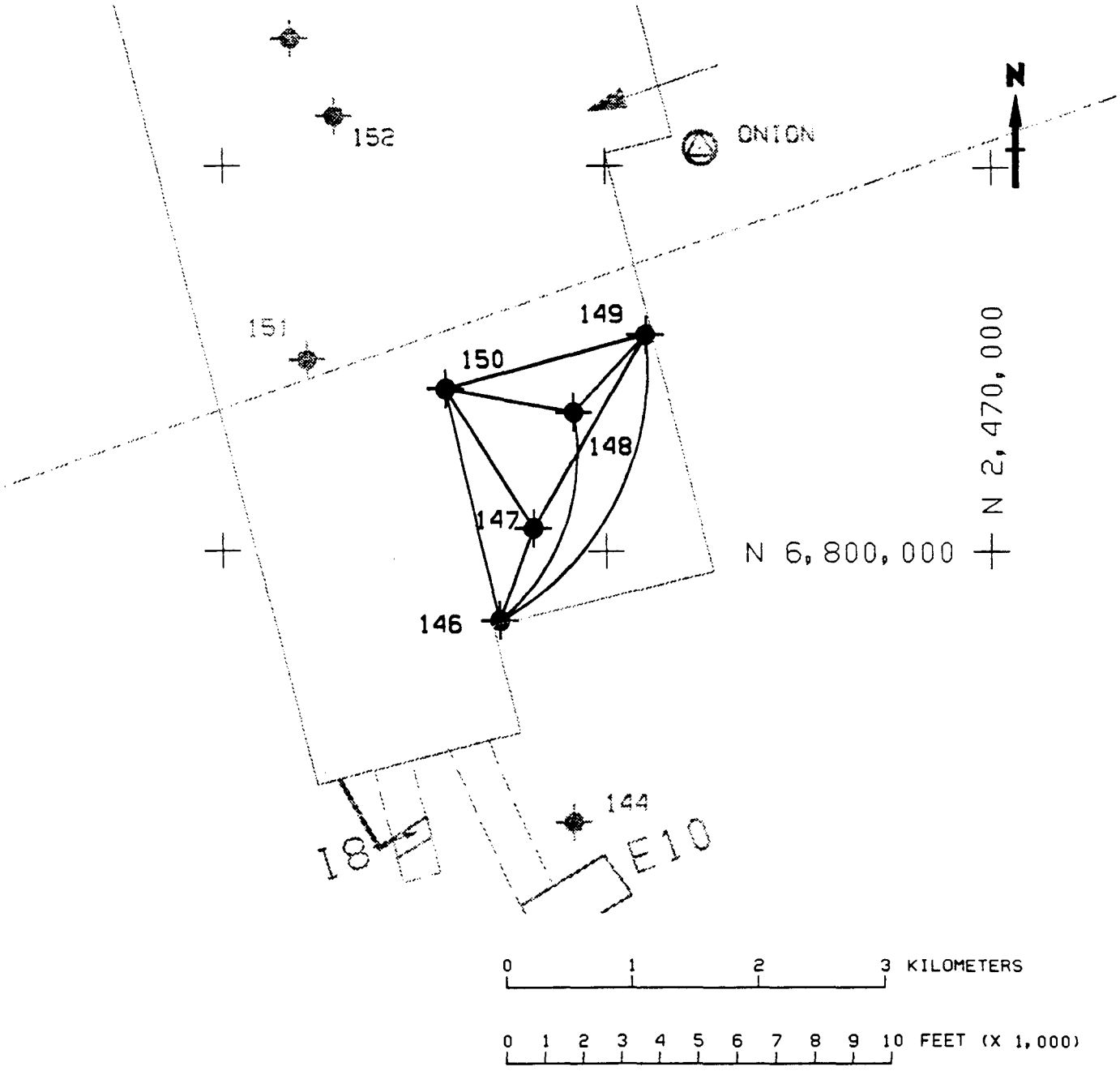


0 2 4 6 KILOMETERS

0 2 4 6 8 10 12 14 16 18 20 FEET (X 1,000)

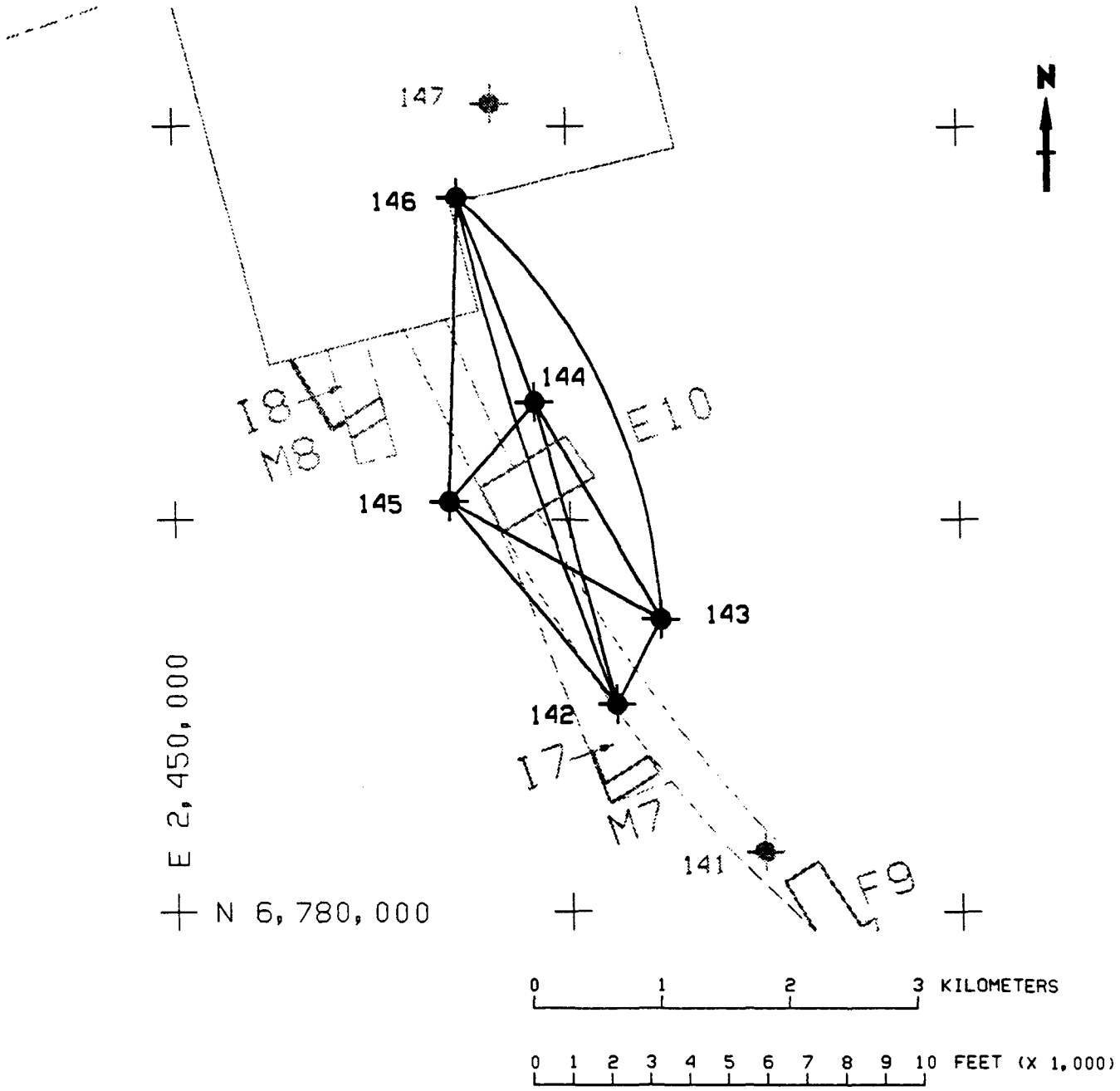
DAY 102 - SESSION 0, 1 & 2

ZG1: [102,4]MON110.DGN



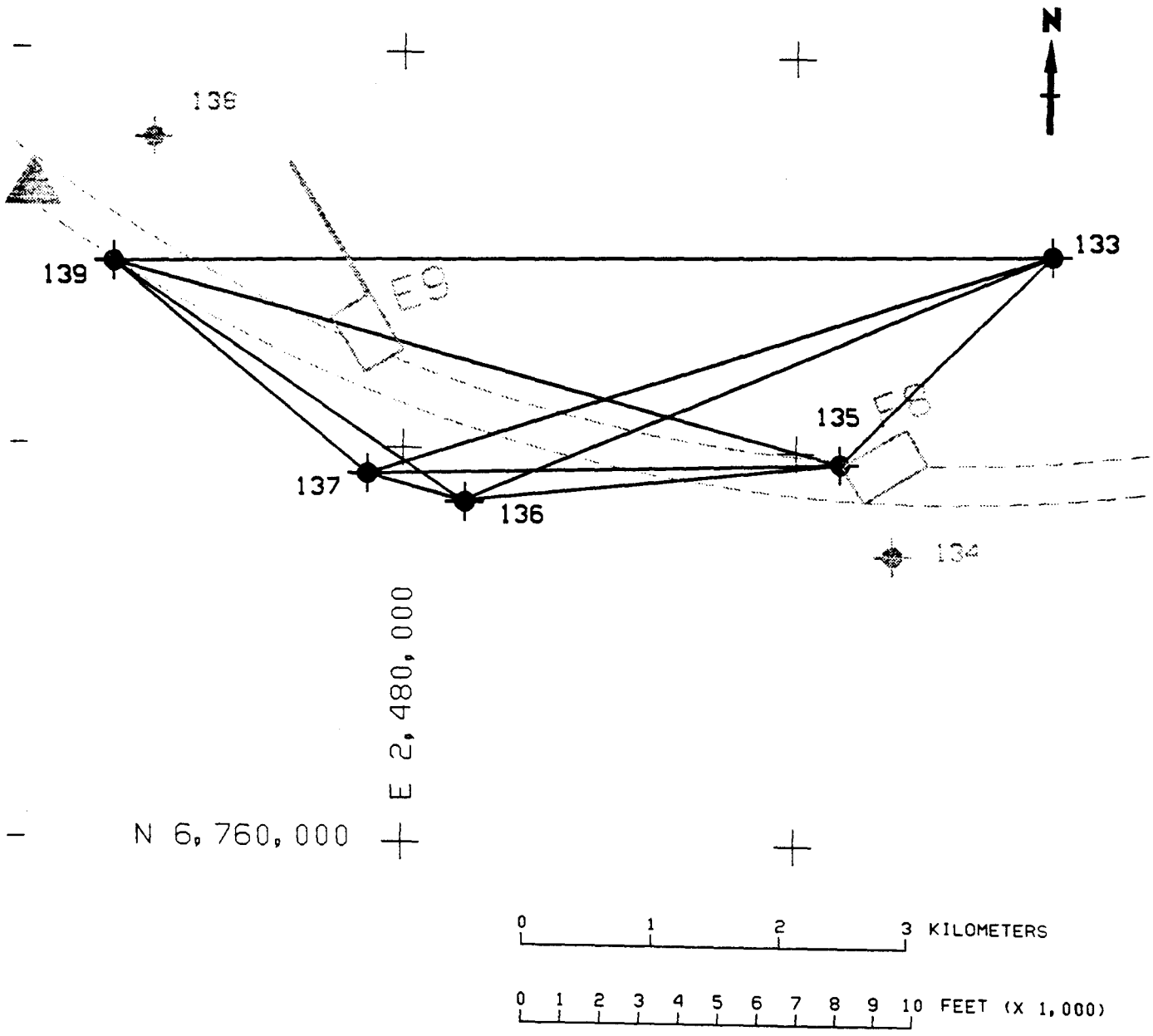
DAY 102 - SESSION 0

ZG1: [102,4]MON111.DGN



DAY 102 - SESSION 1

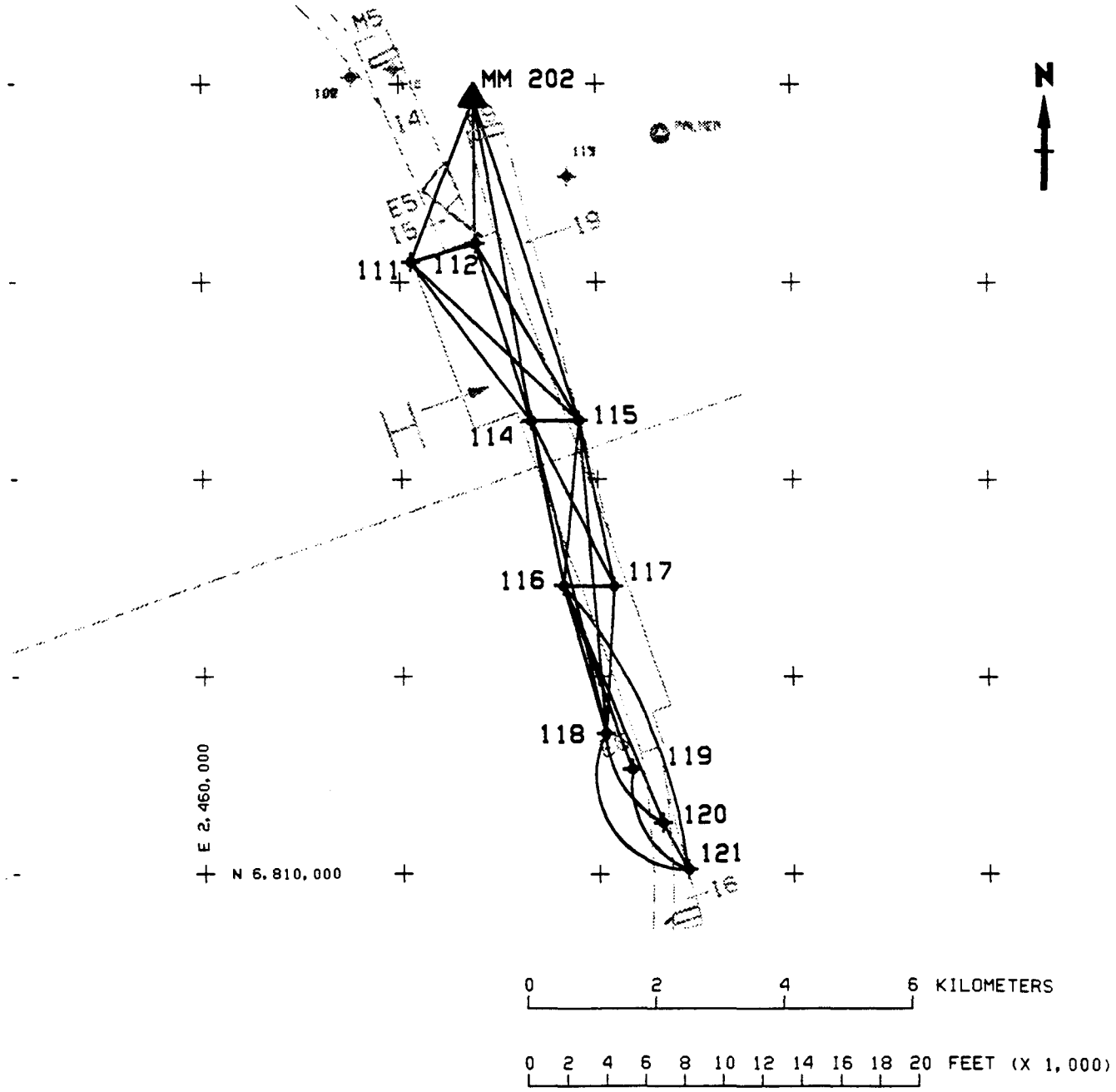
ZG1: [102,4]MON112.DGN



DAY 102 - SESSION 2

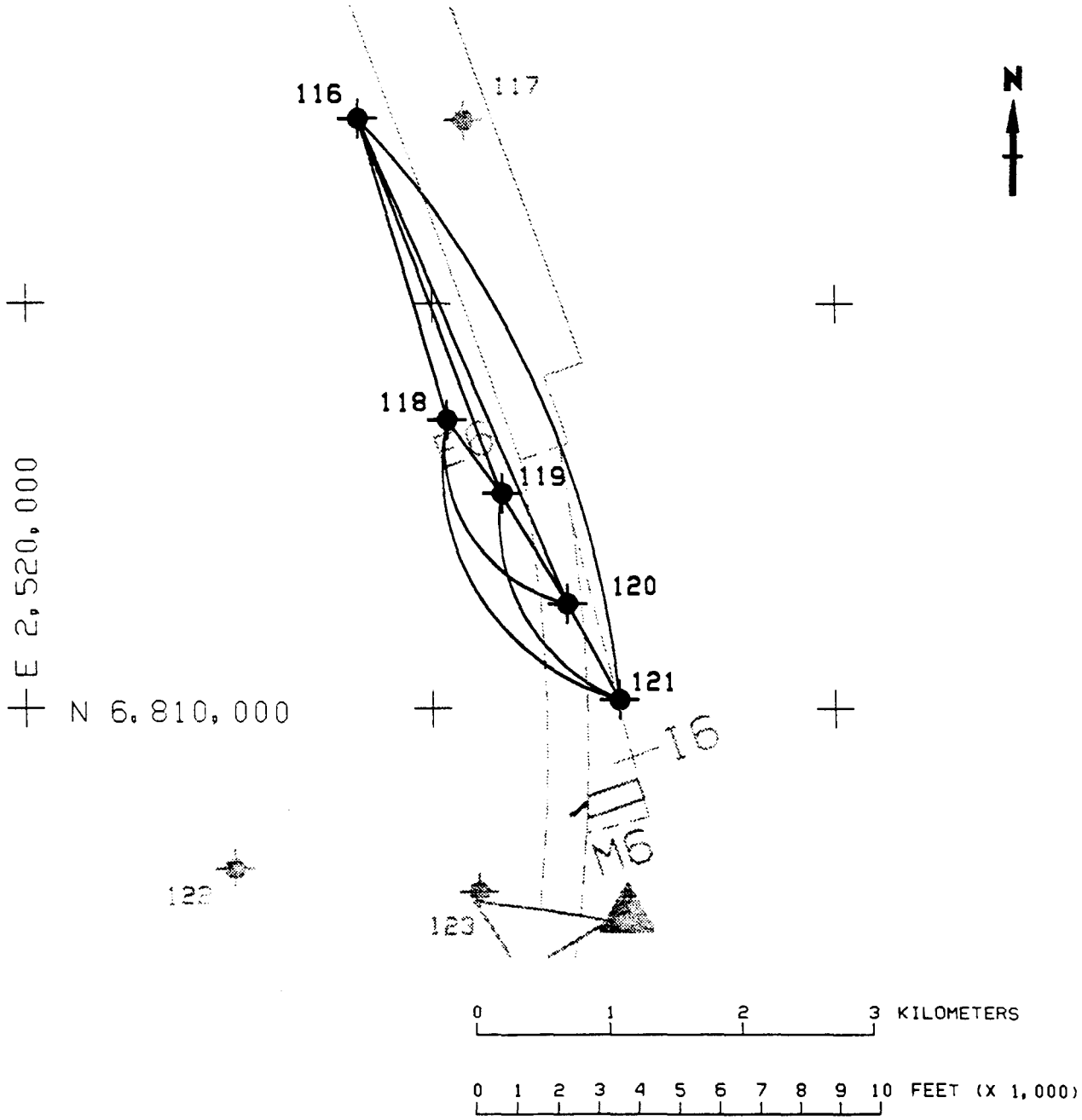
ZG1: [102,4]MON113.DGN

DAY	SESSION	STATIONS OCCUPIED
103	0	116, 118, 119, 120, 121
	1	114, 115, 116, 117, 118
	2	202, 111, 112, 114, 115



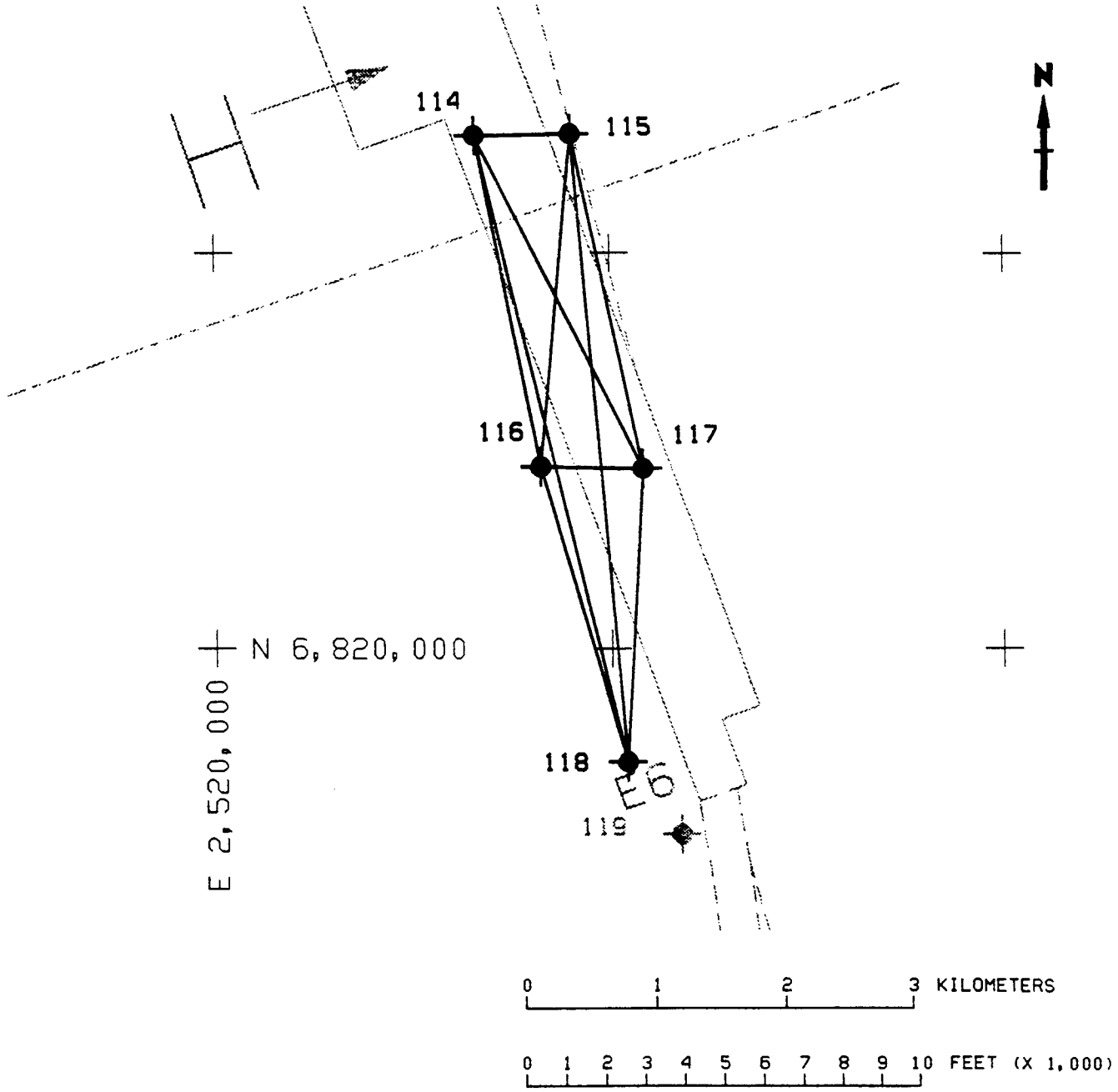
DAY 103 - SESSION 0, 1 & 2

ZG1: [102,4]MON114.DGN



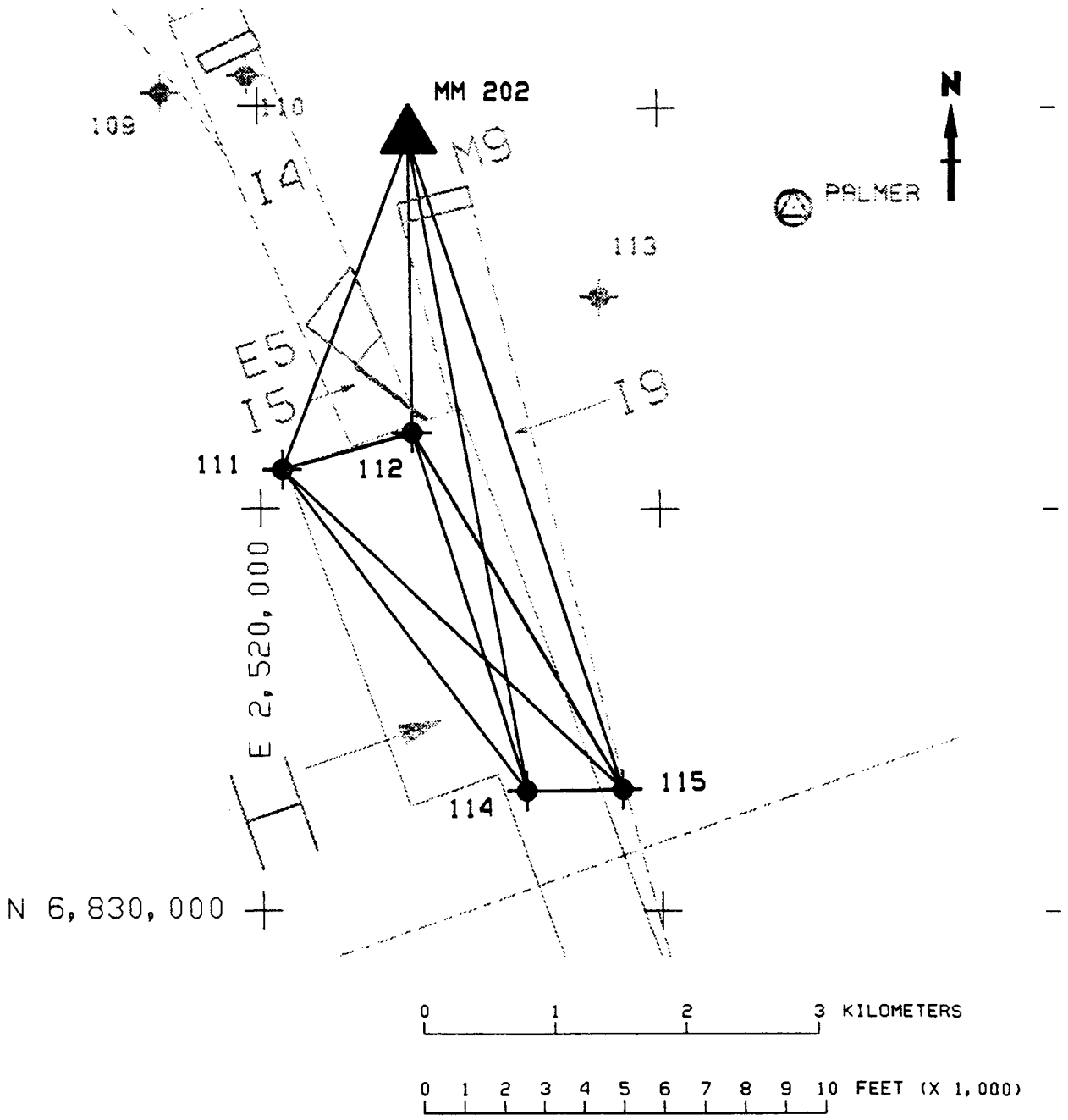
DAY 103 - SESSION 0

ZG1: [102,4]MON115.DGN; 1



DAY 103 - SESSION 1

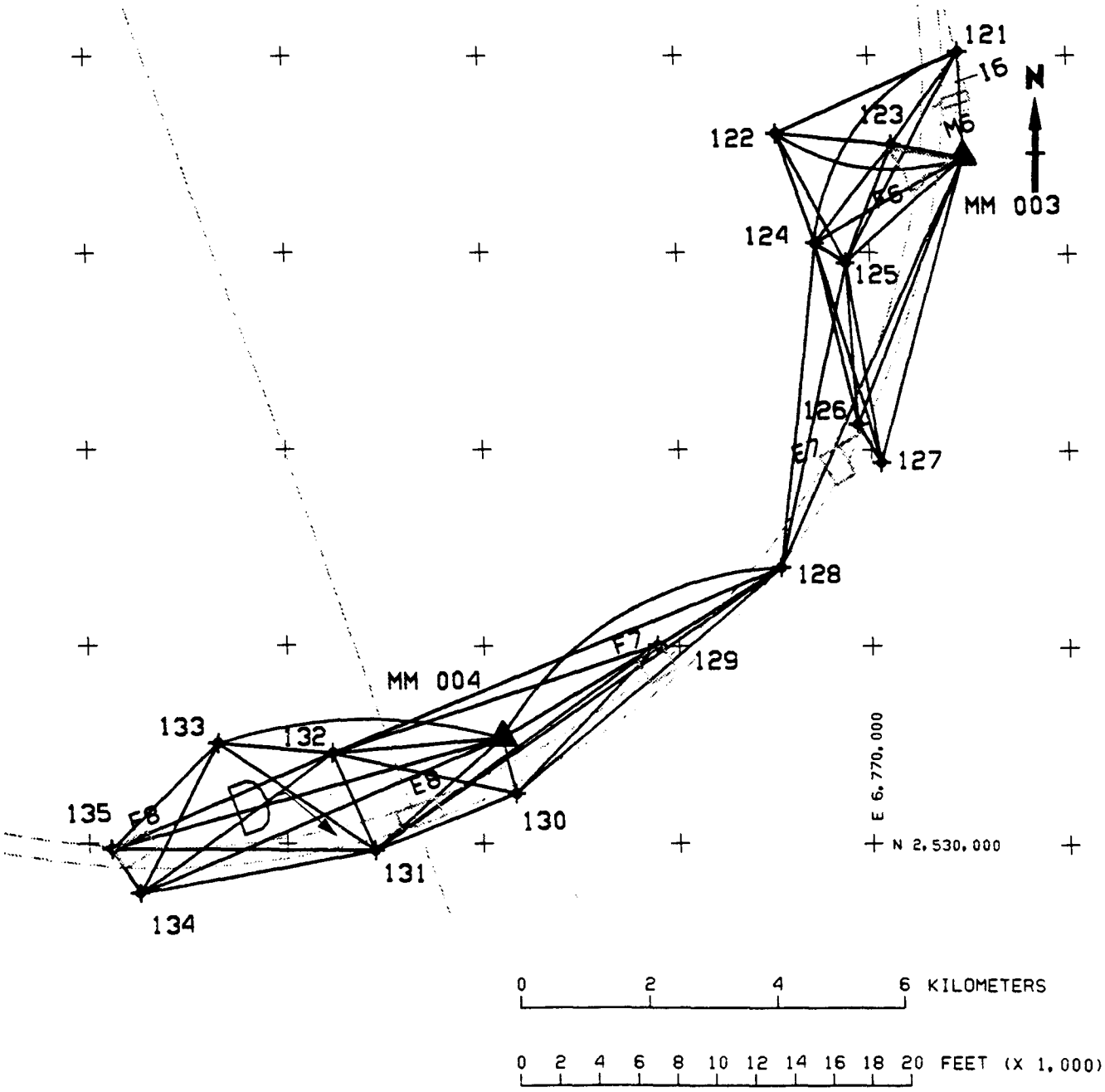
ZG1: [102,4]MON116.DGN



DAY 103 - SESSION 2

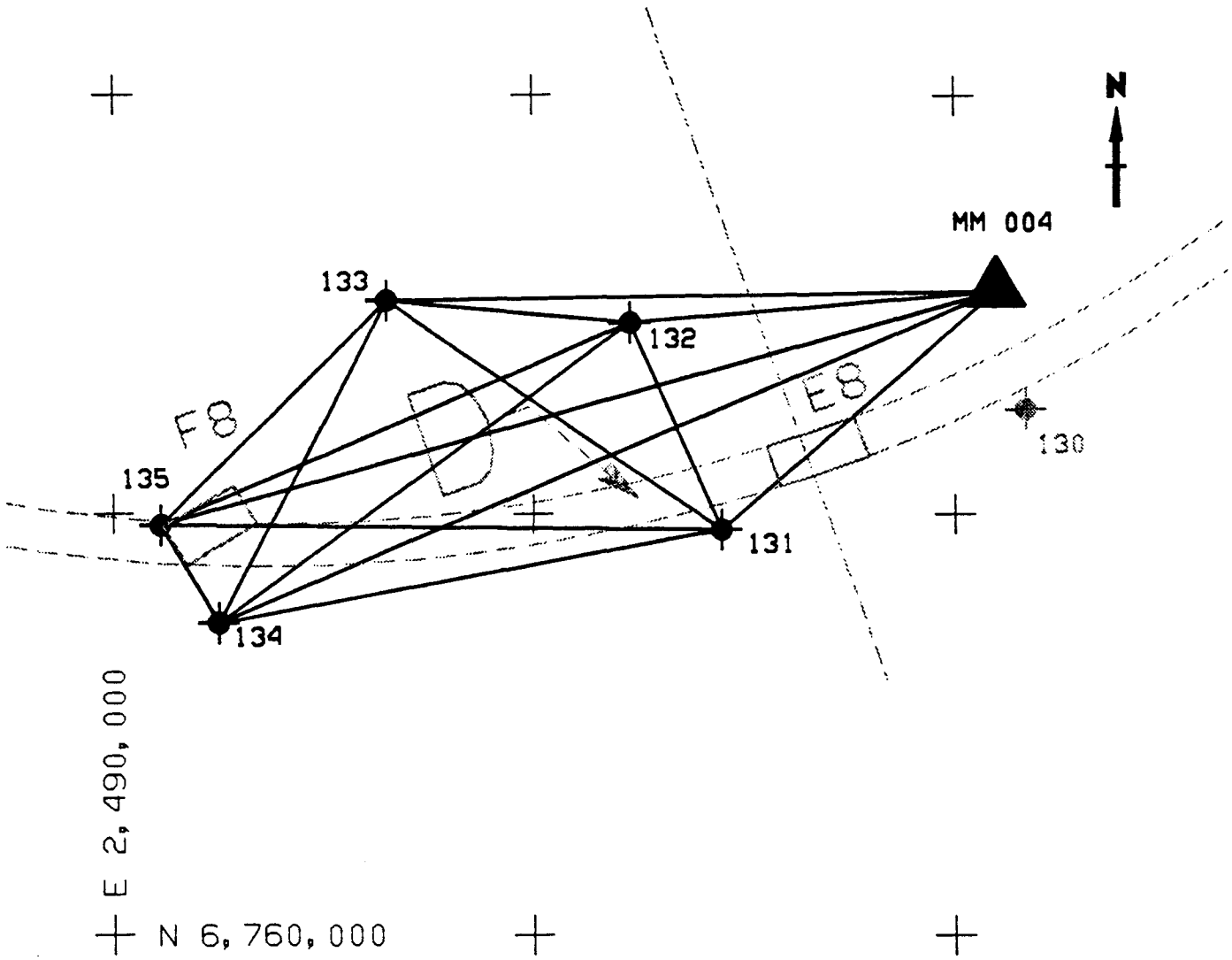
ZG1: [102,4]MON117.DGN

DAY	SESSION	STATIONS OCCUPIED
107	0	004, 131, 132, 133, 134, 135
	1	004, 128, 129, 130, 131, 132
	2	003, 124, 125, 126, 127, 128
	3	003, 121, 122, 123, 124, 125



DAY 107 - SESSION 0, 1, 2 & 3

ZG1: [102,4]MON118.DGN

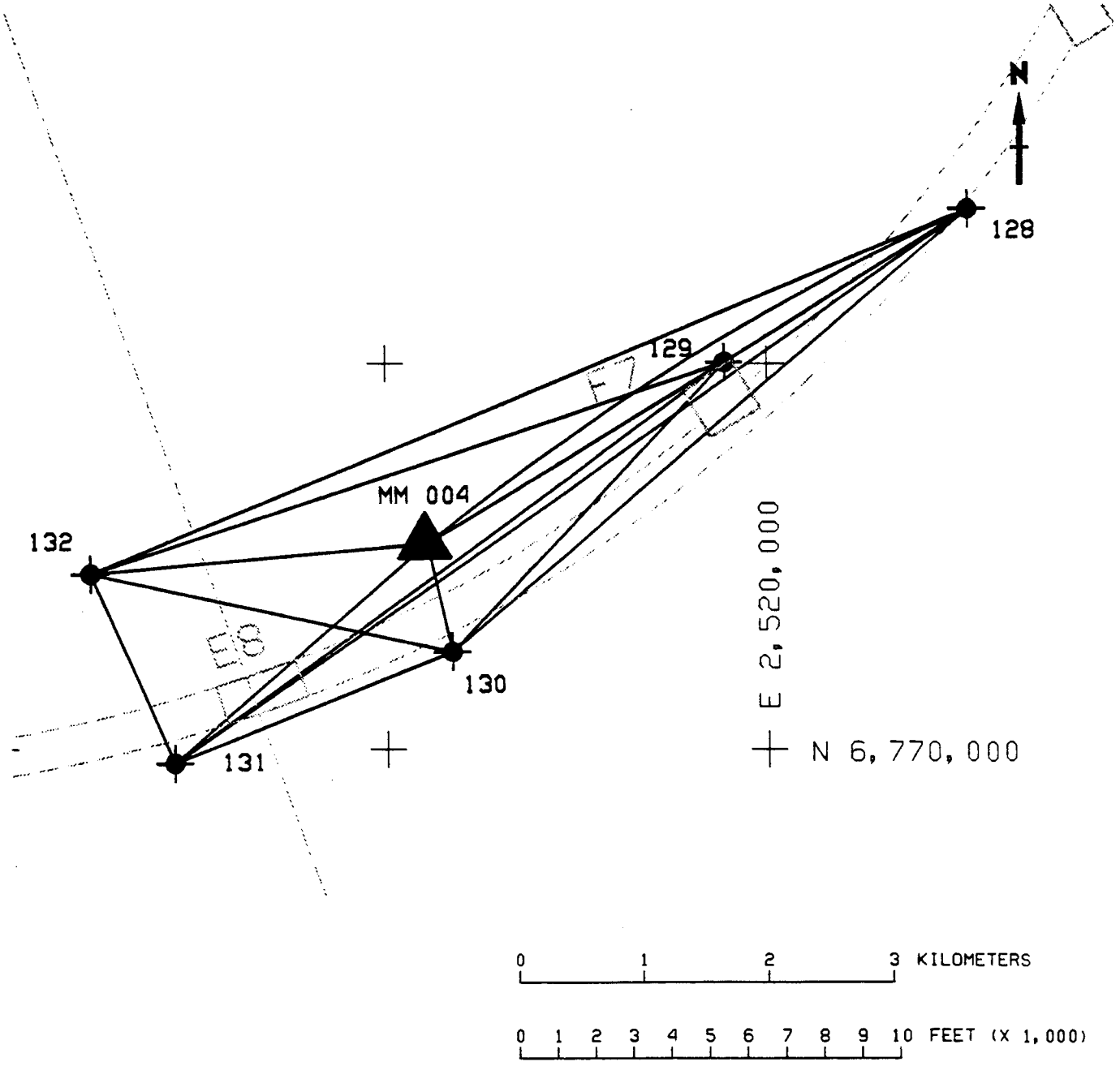


0 1 2 3 KILOMETERS

0 1 2 3 4 5 6 7 8 9 10 FEET (X 1,000)

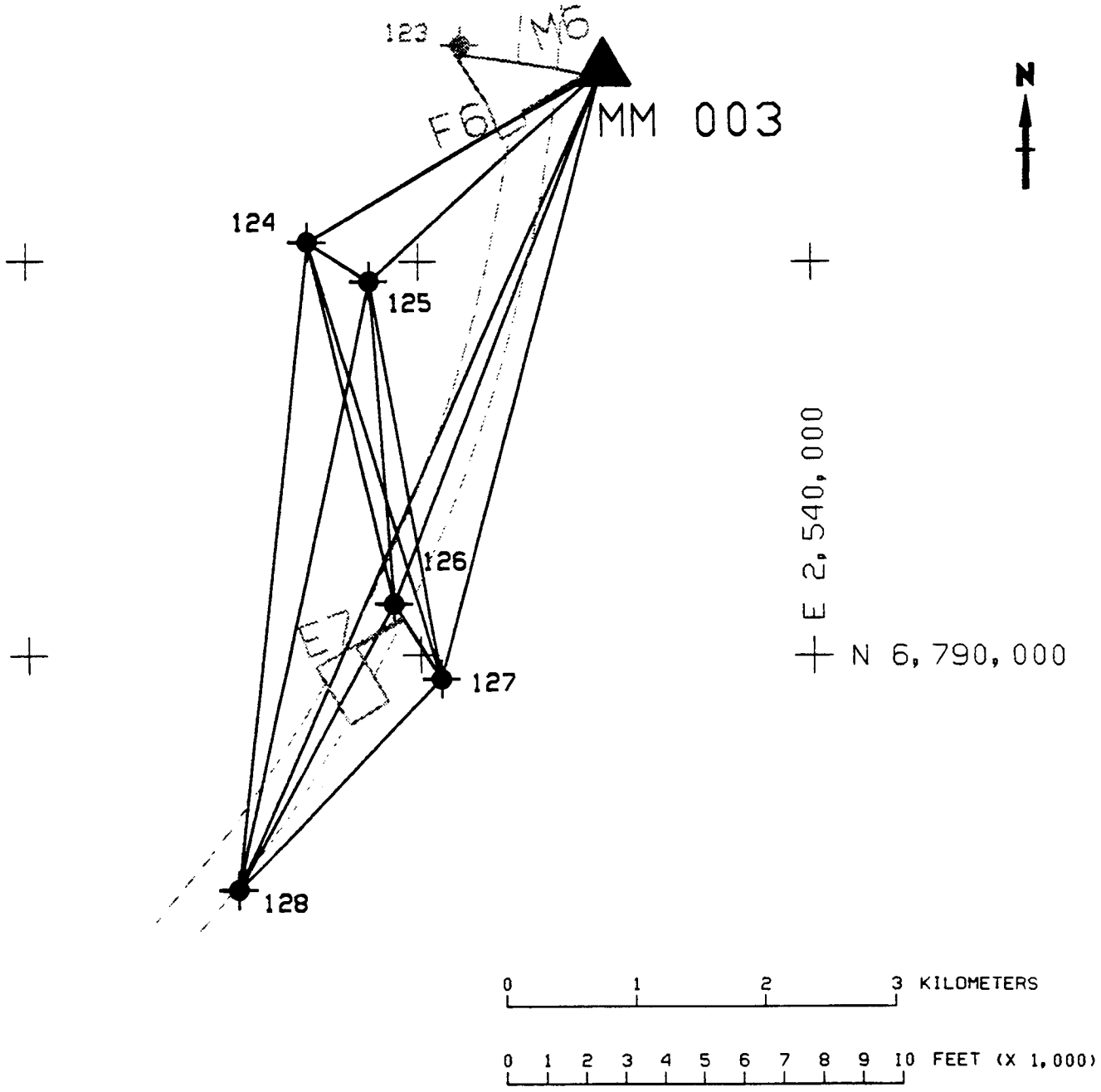
DAY 107 - SESSION 0

ZG1: [102,4]MON122.DGN



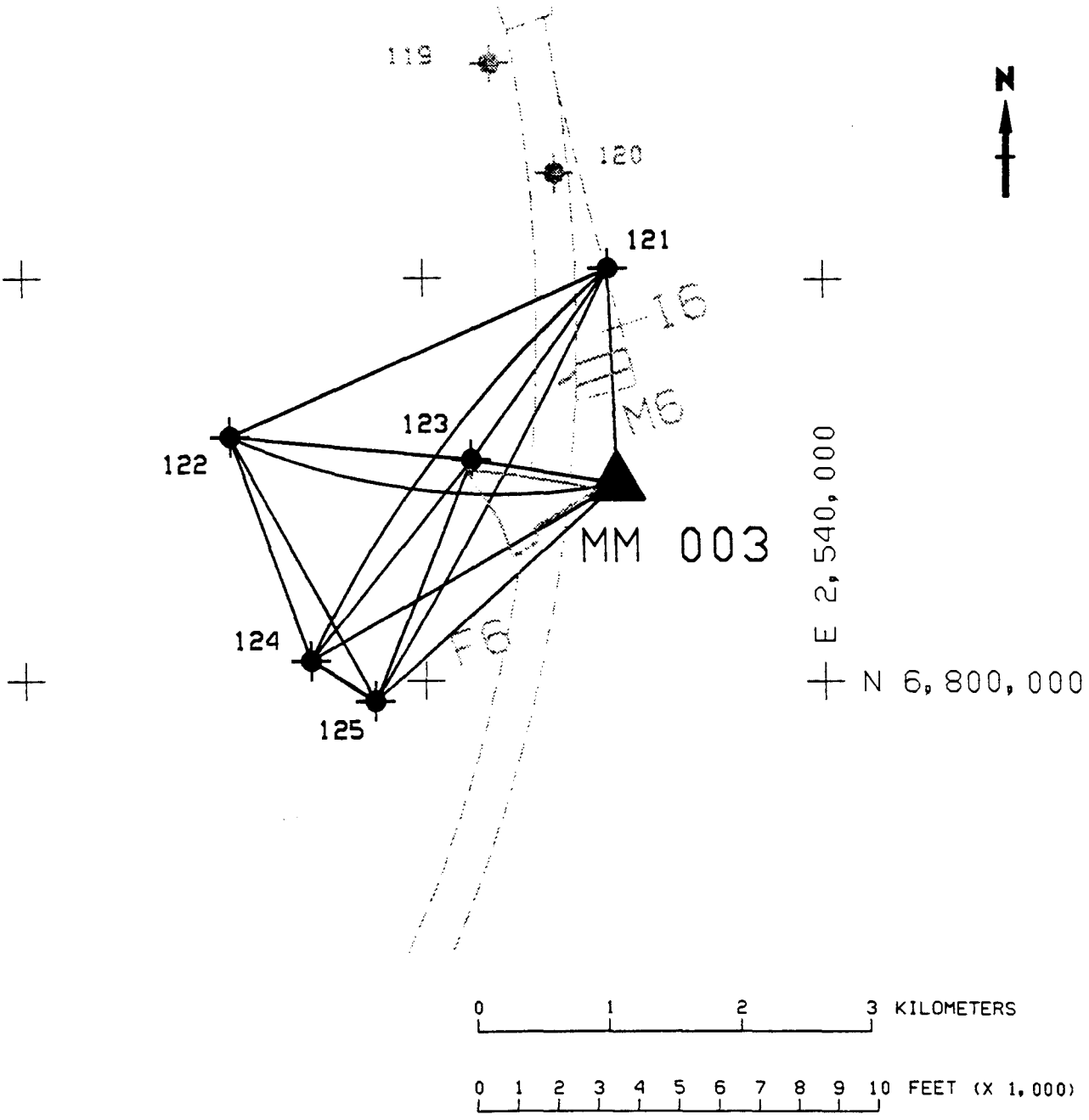
DAY 107 - SESSION 1

ZG1: [102,4]MON119.DGN



DAY 107 - SESSION 2

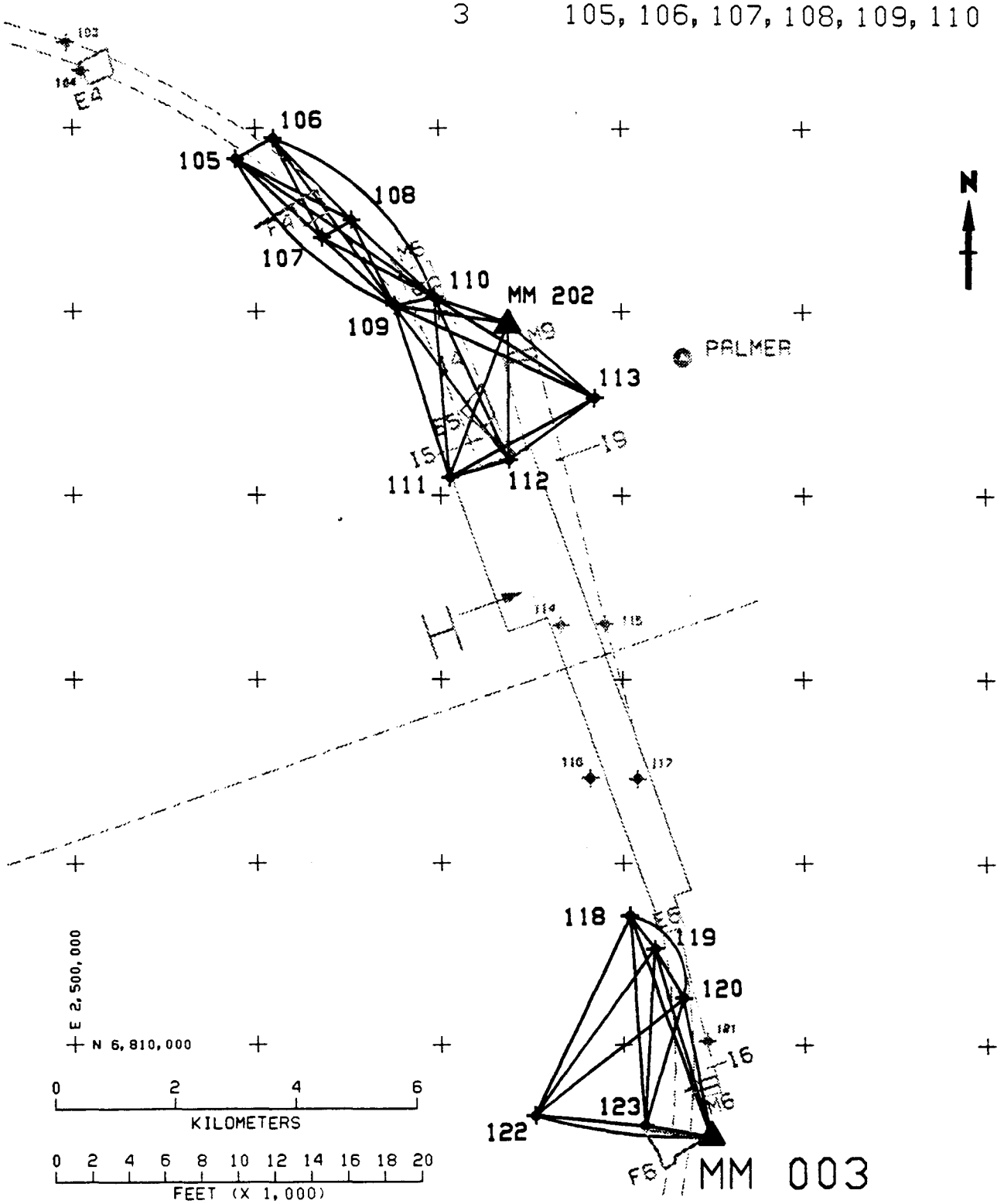
ZG1: [102,4]MON120.DGN



DAY 107 - SESSION 3

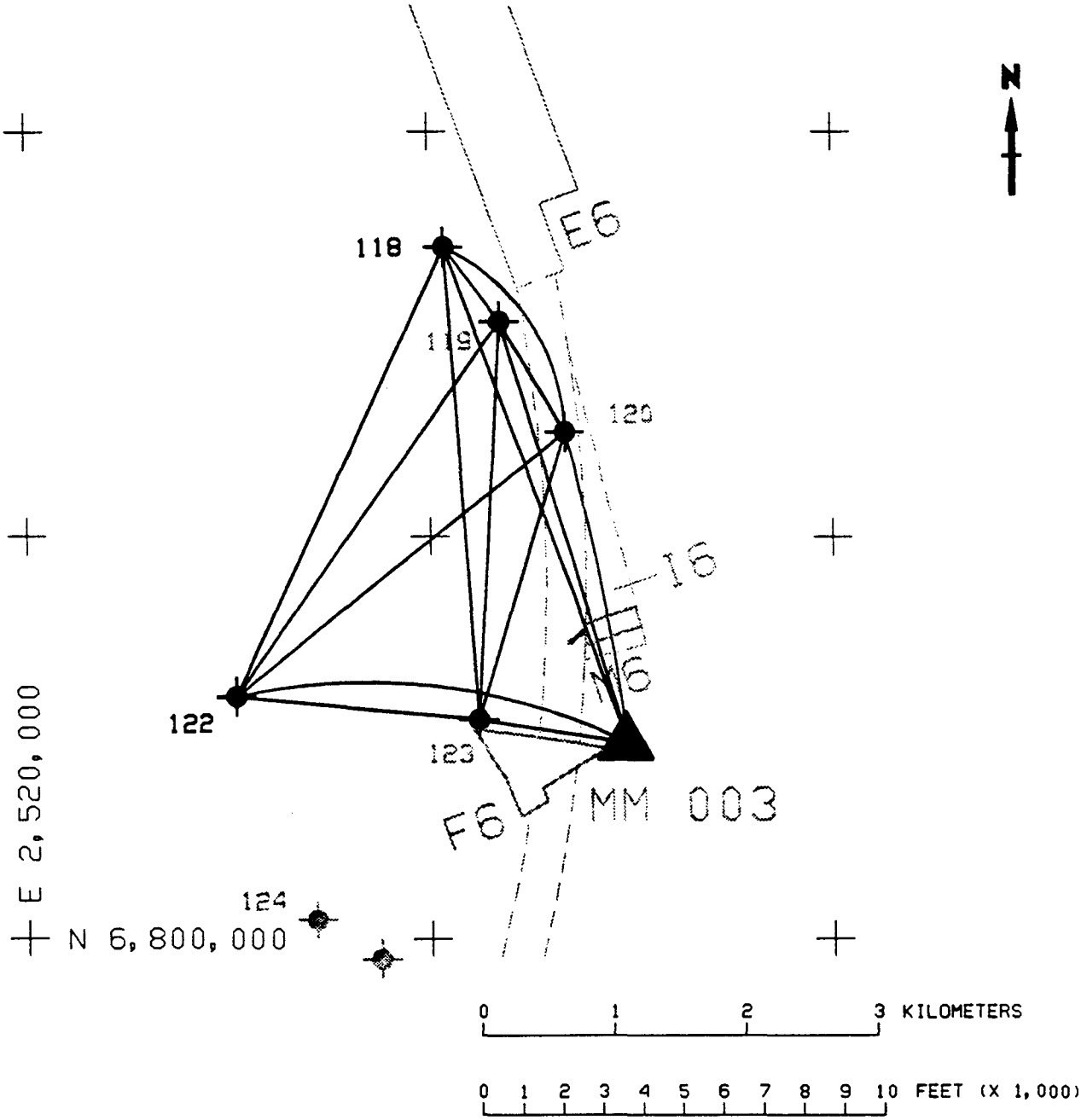
ZG1: [102,4]MON121.DGN;1

DAY	SESSION	STATIONS OCCUPIED
108	0	003, 118, 119, 122, 123
	2	202, 109, 110, 111, 112, 113
	3	105, 106, 107, 108, 109, 110



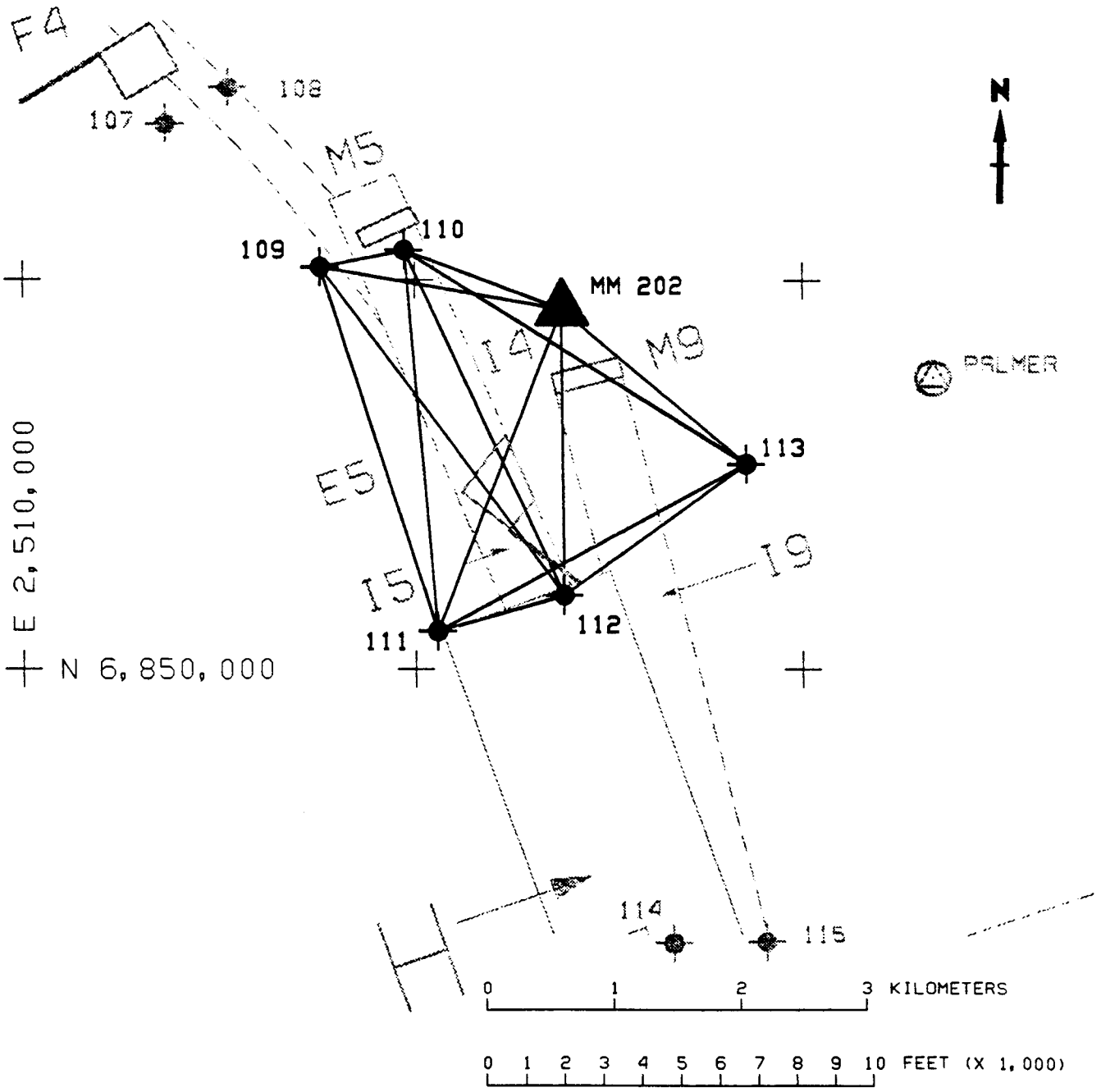
DAY 108 - SESSIONS 0, 2, & 3

ZG1: [102,4]MON123.DGN;1



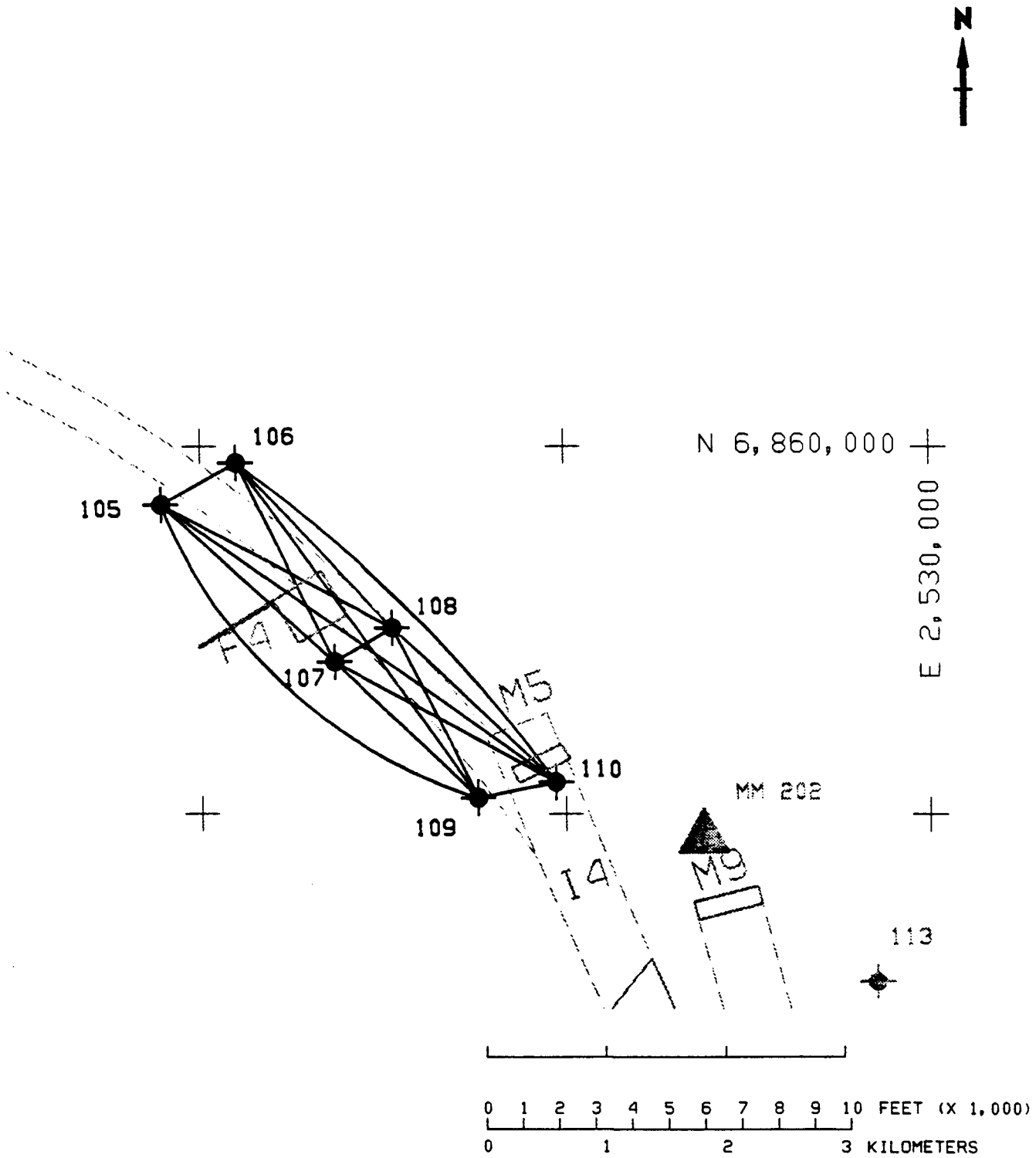
DAY 108 - SESSION 0

ZG1: [102,4]MON124.DGN



DAY 108 - SESSION 2

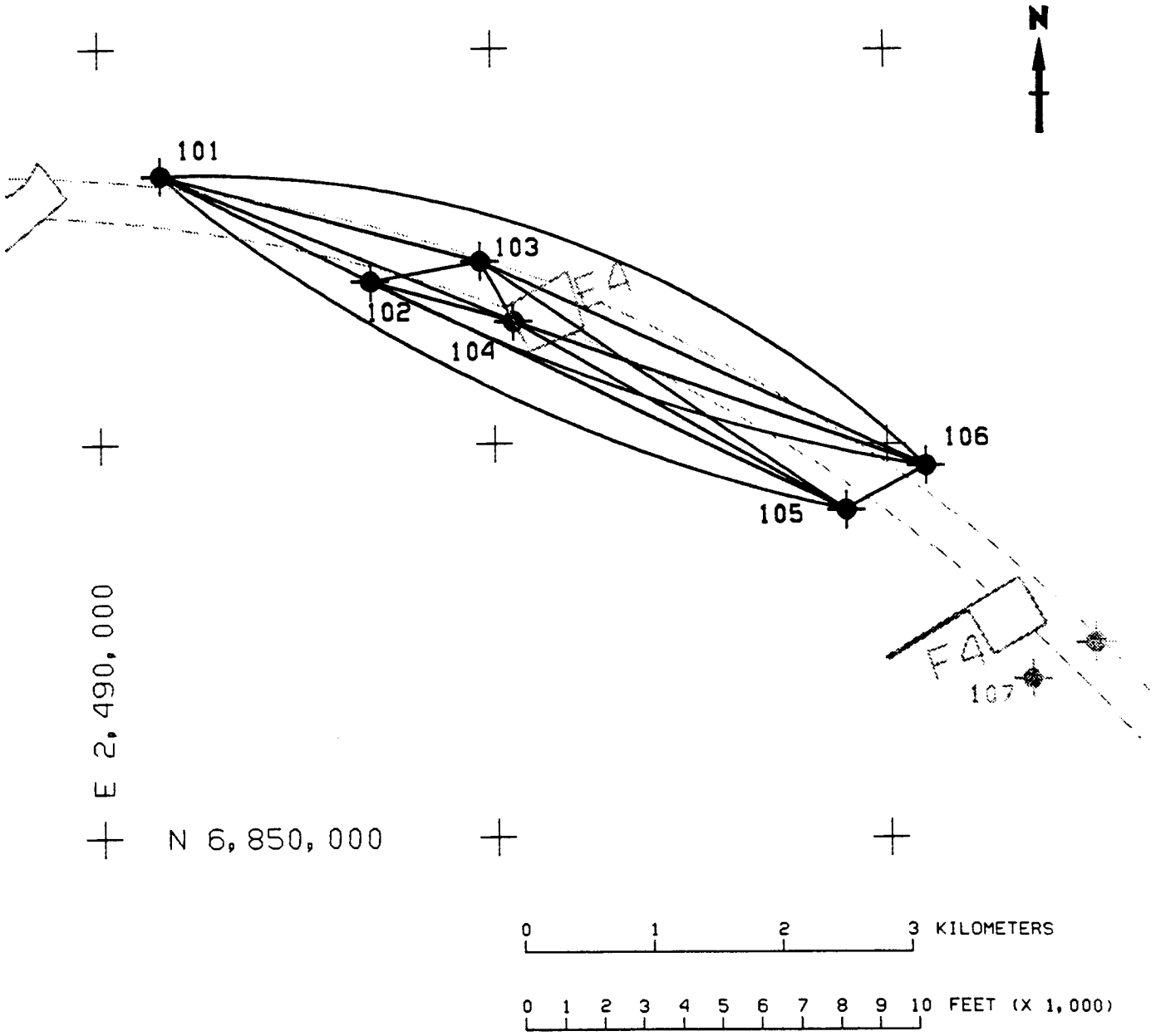
ZG1: [102,4]MON125.DGN



DAY 108 - SESSION 3

ZG1: [102,4]MON126.DGN

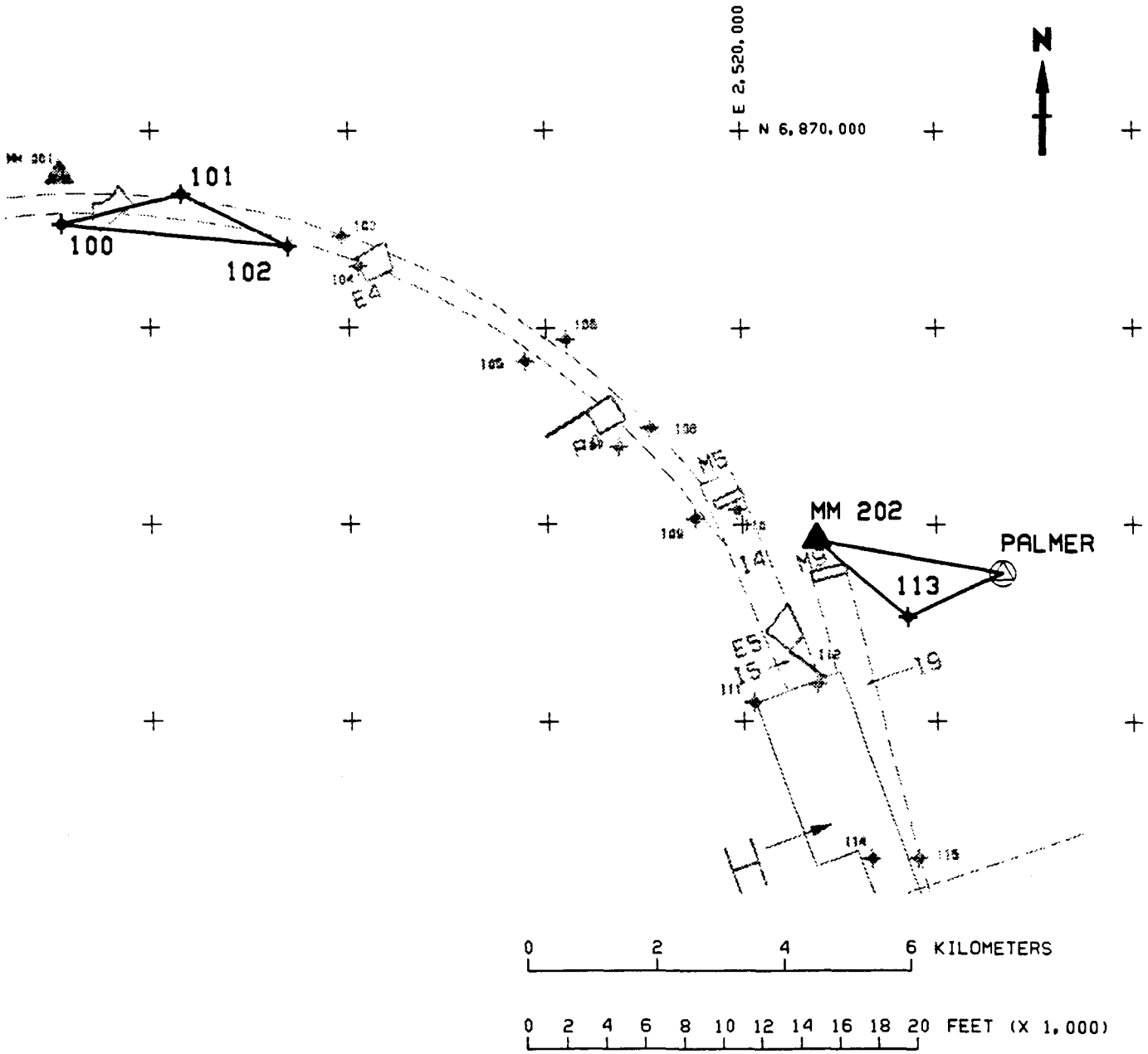
DAY	SESSION	STATIONS OCCUPIED
109	0	101, 102, 103, 104, 105, 106



DAY 109 - SESSION 0

ZG1: [102,4]MON127.DGN

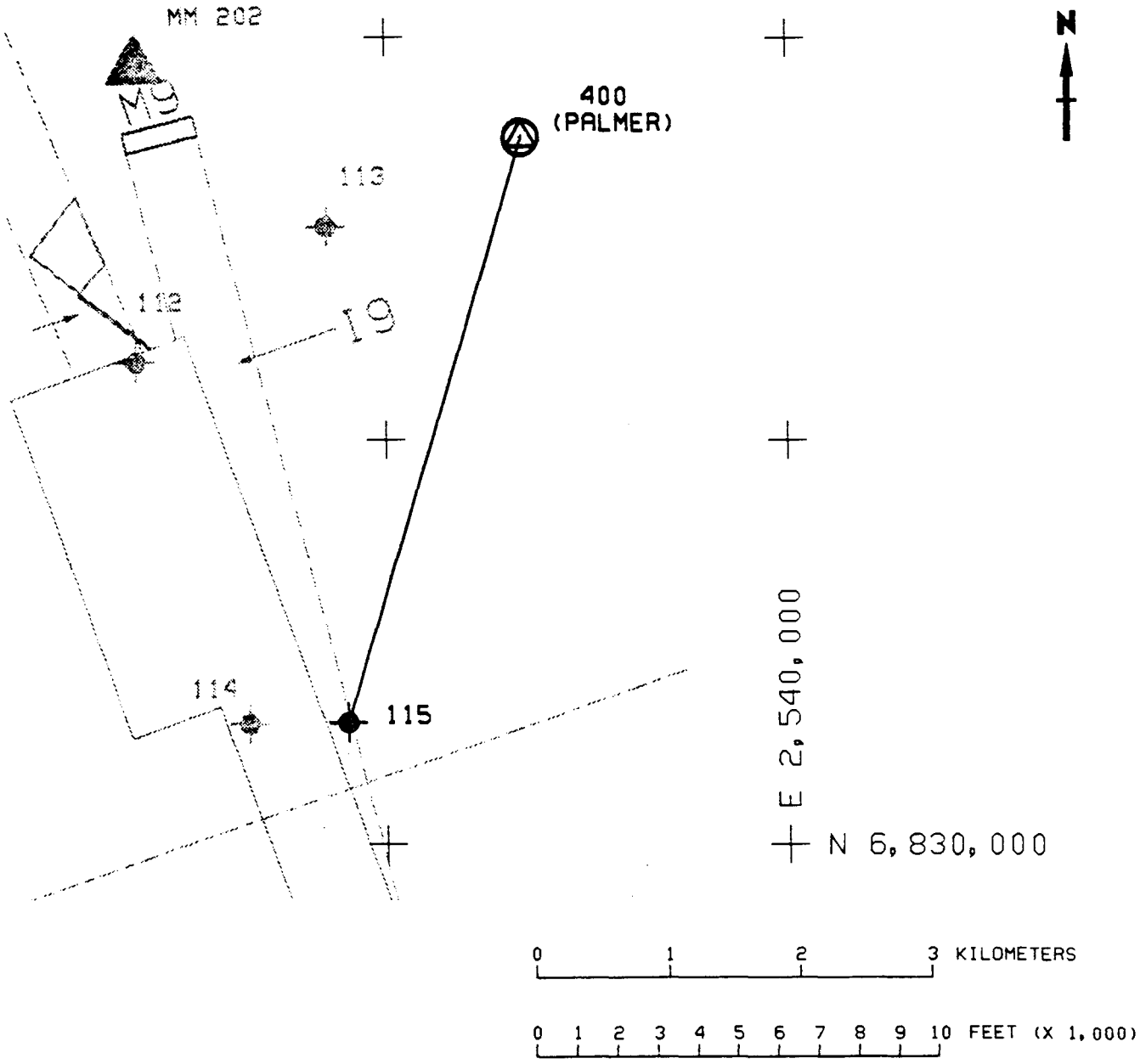
DAY	SESSION	STATIONS OCCUPIED
110	0	113, 115, 202, 400
	1	100, 101, 102



DAY 110 - SESSION 0 & 1

ZG1: [102,4]MON128.DGN;1

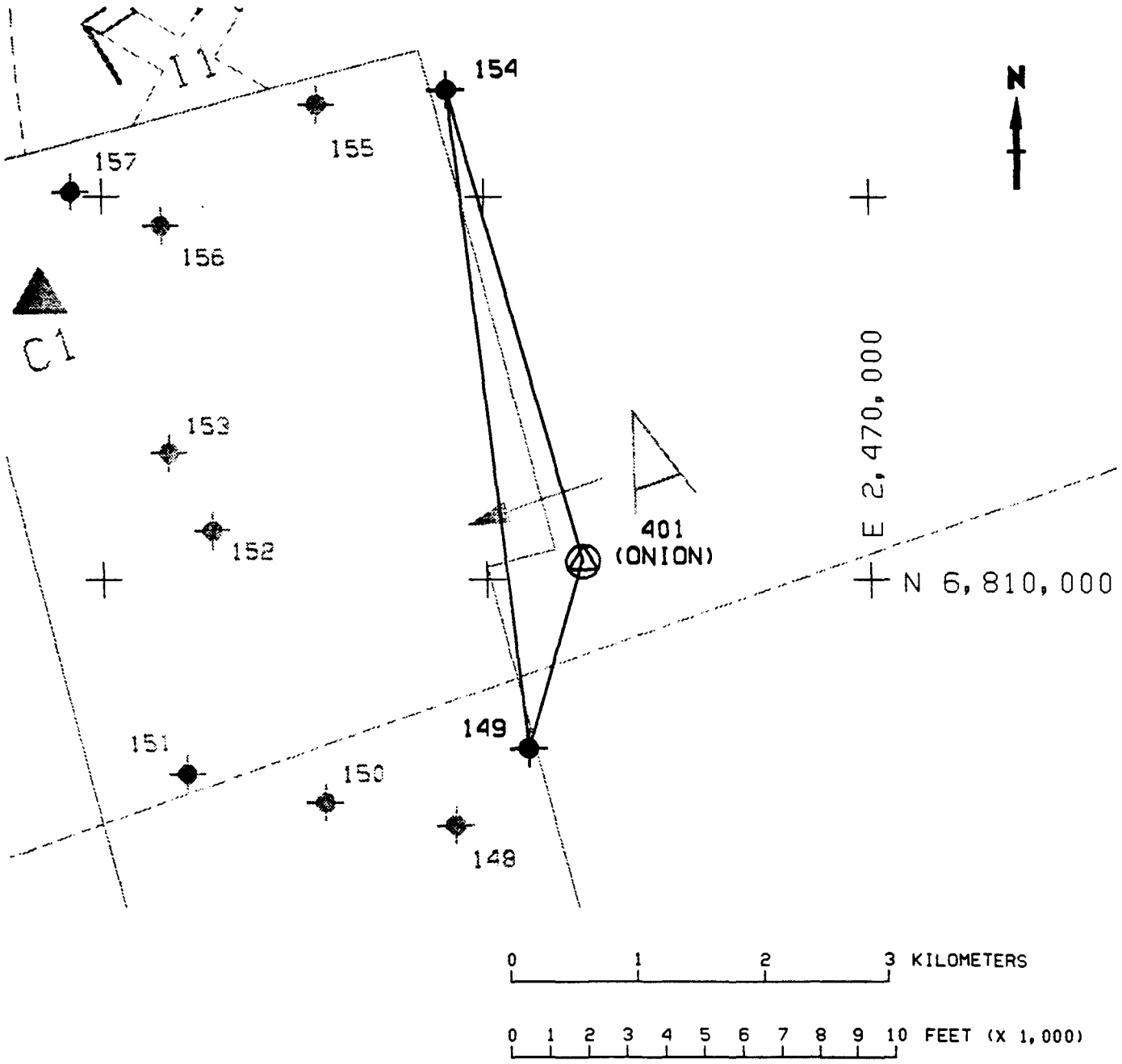
DAY	SESSION	STATIONS OCCUPIED
111	0.2	115, 400



DAY 111 - SESSION 0.1

ZG1: [102,4]MON130.DGN

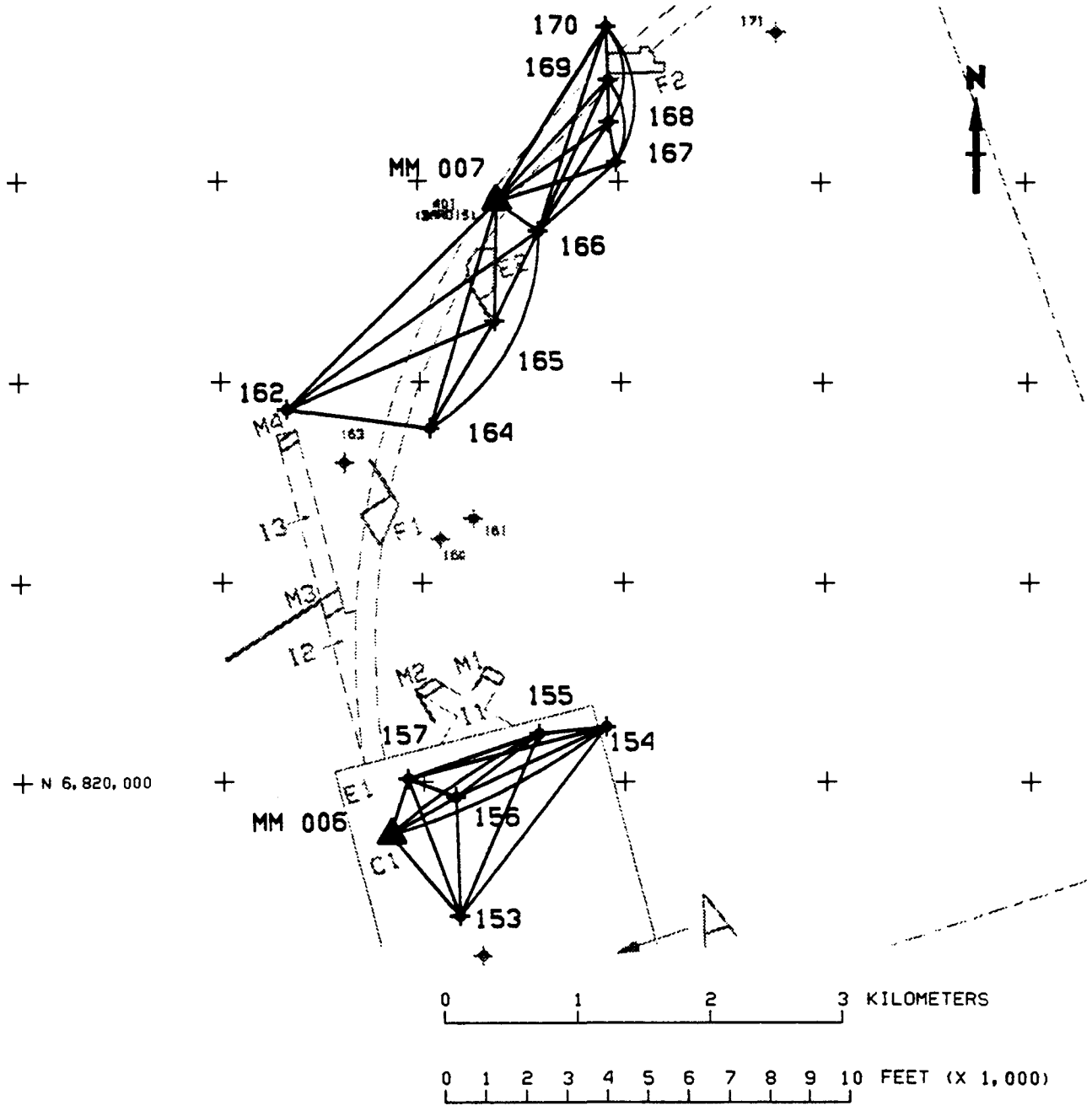
DAY	SESSION	STATIONS OCCUPIED
111	0.2	401, 149, 154



DAY 111 - SESSION 0.2

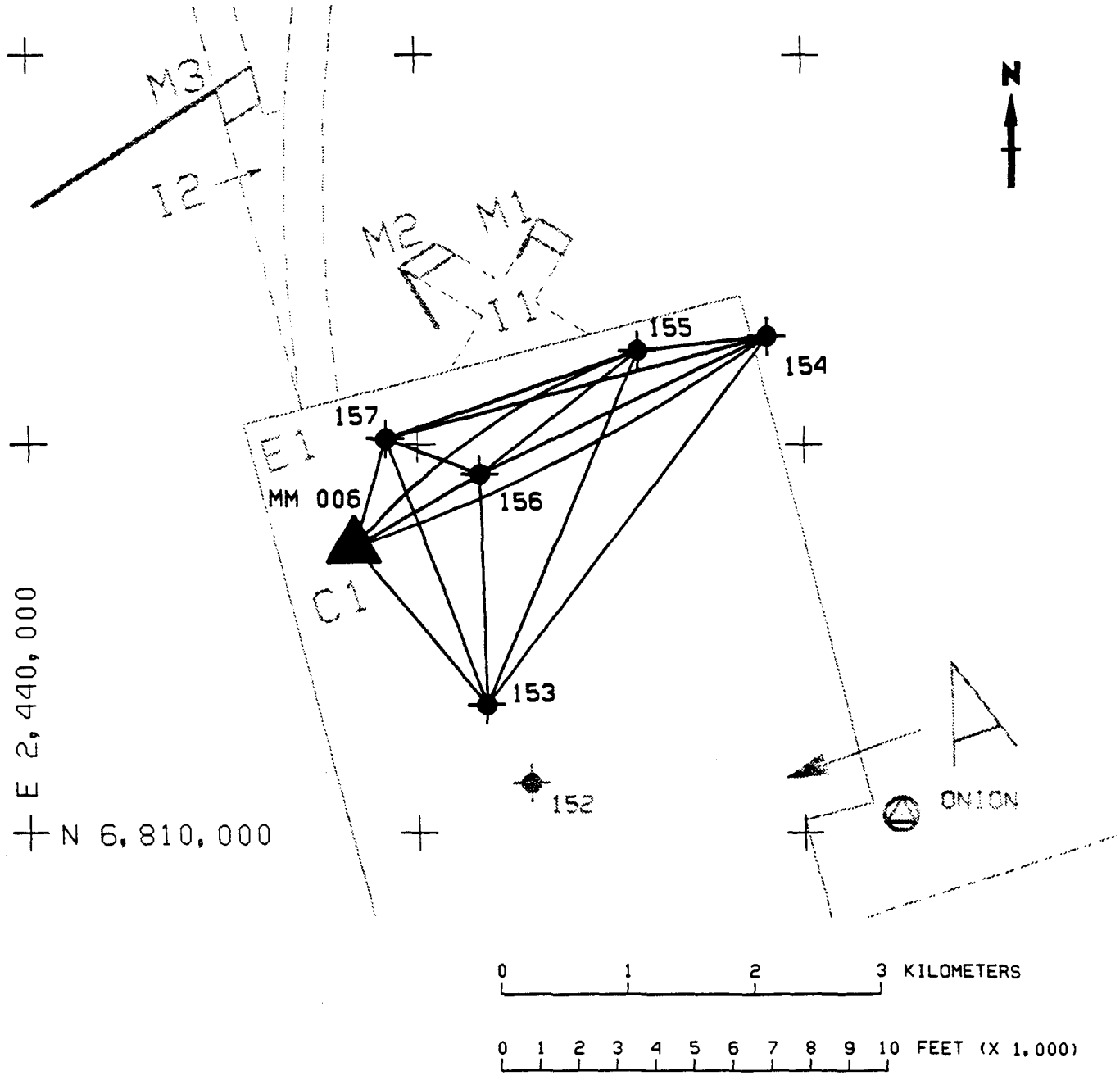
ZG1: [102,4]MON129.DGN;1

DAY	SESSION	STATIONS OCCUPIED
113	0	006, 153, 154, 155, 156, 157
	2	007, 162, 164, 165, 166, 403
	3	007, 166, 167, 168, 169, 170



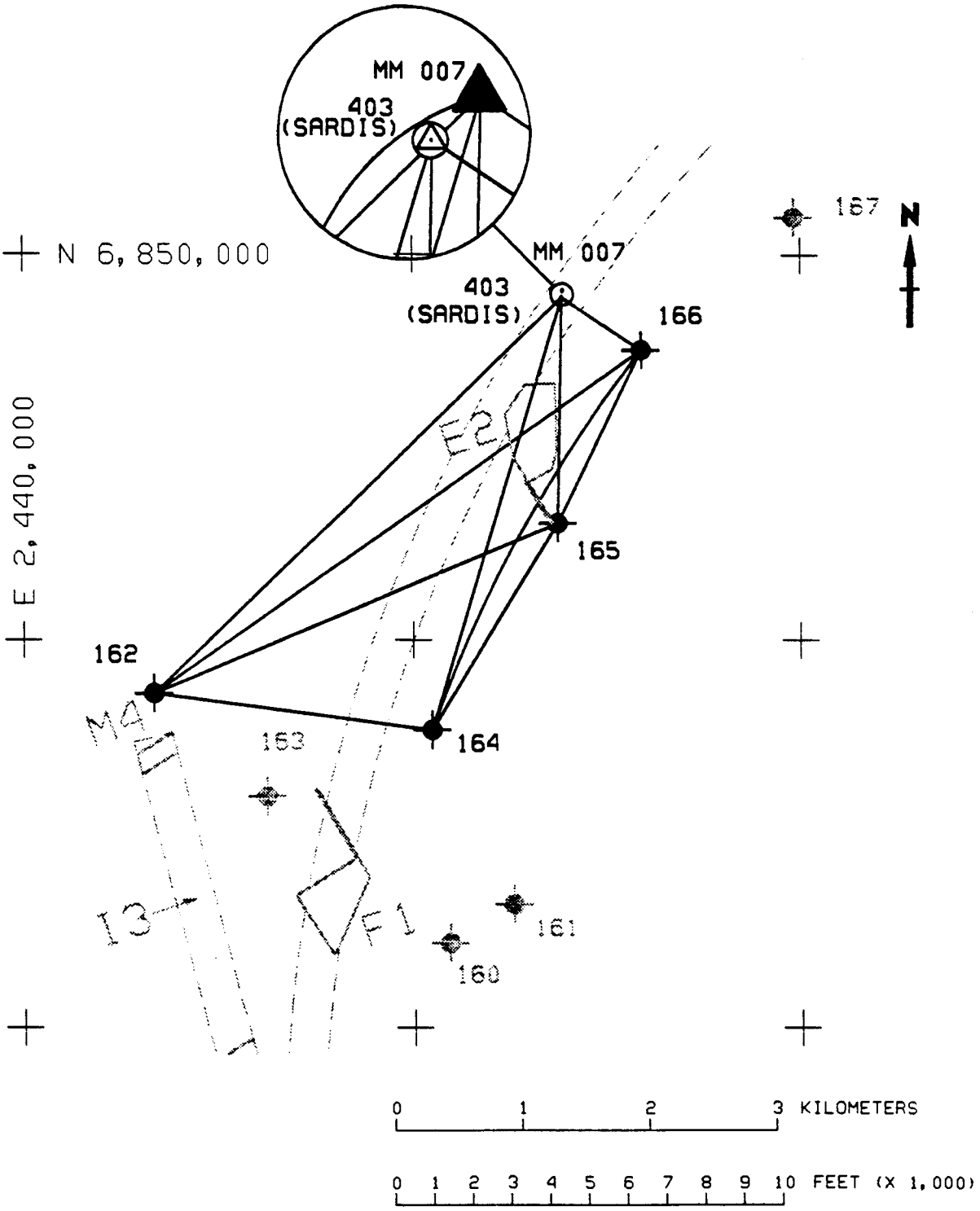
DAY 113 - SESSION 0, 2 & 3

ZG1: [102,4]MON131.DGN



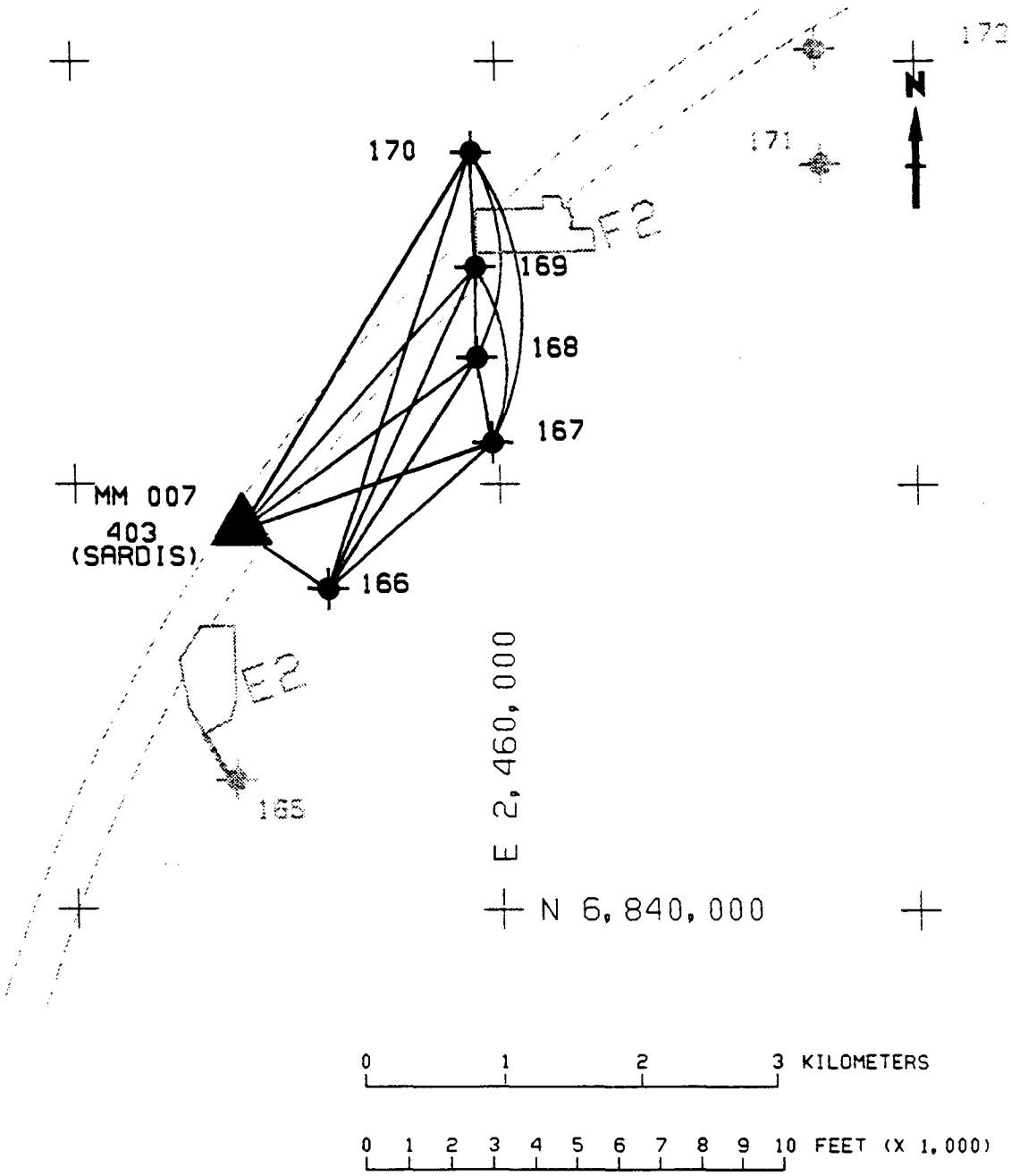
DAY 113 - SESSION 0

ZG1: [102,4]MON132.DGN



DAY 113 - SESSION 2

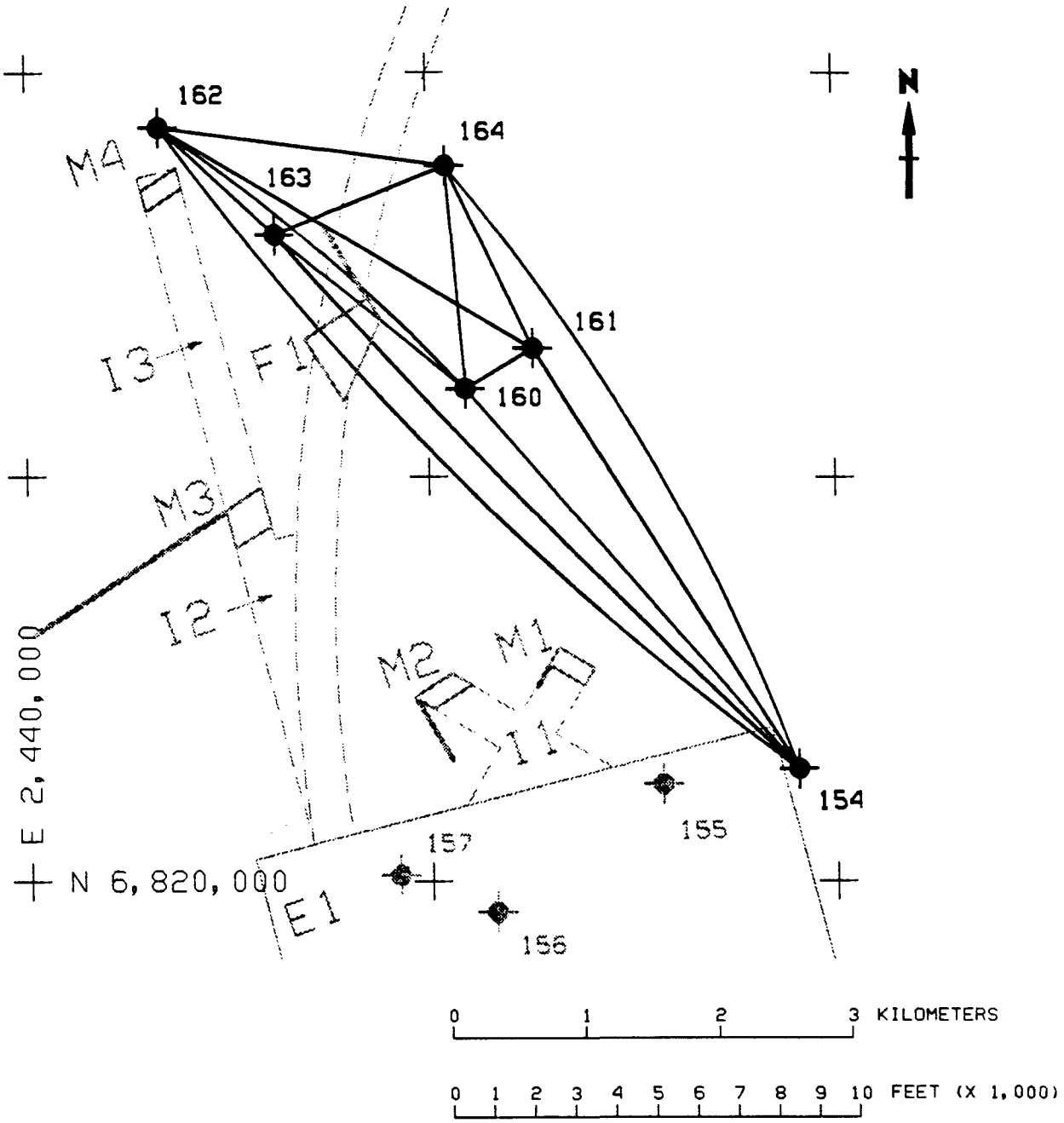
ZG1: [102,4]MON133.DGN;1



DAY 113 - SESSION 3

ZG1: [102,4]MON134.DGN

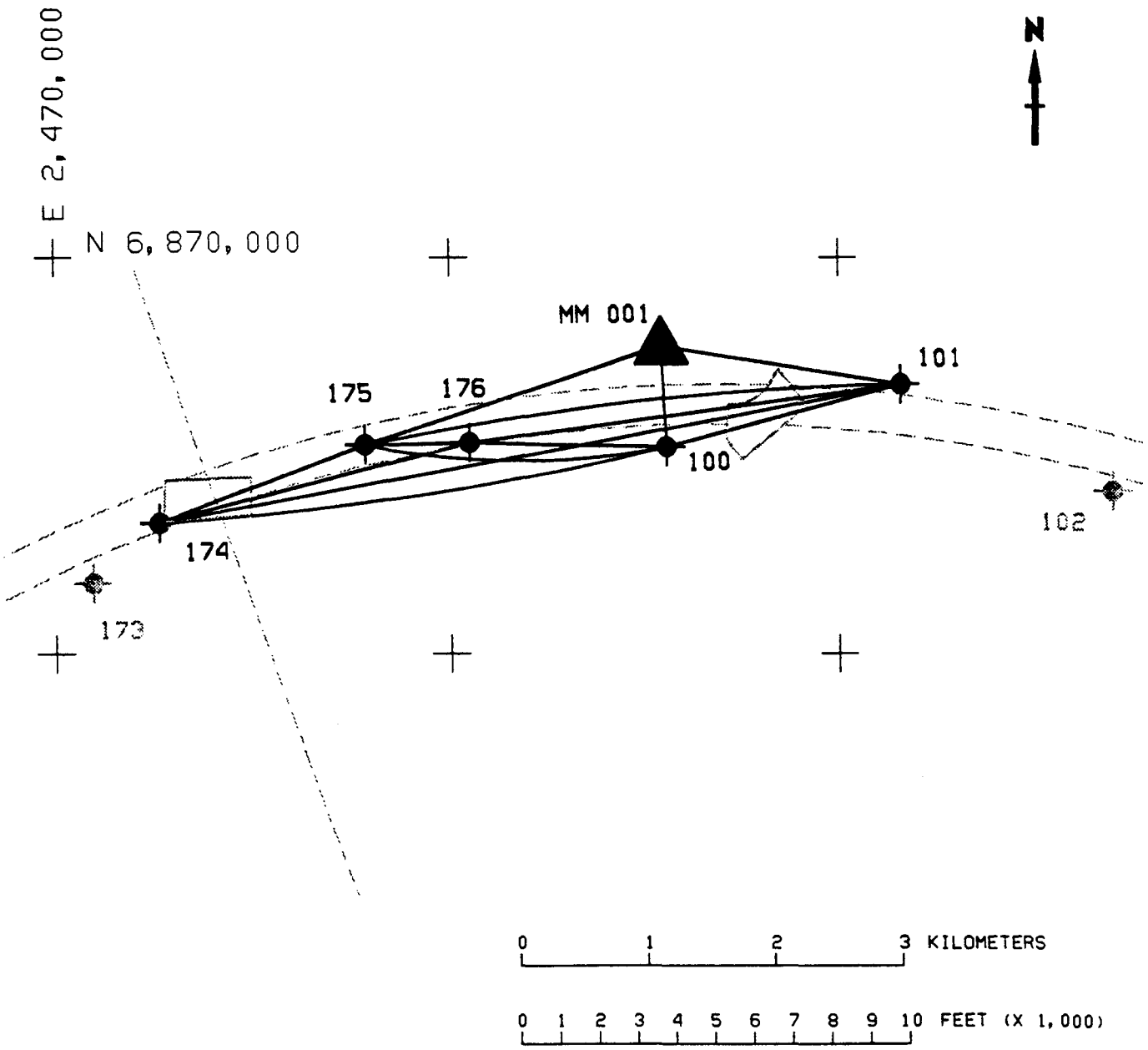
DAY	SESSION	STATIONS OCCUPIED
114	0	154, 160, 161, 162, 163, 164



DAY 114 - SESSION 0

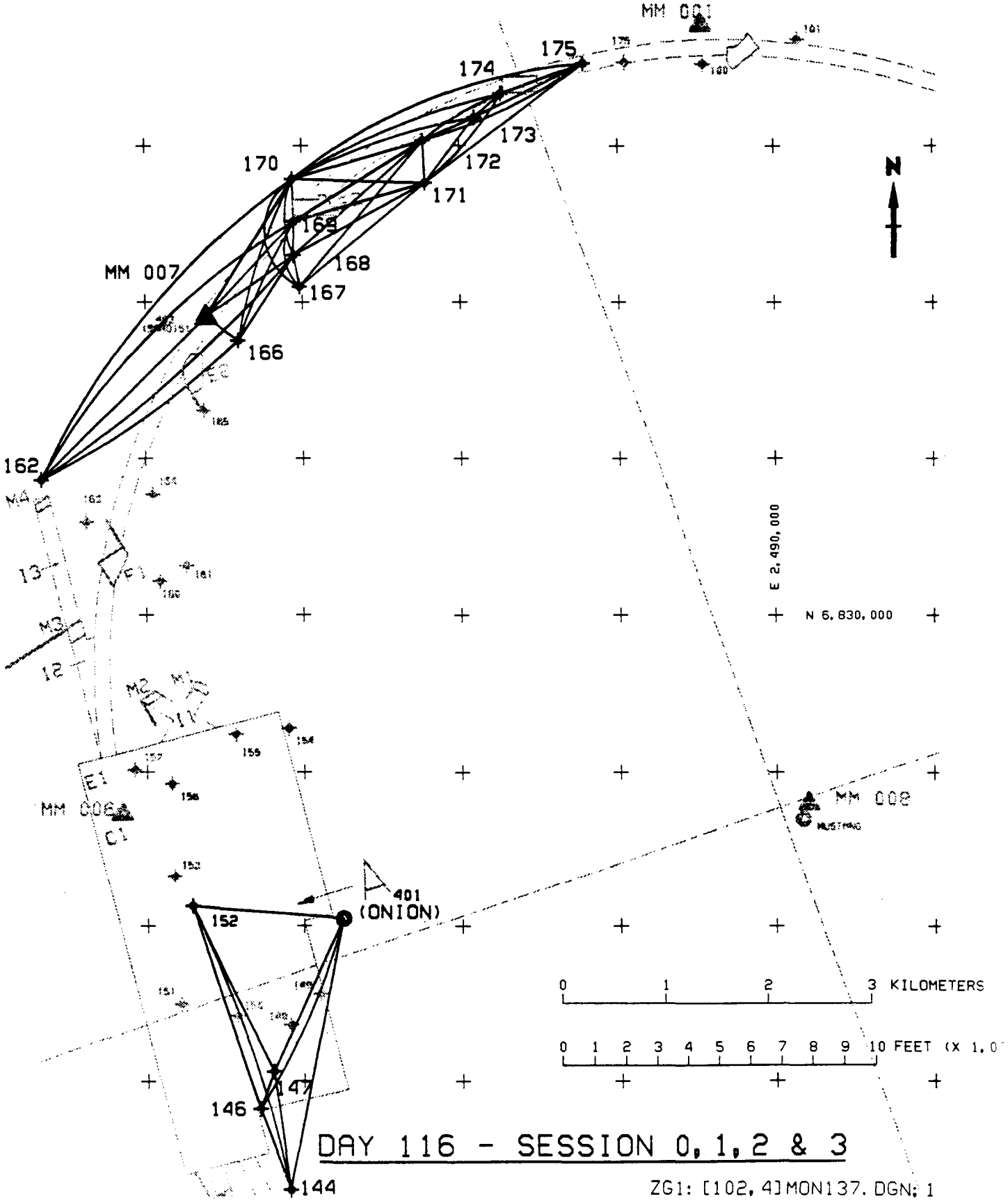
ZG1: [102,4]MON135.DGN

DAY	SESSION	STATIONS OCCUPIED
115	0	001, 100, 101, 174, 175, 176



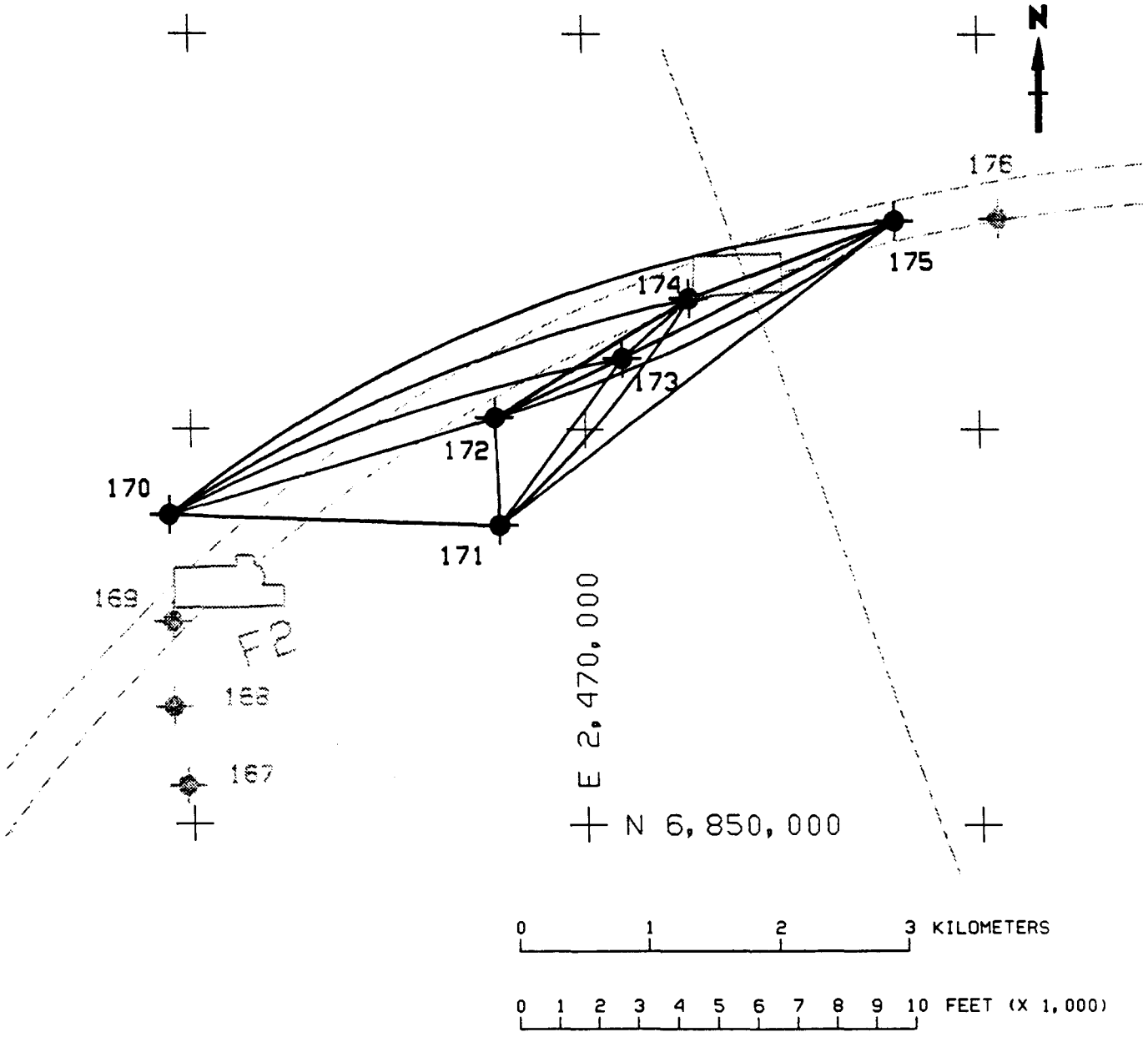
DAY 115 - SESSION 0

DAY	SESSION	STATIONS OCCUPIED
116	0	170, 171, 172, 173, 174, 175
	1	167, 168, 169, 170, 171, 172
	2	007, 162, 166, 168, 169, 170
	3	144, 146, 147, 152, 401



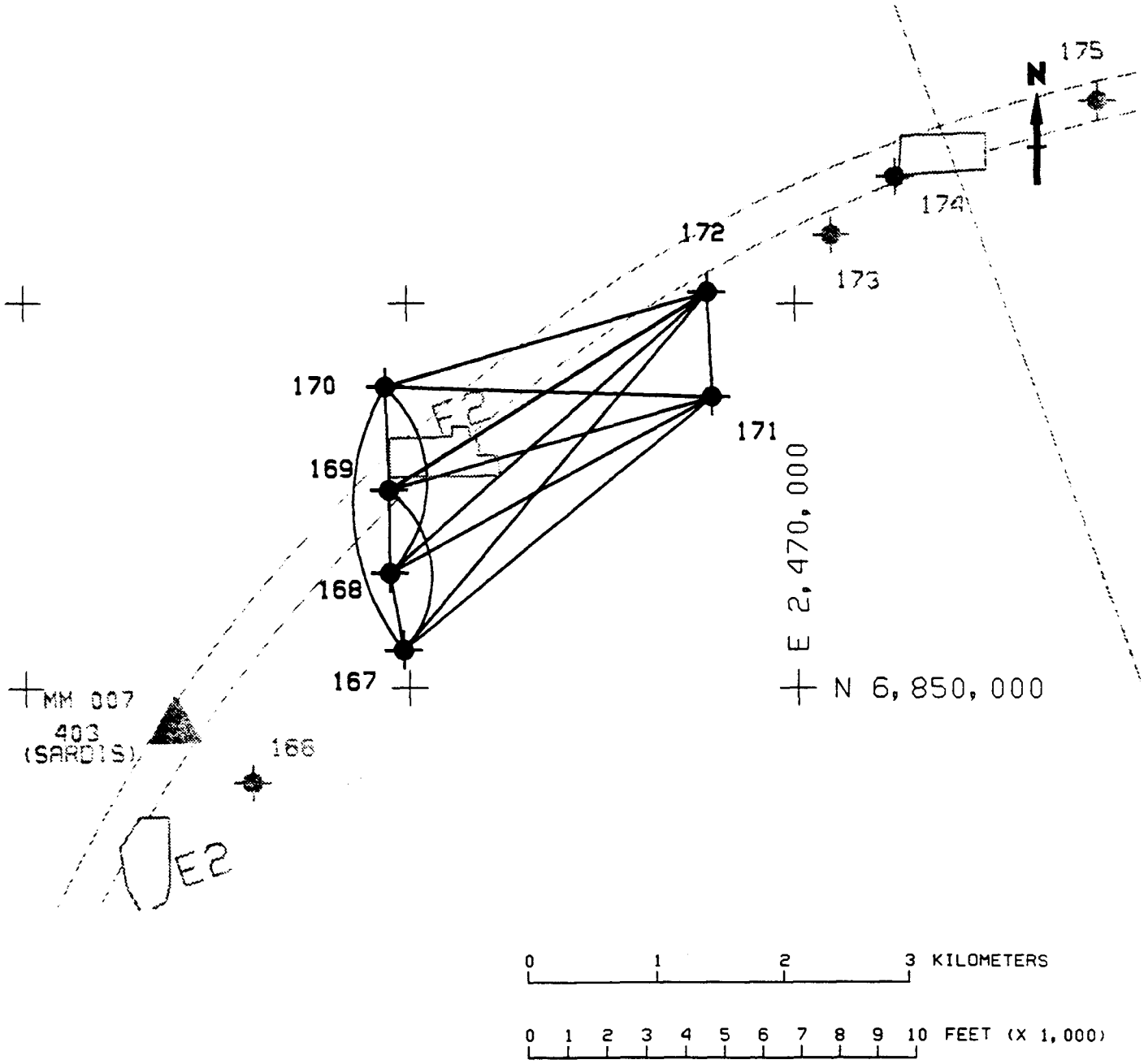
DAY 116 - SESSION 0, 1, 2 & 3

ZG1: [102,4]MON137.DGN; 1



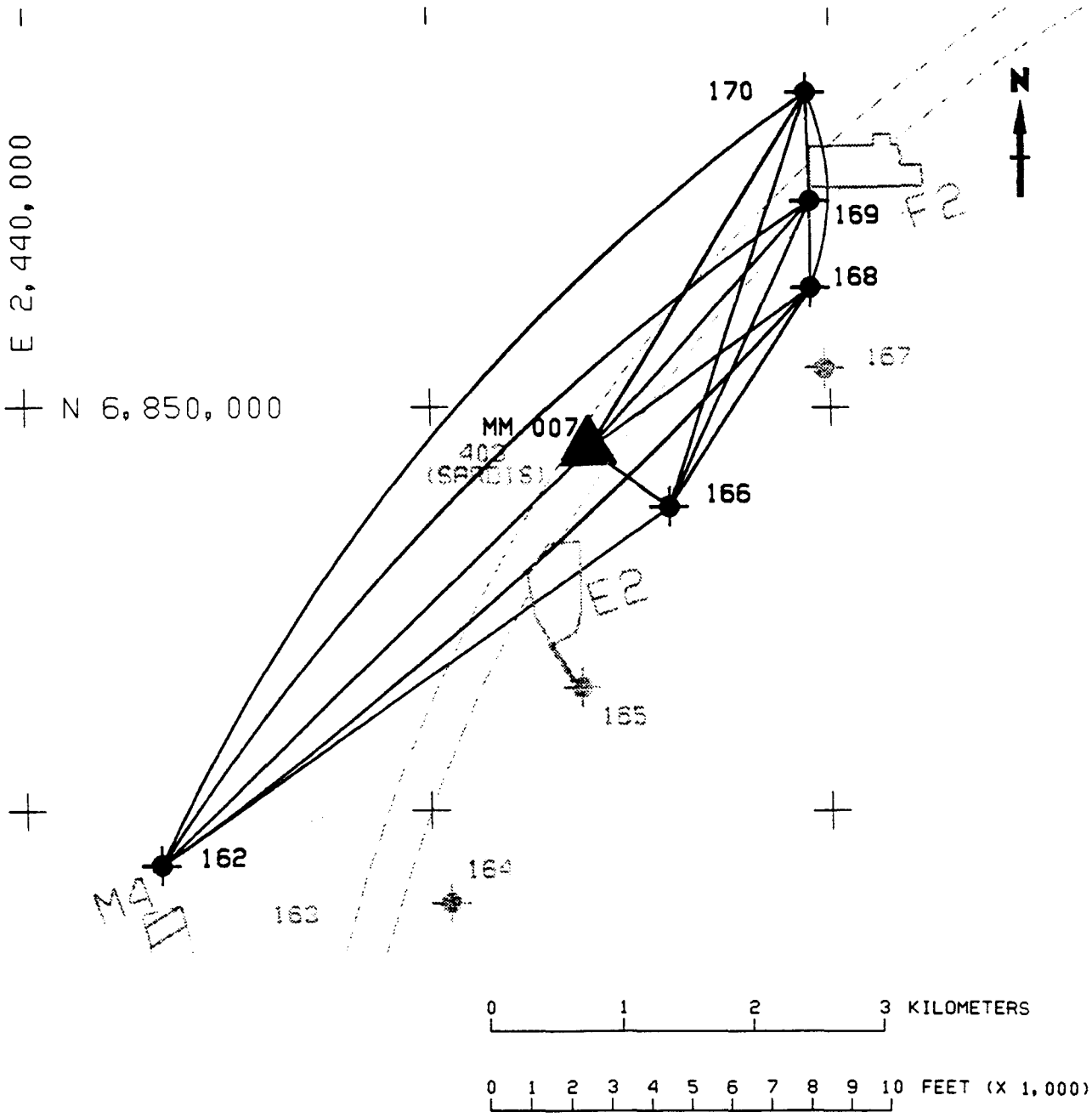
DAY 116 - SESSION 0

7G1: [102.41MON138.DGN: 1



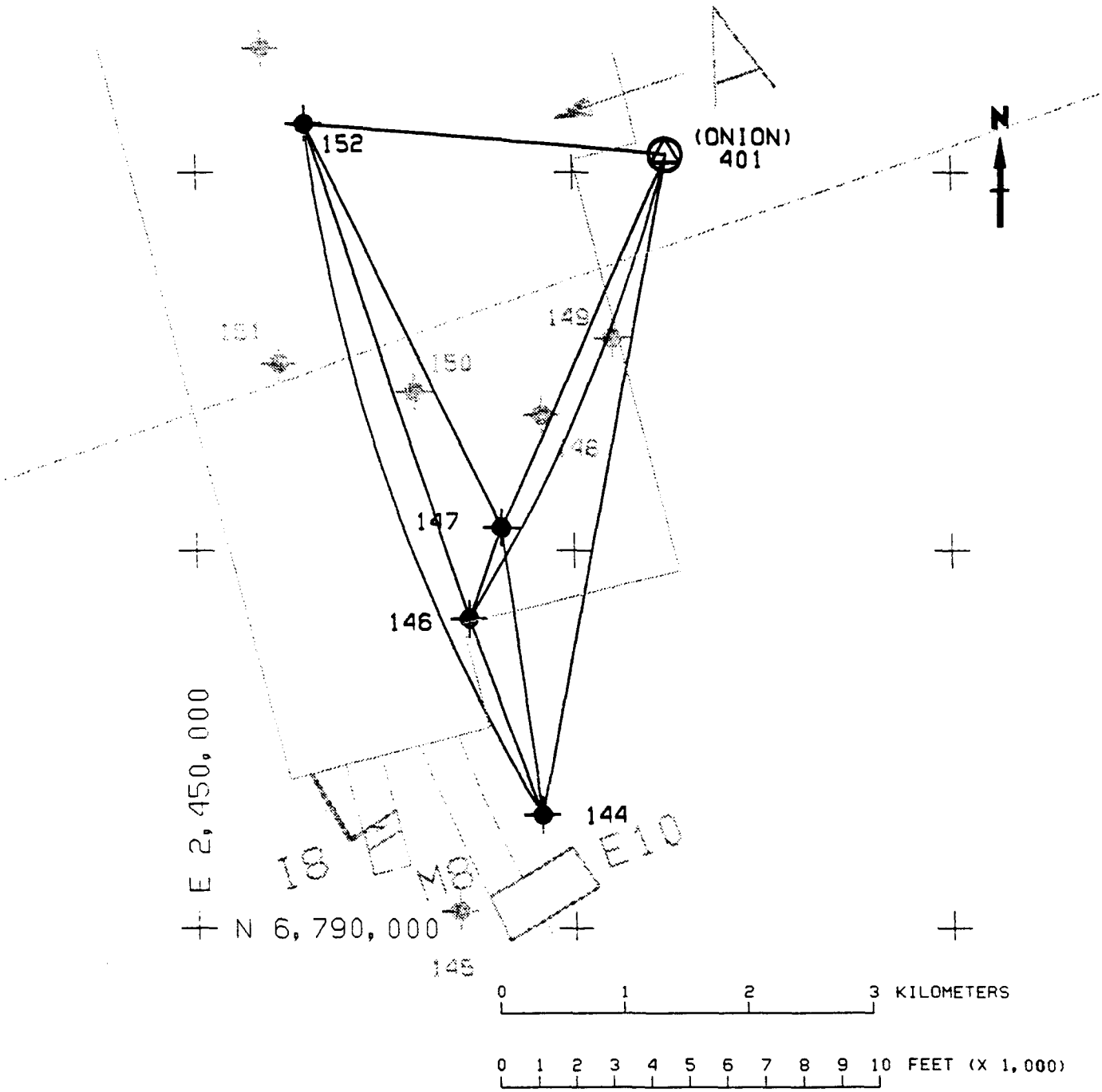
DAY 116 - SESSION 1

ZG1: [102,4]MON139.DGN



DAY 116 - SESSION 2

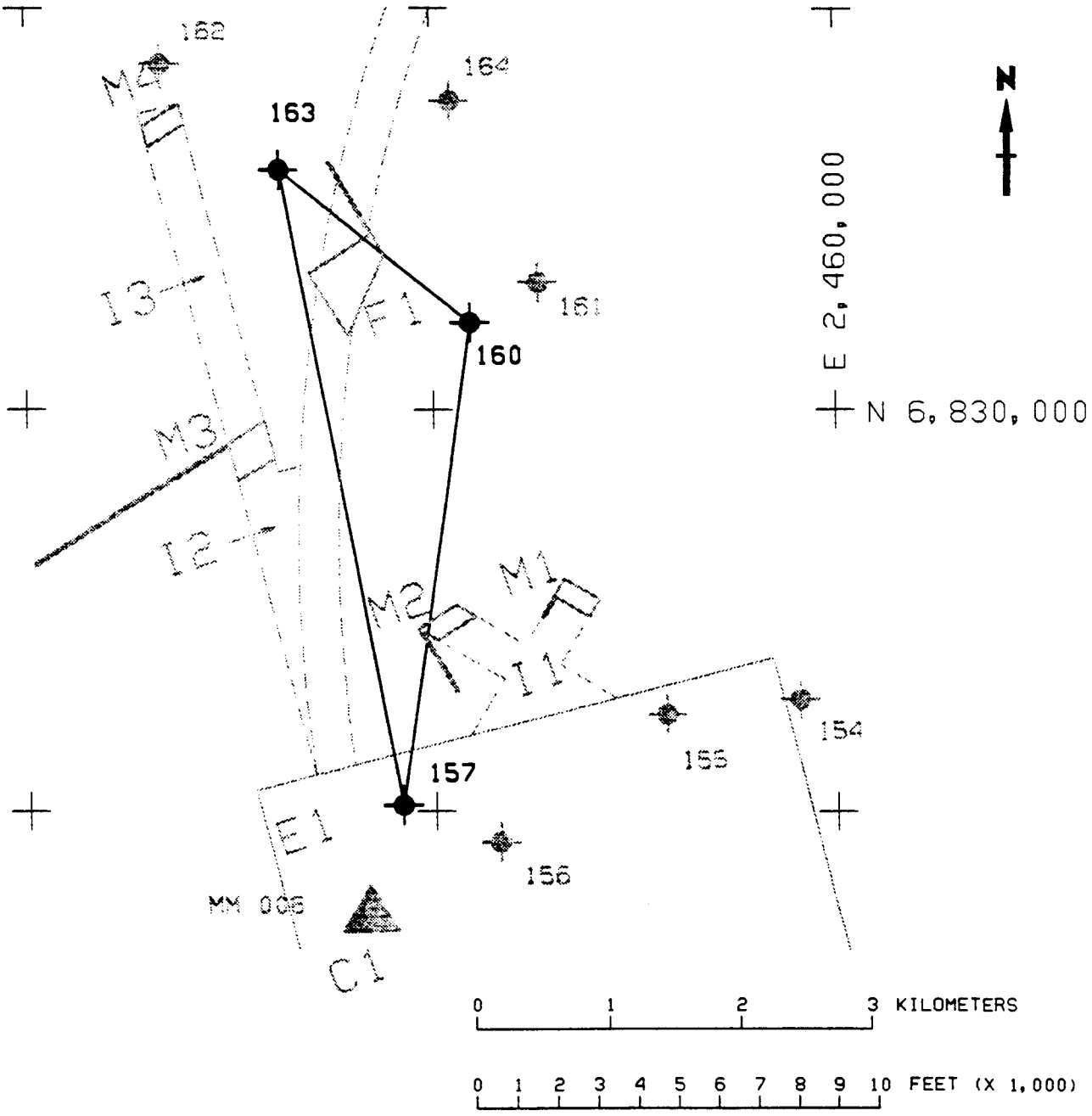
ZG1: [102,4]MON140.DGN



DAY 116 - SESSION 3

ZG1: [102,4]MON141.DGN;2

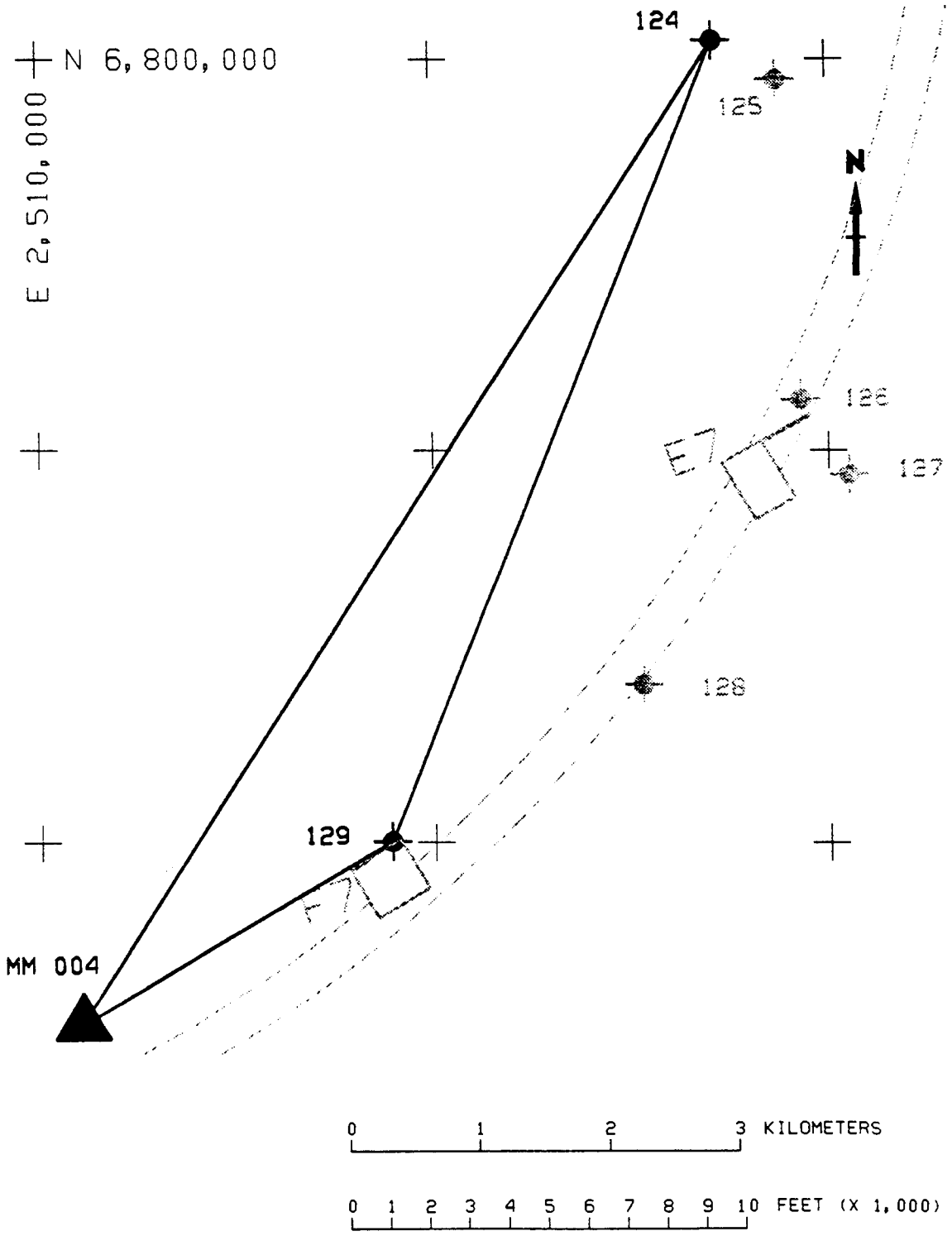
DAY	SESSION	STATIONS OCCUPIED
117	0.1	157, 160, 163
	0.2	004, 124, 129



DAY 117 - SESSION 0.1

ZG1: [102,4]MON142.DGN

DAY	SESSION	STATIONS OCCUPIED
117	0.1	157, 160, 163
	0.2	004, 124, 129



DAY 117 - SESSION 0.2

ZG1: [102,4]MON143.DGN

APPENDIX F

GEOLAB OUTPUT

TOWILL, INC. Concord, Ca. (415) 682-6976
HOLDING MM008 ONLY - ALL ORDER "B" BASELINES

A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000

ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS (95.000 %):

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0012	0013	0.0046	0.0037	156.72	0.0118	48480.9410	0.095 PPM
0012	0004	0.0045	0.0036	156.50	0.0117	24875.0020	0.182 PPM
0012	0202	0.0049	0.0040	155.99	0.0130	32443.2237	0.153 PPM
0012	0010	0.0064	0.0050	157.86	0.0160	54338.1282	0.117 PPM
0012	0003	0.0044	0.0036	155.99	0.0116	20847.8774	0.211 PPM
0012	0008	0.0045	0.0036	156.56	0.0117	34150.2617	0.132 PPM
0008	0013	0.0042	0.0033	154.71	0.0106	35686.2077	0.117 PPM
0008	0007	0.0038	0.0029	154.05	0.0097	15012.2798	0.255 PPM
0008	0202	0.0038	0.0030	155.06	0.0099	13595.0628	0.280 PPM
0008	0006	0.0035	0.0026	154.09	0.0088	13328.7854	0.259 PPM
0008	0004	0.0038	0.0029	156.53	0.0097	14205.4257	0.268 PPM
0008	0010	0.0053	0.0041	158.25	0.0131	34529.1886	0.154 PPM
0008	0003	0.0034	0.0026	155.42	0.0088	13618.0631	0.249 PPM
0008	0014	0.0039	0.0031	154.74	0.0098	33259.7962	0.117 PPM
0008	0001	0.0030	0.0023	155.16	0.0076	15382.8056	0.195 PPM
0008	0005	0.0027	0.0021	154.16	0.0070	14231.8361	0.191 PPM
0005	0013	0.0041	0.0032	154.60	0.0103	21485.5171	0.189 PPM
0005	0007	0.0038	0.0029	153.78	0.0096	22691.2741	0.167 PPM
0005	0202	0.0038	0.0030	154.81	0.0100	27487.7706	0.139 PPM
0005	0006	0.0034	0.0026	153.84	0.0086	14184.3757	0.237 PPM
0005	0004	0.0038	0.0029	156.37	0.0096	12331.2563	0.307 PPM
0005	0003	0.0034	0.0026	155.36	0.0087	21408.4955	0.157 PPM
0005	0014	0.0037	0.0030	154.52	0.0094	32440.2823	0.115 PPM
0005	0001	0.0029	0.0023	154.72	0.0075	28241.9529	0.104 PPM
0003	0004	0.0040	0.0031	156.59	0.0102	11563.1547	0.343 PPM
0003	0202	0.0040	0.0031	155.39	0.0104	13941.3621	0.285 PPM
0003	0010	0.0055	0.0043	157.87	0.0138	38201.1173	0.145 PPM
0003	0001	0.0036	0.0028	155.47	0.0092	24423.1479	0.146 PPM
0004	0013	0.0043	0.0034	155.95	0.0109	28335.5349	0.151 PPM
0004	0006	0.0045	0.0034	156.15	0.0114	22997.6295	0.195 PPM
0013	0014	0.0050	0.0040	154.60	0.0125	43068.3703	0.115 PPM
0001	0007	0.0039	0.0029	154.58	0.0098	11194.8916	0.345 PPM
0001	0006	0.0036	0.0027	154.65	0.0091	19105.6137	0.187 PPM
0001	0202	0.0038	0.0030	154.85	0.0099	13020.7097	0.295 PPM
0001	0010	0.0051	0.0040	158.65	0.0126	20694.8087	0.249 PPM

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0001	0014	0.0038	0.0030	156.20	0.0096	31685.4178	0.121 PPM
0202	0010	0.0056	0.0044	157.42	0.0140	24347.1598	0.232 PPM
0006	0007	0.0040	0.0031	153.84	0.0102	9798.3213	0.413 PPM
0006	0014	0.0042	0.0033	154.74	0.0106	20446.8106	0.206 PPM
0007	0014	0.0045	0.0035	154.80	0.0114	21106.1248	0.214 PPM
0010	0014	0.0057	0.0045	158.25	0.0141	48059.7282	0.119 PPM

ELLIPSE successfully completed - Wednesday, September 26, 1990

TOWILL, INC. CONCORD, CA. (415) 682-6976
PRIMARY CONTROL BASELINES HOLDING ALL MASTER MONUMENTS FIXED

A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000

ELLIPSE:

2-D AND 1-D RELATIVE STATION CONFIDENCE REGIONS (95.000 %):

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0148	0150	0.0027	0.0021	168.92	0.0044	1037.5201	2.634 PPM
0148	0149	0.0037	0.0029	179.63	0.0048	844.3352	4.384 PPM
0148	0147	0.0025	0.0019	169.21	0.0038	970.5330	2.536 PPM
0148	0146	0.0029	0.0023	168.64	0.0046	1752.7785	1.673 PPM
0147	0151	0.0028	0.0023	3.59	0.0070	2238.4881	1.232 PPM
0147	0150	0.0019	0.0014	168.28	0.0039	1301.4557	1.439 PPM
0147	0149	0.0036	0.0030	179.13	0.0049	1776.3491	2.047 PPM
0147	0401	0.0041	0.0033	156.87	0.0079	3303.9797	1.244 PPM
0147	0144	0.0027	0.0023	143.83	0.0068	2336.2459	1.171 PPM
0147	0152	0.0031	0.0027	162.86	0.0069	3622.3997	0.856 PPM
0147	0146	0.0019	0.0015	162.14	0.0036	782.2973	2.461 PPM
0150	0151	0.0027	0.0025	47.37	0.0066	1127.3369	2.363 PPM
0150	0149	0.0038	0.0031	179.07	0.0054	1656.1646	2.312 PPM
0150	0152	0.0032	0.0029	178.35	0.0067	2334.0665	1.361 PPM
0150	0146	0.0025	0.0019	168.12	0.0046	1883.7350	1.326 PPM
0151	0152	0.0034	0.0029	20.22	0.0058	1942.1447	1.732 PPM
0151	0153	0.0045	0.0037	18.37	0.0064	2539.6111	1.776 PPM
0152	0401	0.0047	0.0039	158.27	0.0095	2938.0772	1.611 PPM
0152	0144	0.0036	0.0032	152.22	0.0085	5887.8835	0.611 PPM
0152	0153	0.0039	0.0031	15.14	0.0046	705.7380	5.568 PPM
0152	0146	0.0032	0.0028	160.11	0.0071	4204.8081	0.770 PPM
0153	0006	0.0041	0.0037	10.08	0.0057	1624.2152	2.494 PPM
0153	0155	0.0054	0.0049	3.90	0.0071	3040.9479	1.780 PPM
0153	0156	0.0045	0.0041	179.86	0.0060	1819.9209	2.474 PPM
0153	0157	0.0045	0.0040	4.23	0.0059	2230.9648	1.998 PPM
0153	0154	0.0053	0.0049	1.93	0.0071	3663.5721	1.459 PPM
0005	0138	0.0044	0.0033	4.28	0.0054	1007.2651	4.324 PPM
0005	0141	0.0024	0.0024	162.44	0.0064	2305.9980	1.053 PPM
0005	0140	0.0023	0.0022	11.10	0.0053	1519.2848	1.529 PPM
0005	0139	0.0029	0.0022	166.31	0.0043	859.5095	3.320 PPM
0005	0142	0.0032	0.0030	136.97	0.0082	3930.4011	0.802 PPM
0005	0143	0.0039	0.0033	56.25	0.0081	4184.0252	0.921 PPM
0139	0138	0.0042	0.0031	4.74	0.0051	1011.1857	4.179 PPM
0139	0136	0.0075	0.0048	161.73	0.0163	3275.4101	2.280 PPM
0139	0137	0.0072	0.0044	163.29	0.0158	2542.6516	2.840 PPM

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0139	0140	0.0035	0.0030	170.93	0.0062	2369.0087	1.495 PPM
0139	0133	0.0067	0.0053	175.43	0.0101	7283.4199	0.917 PPM
0139	0135	0.0065	0.0052	177.79	0.0102	5831.3994	1.123 PPM
0138	0140	0.0048	0.0038	5.18	0.0069	2261.0036	2.108 PPM
0140	0141	0.0017	0.0015	87.37	0.0049	848.2318	1.993 PPM
0140	0142	0.0028	0.0025	130.20	0.0081	2454.4429	1.152 PPM
0140	0143	0.0036	0.0030	59.27	0.0079	2813.2668	1.294 PPM
0141	0142	0.0028	0.0025	121.50	0.0081	1625.3628	1.733 PPM
0141	0143	0.0036	0.0030	61.98	0.0079	1968.3691	1.840 PPM
0142	0145	0.0044	0.0033	55.49	0.0085	2021.1508	2.190 PPM
0142	0144	0.0039	0.0030	57.22	0.0079	2414.4151	1.633 PPM
0142	0143	0.0032	0.0023	60.35	0.0060	739.5938	4.383 PPM
0142	0146	0.0040	0.0033	56.87	0.0083	4094.0551	0.988 PPM
0143	0145	0.0046	0.0033	54.49	0.0084	1869.5702	2.449 PPM
0143	0144	0.0041	0.0030	57.00	0.0077	1940.9520	2.137 PPM
0143	0146	0.0043	0.0033	56.45	0.0082	3611.5791	1.183 PPM
0133	0136	0.0088	0.0061	162.74	0.0179	4959.6801	1.775 PPM
0133	0137	0.0087	0.0060	164.37	0.0175	5592.3700	1.556 PPM
0133	0134	0.0058	0.0044	1.36	0.0076	2632.9825	2.195 PPM
0133	0132	0.0060	0.0045	6.29	0.0077	1775.4576	3.384 PPM
0133	0131	0.0062	0.0049	5.00	0.0082	2938.3329	2.113 PPM
0133	0135	0.0051	0.0038	166.55	0.0076	2312.5242	2.213 PPM
0133	0004	0.0063	0.0051	0.27	0.0094	4418.4039	1.433 PPM
0135	0136	0.0086	0.0060	163.52	0.0177	2932.3485	2.921 PPM
0135	0137	0.0085	0.0058	165.12	0.0173	3670.8086	2.307 PPM
0135	0134	0.0047	0.0033	4.40	0.0056	826.6931	5.704 PPM
0135	0132	0.0060	0.0044	11.07	0.0078	3713.2795	1.615 PPM
0135	0131	0.0062	0.0048	8.54	0.0084	4067.4033	1.524 PPM
0135	0004	0.0062	0.0050	3.10	0.0094	6300.5979	0.991 PPM
0136	0137	0.0049	0.0033	158.98	0.0110	783.7027	6.249 PPM
0144	0145	0.0036	0.0026	49.74	0.0071	1019.6356	3.539 PPM
0144	0401	0.0045	0.0037	152.50	0.0097	5430.5010	0.829 PPM
0144	0146	0.0024	0.0022	127.46	0.0064	1683.8539	1.444 PPM
0145	0146	0.0039	0.0031	52.50	0.0082	2355.4144	1.655 PPM
0146	0149	0.0039	0.0032	176.55	0.0055	2549.5011	1.513 PPM
0146	0401	0.0042	0.0034	156.20	0.0082	4084.6737	1.027 PPM
0149	0401	0.0045	0.0040	167.20	0.0071	1551.6862	2.883 PPM
0149	0154	0.0064	0.0057	7.28	0.0090	5266.5175	1.207 PPM
0111	0113	0.0058	0.0034	140.66	0.0080	2764.3091	2.110 PPM
0111	0112	0.0042	0.0025	148.58	0.0063	1033.3438	4.021 PPM
0111	0114	0.0047	0.0031	153.35	0.0094	3064.2422	1.536 PPM
0111	0202	0.0042	0.0027	146.61	0.0064	2729.4705	1.531 PPM
0111	0115	0.0047	0.0032	150.58	0.0094	3546.7670	1.335 PPM

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0111	0110	0.0052	0.0032	139.10	0.0073	2993.2208	1.740 PPM
0111	0109	0.0053	0.0033	139.75	0.0074	2990.3595	1.763 PPM
0202	0400	0.0085	0.0049	139.37	0.0108	2968.7421	2.879 PPM
0202	0113	0.0048	0.0026	139.36	0.0062	1893.7121	2.521 PPM
0202	0114	0.0040	0.0029	157.35	0.0086	5058.4798	0.786 PPM
0202	0112	0.0037	0.0024	149.80	0.0057	2258.4675	1.660 PPM
0202	0115	0.0039	0.0030	156.39	0.0084	5220.1874	0.753 PPM
0202	0109	0.0044	0.0028	137.98	0.0061	1925.1799	2.300 PPM
0202	0110	0.0043	0.0027	136.36	0.0058	1320.3079	3.276 PPM
0114	0117	0.0039	0.0033	60.19	0.0104	2860.5211	1.364 PPM
0114	0112	0.0044	0.0029	159.42	0.0089	2858.1840	1.545 PPM
0114	0116	0.0035	0.0031	48.74	0.0091	2597.1882	1.345 PPM
0114	0115	0.0027	0.0023	143.18	0.0079	734.5523	3.608 PPM
0114	0118	0.0036	0.0033	18.76	0.0088	4958.1265	0.721 PPM
0115	0400	0.0088	0.0056	141.26	0.0122	4617.0408	1.912 PPM
0115	0117	0.0038	0.0031	62.34	0.0102	2630.4292	1.457 PPM
0115	0116	0.0035	0.0030	54.60	0.0089	2575.6725	1.340 PPM
0115	0112	0.0044	0.0030	157.49	0.0089	3145.1659	1.406 PPM
0115	0118	0.0035	0.0033	31.98	0.0086	4855.3122	0.725 PPM
0112	0113	0.0055	0.0032	140.63	0.0074	1769.0110	3.108 PPM
0112	0110	0.0050	0.0031	139.50	0.0069	2972.1266	1.676 PPM
0112	0109	0.0051	0.0032	140.28	0.0071	3193.0028	1.584 PPM
0118	0117	0.0039	0.0032	53.49	0.0092	2267.5457	1.728 PPM
0118	0116	0.0035	0.0029	38.06	0.0063	2365.9534	1.460 PPM
0118	0119	0.0028	0.0021	9.84	0.0032	693.0863	3.984 PPM
0118	0120	0.0032	0.0025	6.98	0.0039	1650.0938	1.948 PPM
0118	0122	0.0046	0.0037	165.85	0.0071	3732.4936	1.223 PPM
0118	0123	0.0039	0.0032	173.36	0.0058	3558.9048	1.105 PPM
0118	0121	0.0037	0.0030	179.81	0.0049	2469.1369	1.479 PPM
0118	0003	0.0036	0.0029	177.90	0.0055	3960.7764	0.908 PPM
0116	0117	0.0036	0.0028	50.19	0.0089	784.6429	4.574 PPM
0116	0119	0.0039	0.0034	22.63	0.0065	3024.7571	1.304 PPM
0116	0120	0.0041	0.0035	16.33	0.0067	3973.5456	1.042 PPM
0116	0121	0.0043	0.0037	3.58	0.0073	4790.6726	0.896 PPM
0119	0120	0.0029	0.0021	3.47	0.0035	959.3473	3.000 PPM
0119	0122	0.0046	0.0037	165.84	0.0070	3457.4803	1.322 PPM
0119	0123	0.0039	0.0032	172.92	0.0057	2998.8263	1.313 PPM
0119	0121	0.0036	0.0029	179.14	0.0046	1779.7072	2.010 PPM
0119	0003	0.0037	0.0029	176.63	0.0054	3302.3424	1.115 PPM
0121	0120	0.0033	0.0026	179.99	0.0041	820.5738	4.050 PPM
0121	0123	0.0036	0.0026	153.25	0.0061	1787.9605	1.990 PPM
0121	0122	0.0043	0.0031	153.21	0.0074	3145.3768	1.382 PPM
0121	0125	0.0040	0.0027	154.54	0.0081	3730.3613	1.065 PPM

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0121	0124	0.0040	0.0028	153.50	0.0080	3742.2976	1.064 PPM
0121	0003	0.0032	0.0022	159.59	0.0057	1619.2225	2.005 PPM
0120	0122	0.0045	0.0036	165.11	0.0069	3183.9035	1.419 PPM
0120	0123	0.0038	0.0030	172.04	0.0056	2263.5943	1.698 PPM
0120	0003	0.0036	0.0027	175.81	0.0053	2381.8051	1.514 PPM
0003	0127	0.0043	0.0031	144.29	0.0111	4913.6088	0.869 PPM
0003	0126	0.0042	0.0031	144.50	0.0107	4478.3820	0.933 PPM
0003	0123	0.0030	0.0022	154.13	0.0051	1125.8910	2.652 PPM
0003	0122	0.0039	0.0028	153.57	0.0068	2956.7090	1.317 PPM
0003	0125	0.0033	0.0023	155.30	0.0071	2482.0718	1.321 PPM
0003	0128	0.0043	0.0038	133.11	0.0114	7003.1098	0.611 PPM
0003	0124	0.0033	0.0023	154.03	0.0070	2699.2602	1.221 PPM
0123	0122	0.0039	0.0028	151.13	0.0067	1832.1392	2.119 PPM
0123	0125	0.0034	0.0024	152.09	0.0074	1970.7376	1.739 PPM
0123	0124	0.0034	0.0024	150.20	0.0073	1955.3890	1.761 PPM
0127	0126	0.0025	0.0019	134.67	0.0077	690.2408	3.654 PPM
0127	0125	0.0039	0.0027	143.01	0.0103	3125.9717	1.234 PPM
0127	0124	0.0039	0.0027	143.56	0.0104	3532.7808	1.102 PPM
0127	0128	0.0046	0.0034	136.41	0.0129	2287.2609	1.994 PPM
0128	0126	0.0045	0.0035	136.56	0.0126	2536.9997	1.766 PPM
0128	0130	0.0052	0.0046	74.65	0.0125	5429.5021	0.957 PPM
0128	0129	0.0062	0.0048	65.46	0.0129	2295.2290	2.689 PPM
0128	0131	0.0057	0.0053	60.49	0.0131	7711.4785	0.743 PPM
0128	0132	0.0058	0.0054	52.10	0.0132	7569.6813	0.768 PPM
0128	0125	0.0044	0.0036	139.43	0.0118	4831.2977	0.914 PPM
0128	0004	0.0043	0.0038	133.11	0.0114	5082.5809	0.842 PPM
0128	0124	0.0044	0.0036	139.52	0.0117	5047.7311	0.877 PPM
0004	0134	0.0065	0.0050	16.56	0.0092	6135.7033	1.067 PPM
0004	0130	0.0037	0.0025	63.00	0.0064	895.1324	4.130 PPM
0004	0129	0.0056	0.0042	62.74	0.0103	2787.7384	2.011 PPM
0004	0131	0.0045	0.0037	49.82	0.0073	2656.4451	1.688 PPM
0004	0132	0.0046	0.0038	43.56	0.0075	2661.5239	1.733 PPM
0004	0124	0.0033	0.0023	154.03	0.0070	9094.4354	0.362 PPM
0129	0130	0.0063	0.0044	62.57	0.0113	3175.0712	1.969 PPM
0129	0131	0.0068	0.0051	59.12	0.0120	5419.9442	1.248 PPM
0129	0132	0.0068	0.0052	57.44	0.0121	5319.7405	1.286 PPM
0129	0124	0.0059	0.0049	62.65	0.0117	6720.9174	0.872 PPM
0131	0130	0.0052	0.0039	56.93	0.0089	2365.4425	2.199 PPM
0131	0134	0.0064	0.0047	18.94	0.0080	3702.4658	1.739 PPM
0131	0132	0.0039	0.0031	36.24	0.0058	1637.1913	2.364 PPM
0132	0130	0.0054	0.0041	53.71	0.0091	2915.9511	1.837 PPM
0132	0134	0.0062	0.0041	21.04	0.0072	3692.7917	1.683 PPM
0122	0125	0.0037	0.0026	153.99	0.0078	2276.2615	1.647 PPM

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0122	0124	0.0037	0.0026	151.39	0.0077	1801.1724	2.044 PPM
0124	0126	0.0038	0.0027	142.93	0.0100	2873.1365	1.316 PPM
0124	0125	0.0021	0.0013	152.84	0.0047	572.1872	3.671 PPM
0125	0126	0.0037	0.0027	142.29	0.0099	2501.2868	1.497 PPM
0106	0107	0.0035	0.0031	140.84	0.0076	1851.5474	1.917 PPM
0106	0108	0.0036	0.0032	148.50	0.0078	1887.4270	1.914 PPM
0106	0103	0.0062	0.0054	8.45	0.0081	3790.4412	1.636 PPM
0106	0104	0.0063	0.0054	7.12	0.0081	3381.0040	1.852 PPM
0106	0102	0.0060	0.0054	1.49	0.0082	4516.0359	1.330 PPM
0106	0105	0.0028	0.0024	164.85	0.0046	714.6718	3.936 PPM
0106	0109	0.0038	0.0032	151.33	0.0077	3431.3821	1.112 PPM
0106	0110	0.0040	0.0034	148.71	0.0079	3757.2066	1.072 PPM
0106	0101	0.0059	0.0053	172.38	0.0085	6320.0283	0.934 PPM
0105	0107	0.0037	0.0033	146.82	0.0077	1952.0122	1.893 PPM
0105	0108	0.0038	0.0033	151.26	0.0079	2178.8359	1.739 PPM
0105	0103	0.0062	0.0054	8.89	0.0080	3413.3741	1.813 PPM
0105	0104	0.0063	0.0053	7.49	0.0080	2951.5503	2.119 PPM
0105	0102	0.0060	0.0054	2.44	0.0081	4064.2557	1.478 PPM
0105	0109	0.0040	0.0034	152.55	0.0079	3589.1428	1.102 PPM
0105	0110	0.0042	0.0035	150.02	0.0081	4017.0957	1.034 PPM
0105	0101	0.0059	0.0053	173.65	0.0085	5882.1814	1.006 PPM
0107	0108	0.0031	0.0027	132.02	0.0070	562.0959	5.599 PPM
0107	0109	0.0035	0.0030	140.54	0.0074	1637.1803	2.133 PPM
0107	0110	0.0038	0.0032	141.06	0.0078	2097.2619	1.808 PPM
0108	0109	0.0032	0.0027	151.64	0.0071	1579.2725	2.058 PPM
0108	0110	0.0036	0.0030	148.23	0.0075	1871.7663	1.908 PPM
0109	0113	0.0059	0.0034	138.06	0.0078	3677.0274	1.601 PPM
0109	0110	0.0029	0.0021	142.35	0.0048	669.2065	4.271 PPM
0110	0113	0.0058	0.0033	137.50	0.0076	3161.7726	1.837 PPM
0113	0400	0.0086	0.0047	139.60	0.0108	1626.8303	5.269 PPM
0101	0001	0.0052	0.0050	171.85	0.0075	1925.8689	2.714 PPM
0101	0176	0.0058	0.0056	124.28	0.0080	3414.1756	1.684 PPM
0101	0100	0.0048	0.0043	134.17	0.0071	1903.7034	2.496 PPM
0101	0104	0.0053	0.0048	6.01	0.0073	2941.7175	1.799 PPM
0101	0103	0.0051	0.0048	10.58	0.0071	2550.6650	2.014 PPM
0101	0102	0.0043	0.0041	146.14	0.0066	1818.1401	2.353 PPM
0101	0174	0.0057	0.0055	163.29	0.0083	5875.0957	0.973 PPM
0101	0175	0.0054	0.0053	126.41	0.0077	4212.3520	1.290 PPM
0104	0103	0.0034	0.0031	38.67	0.0041	529.9987	6.440 PPM
0104	0102	0.0043	0.0038	17.05	0.0053	1136.5924	3.741 PPM
0102	0103	0.0041	0.0038	36.70	0.0050	854.7214	4.740 PPM
0102	0100	0.0059	0.0054	135.84	0.0091	3482.5504	1.682 PPM
0100	0176	0.0053	0.0049	115.46	0.0068	1542.8391	3.419 PPM

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0100	0174	0.0057	0.0054	132.78	0.0078	3978.6140	1.436 PPM
0100	0175	0.0053	0.0049	110.26	0.0068	2344.0651	2.258 PPM
0401	0154	0.0063	0.0057	174.98	0.0101	3889.6947	1.631 PPM
0154	0006	0.0048	0.0043	177.06	0.0063	3646.6033	1.312 PPM
0154	0155	0.0049	0.0043	0.71	0.0064	1024.1579	4.767 PPM
0154	0156	0.0051	0.0045	178.68	0.0066	2518.2225	2.012 PPM
0154	0161	0.0061	0.0055	167.17	0.0081	3733.8289	1.630 PPM
0154	0163	0.0061	0.0055	167.16	0.0083	5609.1343	1.083 PPM
0154	0160	0.0059	0.0054	166.28	0.0080	3788.4078	1.564 PPM
0154	0157	0.0050	0.0045	0.46	0.0065	3110.4859	1.611 PPM
0154	0164	0.0058	0.0050	153.21	0.0077	5242.6403	1.107 PPM
0154	0162	0.0060	0.0052	158.09	0.0083	6804.5072	0.886 PPM
0006	0155	0.0049	0.0044	1.50	0.0064	2708.7721	1.824 PPM
0006	0156	0.0038	0.0032	177.22	0.0050	1130.3641	3.376 PPM
0006	0157	0.0034	0.0029	0.04	0.0043	869.6301	3.895 PPM
0155	0156	0.0049	0.0044	0.75	0.0063	1584.9811	3.082 PPM
0155	0157	0.0050	0.0044	1.88	0.0064	2103.2270	2.379 PPM
0156	0157	0.0037	0.0029	176.90	0.0048	780.3181	4.701 PPM
0157	0160	0.0056	0.0049	156.67	0.0078	3702.2446	1.510 PPM
0157	0163	0.0057	0.0049	158.15	0.0080	4903.6999	1.157 PPM
0007	0165	0.0048	0.0024	139.23	0.0060	1842.6449	2.617 PPM
0007	0167	0.0024	0.0018	109.77	0.0053	1899.4645	1.288 PPM
0007	0168	0.0022	0.0017	119.44	0.0046	2076.4640	1.064 PPM
0007	0169	0.0022	0.0017	120.37	0.0046	2506.9576	0.886 PPM
0007	0166	0.0018	0.0012	127.48	0.0028	779.8614	2.352 PPM
0007	0164	0.0049	0.0033	141.01	0.0066	3630.8543	1.360 PPM
0007	0170	0.0023	0.0018	120.22	0.0047	3150.0911	0.723 PPM
0007	0162	0.0050	0.0035	146.02	0.0073	4535.8637	1.108 PPM
0403	0165	0.0050	0.0024	138.56	0.0062	1839.8984	2.709 PPM
0403	0164	0.0053	0.0034	139.16	0.0069	3627.6253	1.452 PPM
0403	0166	0.0027	0.0015	129.60	0.0034	780.0234	3.420 PPM
0403	0162	0.0054	0.0036	143.03	0.0076	4532.3540	1.184 PPM
0162	0165	0.0064	0.0038	142.07	0.0086	3448.1375	1.859 PPM
0162	0161	0.0050	0.0043	163.90	0.0068	3273.1669	1.526 PPM
0162	0160	0.0048	0.0042	162.03	0.0065	3035.8160	1.570 PPM
0162	0163	0.0044	0.0039	167.16	0.0061	1196.7995	3.707 PPM
0162	0168	0.0053	0.0038	144.79	0.0083	6590.9387	0.802 PPM
0162	0169	0.0053	0.0038	144.90	0.0083	7040.8921	0.752 PPM
0162	0166	0.0052	0.0036	145.09	0.0075	4701.3353	1.097 PPM
0162	0164	0.0045	0.0035	146.43	0.0061	2195.4286	2.054 PPM
0162	0170	0.0053	0.0038	144.93	0.0084	7637.0553	0.696 PPM
0164	0165	0.0062	0.0035	139.85	0.0079	1914.5194	3.226 PPM
0164	0161	0.0043	0.0038	174.74	0.0056	1516.2315	2.808 PPM

FROM	TO	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICAL	SPATIAL DIST.	PRECISION
0164	0160	0.0042	0.0038	168.25	0.0056	1684.4805	2.488 PPM
0164	0163	0.0043	0.0039	162.64	0.0059	1399.0449	3.096 PPM
0164	0166	0.0051	0.0033	140.30	0.0069	3428.7514	1.485 PPM
0165	0166	0.0049	0.0024	139.10	0.0062	1517.9179	3.237 PPM
0166	0167	0.0024	0.0018	108.49	0.0053	1593.8550	1.485 PPM
0166	0168	0.0021	0.0017	118.81	0.0045	1988.6314	1.063 PPM
0166	0169	0.0021	0.0017	119.64	0.0046	2561.0240	0.834 PPM
0166	0170	0.0022	0.0018	119.33	0.0047	3318.7554	0.664 PPM
0167	0168	0.0014	0.0009	99.45	0.0035	616.7478	2.301 PPM
0167	0169	0.0015	0.0010	99.75	0.0039	1267.8454	1.219 PPM
0167	0171	0.0033	0.0030	82.97	0.0075	3150.4345	1.042 PPM
0167	0172	0.0033	0.0029	84.30	0.0075	3714.9272	0.879 PPM
0167	0170	0.0017	0.0012	98.56	0.0043	2091.8278	0.801 PPM
0168	0169	0.0010	0.0008	121.91	0.0025	655.4661	1.518 PPM
0168	0171	0.0031	0.0029	77.89	0.0070	2893.3146	1.079 PPM
0168	0172	0.0031	0.0029	79.92	0.0070	3351.4427	0.926 PPM
0168	0170	0.0012	0.0010	115.14	0.0032	1480.1748	0.834 PPM
0169	0171	0.0031	0.0029	75.65	0.0070	2641.8868	1.177 PPM
0169	0172	0.0031	0.0029	77.71	0.0069	2958.5528	1.045 PPM
0169	0170	0.0011	0.0010	121.45	0.0029	824.8117	1.317 PPM
0170	0173	0.0043	0.0042	173.25	0.0073	3721.5379	1.164 PPM
0170	0171	0.0031	0.0029	70.79	0.0068	2558.4010	1.208 PPM
0170	0172	0.0031	0.0029	72.83	0.0067	2636.2461	1.165 PPM
0170	0174	0.0043	0.0042	173.38	0.0072	4365.2618	0.993 PPM
0170	0175	0.0047	0.0046	164.92	0.0074	6065.3482	0.782 PPM
0161	0160	0.0037	0.0031	179.48	0.0046	593.5104	6.225 PPM
0161	0163	0.0045	0.0041	0.50	0.0061	2118.7930	2.131 PPM
0163	0160	0.0040	0.0038	176.13	0.0056	1840.6600	2.185 PPM
0174	0176	0.0052	0.0052	5.48	0.0071	2471.8085	2.124 PPM
0174	0173	0.0036	0.0031	178.25	0.0046	691.1922	5.155 PPM
0174	0172	0.0039	0.0036	172.24	0.0056	1764.4954	2.216 PPM
0174	0171	0.0040	0.0037	174.96	0.0058	2288.3948	1.732 PPM
0174	0175	0.0042	0.0038	175.50	0.0057	1700.7370	2.466 PPM
0176	0175	0.0045	0.0041	80.18	0.0055	801.8260	5.589 PPM
0001	0175	0.0048	0.0047	155.71	0.0074	2439.5004	1.962 PPM
0175	0173	0.0047	0.0044	175.17	0.0064	2357.5755	2.003 PPM
0175	0171	0.0046	0.0044	173.78	0.0069	3863.3355	1.201 PPM
0175	0172	0.0046	0.0044	171.84	0.0067	3449.9952	1.336 PPM
0171	0173	0.0039	0.0036	173.82	0.0056	1606.1422	2.403 PPM
0171	0172	0.0018	0.0016	19.86	0.0039	829.9910	2.149 PPM
0172	0173	0.0038	0.0035	170.55	0.0054	1093.0231	3.474 PPM
0008	0402	0.0017	0.0009	139.14	0.0068	296.2321	5.609 PPM

ELLIPSE successfully completed. 11:02:52 - Saturday, September 29, 1990

APPENDIX G

SURVEY MONUMENTATION RECORDS

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

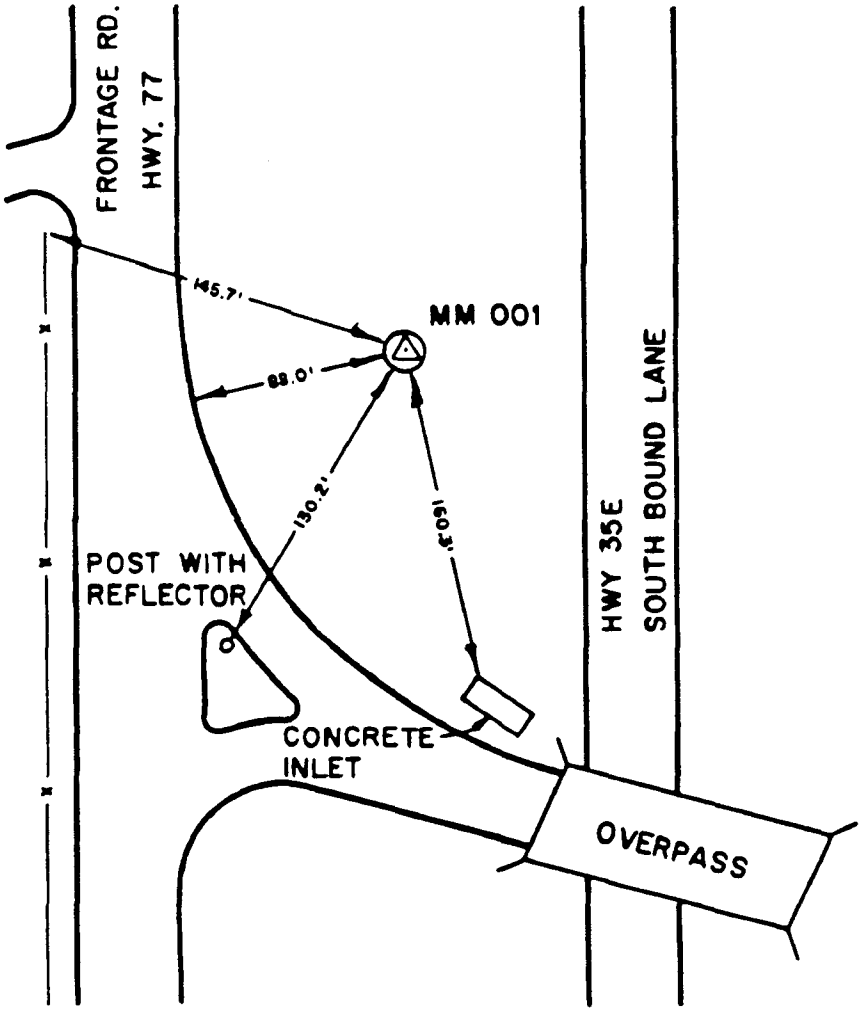
STATION		Point Grid Factor	SHEET
MM 001		0.99989448	1
N (ft) 6867989.429	E (ft) 2485399.024	Elev (ft) 602.581	OF 1

LATITUDE	32°29'50.29521" N
LONGITUDE	96°49'24.07001" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 100	176°41'51"	2761.437
PC 101	100°51'32"	6317.567
PC 176	241°38'20"	5568.845

DESCRIPTION, PLAT:

Approximately 1.6 miles southeast of Red Oak. From Highway I 35 E southbound, take exit number 408 and continue south on Highway 77 for 0.33 miles to a divider and the station on the left before an overpass. The station is located on top of a small hill and is approximately 8-feet higher than the road.



Legend

1" Diameter
Dywidag Rod
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

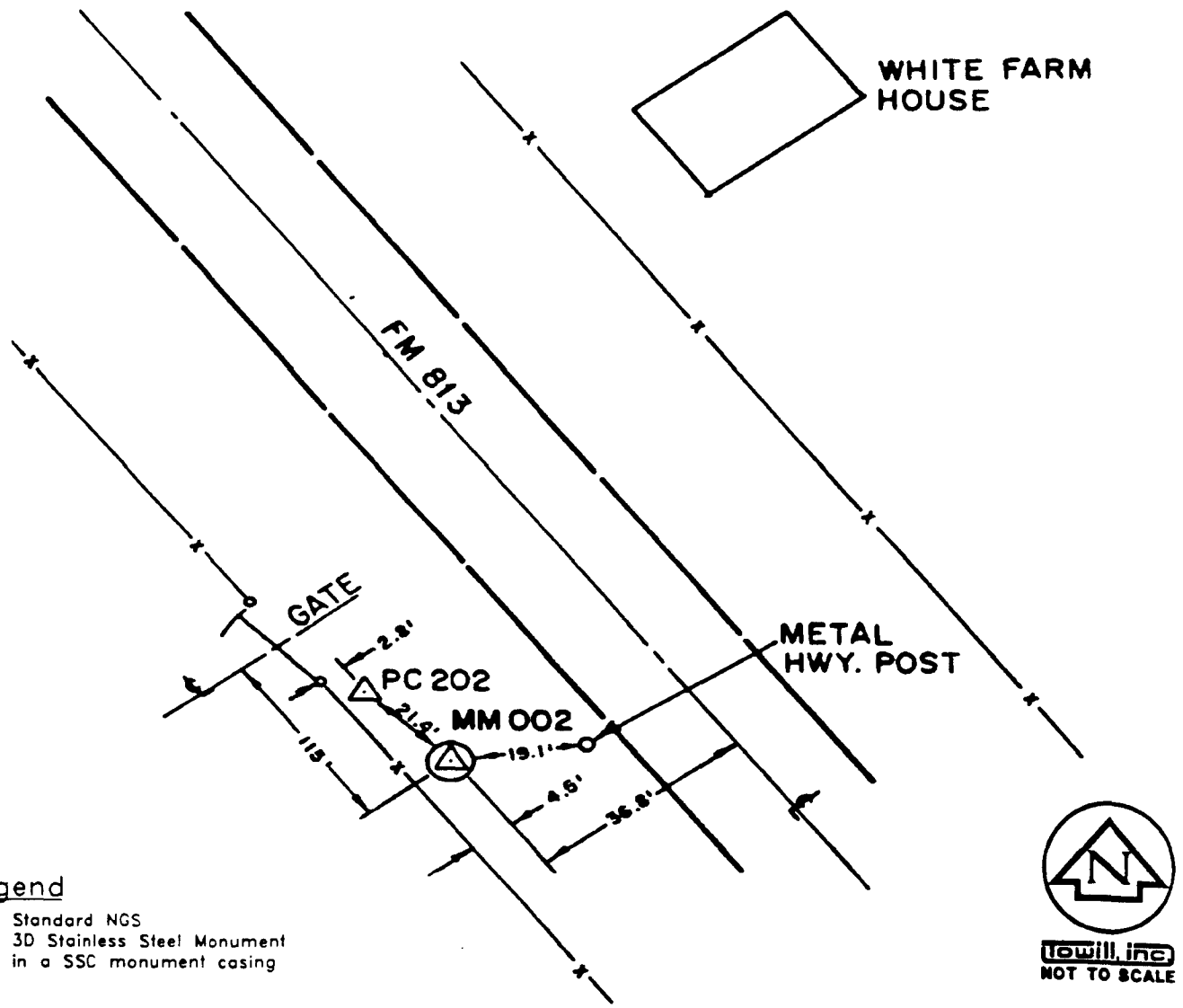
STATION		Point Grid Factor	SHEET
PC 202		0.99991008	1
N (ft) 6849318.684	E (ft) 2523816.778	Elev (ft) 469.993	OF 1

LATITUDE	32°26'39.27286" N
LONGITUDE	96°41'59.27893" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order B, Type GPS
VERT NGVD 28	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 113	130°30'45"	6212.395

DESCRIPTION, PLAT.

Northwest of Palmer. From the intersection of FM 878 and FM 813, go north on FM 813 for 1.66 miles to the crest of a rise and the station on the left. PC 202 is 2.8-feet east of the west right-of-way fence and 94-feet south of a galvanized metal farm road gate.



SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

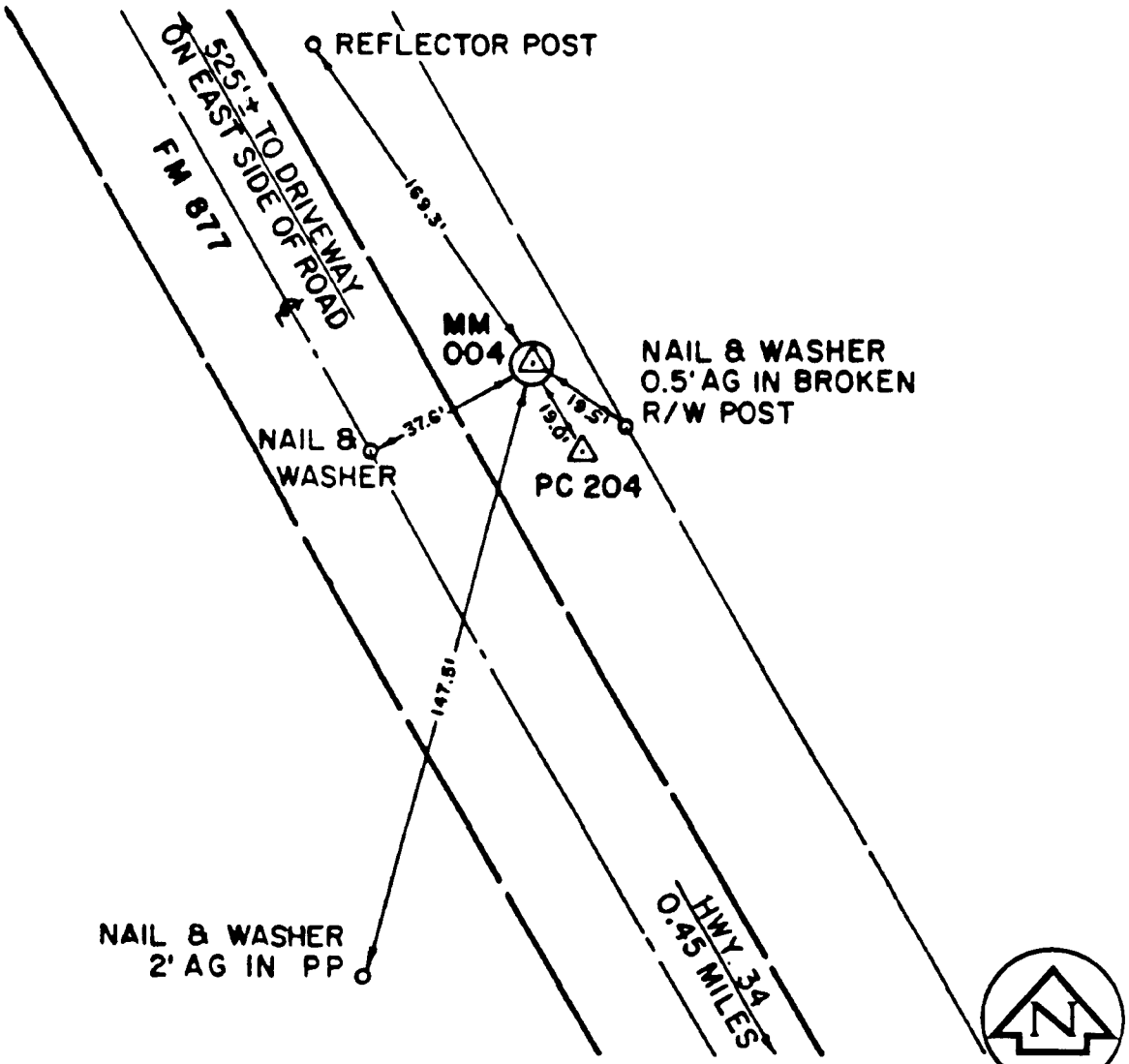
STATION		Point Grid Factor	SHEET
MM 004		0.99995320	1
N (ft) 6775386.223	E (ft) 2511021.079	Elev (ft) 474.993	OF 1

LATITUDE	32°14'29.92239" N
LONGITUDE	96°44'42.99093" W
INDEX SHEET (Quadrangle Sheet)	Cryer Creek
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 130	167°01'14"	2936.613

DESCRIPTION, PLAT.

Southwest of Bardwell. From the junction of Highway 34 and FM 877, located 3.4 miles southwest of Bardwell, go north-northwest on Farm Road 877 0.45 miles to the station on the right.



Legend

1" Diameter Dywidag Rod in a SSC monument casing

Towill, inc.

NOT TO SCALE

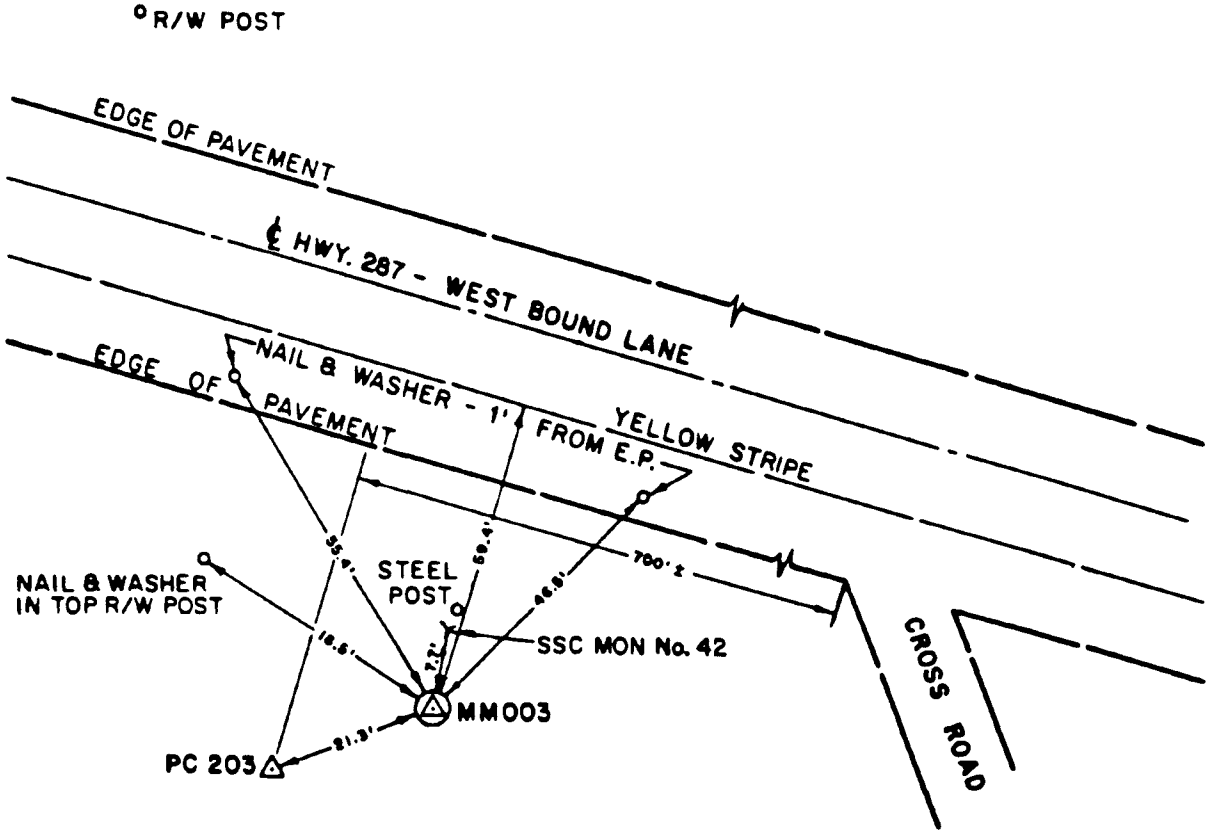
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
MM 003		0.99993371	1
N (ft) 6804926.432	E (ft) 2534820.498	Elev (ft) 492.852	OF 1

LATITUDE	32°19'18.17178" N
LONGITUDE	96°39'59.92816" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 123	278°44'34"	3693.458

DESCRIPTION, PLAT:
West of Ennis. From the intersection of Business Route Highway 45 and Highway 287, in East Ennis, go southwest and westerly for 2.67 miles along Highway 287 to the crest of a rise and the station on the left. The station is in the median and is approximately 4-feet higher than the road level.



Legend
1" Diameter Dywidag Rod in a SSC monument casing

Towill, Inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

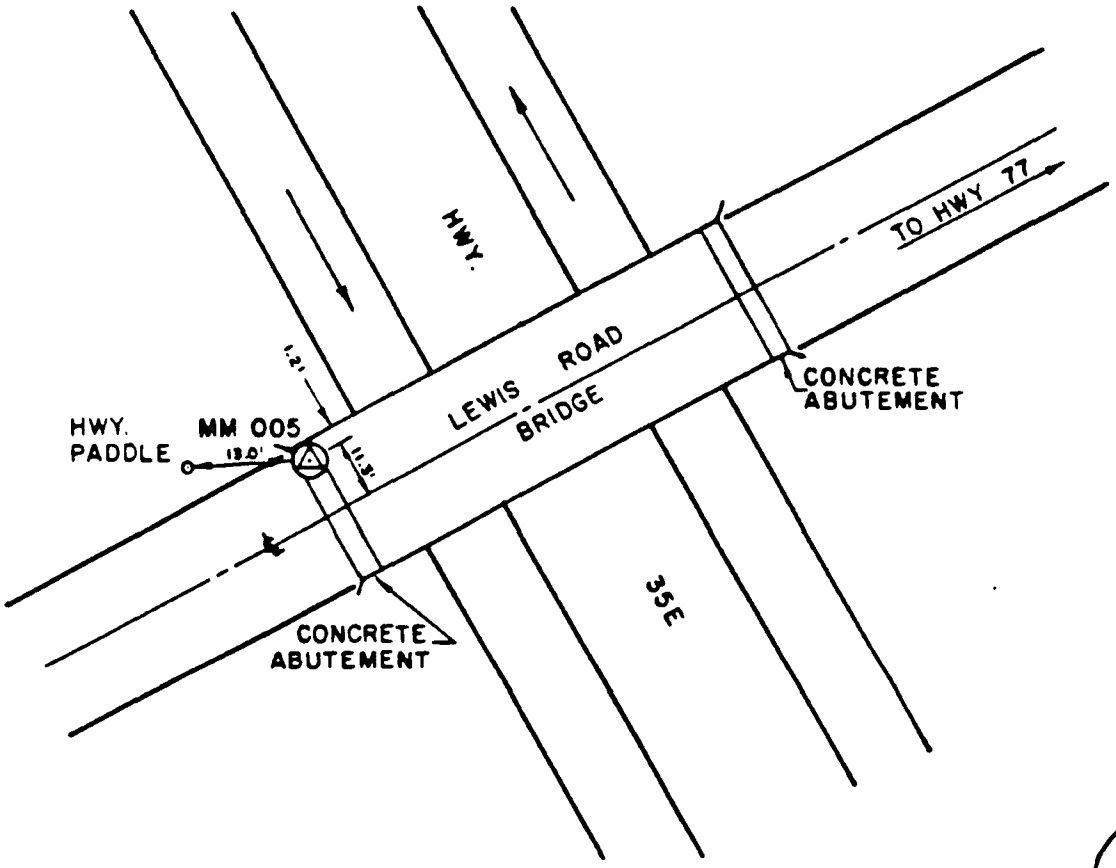
STATION		Point Grid Factor	SHEET
MM 005		0.99994889	1
N (ft) 6776532.036	E (ft) 2470582.538	Elev (ft) 541.121	OF 1

LATITUDE	32°14'47.69385" N
LONGITUDE	96°52'33.56512" W
INDEX SHEET (Quadrangle Sheet)	Italy
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 138	68°07'45"	3304.476

DESCRIPTION, PLAT.

Approximately 1.0 miles southwest of Forreston. The station is a brass disk stamped SSC Survey Monument No. MM 005, recessed and set into the northwest corner of the Lewis Road bridge over Highway I 35 E. To reach the monument from the intersection of Main and Highway 77 in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, travel south on Highway 77 for 0.79 miles to Lumkins Road on the left and Lewis Road on the right (no sign). Turn right on Lewis Road and continue easterly for 0.48 miles to the bridge and the station.



Legend

3" Diameter Brass Cap in a SSC monument casing

Towill, inc

NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

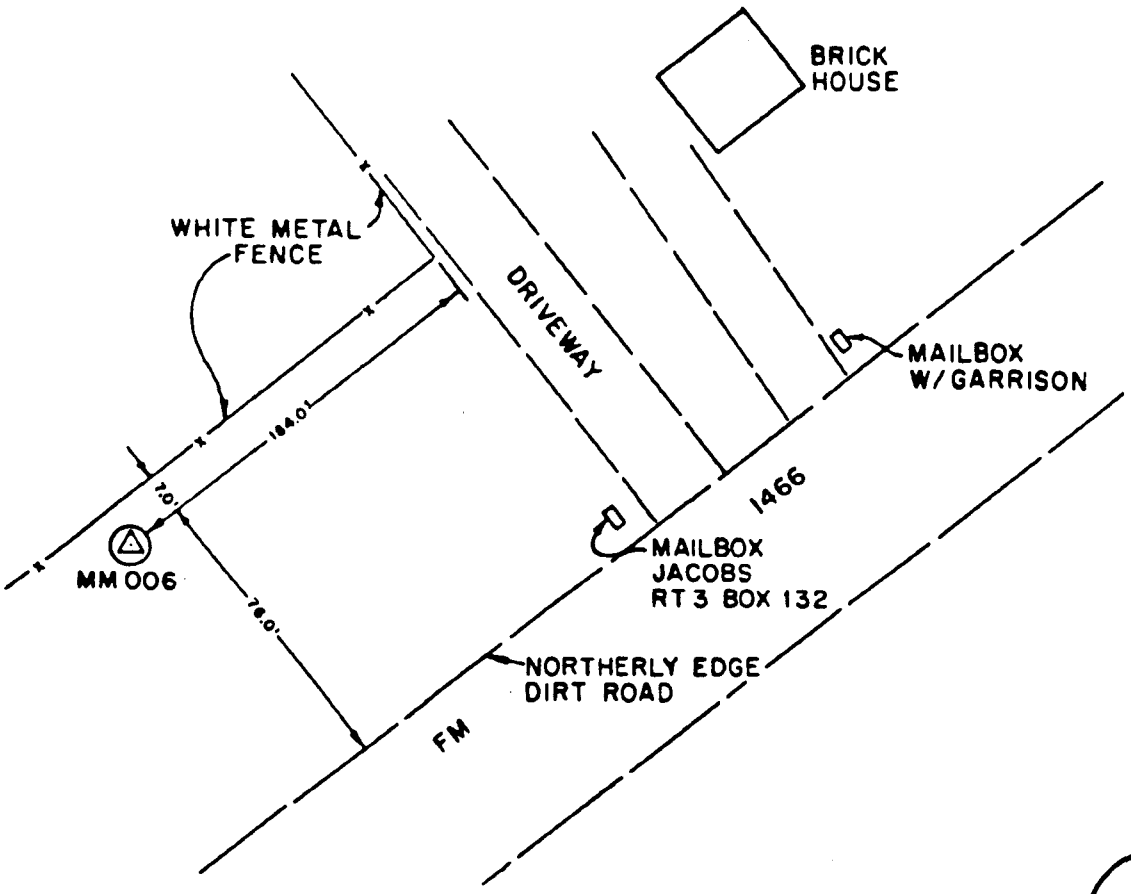
STATION		Point Grid Factor	SHEET
MM 006		0.99991330	1
N (ft) 6817421.113	E (ft) 2448370.082	Elev (ft) 750.593	OF 1

LATITUDE	32°21'35.58857" N
LONGITUDE	96°56'45.13346" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET

DESCRIPTION, PLAT.

West of Waxahachie. From the center of the FM 1446 (also known as Buena Vista Road) overpass over I 35 E, go west on FM 1446 2.62 miles to Lone Elm Road on the right. Continue west of FM 1446 for 2.26 miles to the end of the paving. Continue straight ahead on the dirt road for 0.18 miles to a dirt driveway leading through a white metal fence. On the west side of the driveway is a black mailbox - Route 3, Box 132, Jacobs. Continue west for 185-feet to the station on the right.



Legend

1" Diameter Dywidag Rod in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

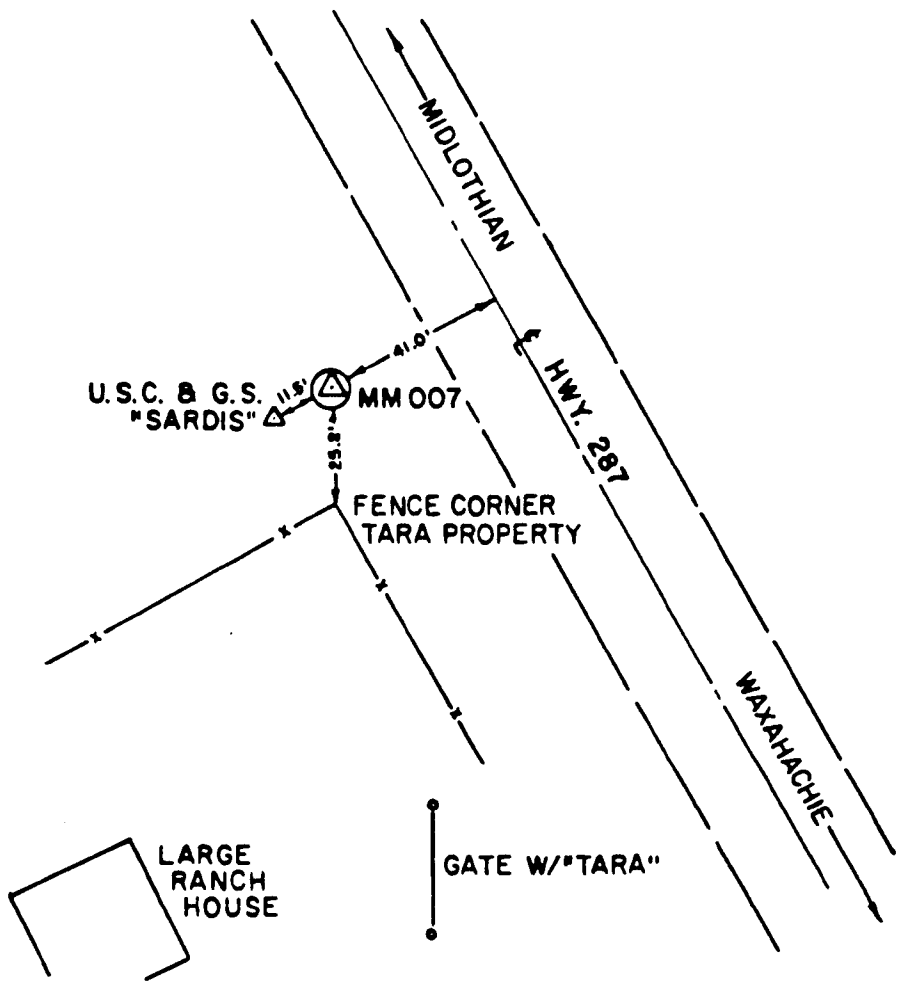
STATION		Point Grid Factor	SHEET
MM 007		0.99990209	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6849082.711	2453914.913	629.476	1

LATITUDE	32°26'48.04489" N
LONGITUDE	96°55'34.96608" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order B — Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 166	127°49'51"	2558.316

DESCRIPTION, PLAT.

Northwest of Waxahachie. From the Sardis crossing on Highway 287 north, go northwesterly towards Midlothian for 1.33 miles to a rise and the station on the left. The station is approximately 26-feet north of the northerly fence corner of a piece of property named Tara.



Legend

1" Diameter Dywidag Rod in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

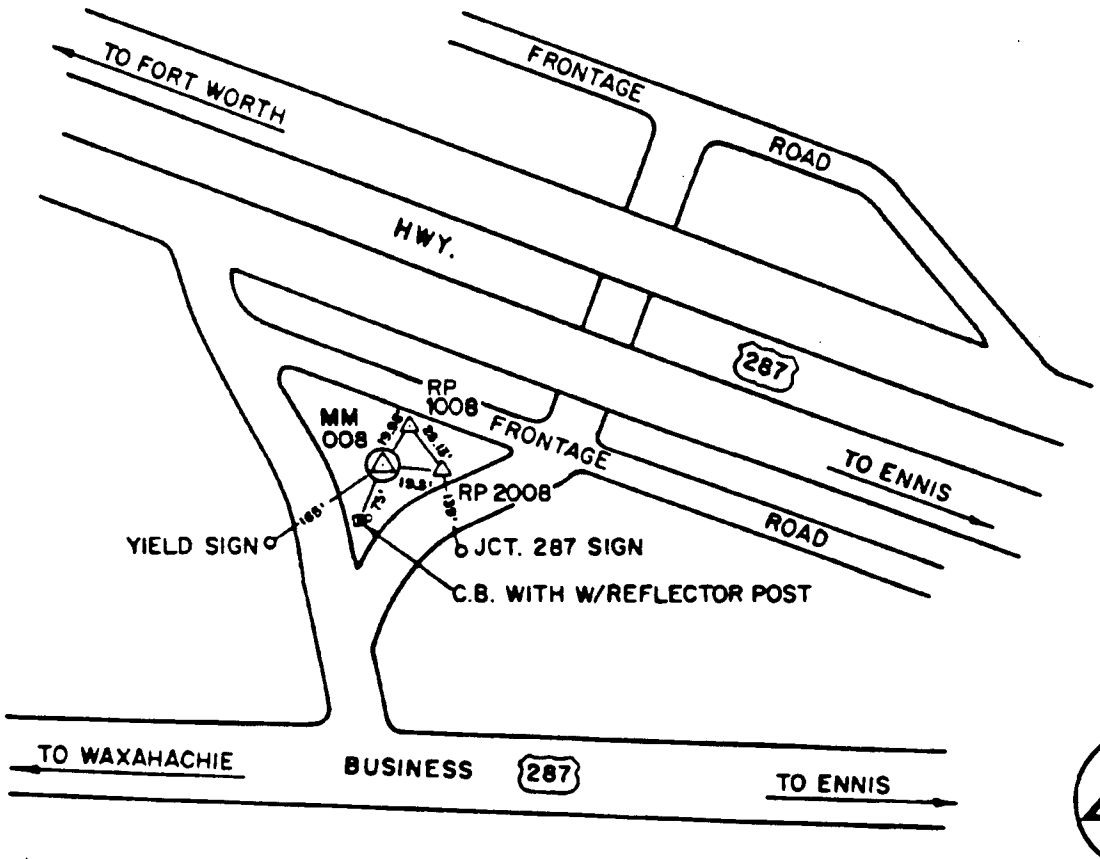
STATION		Point Grid Factor	SHEET
MM 008		0.99992306	1
N (ft)	E (ft)	Elev (ft)	OF
6817971.483	2492092.105	547.024	1

LATITUDE	32°21'34.34229" N
LONGITUDE	96°48'15.35409" W
INDEX SHEET (Quadrangle Sheet)	Forreston
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
NGS' MUSTANG	201°26'05"	971.755

DESCRIPTION, PLAT.

East of Waxahachie. This station is located near the center of the "ring" on the east side of Waxahachie near the junction of Highway 287 Business and Highway 287. From the north side of Waxahachie at the crossing of Highway 287 south over Highway 77, go southeasterly on Highway 287 south for 4.17 miles to an exit marked Frontage Road. Take this exit and follow the Frontage Road for 0.60 miles to a split marked 287 South left and Business 287 right. Bear right towards Business 287 for 0.10 miles to the station on the left in the large grassy triangle created by the Frontage Road and the exits from Highway 287 north and south to Business 287.



Legend

1" Diameter Dywidag Rod in a SSC monument casing

Towill, inc.
NOT TO SCALE

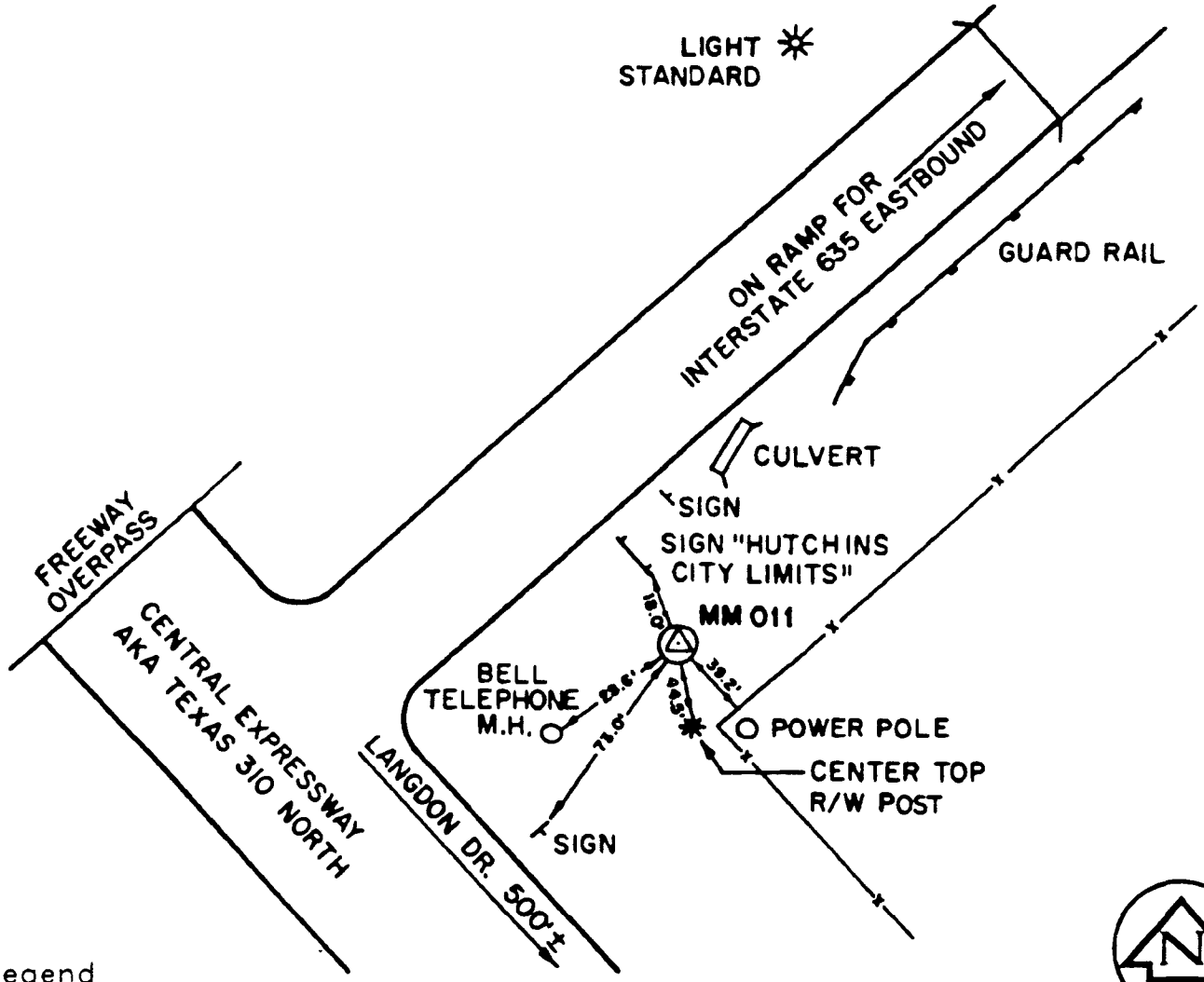
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
MM 011		0.99987769	1
N (ft) 6928769.607	E (ft) 2515641.266	Elev (ft) 458.940	OF 1

LATITUDE 32°39'46.74561" N		
LONGITUDE 96°43'18.97954" W		
INDEX SHEET (Quadrangle Sheet) Hutchins		
HORZ NAD 83	Order B	Type GPS
VERT NGVD 29	FIRST	

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET

DESCRIPTION, PLAT:
North of Hutchins, south of Dallas. The master monument is located at the eastbound entrance to Interstates 20 and 635 from the Central Expressway, also known as Texas 310 north, at the Hutchins and Dallas City limits, approximately 500-feet north of Langdon Drive.



Legend
1" Diameter Dywidag Rod in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

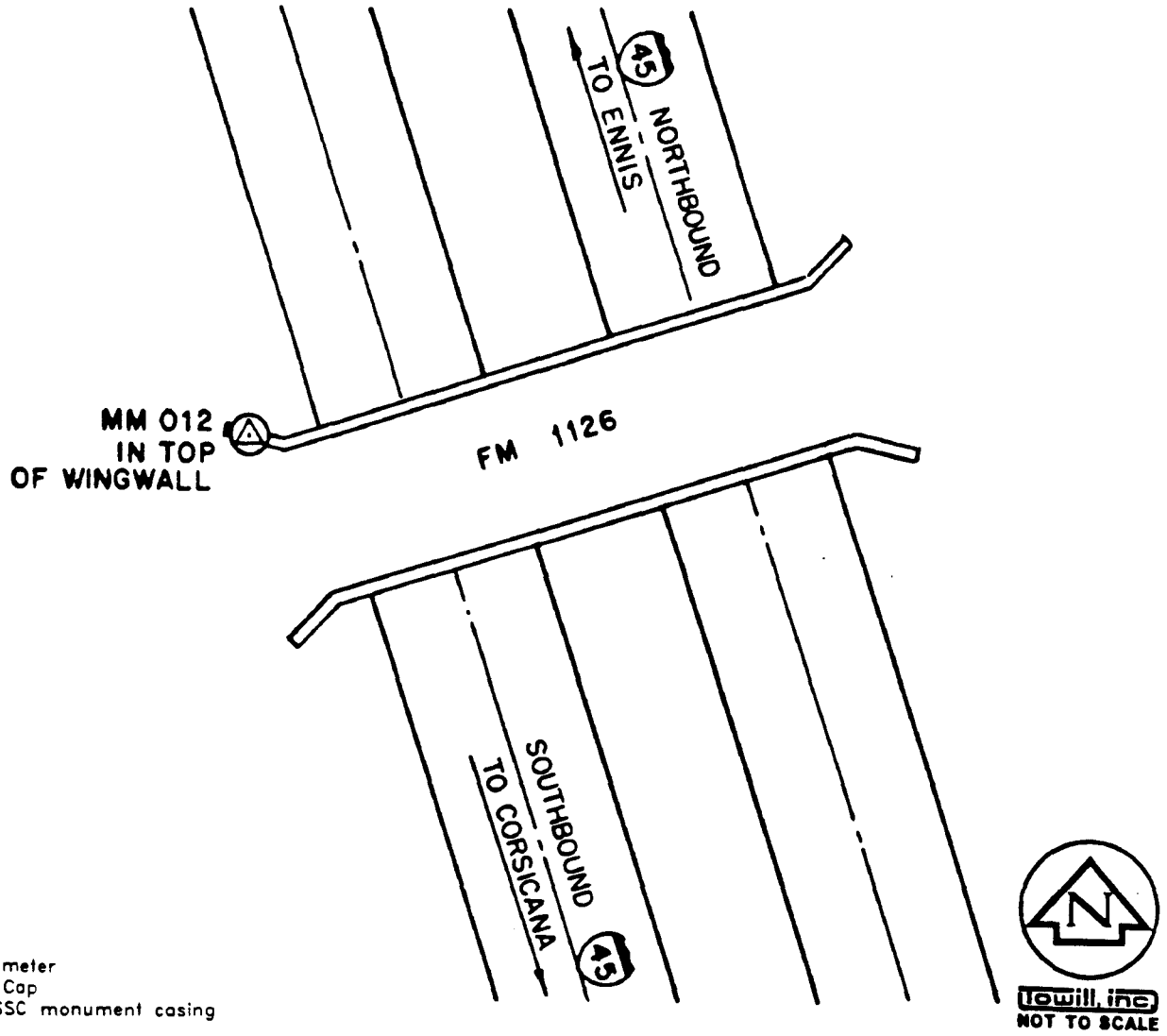
STATION		Point Grid Factor	SHEET
MM 012		0.99996067	1
N (ft) 6767824.258	E (ft) 2592277.236	Elev (ft) 445.611	OF 1

LATITUDE	32°13'00.67236" N
LONGITUDE	96°28'58.76792" W
INDEX SHEET (Quadrangle Sheet)	Chatfield
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET

DESCRIPTION, PLAT.

Southeast of Rice. From the Interstate 45 overpass in Rice, go southeasterly on Interstate 45 for 2.07 miles to an overpass for FM 1126 and the station. The station is a brass disk stamped SSC Survey Monument No. MM 012, recessed and set in the northwest wingwall of the overpass abutment on the west side of Interstate 45.



Legend

3" Diameter Brass Cap in a SSC monument casing

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

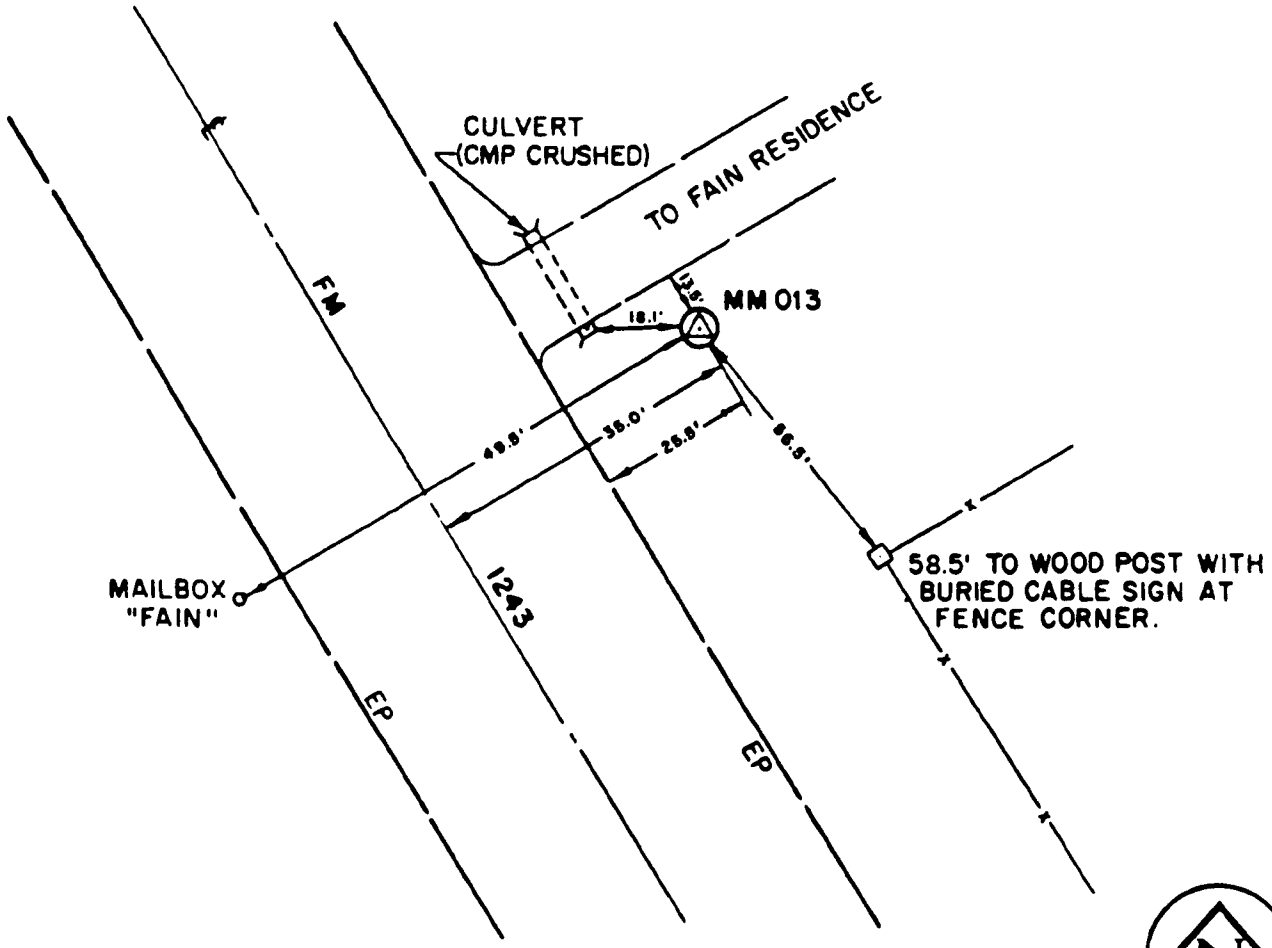
STATION		Point Grid Factor	SHEET
MM 013		0.99999230	1
N (ft)	E (ft)	Elev (ft)	OF
6711431.003	2443555.749		1

LATITUDE	32°04'07.58922" N
LONGITUDE	96°57'59.29403" W
INDEX SHEET (Quadrangle Sheet)	Mertens
HORZ NAD 83	Order B — Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET

DESCRIPTION, PLAT.

South of Milford. From the intersection of Highway 77 and FM 1243, located approximately 2.9 miles south of Milford, go southeast on FM 1243 for 2.44 miles to the station on the left. The station is opposite a mailbox with the name "Fain" and is 13.5-feet southeast of a farm driveway. THIS MONUMENT HAS BEEN DESTROYED.



Legend

1" Diameter Dywidag Rod in a SSC monument casing

Towill, inc
NOT TO SCALE

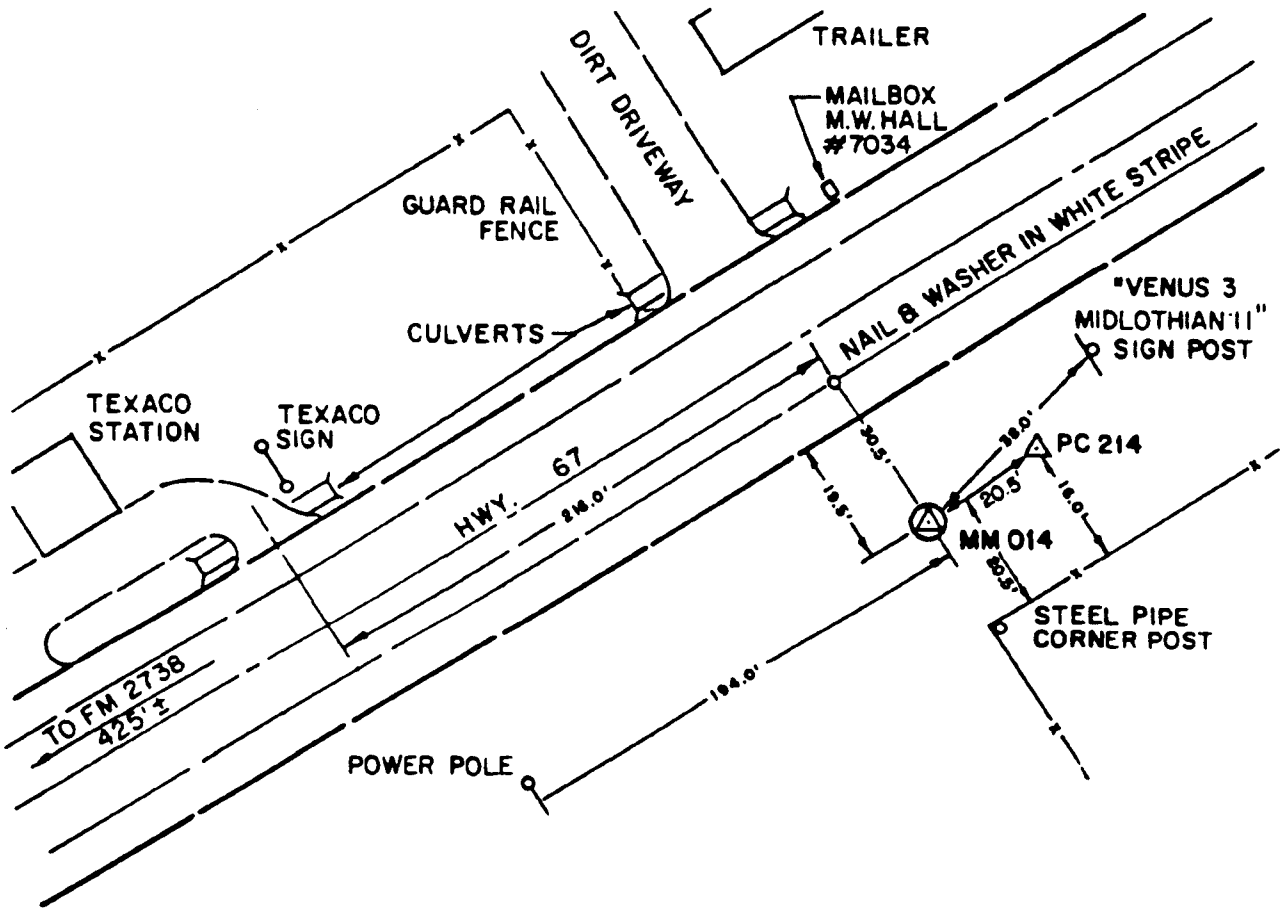
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
MM 014		0.99990224	1
N (ft) 6840135.216	E (ft) 2385256.585	Elev (ft) 713.411	OF 1

LATITUDE	32°25'28.96911" N
LONGITUDE	97°08'57.48987" W
INDEX SHEET (Quadrangle Sheet)	Alvarado
HORZ NAD 83	Order B, Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET

DESCRIPTION, PLAY:
East of Alvarado, west of Venus. From the junction of Highway 67 and Farm Road 2738, located 4 miles east of Alvarado at a Texaco Station, go northeast on Highway 67 for 0.09 miles to a fence corner and the station on the right.



Legend

1" Diameter
Dywidag Rod
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

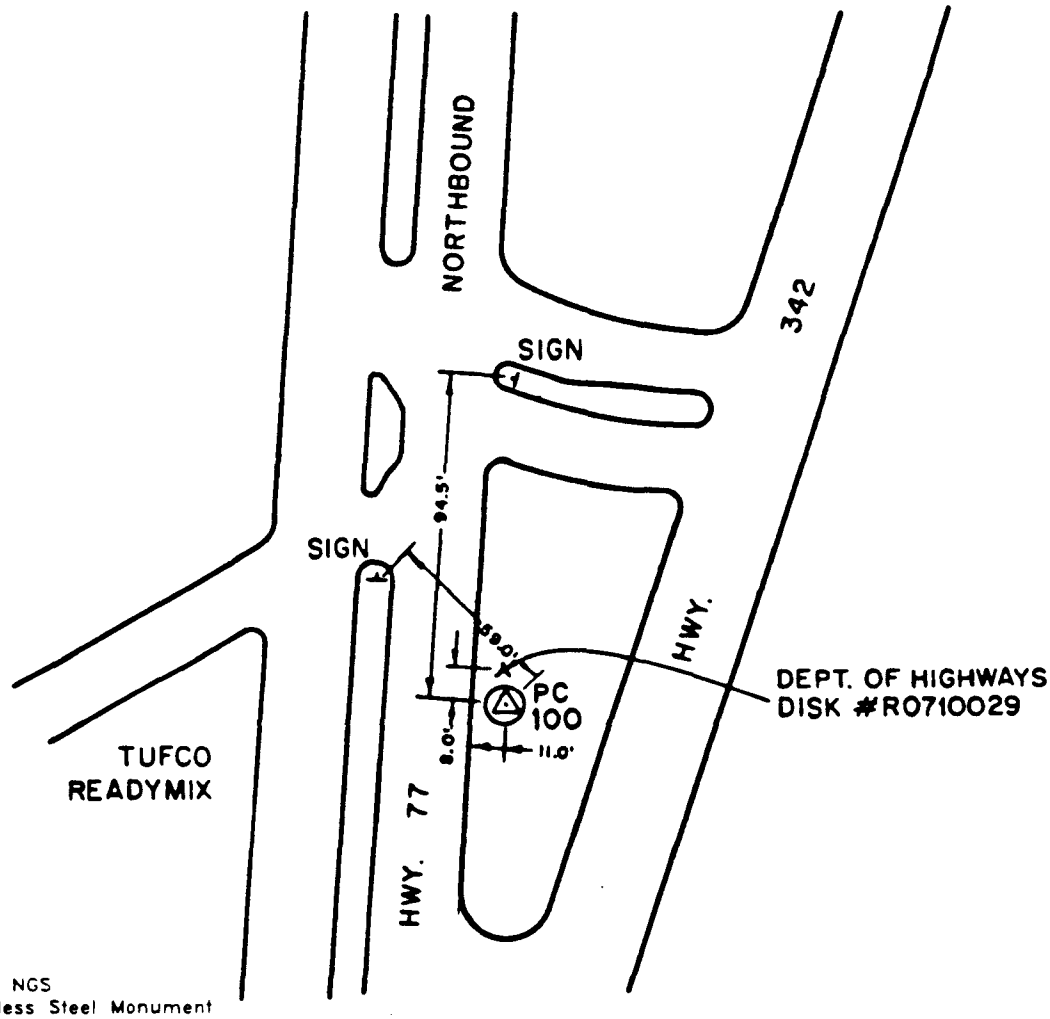
STATION		Point Grid Factor	SHEET
PC 100		0.99989752	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6865232.578	2485558.101	565.750	1

LATITUDE	32°29'22.99304" N
LONGITUDE	96°49'22.72661" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
MM 001	356°41'51"	2761.437

DESCRIPTION, PLAT:

South of Red Oak. PC 100 is located in the easterly traffic island at the intersection of Highways 77 and 342, between Highway 342 northbound and Highway 77 northbound, 11-feet easterly of the westerly edge of the island. The intersection is two (2) miles south of Red Oak. From the center of the overpass at exit number 408 on Highway I 35 E south, continue southbound on Highway 77 for 0.43 miles to Tufco Ready Mix, Inc. on the right and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

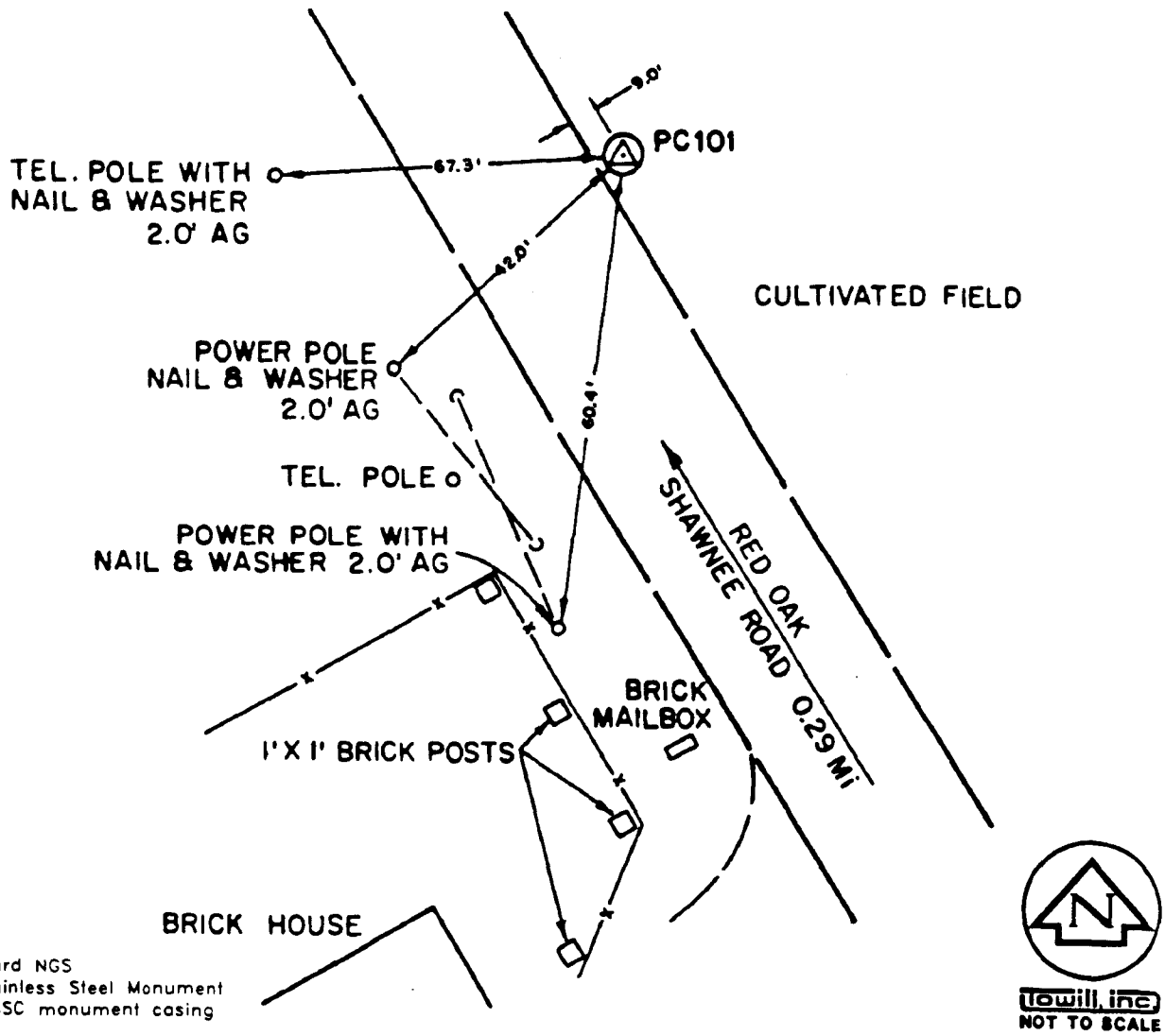
STATION		Point Grid Factor	SHEET
PC 101		0.99989766	1
N (ft) 6866799.244	E (ft) 2491603.467	Elev (ft) 548.371	OF 1

LATITUDE	32°29'37.53351" N
LONGITUDE	96°48'11.85649" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
MM 001	280°51'32"	6317.567

DESCRIPTION, PLAT:

Southeast of Red Oak. From the Post Office in Red Oak located on the east side of Highway 342, go south on Highway 342 for 0.40 miles to the intersection of FM 2377. Turn left on Farm Road 2377 and continue 0.40 miles to Shawnee Road. Turn right onto Shawnee Road and continue ahead for 0.55 miles to a road on the left. Turn left and go 0.28 miles to the station on the left.



SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

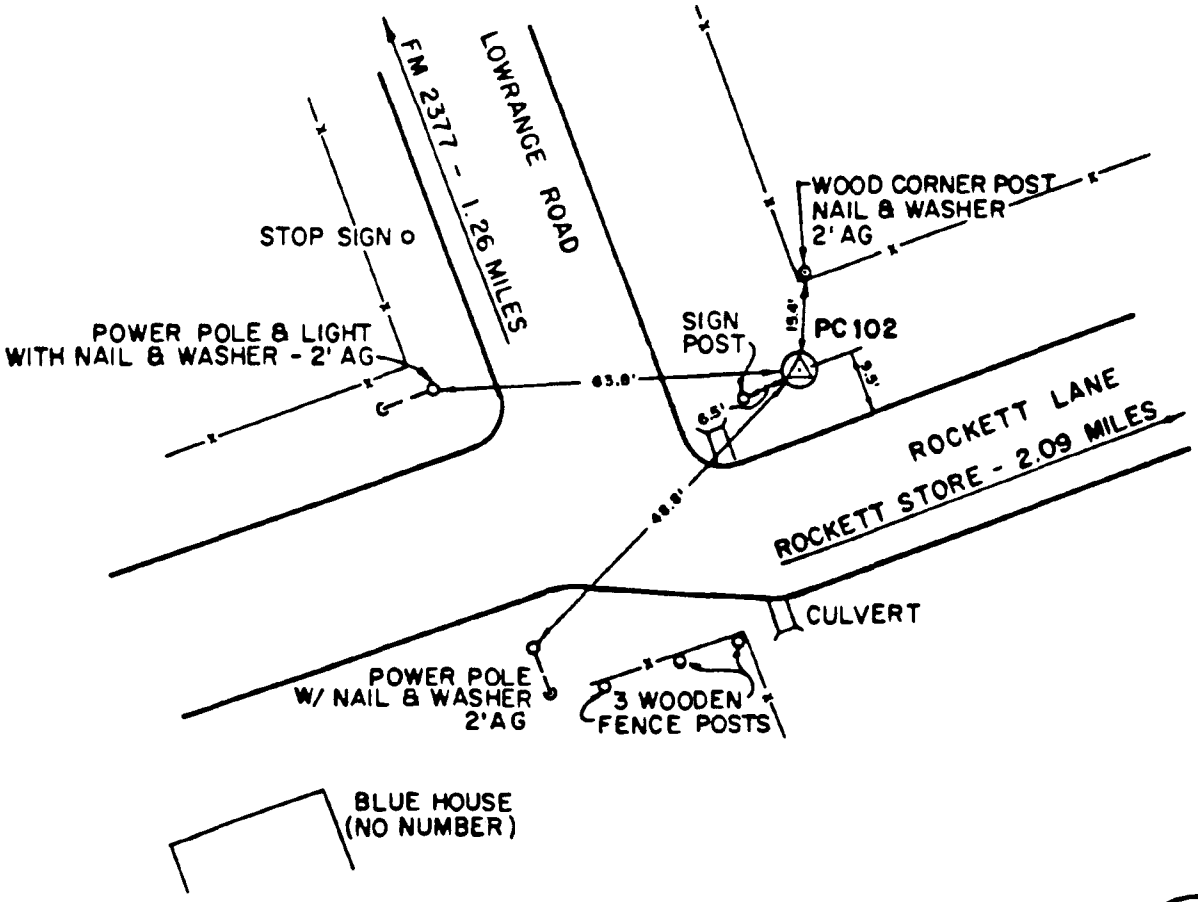
STATION		Point Grid Factor	SHEET
PC 102		0.99989931	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6864110.244	2496927.319	540.747	1

LATITUDE	32°29'10.07280" N
LONGITUDE	96°47'10.21442" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 103	79°25'05"	2803.911

DESCRIPTION, PLAT.

Southeast of Red Oak. From the Post Office in Red Oak located on the east side of Highway 342, go south on Highway 342 for 0.40 miles to the intersection of Highway 342 and FM 2377. Turn left and continue on Farm Road 2377 for 0.92 miles to Lowrance Road, turn right on Lowrance Road and continue 1.26 miles to Rockett Lane, a "T" intersection and the station on the left.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

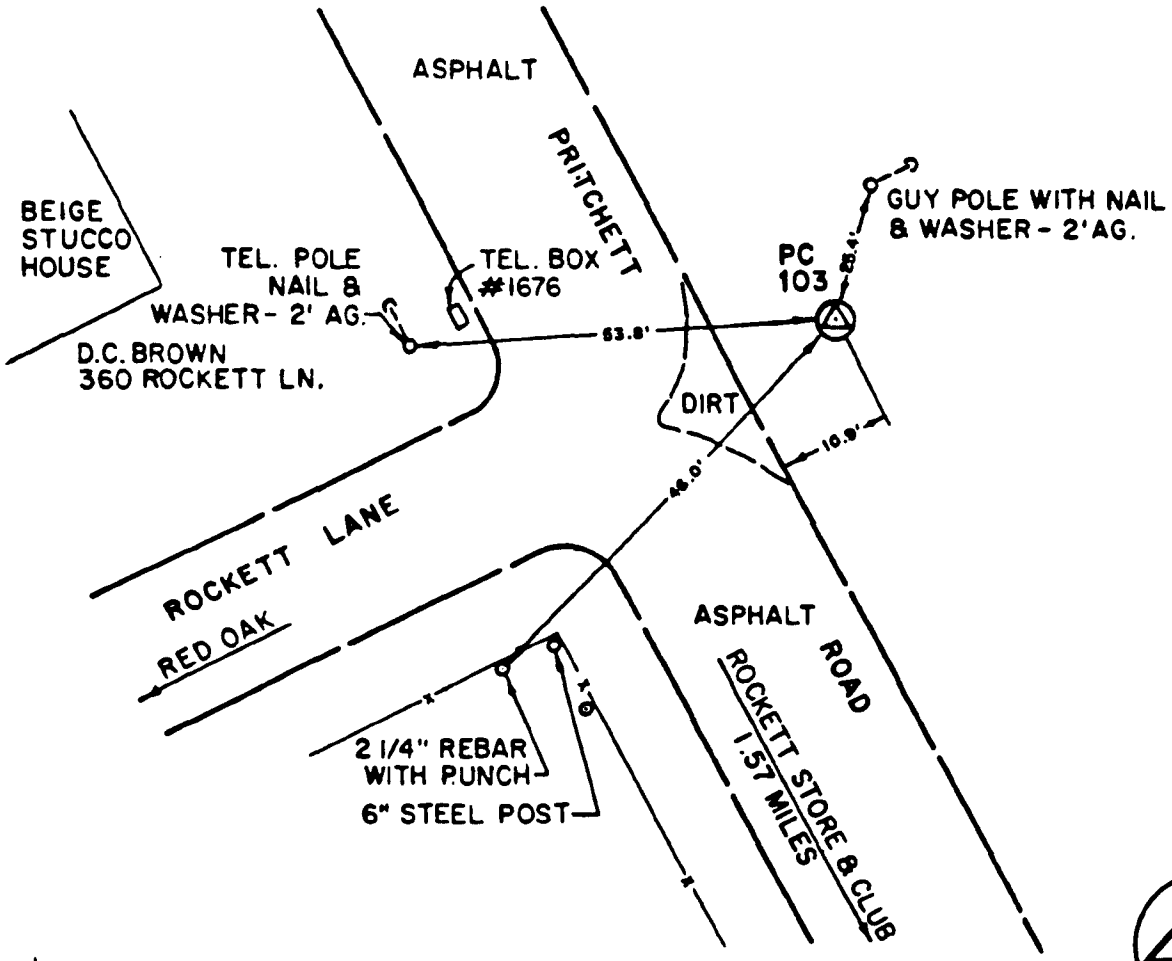
STATION		Point Grid Factor	SHEET
PC 103		0.99989884	1
N (ft) 6864625.157	E (ft) 2499683.545	Elev (ft) 545.861	OF 1

LATITUDE	32°29'14.72137" N
LONGITUDE	96°46'37.94058" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 102	259°25'05"	2803.911
PC 104	151°23'23"	1738.661

DESCRIPTION, PLAT:

Northwest of Rockett. From the Rockett Store and Cafe/Club on Farm Road 813 in Rockett, located 0.62 miles west of the intersection of FM 983 and FM 813, go north on Loma Linda for 0.88 miles to Pritchett Road. Turn right on Pritchett Road and continue north 0.73 miles to a "T" intersection of Pritchett Road and Rockett Lane and the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

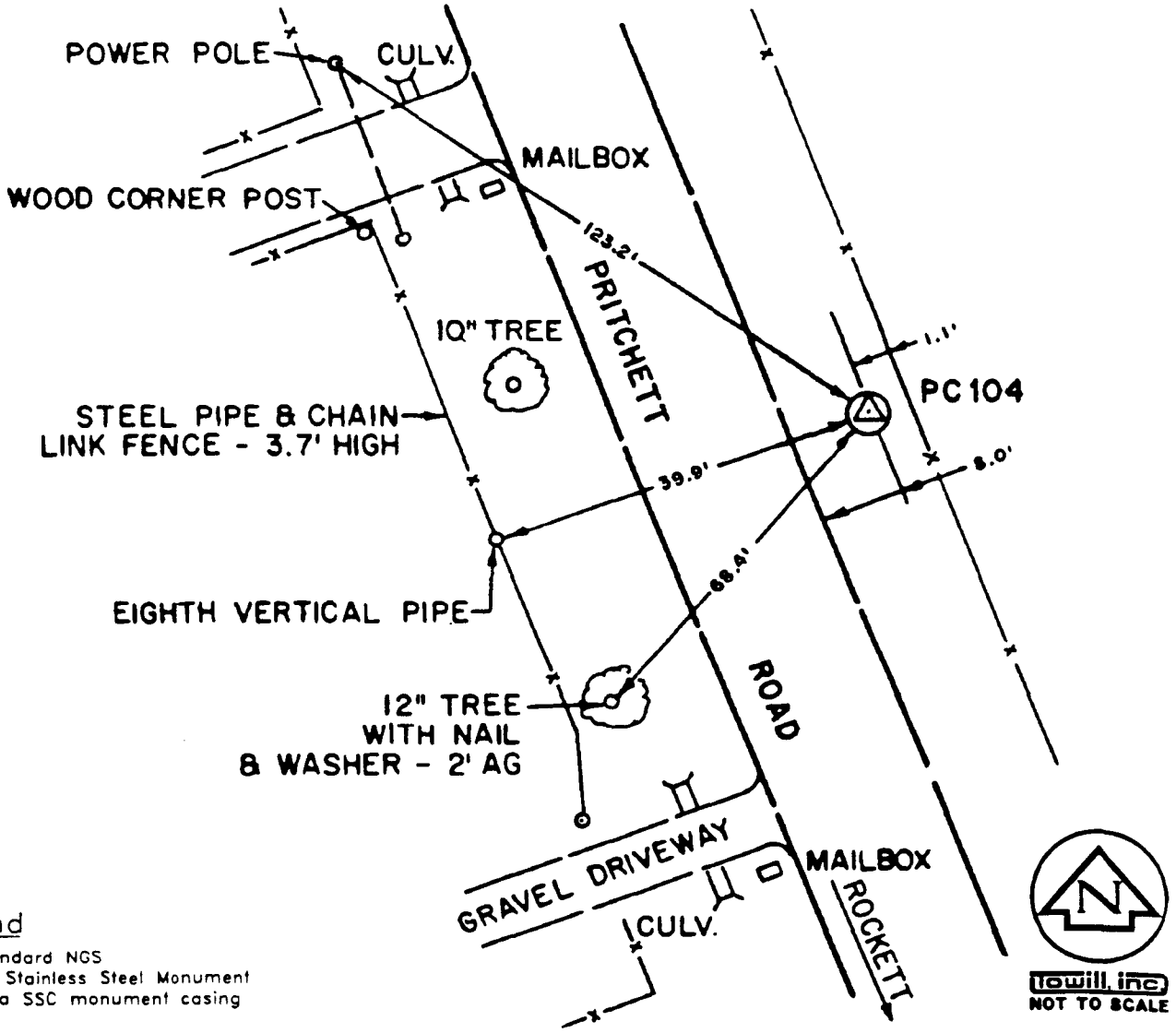
STATION		Point Grid Factor	SHEET
PC 104		0.99989958	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6863098.791	2500516.101	545.564	1

LATITUDE	32°28'59.48399" N
LONGITUDE	96°46'28.51414" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 103	331°23'23"	1738.661

DESCRIPTION, PLAT:

Northwest of Rockett. From the Rockett Store and Cafe/Club on Farm Road 813 in Rockett, located 0.62 miles west of the intersection of FM 983 and FM 813, go north on Loma Linda for 0.88 miles to Pritchett Road. Turn right on Pritchett Road and continue north 0.41 miles to a chain link fence on the left and the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

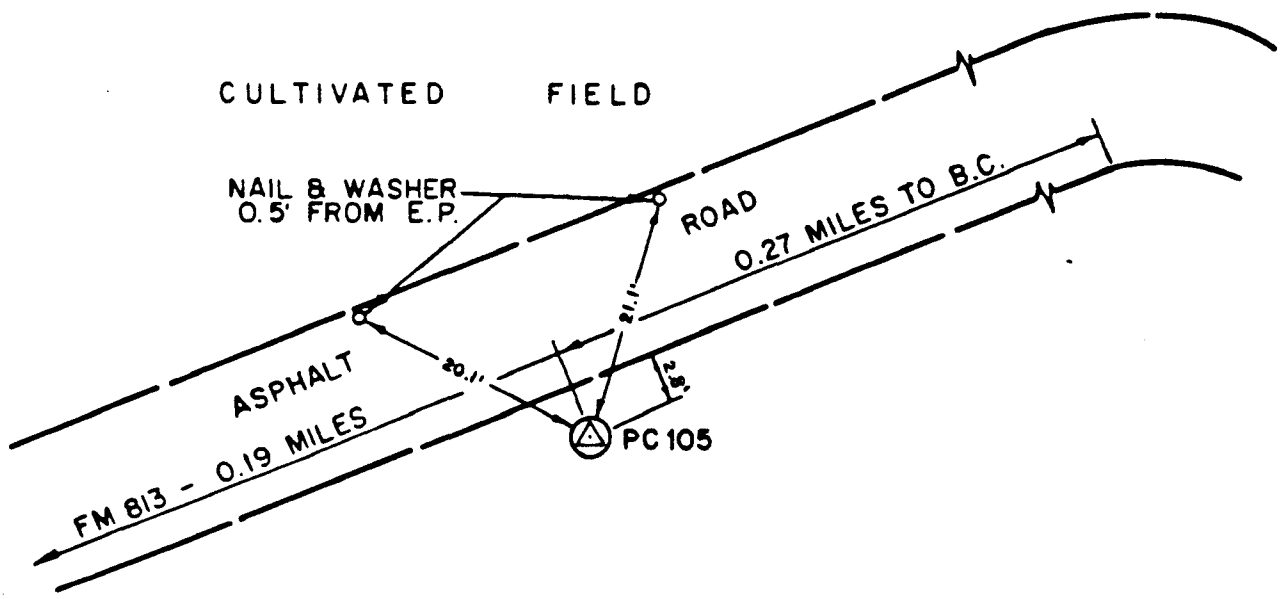
STATION		Point Grid Factor	SHEET
PC 105		0.99990334	1
N (ft) 6858319.830	E (ft) 2508937.102	Elev (ft) 515.795	OF 1

LATITUDE	32°28'10.82081" N
LONGITUDE	96°44'51.14461" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 106	61°08'46"	2344.488

DESCRIPTION, PLAT,

East of Rockett. From the intersection of FM 813 and FM 983, approximately 0.6 miles east of Rockett, take FM 813 east towards Palmer for 0.43 miles to a paved road on the left. Turn left and go east for 0.21 miles to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

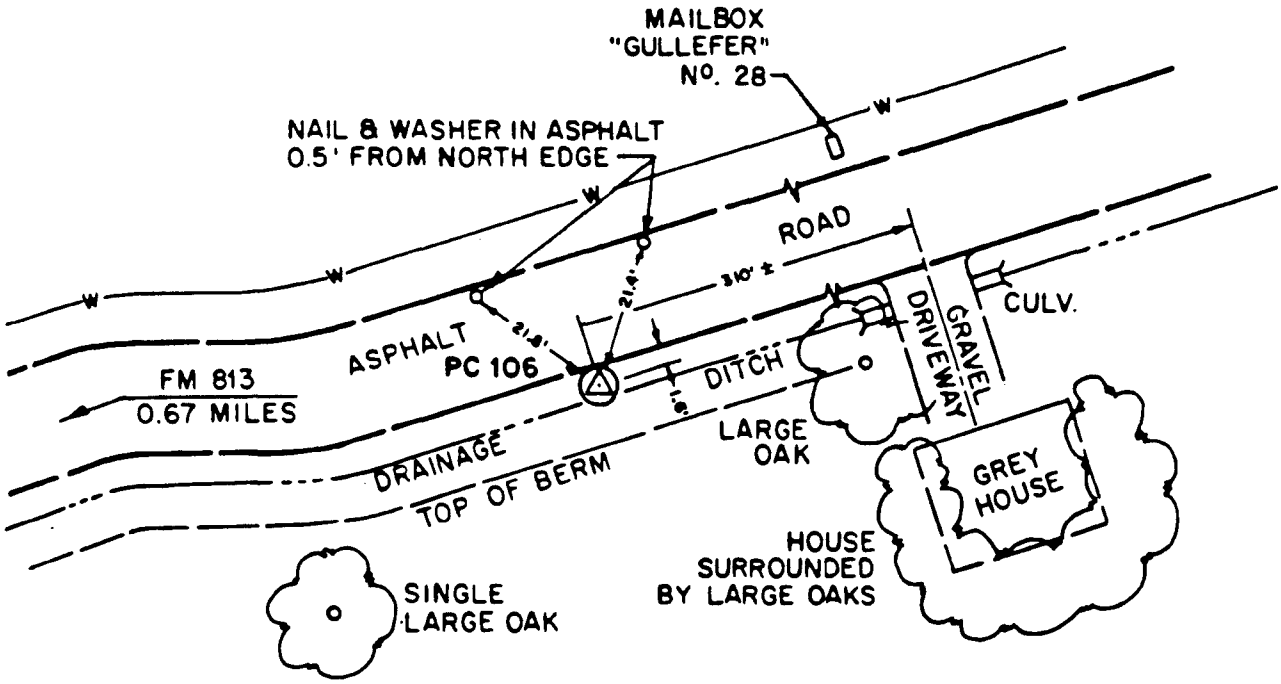
STATION		Point Grid Factor	SHEET
PC 106		0.99990301	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6859451.226	2510990.530	511.623	1

LATITUDE	32°28'21.67541" N
LONGITUDE	96°44'26.95700" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order: FIRST; Type: GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 105	241°08'46"	2344.488

DESCRIPTION, PLAT:

East of Rockett. From the intersection of FM 813 and FM 983, approximately 0.6 miles east of Rockett, take FM 813 east towards Palmer for 0.43 miles to a paved road on the left. Turn left and go east for 0.66 miles to the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

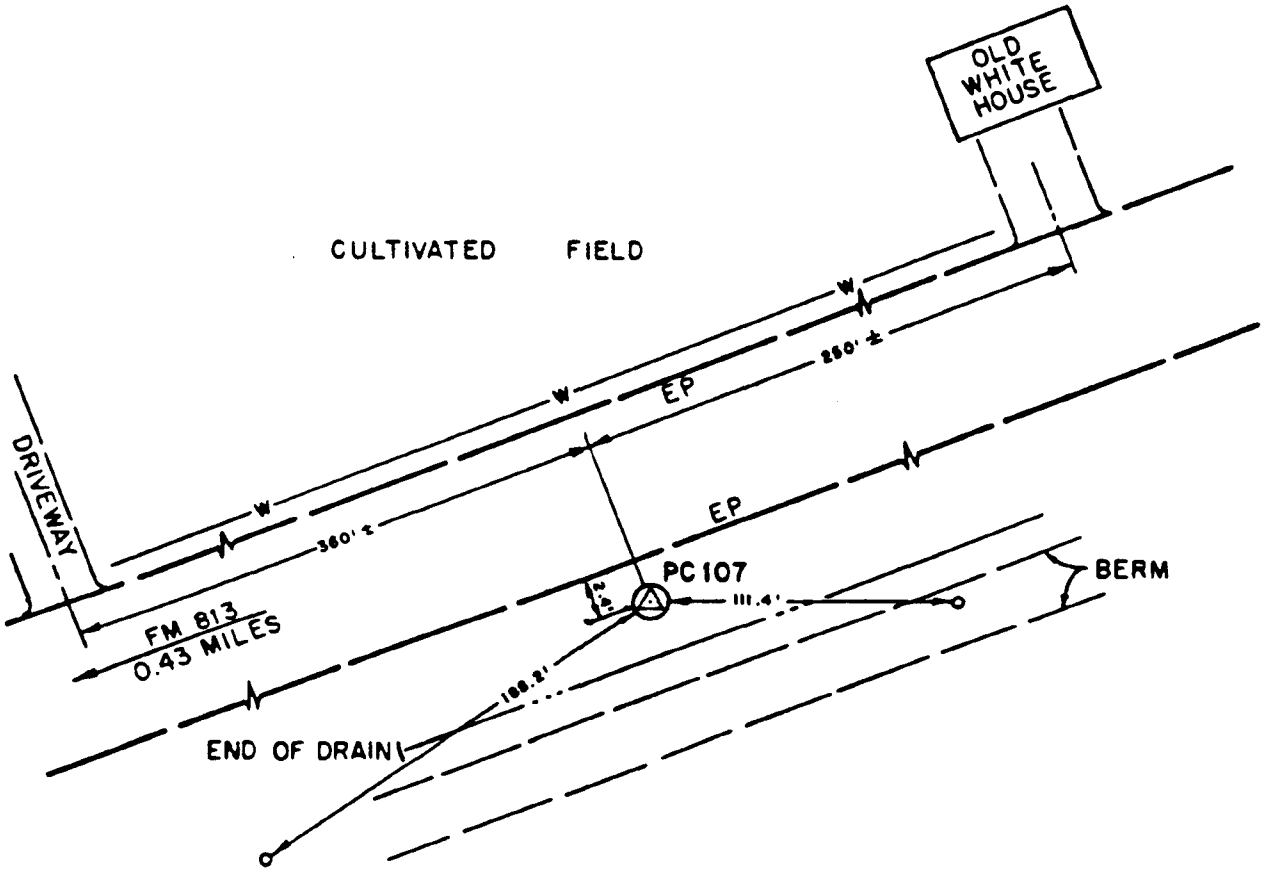
Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 107		0.99990645	1
N (ft) 6853995.082	E (ft) 2513659.650	Elev (ft) 495.663	OF 1

LATITUDE 32°27'27.24825" N			STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
LONGITUDE 96°43'56.87509" W			PC 108	58°55'18"	1843.971
INDEX SHEET (Quadrangle Sheet) Palmer					
HORZ NAD 83	Order FIRST	Type GPS			
VERT NGVD 29	FIRST				

DESCRIPTION, PLAT:
Northwest of Palmer. From the intersection of FM 813 and FM 983, approximately 0.6 miles east of Rockett, take FM 813 east towards Palmer for 1.66 miles to a paved crossroad. Turn left and go 0.45 miles to the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

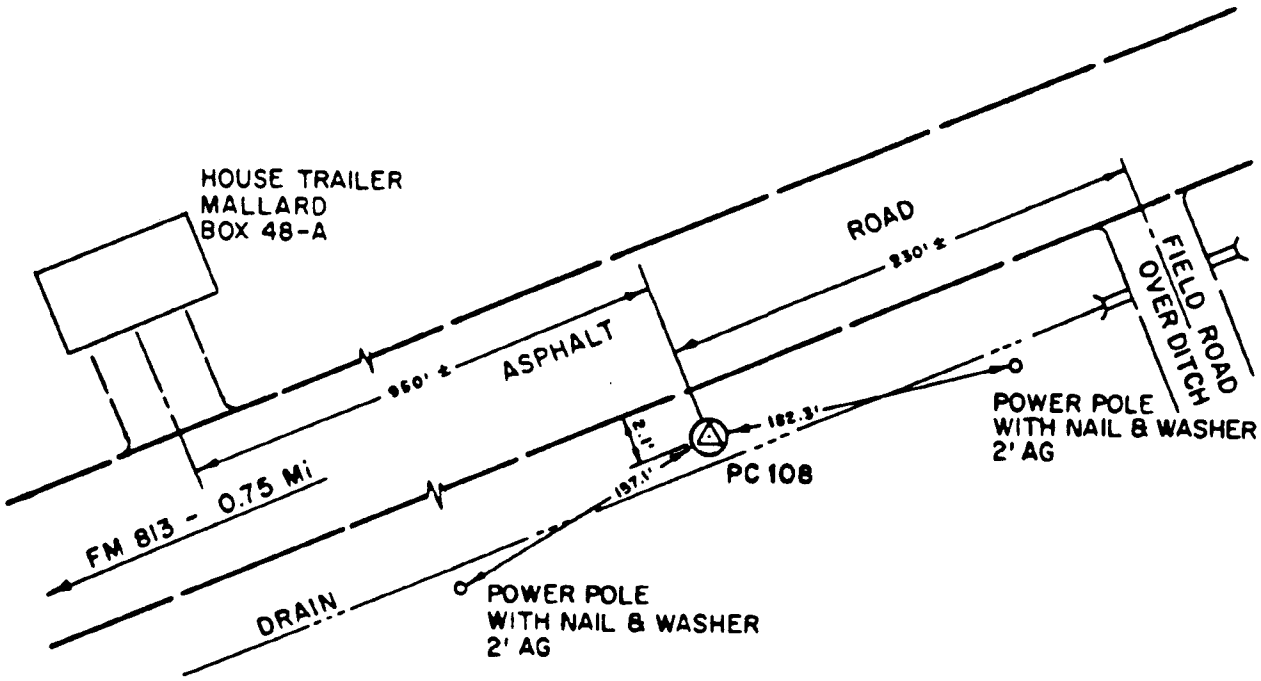
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 108		0.99990599	1
N (ft) 6854946.958	E (ft) 2515238.941	Elev (ft) 495.601	OF 1

LATITUDE	32°27'36.40292" N
LONGITUDE	96°43'38.25758" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 107	238°55'18"	1843.971

DESCRIPTION, PLAT:
Northwest of Palmer. From the intersection of FM 813 and FM 983, approximately 0.6 miles east of Rockett, take FM 813 east towards Palmer for 1.66 miles to a paved crossroad. Turn left and continue 0.80 miles to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

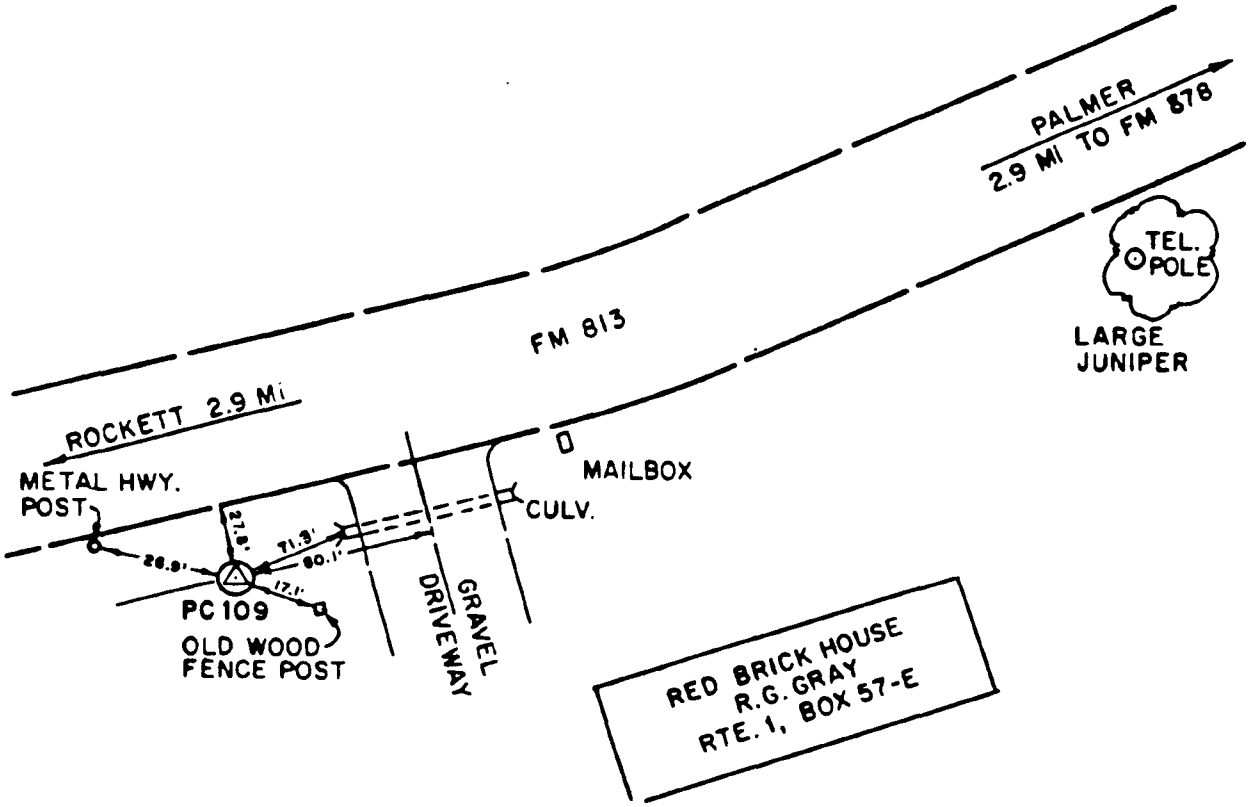
STATION		Point Grid Factor	SHEET
PC 109		0.99990890	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6850326.260	2517582.060	483.149	1

LATITUDE	32°26'50.29316" N
LONGITUDE	96°43'11.82682" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 110	78°31'05"	2195.355

DESCRIPTION, PLAT.

Northwest of Palmer. From the intersection of FM 813 and FM 878 in Palmer at the "First United Methodist Church", go west on Farm Road 813 for 3.03 miles to the R. G. Gray residence, a red brick house on the left and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

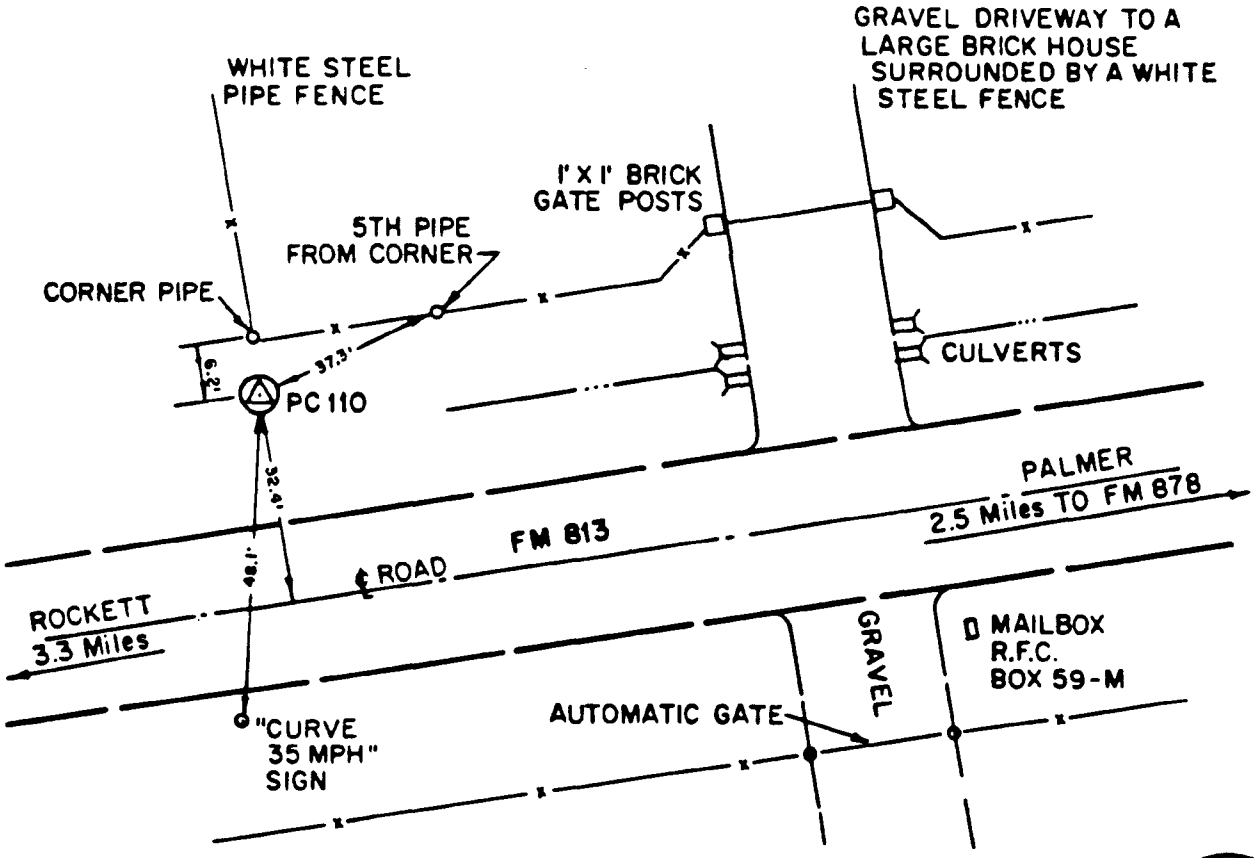
STATION		Point Grid Factor	SHEET
PC 110		0.99990869	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6850763.265	2519733.480	483.353	1

LATITUDE	32°26'54.25551" N
LONGITUDE	96°42'46.63632" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 109	258°31'05"	2195.355

DESCRIPTION, PLAT:

Northwest of Palmer. From the intersection of FM 813 and FM 878 at the "First United Methodist Church" in Palmer, go west on Farm Road 813 for 2.62 miles to a large brick house with a white steel post fence on the right. The station is located at the southwest corner of the fence.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

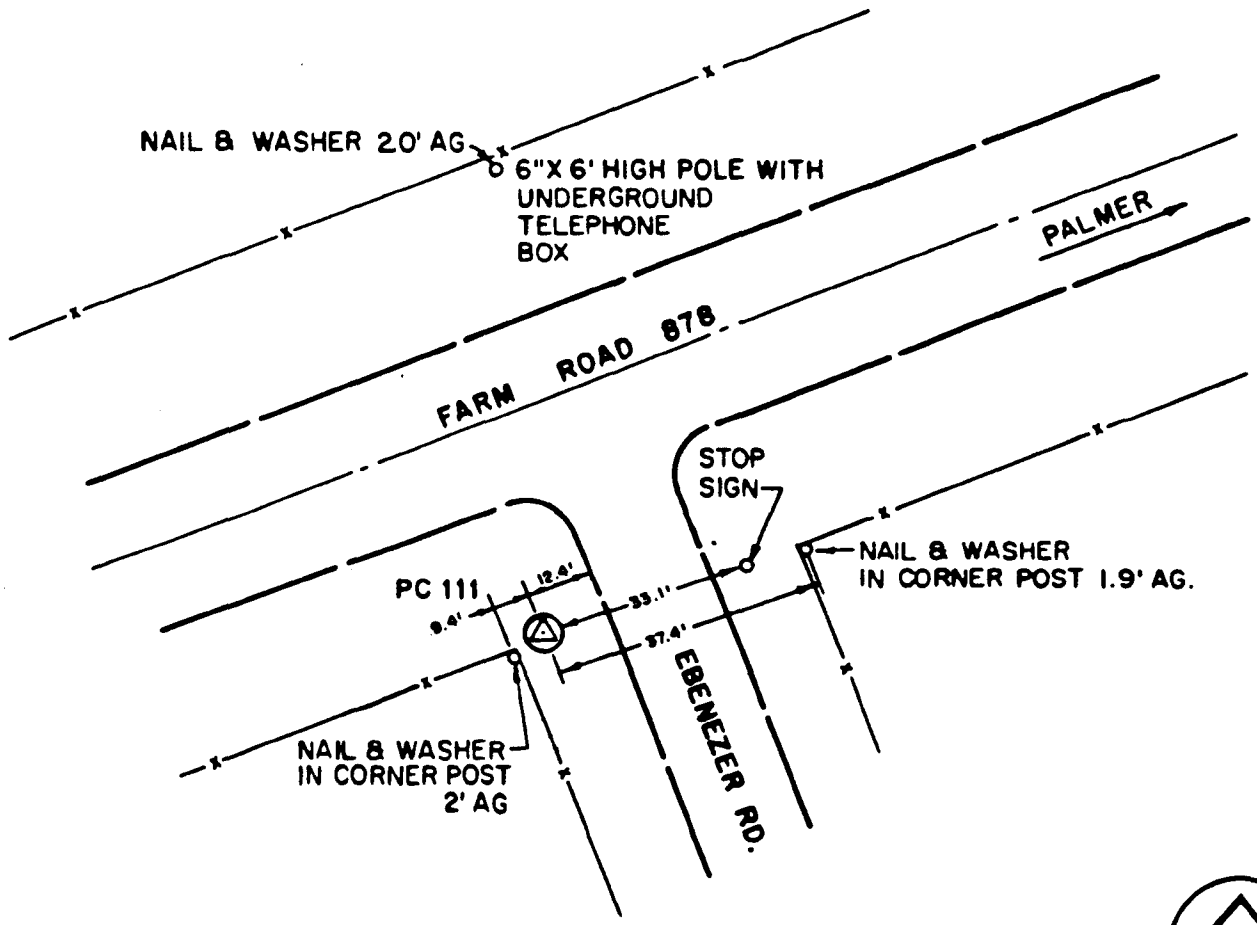
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 111		0.99991395	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6840978.564	2520558.078	478.136	1

LATITUDE	32°25'17.30589" N
LONGITUDE	96°42'38.95911" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 112	74°03'27"	3389.936

DESCRIPTION, PLAT:
West of Palmer. From the intersection of FM 813 and FM 878 at the "First United Methodist Church" in Palmer, go west on Farm Road 878 for 1.98 miles to Ebenezer Road and the station, located in the southwest corner of the "T" intersection.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

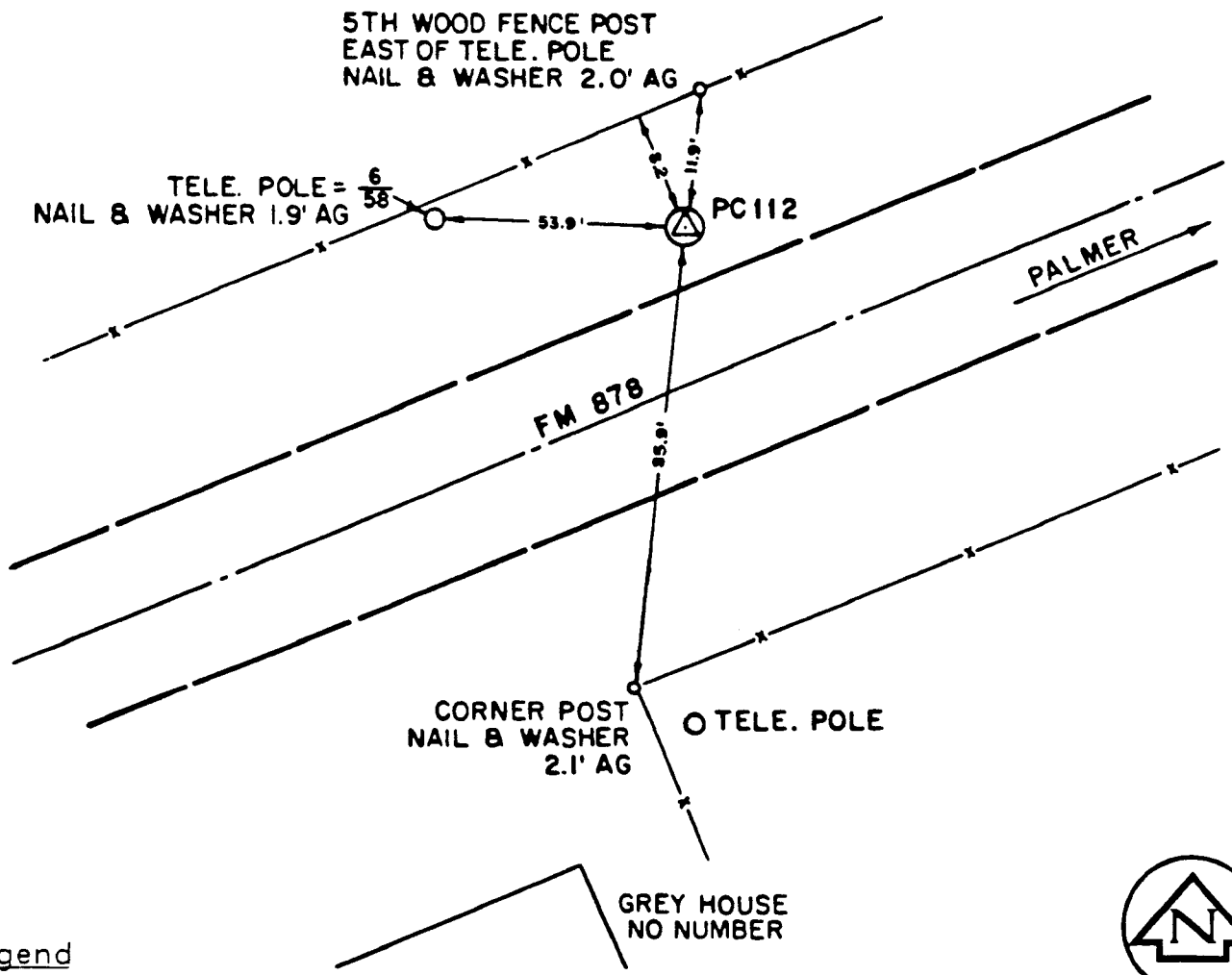
STATION		Point Grid Factor	SHEET
PC 112		0.99991342	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6841909.689	2523817.629	479.683	1

LATITUDE	32°25'25.96758" N
LONGITUDE	96°42'00.75019" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order: FIRST Type: GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 111	254°03'27"	3389.936

DESCRIPTION, PLAT:

West of Palmer. From the intersection of FM 813 and FM 878 at the "First United Methodist Church" in Palmer, go west on Farm Road 878 for 1.34 miles to a gray house on the left and the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

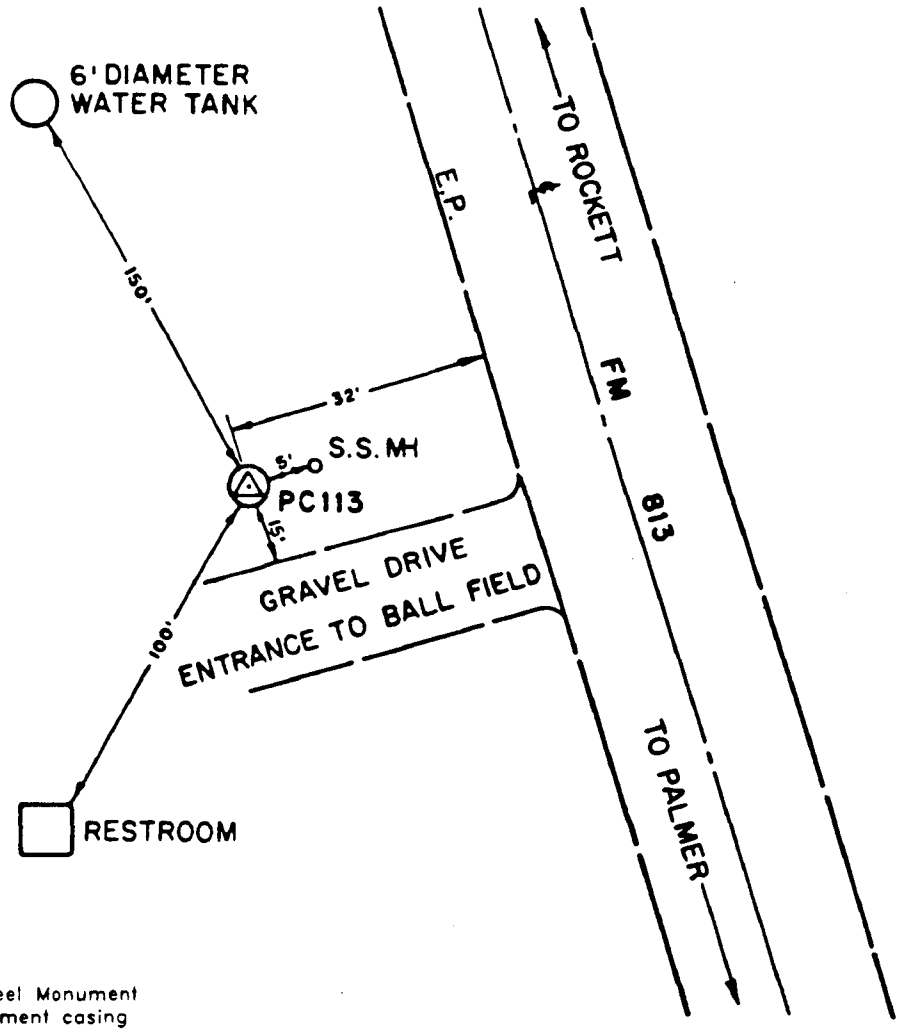
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 113		0.99991177	1
N (ft) 6845283.018	E (ft) 2528539.833	Elev (ft) 478.294	OF 1

LATITUDE	32°25'58.53953" N
LONGITUDE	96°41'04.98407" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 202	310°30'45"	6212.395

DESCRIPTION, PLAT:
Northwest of Palmer. From the intersection of FM 878 and FM 813, go northwesterly on FM 813 for 0.47 miles to the top of a hill at the Palmer Middle School baseball field and the City of Palmer Water Well No. 2. The station is 32-feet west of the west EP of FM 813, 5-feet west of a sanitary sewer manhole, 15-feet north of a gravel drive, 100-feet northeast of a rest room building and 150-feet southeast of a 6-foot diameter water tank.



Legend
Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

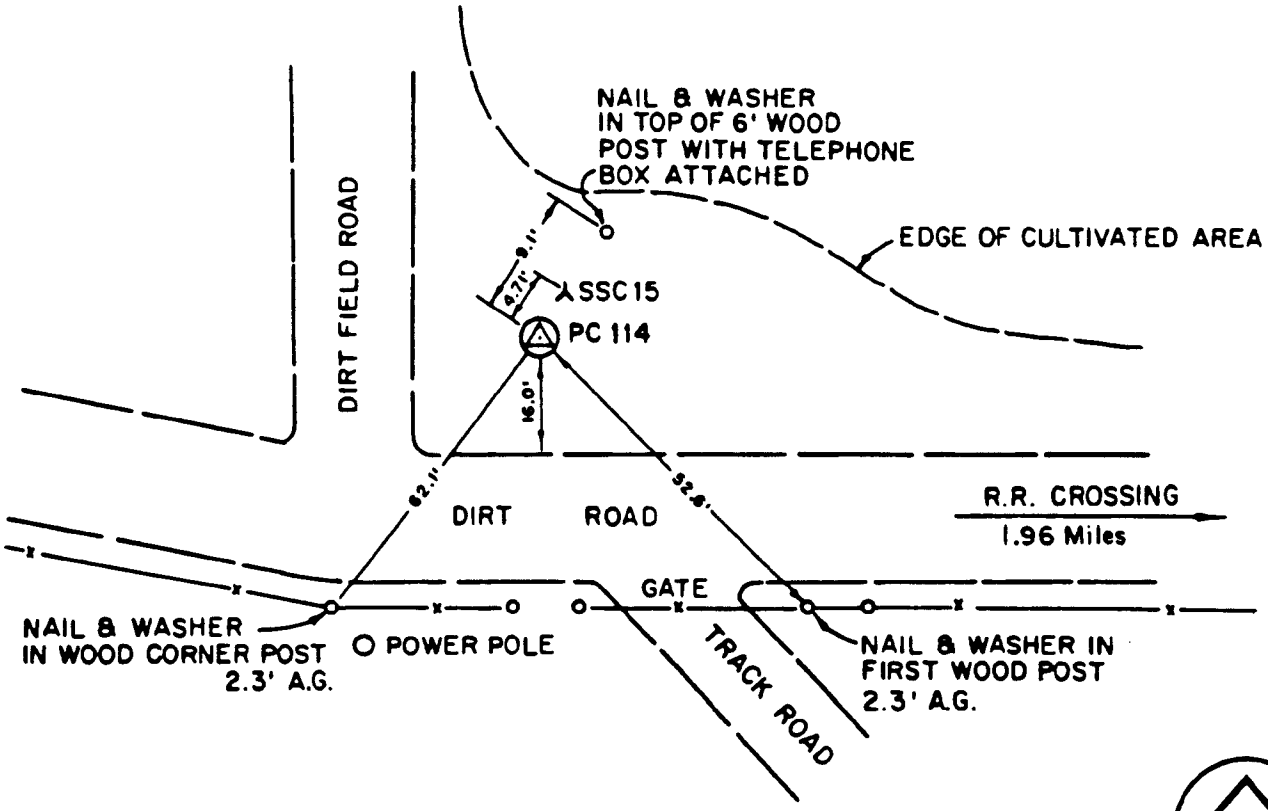
STATION		Point Grid Factor	SHEET
PC 114		0.99991874	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6832963.432	2526625.107	468.235	1

LATITUDE	32°23'56.97571" N
LONGITUDE	96°41'29.79663" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 115	88°56'42"	2409.742

DESCRIPTION, PLAT:

Southwest of Palmer. From the Post Office in Palmer at exit number 259 on Highway I 45, go west on FM 813 for 0.33 miles to Stacks Road. Turn left on Stacks Road and go south on the east side of the railroad tracks for 0.81 miles to the end of the paved road. Continue ahead on the east side of the railroad tracks on a dirt road for 0.98 miles to a railroad crossing on the right. Turn right across the railroad tracks and continue following the dirt road for 1.59 miles to a "T" intersection at the fourth 90-degree bend. Turn right and continue west from this point on the dirt road for 0.46 miles to a gate on the left and the station on the right at the junction with a field road to the north.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

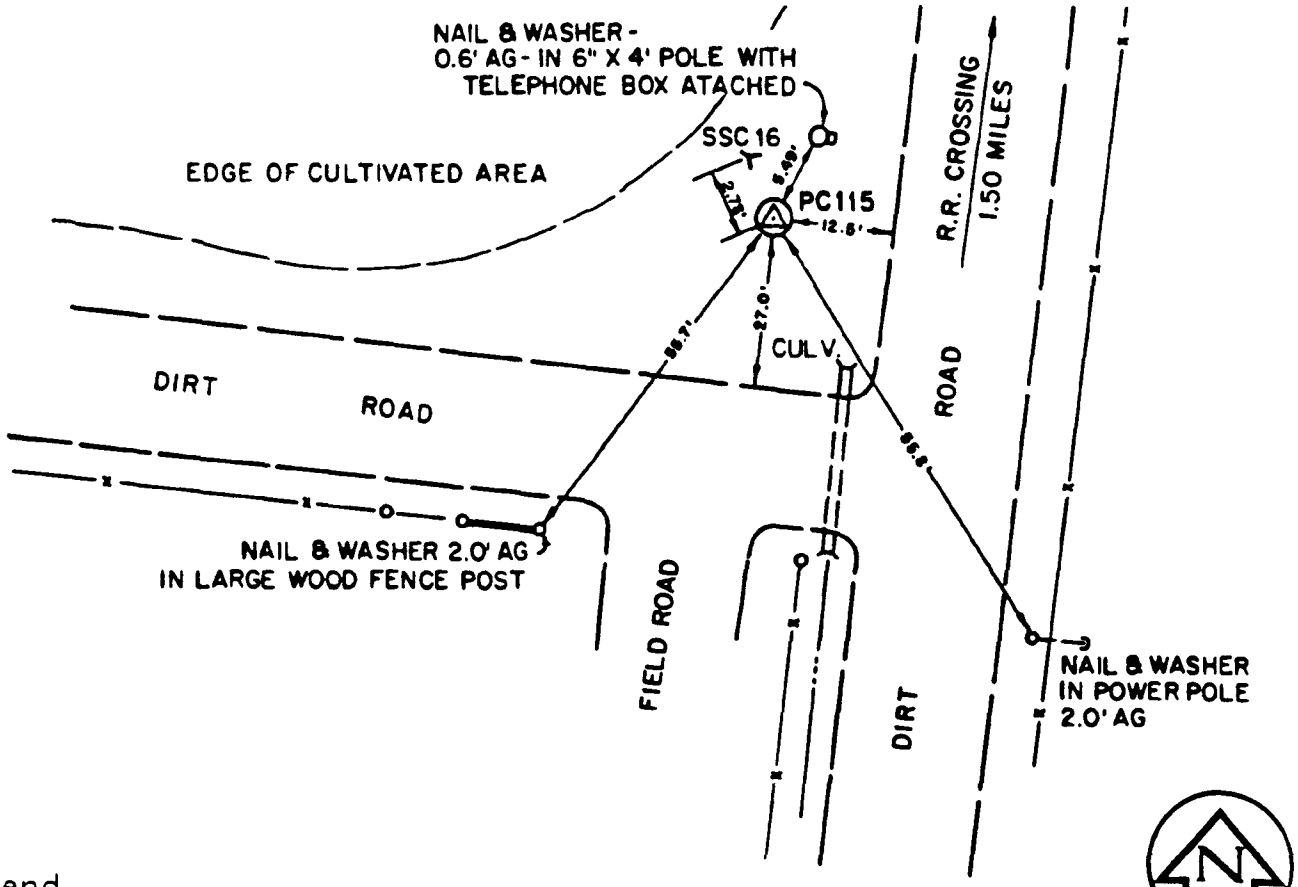
STATION		Point Grid Factor	SHEET
PC 115		0.99991899	1
N (ft) 6833007.798	E (ft) 2529034.441	Elev (ft)	OF 1

LATITUDE	32°23'57.00340" N
LONGITUDE	96°41'01.68980" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 114	268°56'42"	2409.742

DESCRIPTION, PLAT:

Southwest of Palmer. From the Post Office in Palmer at exit number 259 on Highway I 45, go west on FM 813 (Jefferson Street) for 0.33 miles to Stacks Road 60-feet east of the Southern Pacific Railroad crossing. Turn left and go south on Stacks Road paralleling and east of the railroad for 0.81 miles to the end of the paved road. Continue ahead on a dirt road to the east side of the railroad for 0.98 miles to a railroad crossing on the right. Turn right and go west following the main dirt road for 1.59 miles to a "T" intersection at the fourth 90-degree bend and the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

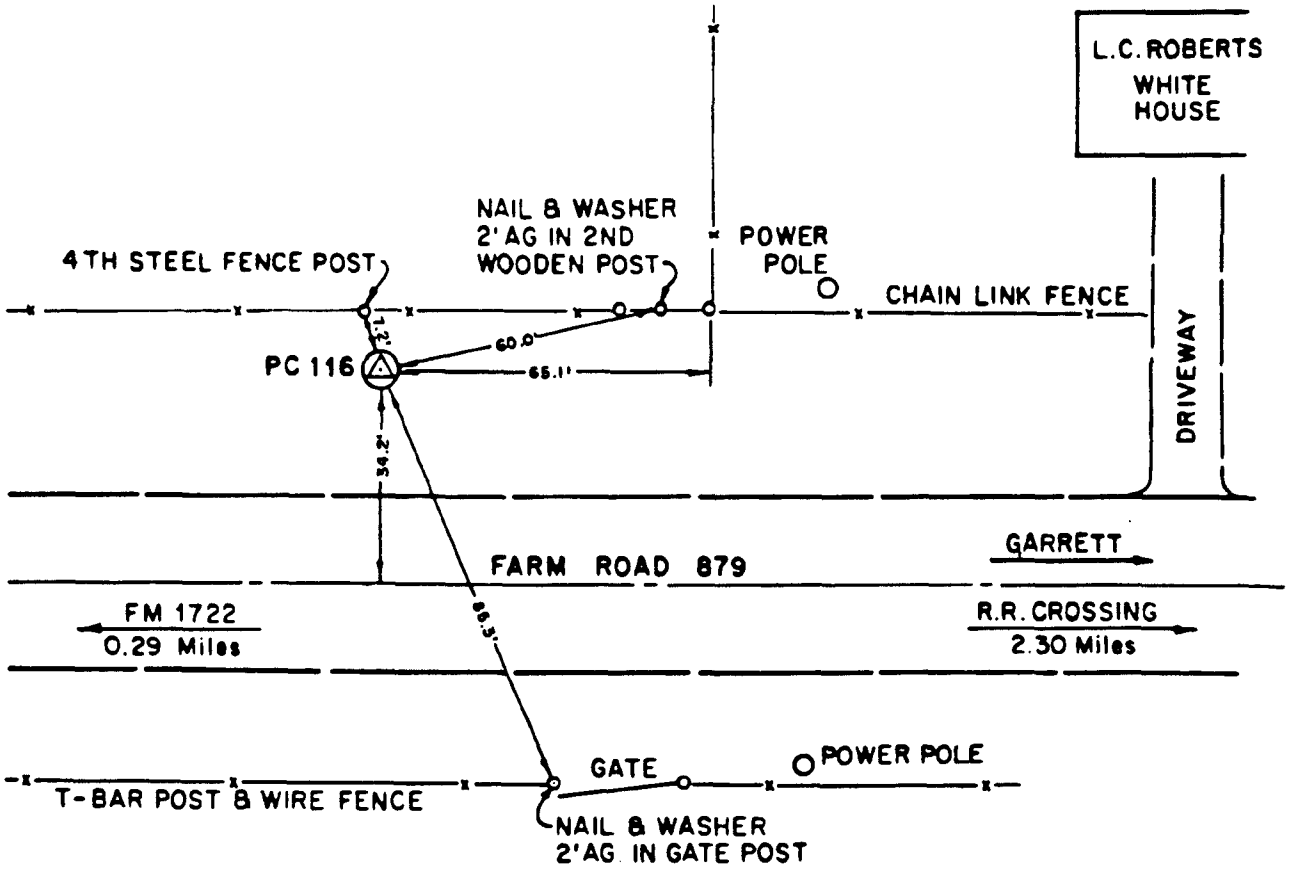
STATION		Point Grid Factor	SHEET
PC 116		0.99992185	1
N (ft) 6824596.303	E (ft) 2528232.906	Elev (ft) 499.912	OF 1

LATITUDE	32°22'33.91679" N
LONGITUDE	96°41'12.73059" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 117	90°45'14"	2573.992

DESCRIPTION, PLAT:

East of Boyce. From the intersection of FM 1722 and FM 879, approximately 3 miles east of Boyce, go east on Farm Road 879 for 0.32 miles to the station on the left. From the railroad crossing FM 879 in Garrett at Gibson and Garrett Avenue, go west on FM 879 for 2.36 miles to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

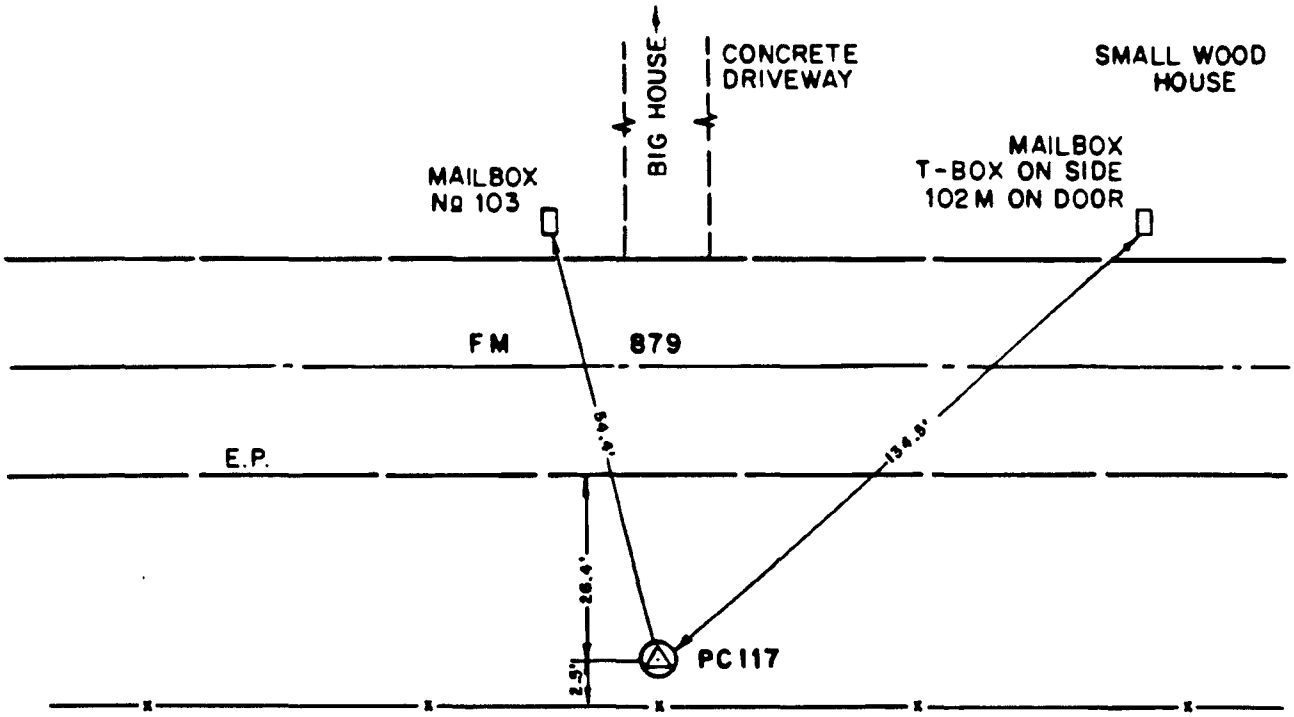
STATION		Point Grid Factor	SHEET
PC 117		0.99992292	1
N (ft) 6824562.441	E (ft) 2530806.675	Elev (ft)	OF 1

LATITUDE	32°22'33.14120" N
LONGITUDE	96°40'42.72968" W
INDEX SHEET (Quadrangle Sheet)	Palmer
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 28	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 116	270°45'14"	2573.992

DESCRIPTION, PLAT:

East of Boyce. From the intersection of FM 1722 and FM 879, approximately 3 miles east of Boyce, go east on Farm Road 879 for 0.77 miles to the station on the right. From the railroad crossing FM 879 in Garrett at Gibson and Garrett Avenue, go west on FM 879 for 1.91 miles to the station on the left. The station is on the extension of a concrete driveway across the road, to the north, near mailbox no. 103.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

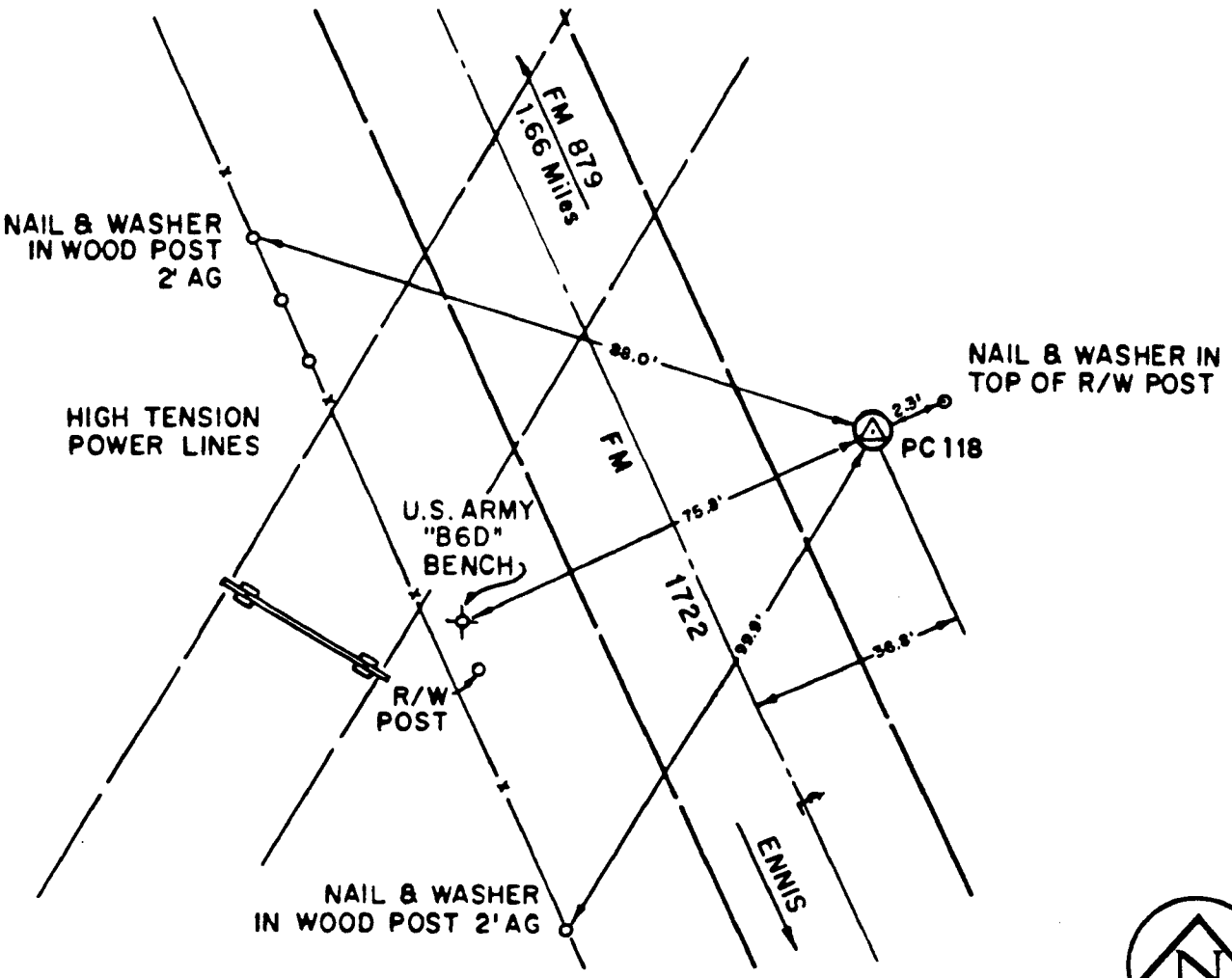
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 118		0.99992698	1
N (ft) 6817136.090	E (ft) 2530375.114	Elev (ft) 481.730	OF 1

LATITUDE	32°21'19.73879" N
LONGITUDE	96°40'49.26116" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 119	143°26'13"	2273.723

DESCRIPTION, PLAT:
Northwest of Ennis. From the intersection of FM 879 and FM 1722, approximately 3 miles east of Boyce, go south on FM 1722 for 1.66 miles to a high tension power line crossing and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

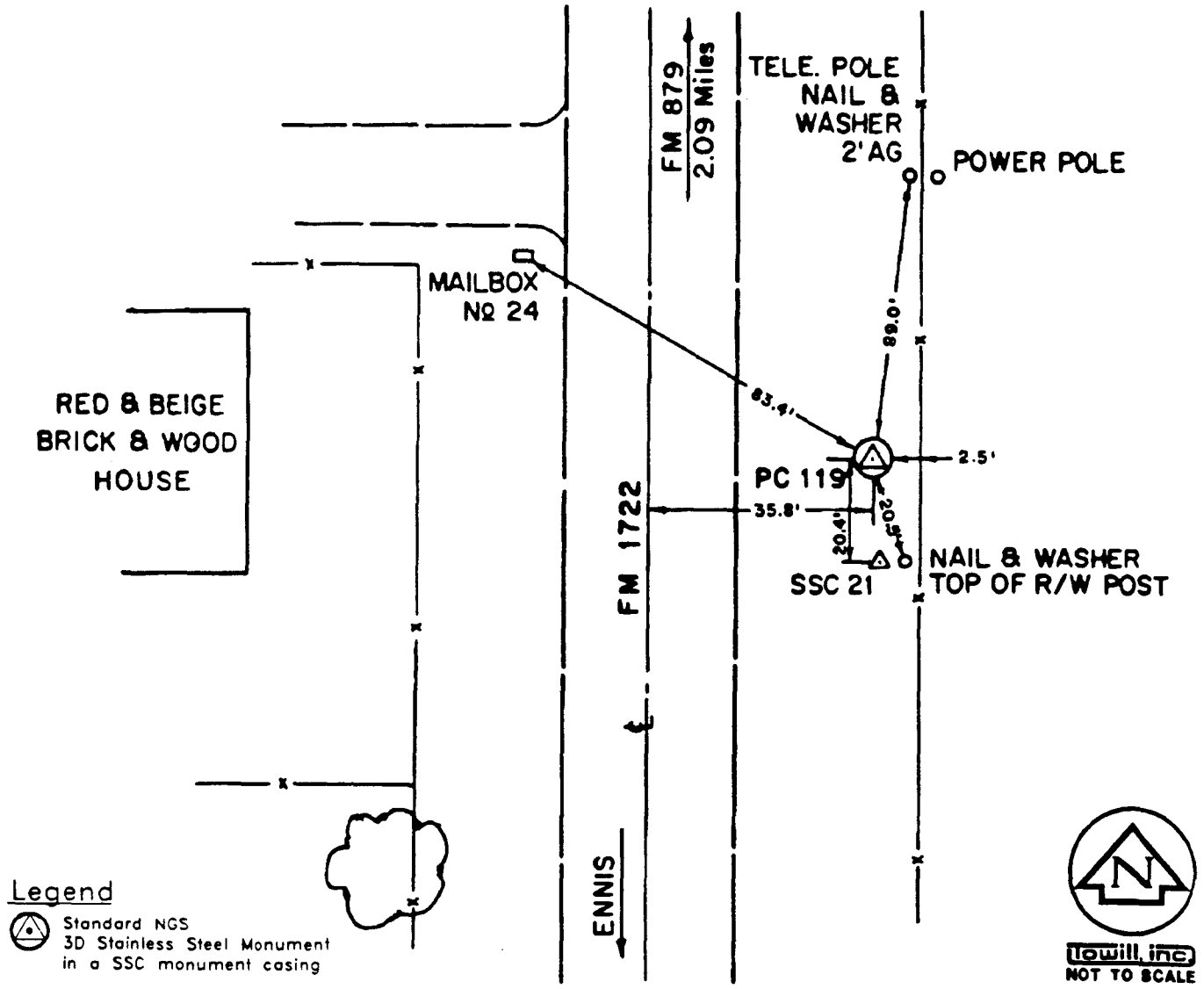
STATION		Point Grid Factor	SHEET
PC 119		0.99992769	1
N (ft) 6815309.829	E (ft) 2531729.583	Elev (ft) 489.191	OF 1

LATITUDE	32°21'01.43733" N
LONGITUDE	96°40'33.84260" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 118	323°26'13"	2273.723

DESCRIPTION, PLAT.

Northwest of Ennis. From the intersection of FM 879 and FM 1722, approximately 3 miles east of Boyce, go south on FM 1722 for 2.09 miles to a red and beige, brick and wood house on the right and the station on the left.



SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

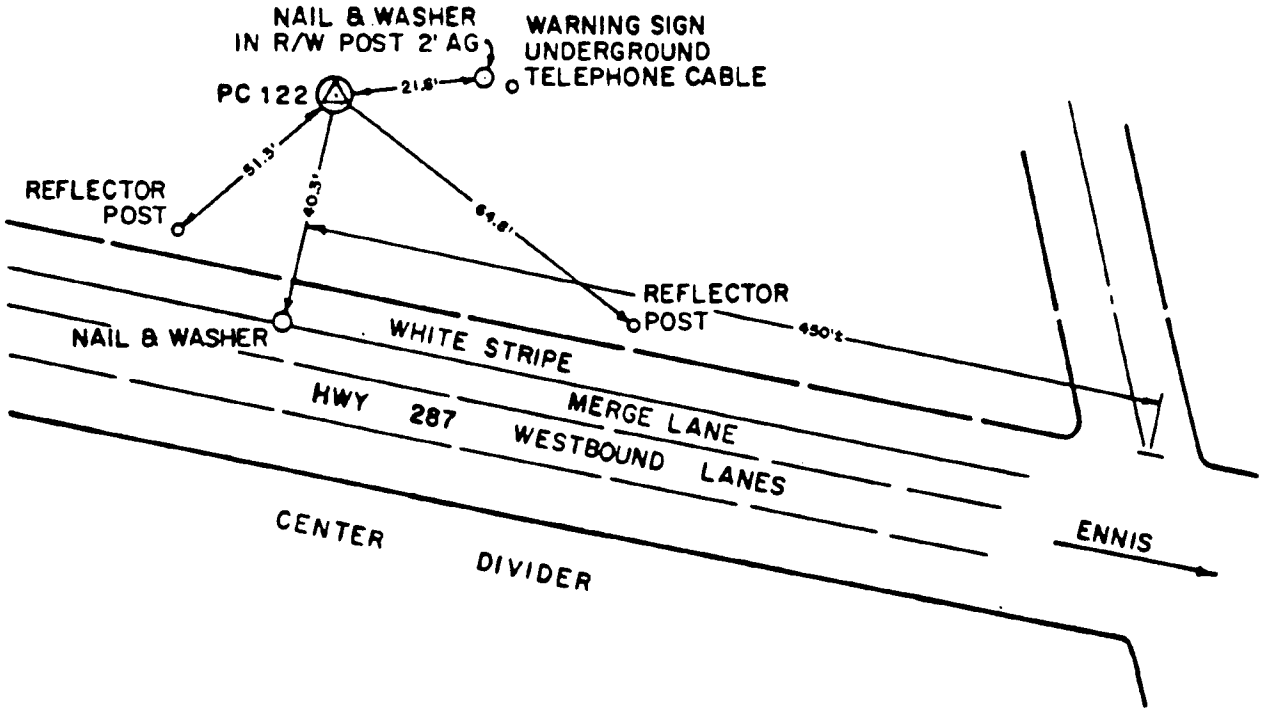
STATION		Point Grid Factor	SHEET
PC 122		0.99993285	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6806045.421	2525185.436	494.753	1

LATITUDE	32°19'30.89274" N
LONGITUDE	96°41'51.97219" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 123	95°19'23"	6010.439

DESCRIPTION, PLAT:

West of Ennis. From the intersection of Highway 287 and Business 45 at Kaufmann and East Ennis Street in Ennis, go west on Highway 287 for 1.98 miles to the start of a divided roadway. Continue west on Highway 287 for 2.44 miles to a road crossing Highway 287. Continue west on Highway 287 450-feet to a right-of-way post and the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

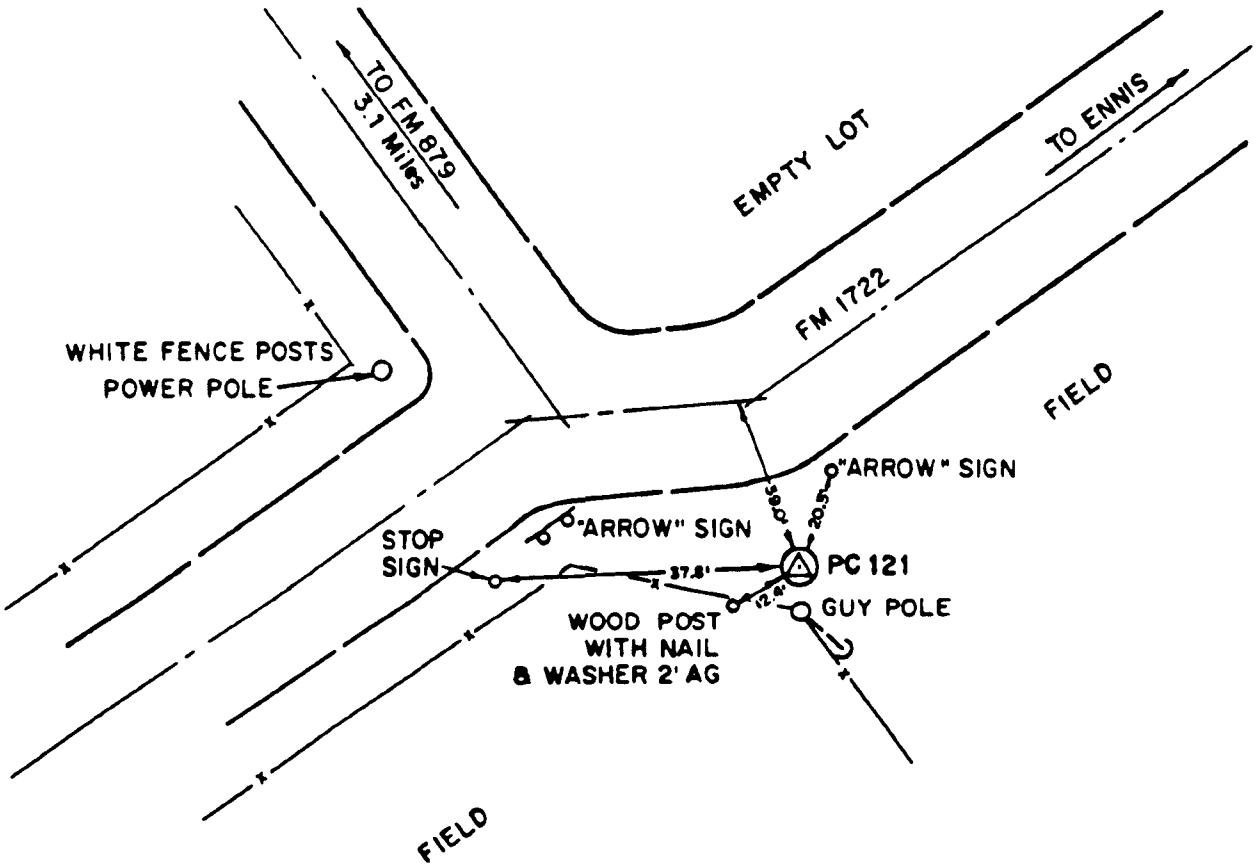
STATION		Point Grid Factor	SHEET
PC 121		0.99993009	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6810234.508	2534615.606	501.933	1

LATITUDE	32°20'10.72512" N
LONGITUDE	96°40'01.23629" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order: FIRST Type: GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 120	331°16'32"	2691.888

DESCRIPTION, PLAT.

West of Ennis. From the intersection of FM 879 and FM 1722, approximately 3 miles east of Boyce, go south on FM 1722 for 3.21 miles to a curve to the east and Rider Road to the west and the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

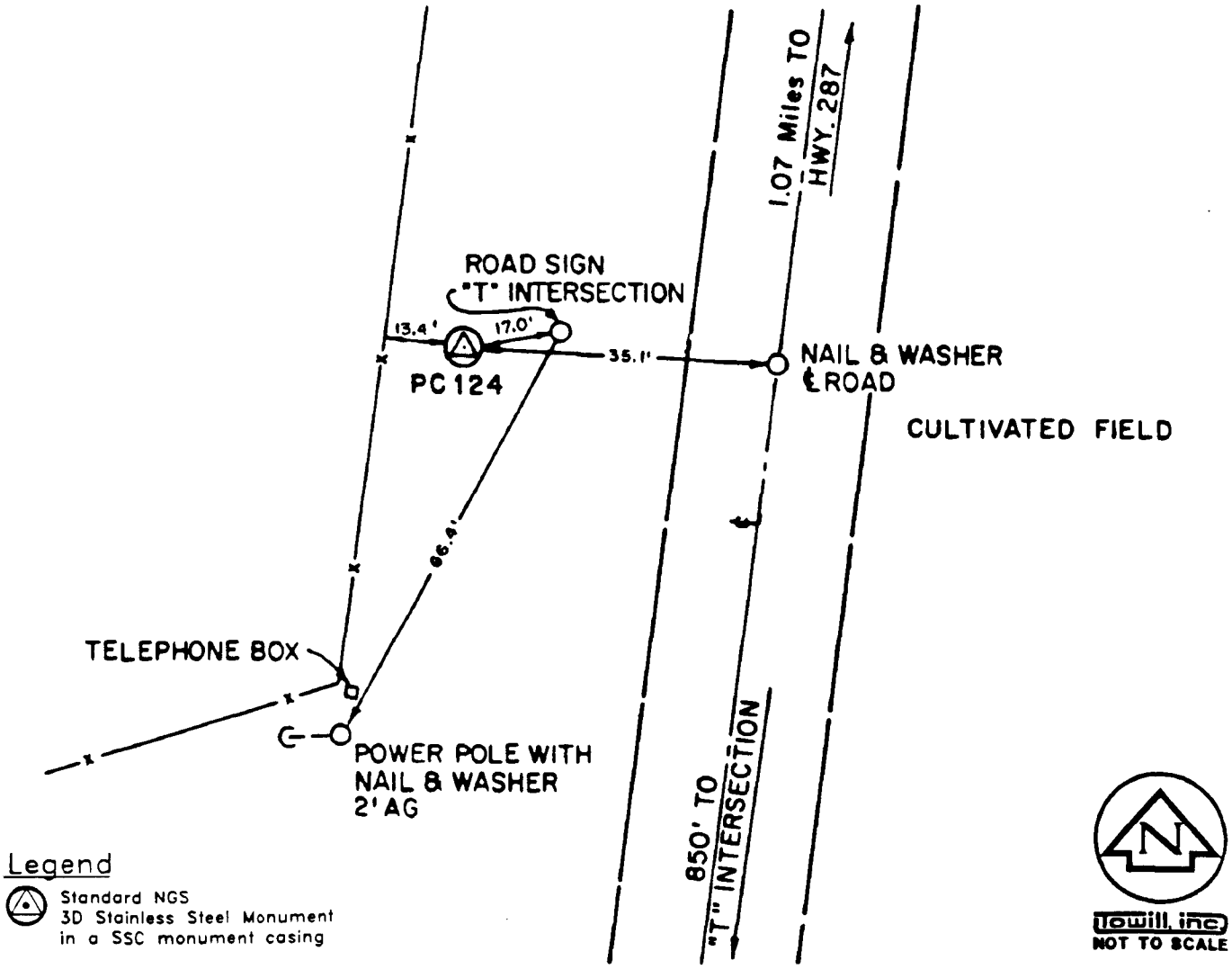
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 124		0.99993736	1
N (ft) 6800477.583	E (ft) 2527163.946	Elev (ft) 471.871	OF 1

LATITUDE	32°18'35.46806" N
LONGITUDE	96°41'30.03459" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 125	121°47'17"	1877.132

DESCRIPTION, PLAT:
West of Ennis. From the paved cross road 900-feet west of the 60-foot high "Winston Drag Racing" sign at the Texas Motorplex on Highway 287 5 miles west of downtown Ennis, take Highway 287 east for 1.44 miles to Cooke Road. Turn right and go south 1.09 miles to the station on the right.



SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

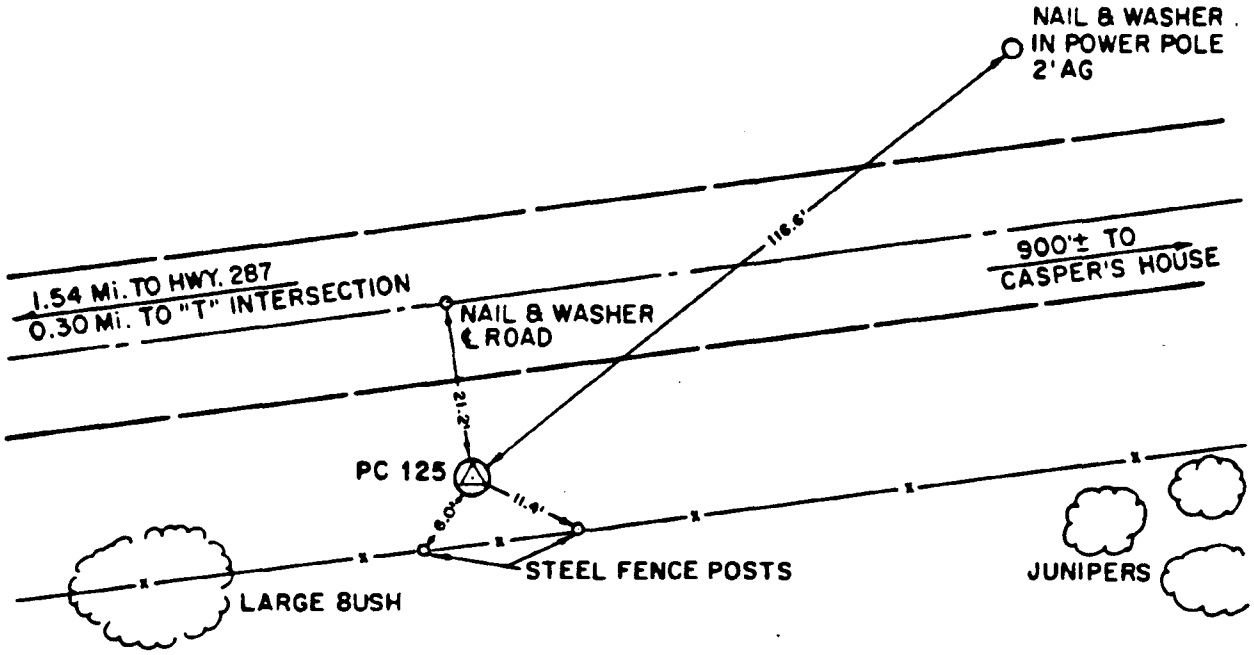
STATION		Point Grid Factor	SHEET
PC 125		0.99993784	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6799488.752	2528759.514	474.756	1

LATITUDE	32°18'25.41242" N
LONGITUDE	96°41'11.64443" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 124	301°47'17"	1877.132

DESCRIPTION, PLAT:

West of Ennis. From the paved cross road 900-feet west of the 60-foot high "Winston Drag Racing" sign at the Texas Motorplex, located on Highway 287 5 miles west of Ennis, go east on Highway 287 for 1.44 miles to Cooke Road. Turn right and go south for 1.26 miles to a "T" intersection with Old Waxahachie Road, turn left and go east for 0.30-miles to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc
NOT TO SCALE

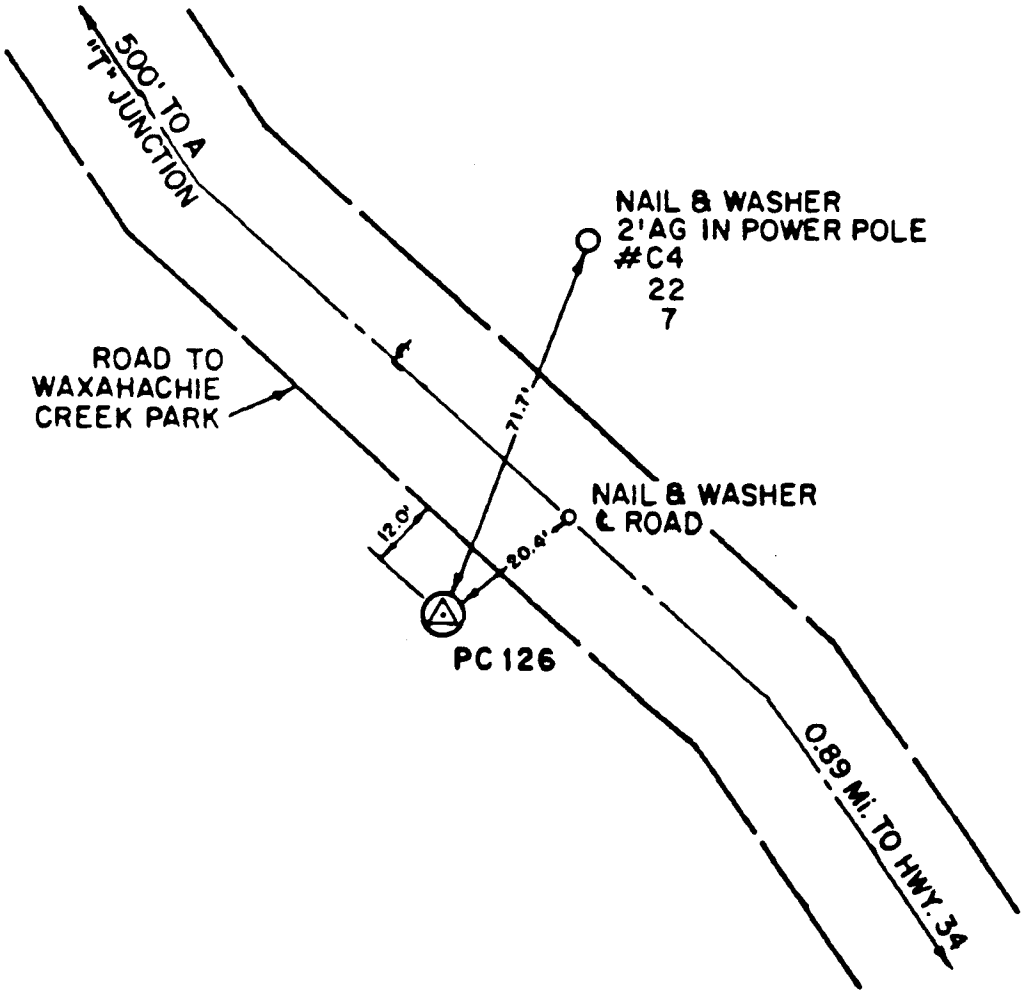
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 126		0.99994351	1
N (ft) 6791302.244	E (ft) 2529322.022	Elev (ft) 463.690	OF 1

LATITUDE	32°17'04.31913" N
LONGITUDE	96°41'06.73890" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 28	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 127	147°43'08"	2264.435

DESCRIPTION, PLAT:
Southwest of Ennis. From the junction of Highway 34 and FM 985 approximately 0.5 miles east-northeast of Bardwell, go east-northeast on Highway 34 for 0.61 miles to a paved road on the left leading to the Waxahachie Creek Park. Turn left and go 0.93 miles to a power pole on the right and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

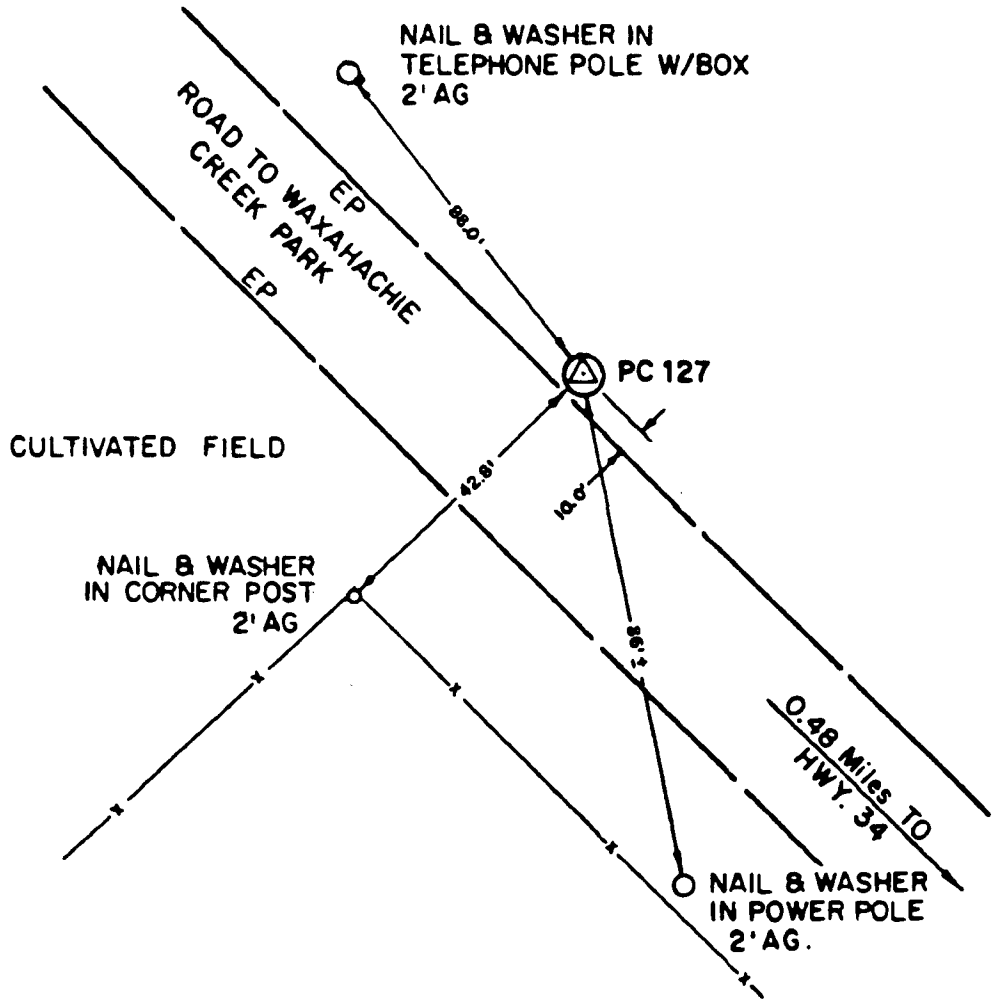
STATION		Point Grid Factor	SHEET
PC 127		0.99994493	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6789387.805	2530531.398	459.776	1

LATITUDE	32°16'45.17079" N
LONGITUDE	96°40'53.03920" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 28	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 127	327°43'08"	2264.435

DESCRIPTION, PLAT:

Southwest of Ennis. From the junction of Highway 34 and FM 985 located approximately 0.5 miles east-northeast of Bardwell, go east-northeast on Highway 34 for 0.61-miles to a paved road on the left leading to the Waxahachie Creek Park. Turn left and go 0.46 miles to a fence corner on the left and the station on the right, on the extension of the fence line across the road.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

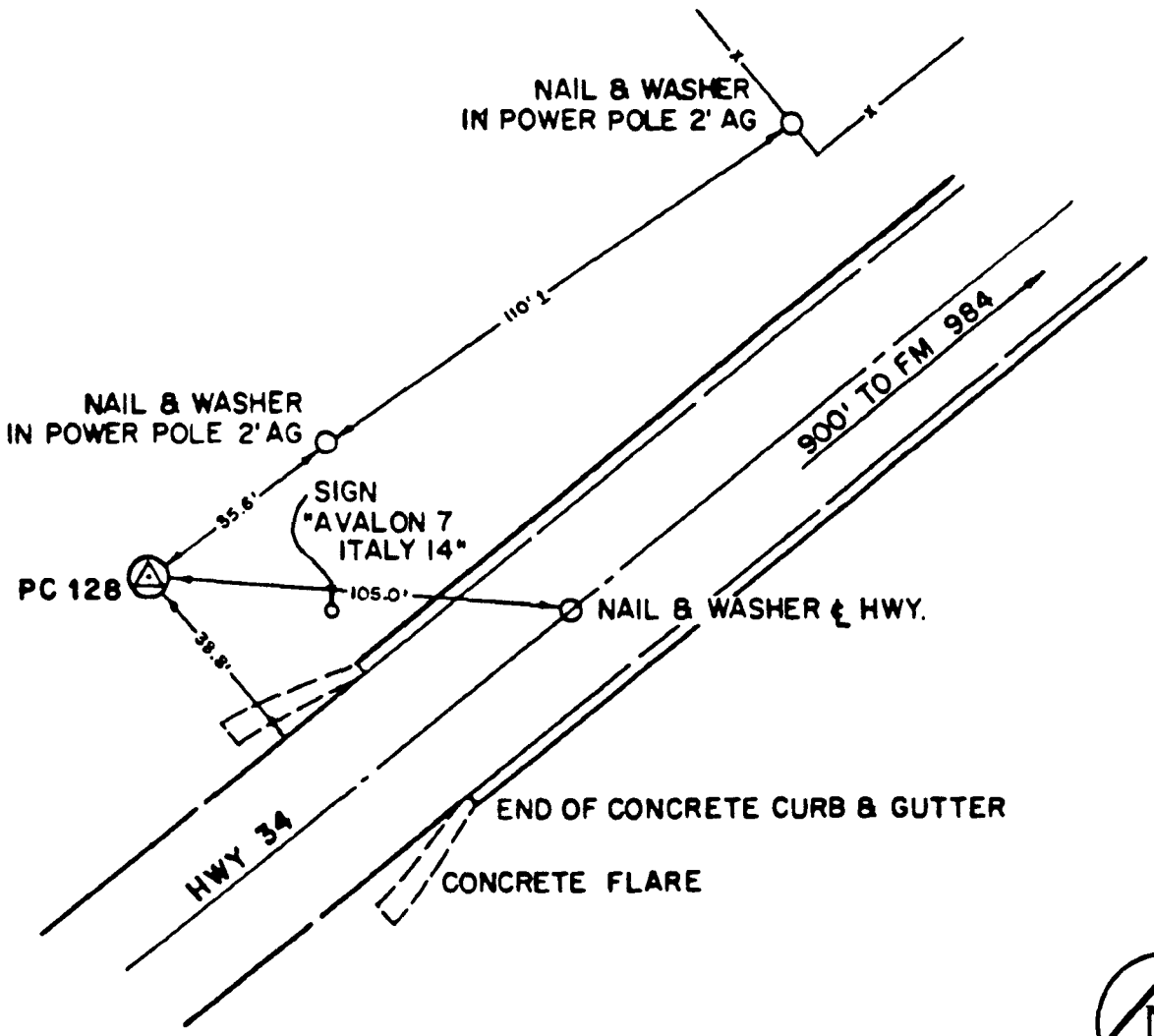
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 128		0.99994745	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6784024.939	2525283.054	478.536	1

LATITUDE	32°15'53.00547" N
LONGITUDE	96°41'55.23484" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 129	238°01'36"	7529.865

DESCRIPTION, PLAT:
In Bardwell. The station is located on the north side of Highway 34, 1100-feet west-southwest of the railroad crossing on Highway 34, in the center of Bardwell.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc
NOT TO SCALE

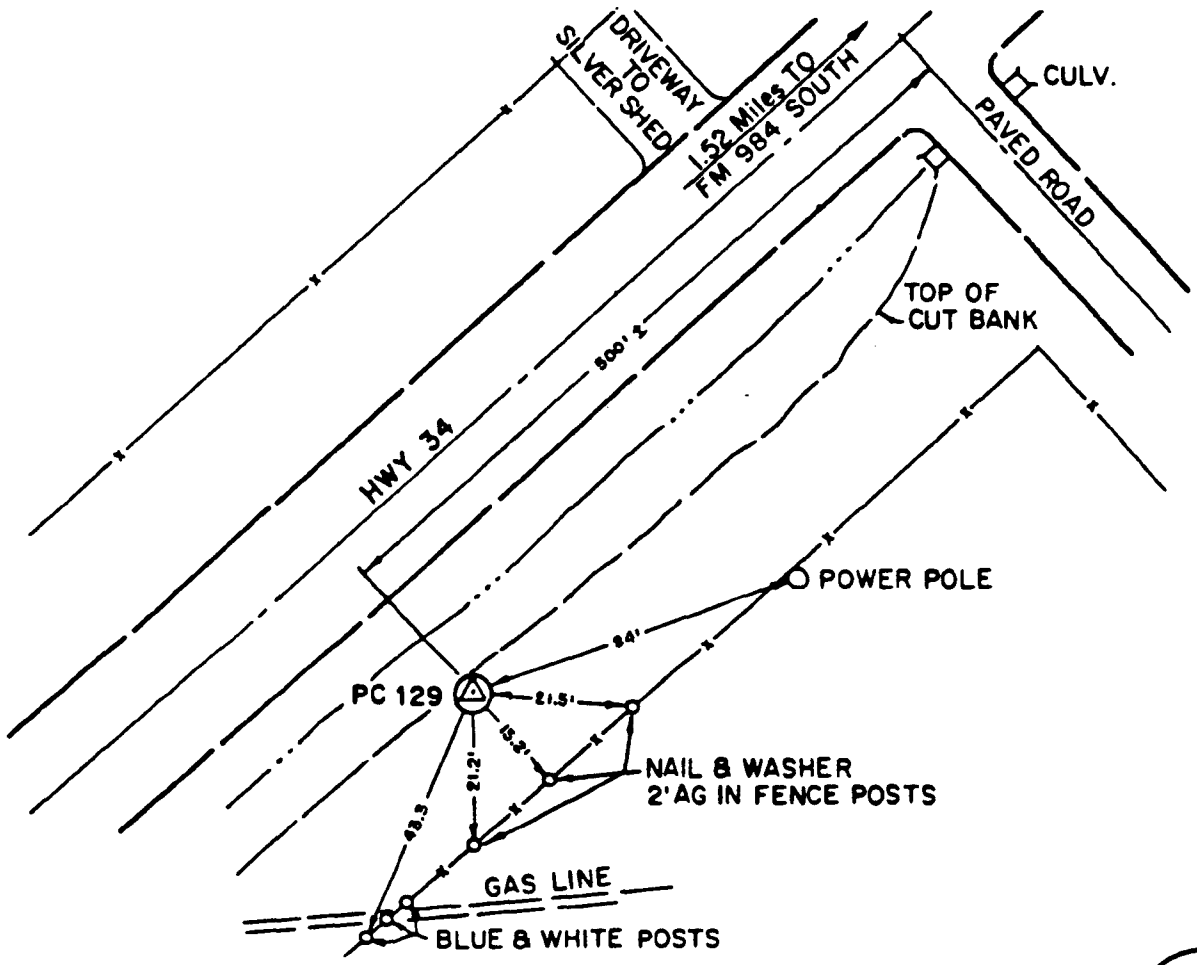
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 129		0.99994940	1
N (ft) 6780037.690	E (ft) 2518895.511	Elev (ft) 491.114	OF 1

LATITUDE	32°15'14.63311" N
LONGITUDE	96°43'10.40219" W
INDEX SHEET (Quadrangle Sheet)	Ennis West
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 128	58°01'36"	7529.865

DESCRIPTION, PLAT:
Southwest of Bardwell. From the railroad tracks crossing Highway 34 in Bardwell, go southwest on Highway 34 for 1.67 miles to the top of a hill and the station on the top of a cut bank on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

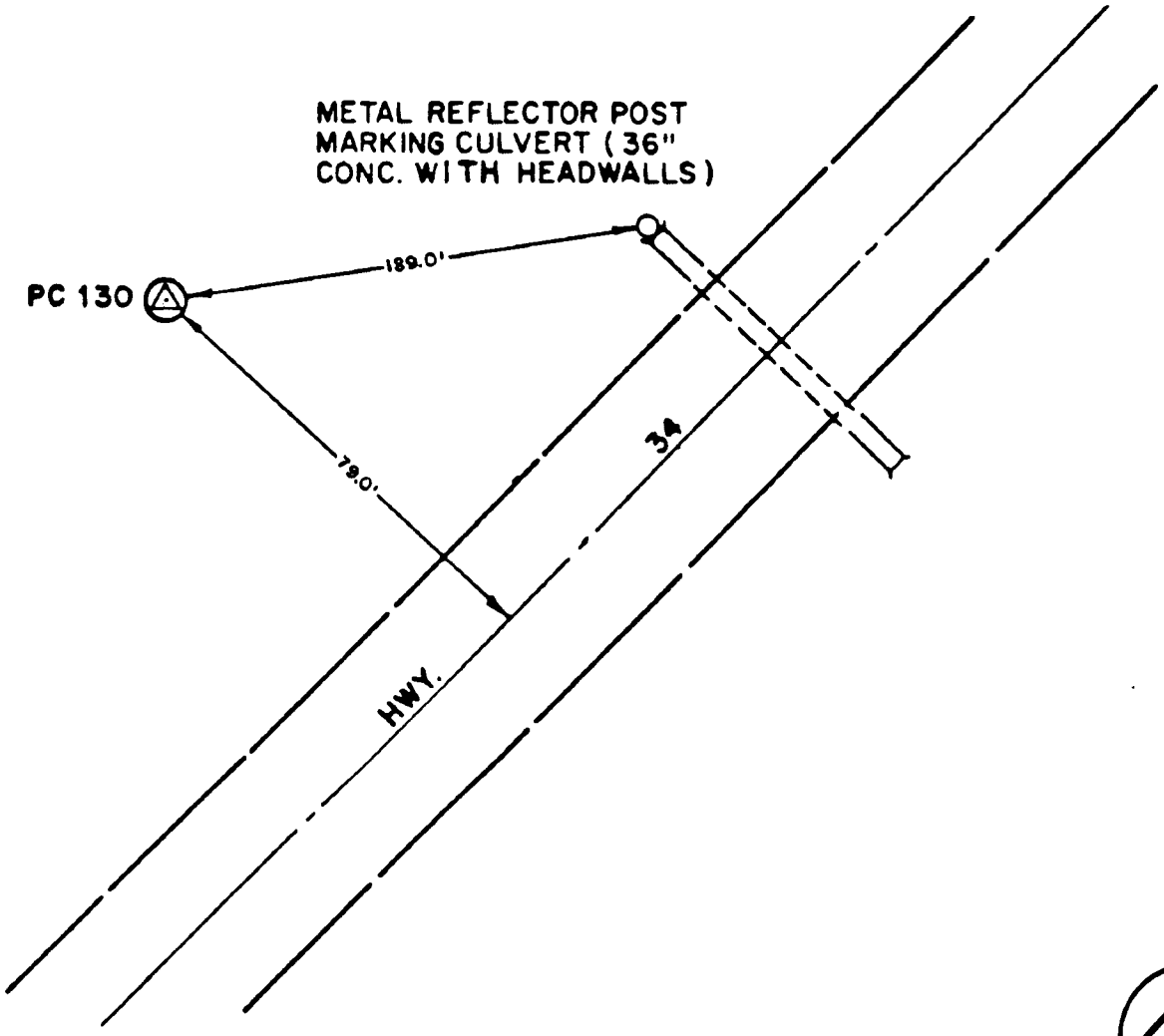
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 130		0.99995582	1
N (ft) 6772524.639	E (ft) 2511680.649	Elev (ft) 460.711	OF 1

LATITUDE	32°14'01.50072" N
LONGITUDE	96°44'35.86958" W
INDEX SHEET (Quadrangle Sheet)	Cryer Creek
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
MM 004	347°01'14"	2936.613

DESCRIPTION, PLAT:
Southwest of Bardwell. From the junction of Highway 34 and FM 877, located 3.4 miles southwest of Bardwell, go southwesterly 0.20 miles on Highway 34 to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

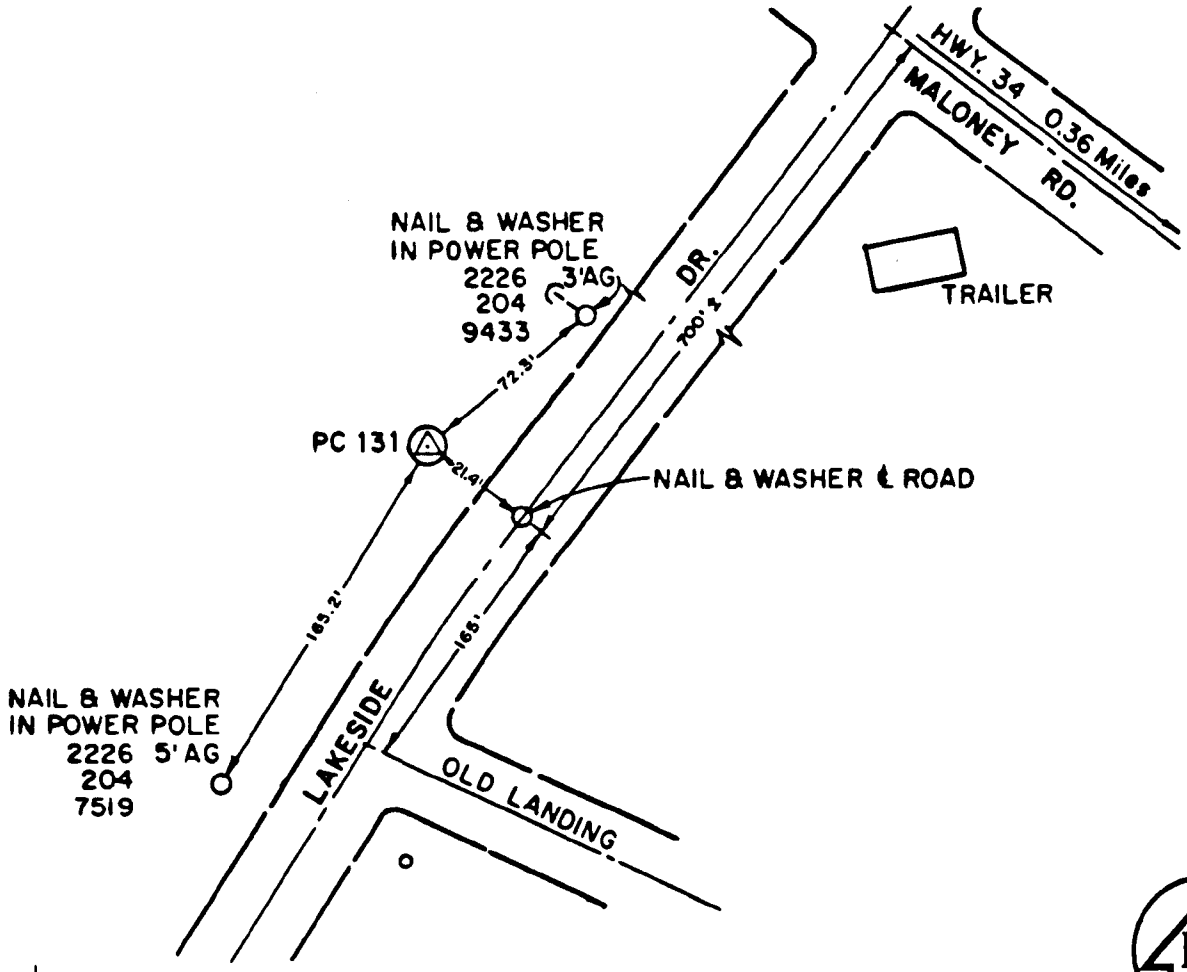
STATION		Point Grid Factor	SHEET
PC 131		0.99995646	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6769624.098	2504482.860	487.045	1

LATITUDE	32°13'33.98567" N
LONGITUDE	96°46'00.21363" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 132	336°22'17"	5371.094

DESCRIPTION, PLAT:

Northeast of Avalon. From the junction of Highway 34 and FM 55 south in Avalon, go east on Highway 34 for 2.18 miles to Feaster Road, a dirt road on the left. Turn left and go northwest for 0.36 miles to Lakeside Drive, a dirt road on the left. Turn left and go 0.12 miles to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

N

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

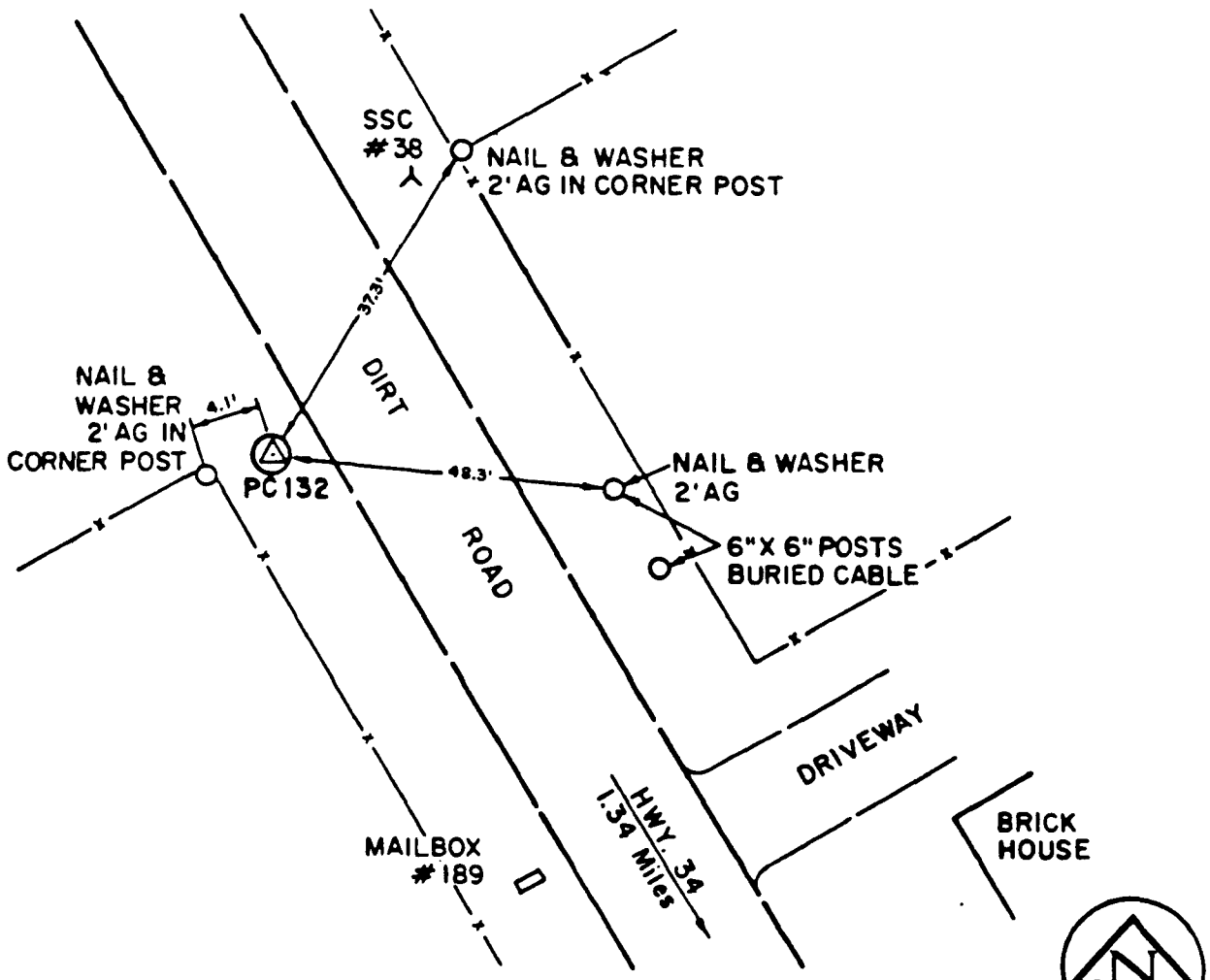
STATION		Point Grid Factor	SHEET
PC 132		0.99995374	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6774544.896	2502330.096	473.597	1

LATITUDE	32°14'23.02315" N
LONGITUDE	96°46'24.32965" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 131	156°22'17"	5371.094
PC 133	275°10'37"	5824.706

DESCRIPTION, PLAT:

Northeast of Avalon. From the junction of Highway 34 and FM 55 south in Avalon, go east on Highway 34 for 2.18 miles to Feaster Road, a dirt road on the left. Turn left and go northwest for 1.38 miles to a fence corner and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

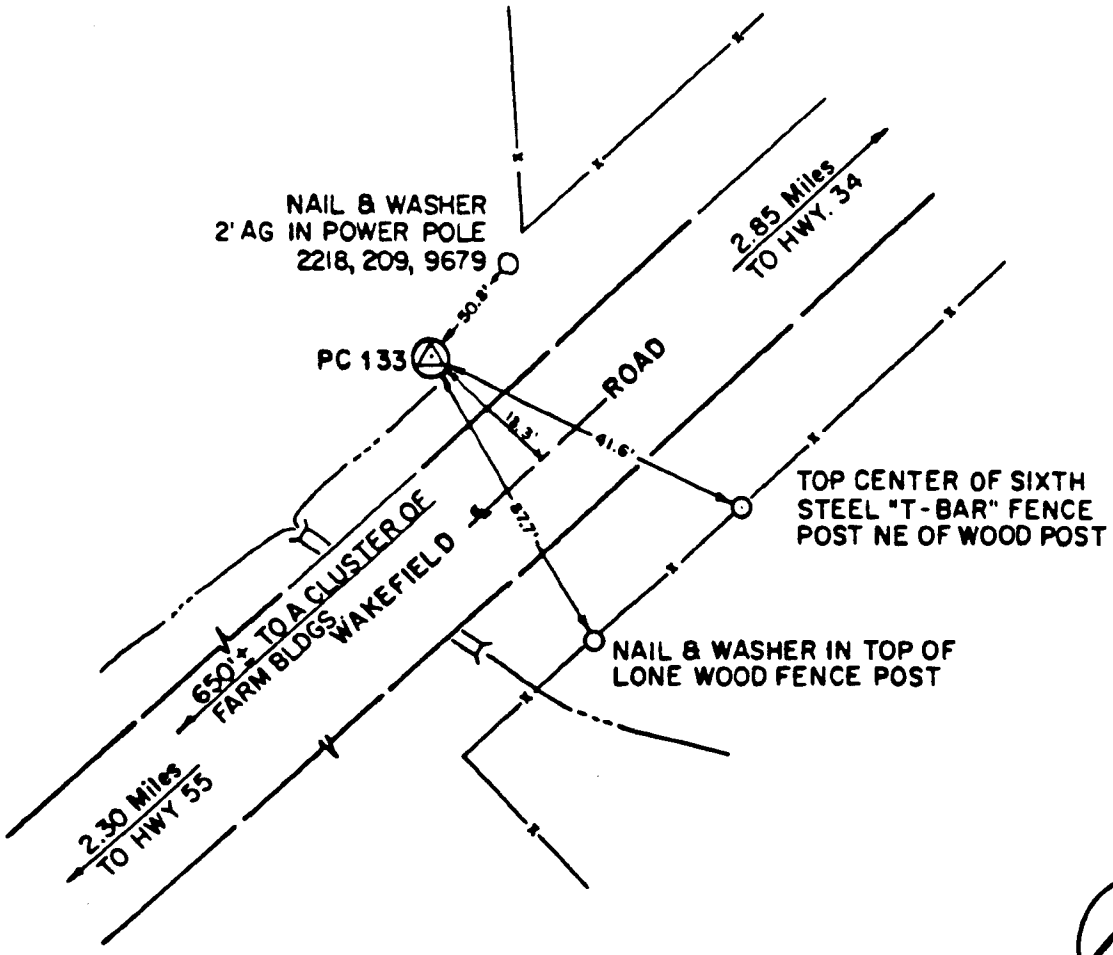
STATION		Point Grid Factor	SHEET
PC 133		0.99995308	1
N (ft) 6775070.483	E (ft) 2496529.151	Elev (ft) 478.927	OF 1

LATITUDE	32°14'29.16162" N
LONGITUDE	96°47'31.76173" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 28	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 132	95°10'37"	5824.706
PC 135	225°16'11"	7586.593
PC 134	207°30'18"	8637.709

DESCRIPTION, PLAT:

North of Avalon. From the junction of Highway 34 and FM 55 south in Avalon, go east on Highway 34 for 2.18 miles to Feaster Road, a dirt road on the left. Turn left and go northwest for 2.00 miles to a blue grey house and Wakeland Road, a dirt road on the left. Turn left and go southwest for 0.92 miles to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

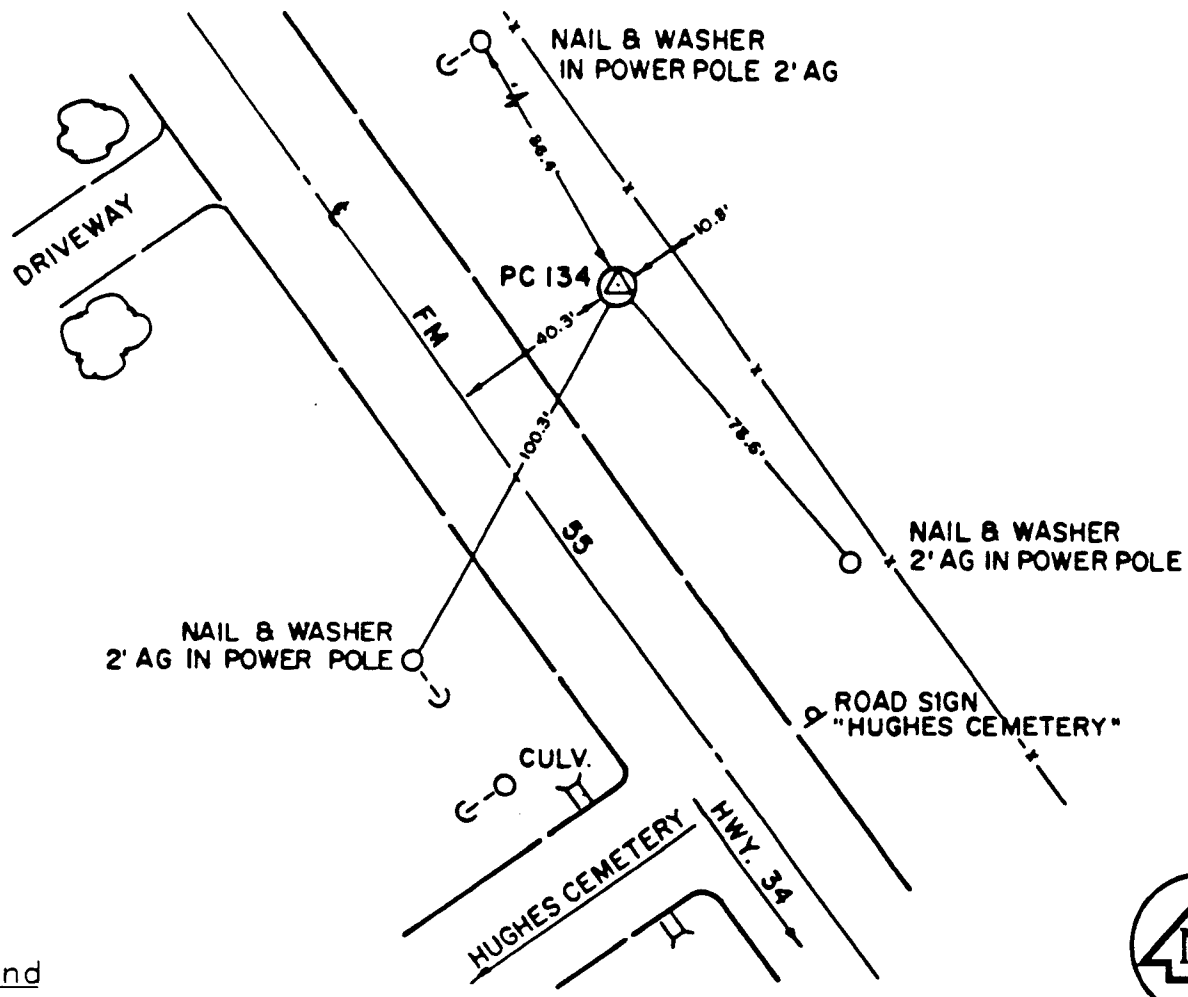
STATION		Point Grid Factor	SHEET
PC 134		0.99995497	1
N (ft) 6767409.084	E (ft) 2492540.044	Elev (ft)	OF 1

LATITUDE	32°13'13.99809" N
LONGITUDE	96°48'19.64060" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 135	328°54'14"	2711.869
PC 133	27°30'18"	8637.709

DESCRIPTION, PLAT.

Northwest of Avalon. From the junction of Highway 34 and FM 55 in Avalon, go north-northwest on FM 55 for 1.39 miles to a paved road on the left leading to the "Hughes Cemetery" and the station on the right; 80-feet north-northwest of the road intersection and 40-feet right of FM 55 centerline.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

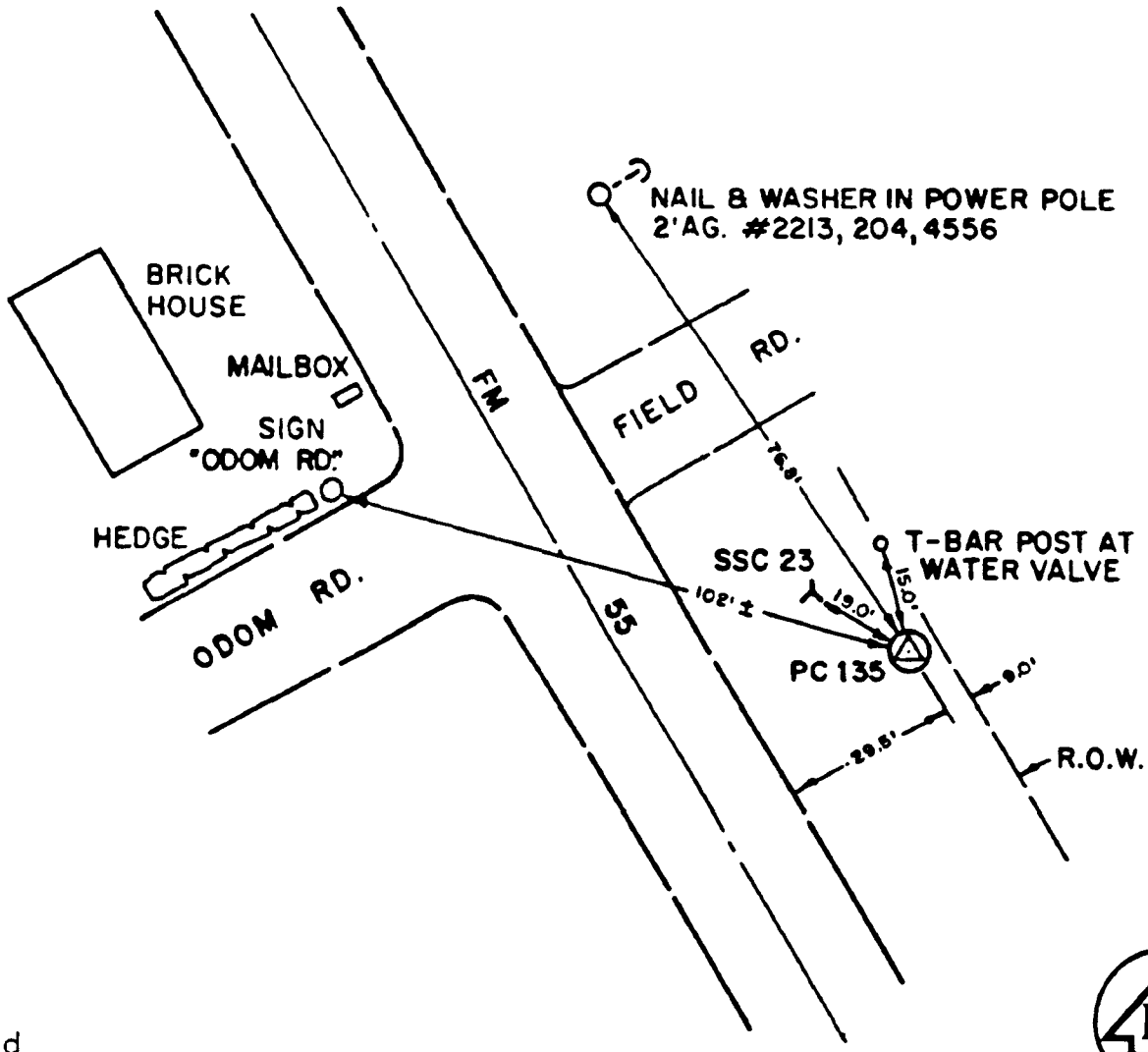
STATION		Point Grid Factor	SHEET
PC 135		0.99995513	1
N (ft) 6769731.262	E (ft) 2491139.428	Elev (ft) 510.725	OF 1

LATITUDE	32°13'37.19725" N
LONGITUDE	96°48'35.50751" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 133	45°16'11"	7586.593
PC 134	148°54'14"	2711.869

DESCRIPTION, PLAT.

Northwest of Avalon. From the junction of Highway 34 and FM 55 in Avalon, go north-northwest on FM 55 for 1.94 miles to Odom Road on the left and the station on the right at the southeast corner of the intersection.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

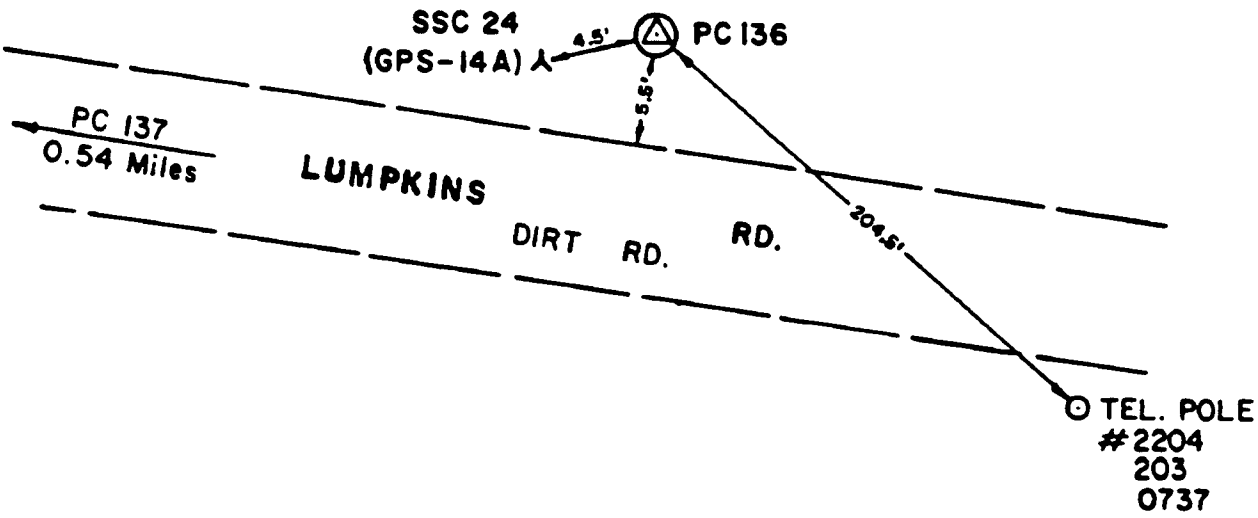
STATION		Point Grid Factor	SHEET
PC 136		0.99995590	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6768643.912	2481580.958	508.217	1

LATITUDE	32°13'27.94655" N
LONGITUDE	96°50'26.96707" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 137	285°29'40"	2571.084

DESCRIPTION, PLAT:

Southeast of Forreston. From Main Street and Highway 77 in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go south on Highway 77 for 0.79 miles to Lumpkins Road. Turn left on Lumpkins Road and go 0.20 miles to a right bend. Turn right and go 0.73 miles to a 90-degree left turn (road straight ahead to the south goes to the Forreston Cemetery). Continue easterly on Lumpkins from this point 1.97 miles to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

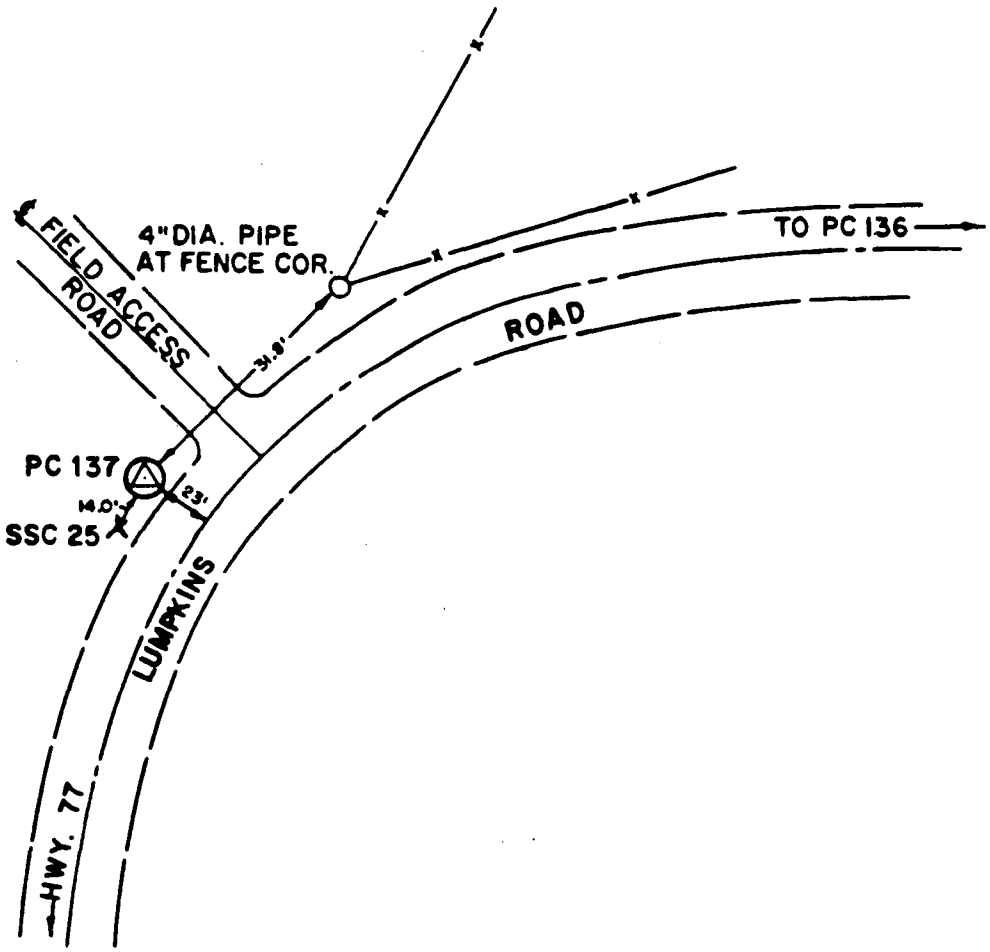
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 137		0.99995540	1
N (ft) 6769330.764	E (ft) 2479103.317	Elev (ft) 508.419	OF 1

LATITUDE	32°13'35.12866" N
LONGITUDE	96°50'55.68011" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 136	105°29'40"	2571.084

DESCRIPTION, PLAT:
Southeast of Forreston, From Main Street and Highway 77 in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go south on Highway 77 for 0.79 miles to Lumpkins Road. Turn left on Lumpkins Road and go 0.20 miles to a right bend. Turn right and go 0.73 miles to a 90-degree left turn (road straight ahead to the south goes to the Forreston Cemetery). Continue easterly on Lumpkins from this point 1.43 miles to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Topwill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

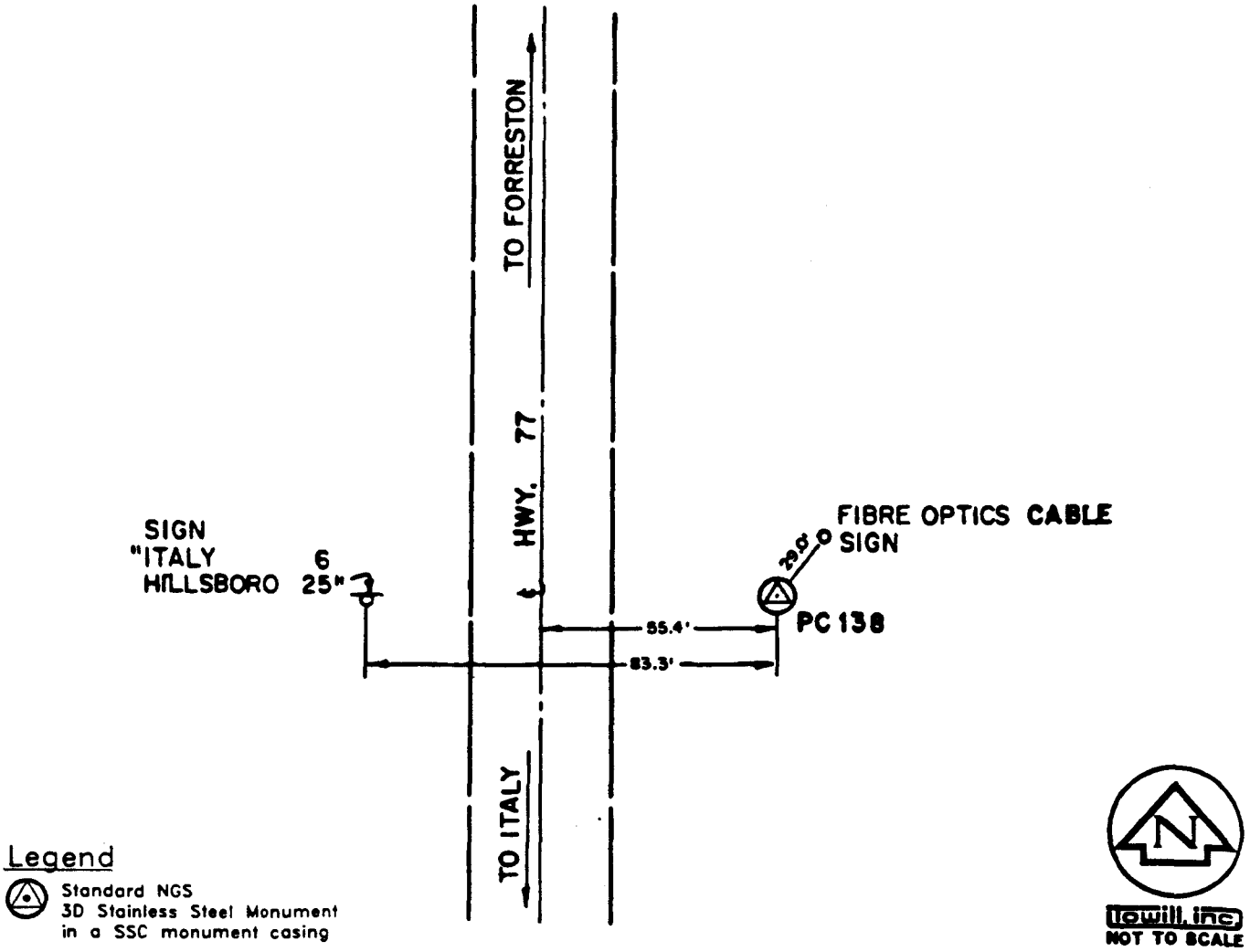
STATION		Point Grid Factor	SHEET
PC 138		0.99994870	1
N (ft) 6777763.002	E (ft) 2473649.179	Elev (ft) 528.533	OF 1

LATITUDE	32°14'59.40279" N
LONGITUDE	96°51'57.63883" W
INDEX SHEET (Quadrangle Sheet)	Forreston
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
MM 005	248°07'45"	3304.476
PC 139	197°43'31"	3317.347

DESCRIPTION, PLAT:

South of Forreston. From the intersection of Main Street and Highway 77 in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go south on Highway 77 for 0.39 miles to the station on the left opposite a sign on the west side of the highway giving mileage to Italy and Hillsboro.



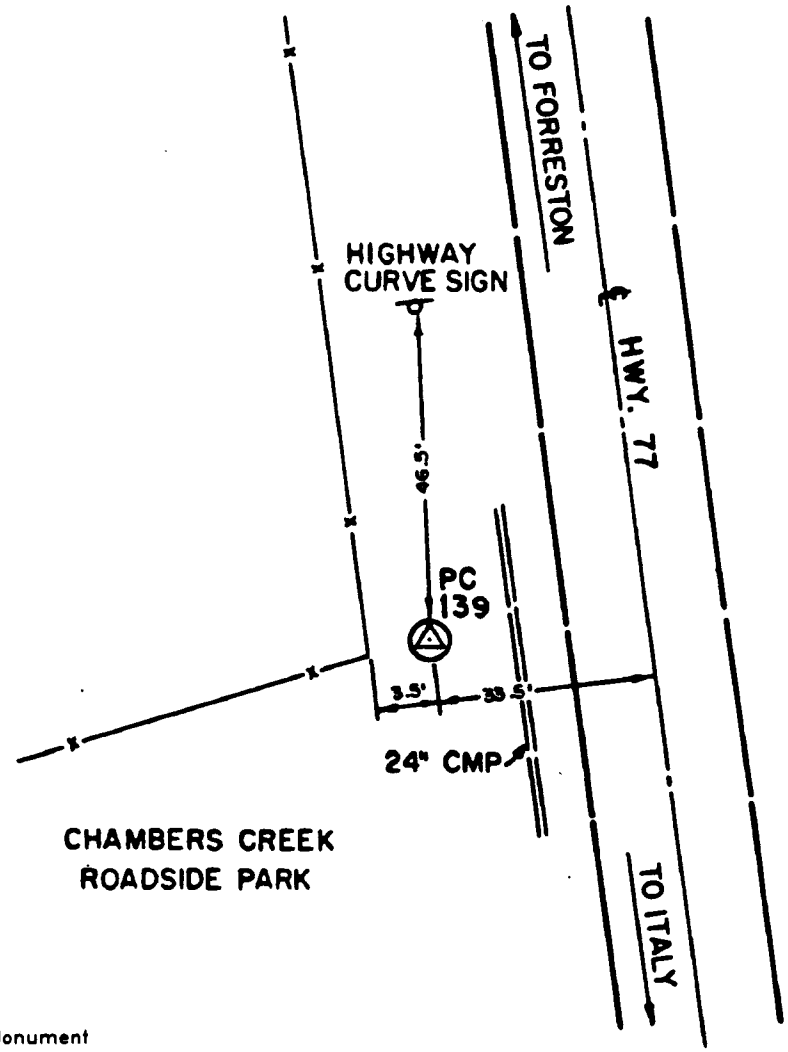
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 139		0.99995133	1
N (ft) 6774603.137	E (ft) 2472639.205	Elev (ft) 517.402	OF 1

LATITUDE	32°14'28.29365" N
LONGITUDE	96°52'09.96896" W
INDEX SHEET (Quadrangle Sheet)	Avalon
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 138	17°43'31"	3317.347

DESCRIPTION, PLAY:
South of Forreston. From Main Street and Highway 77 in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go southerly on Highway 77 for 1.02 miles to the station on the right. The station is on the extension of the northerly fence-line of Chambers Creek Roadside Park, 3.5-feet northeasterly of the fence corner.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, Inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

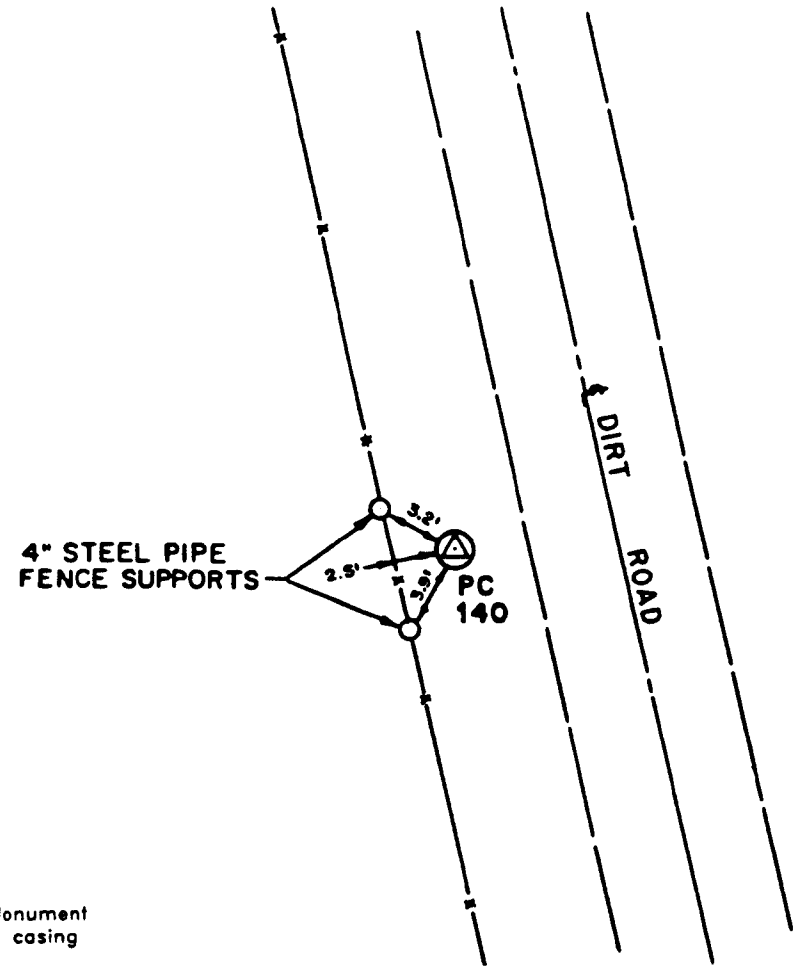
STATION		Point Grid Factor	SHEET
PC 140		0.99994715	1
N (ft) 6779199.242	E (ft) 2466371.972	Elev (ft) 539.699	OF 1

LATITUDE	32°15'14.72526" N
LONGITUDE	96°53'22.11070" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 141	329°40'21"	2782.737

DESCRIPTION, PLAT:

West of Forreston. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go south-southwest on FM 876 for 4.87 miles to the community of Five Points and a 4-way intersection. Turn left on a dirt road - Bethel Anderson Road, and go south-southeast for 1.29 miles to a 90-degree turn to the right. Turn right and go westerly for 0.20 miles to a "T" intersection and station PC 141 on the right. Turn left and go south-southeast for 0.54 miles to a 4-inch iron pipe "H" support for a fence, and the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

N

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

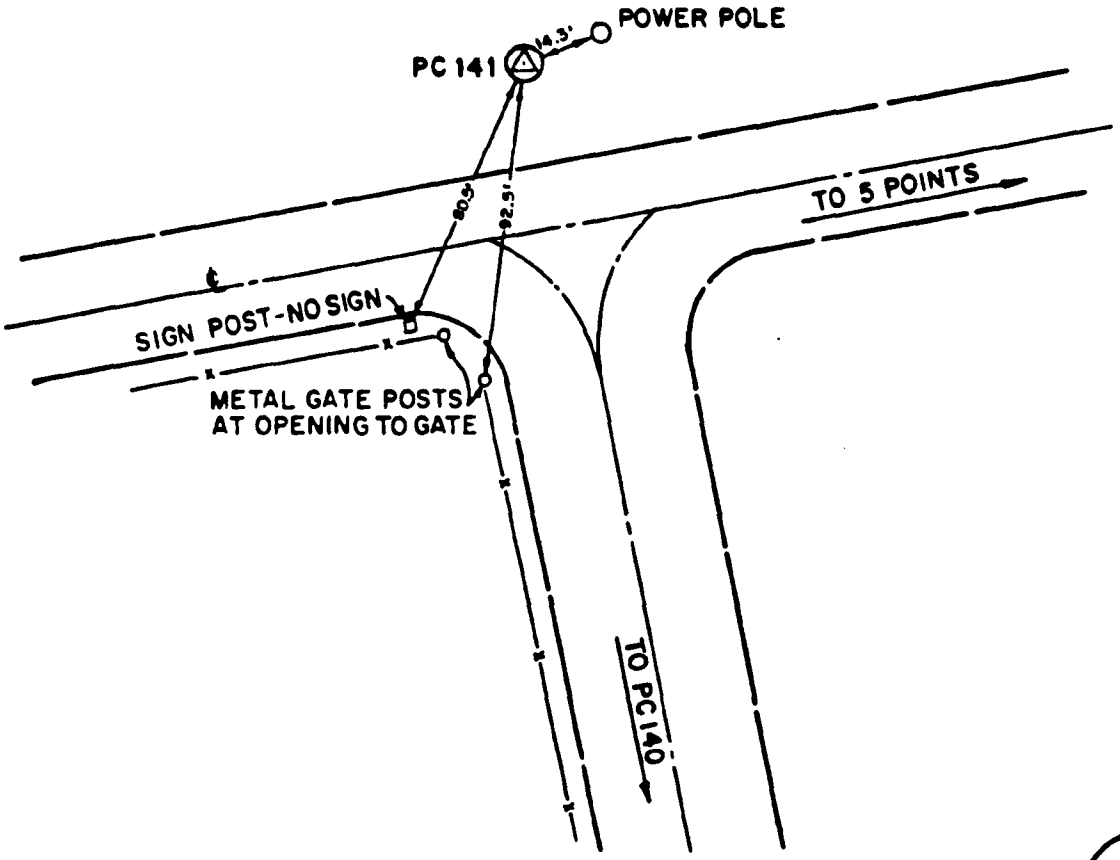
STATION		Point Grid Factor	SHEET
PC 141		0.99994504	1
N (ft) 6781601.169	E (ft) 2464966.848	Elev (ft) 550.353	OF 1

LATITUDE	32°15'38.70343" N
LONGITUDE	96°53'38.04369" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 140	149°40'21"	2782.737

DESCRIPTION, PLAT,

West of Forreston. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go south-southwest on FM 876 for 4.87 miles to the community of Five Points and a 4-way intersection, turn left on a dirt road - Bethel Anderson Road and go south-southeast 1.29 miles to a 90-degree turn to the right. Turn right and go westerly for 0.20 miles to a "T" intersection and the station on the right on top of a bank.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

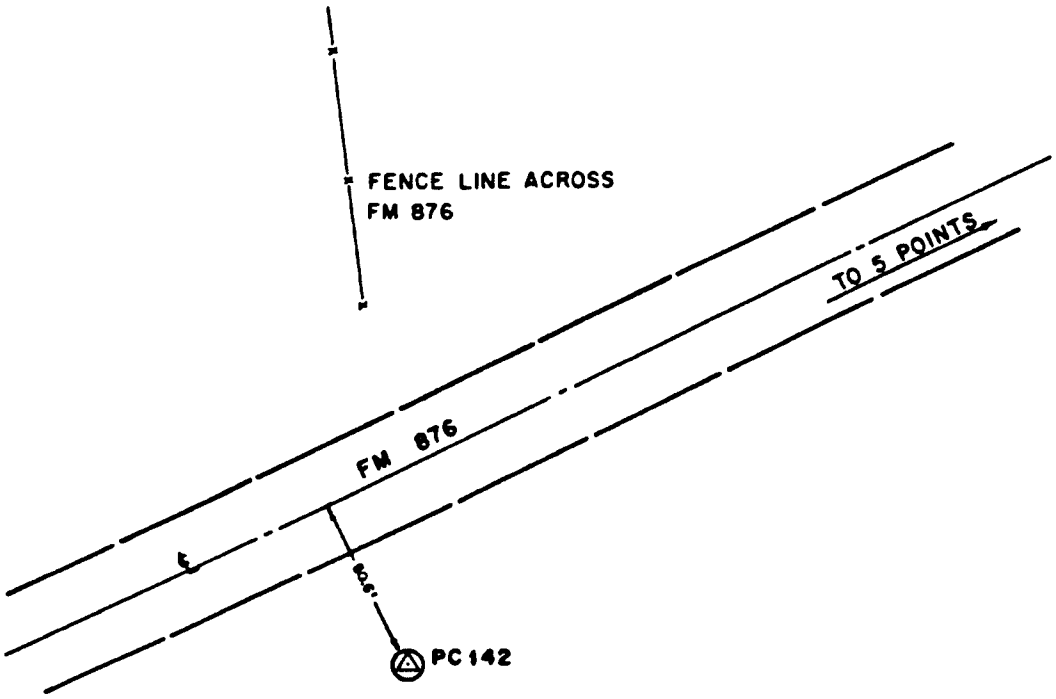
STATION		Point Grid Factor	SHEET
PC 142		0.99994149	1
N (ft) 6785347.723	E (ft) 2461172.690	Elev (ft)	OF 1

LATITUDE	32°16'16.34474" N
LONGITUDE	96°54'21.56243" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 143	28°04'10"	2426.147

DESCRIPTION, PLAY:

Southwest of Waxahachie. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go south-southwest on FM 876 for 4.87 miles to the community of Five Points and a 4-way intersection, continue southwesterly on FM 876 for 0.57 miles to the station on the left. The station is in the back portion of the right-of-way and on the extension of a property line fence across the road.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

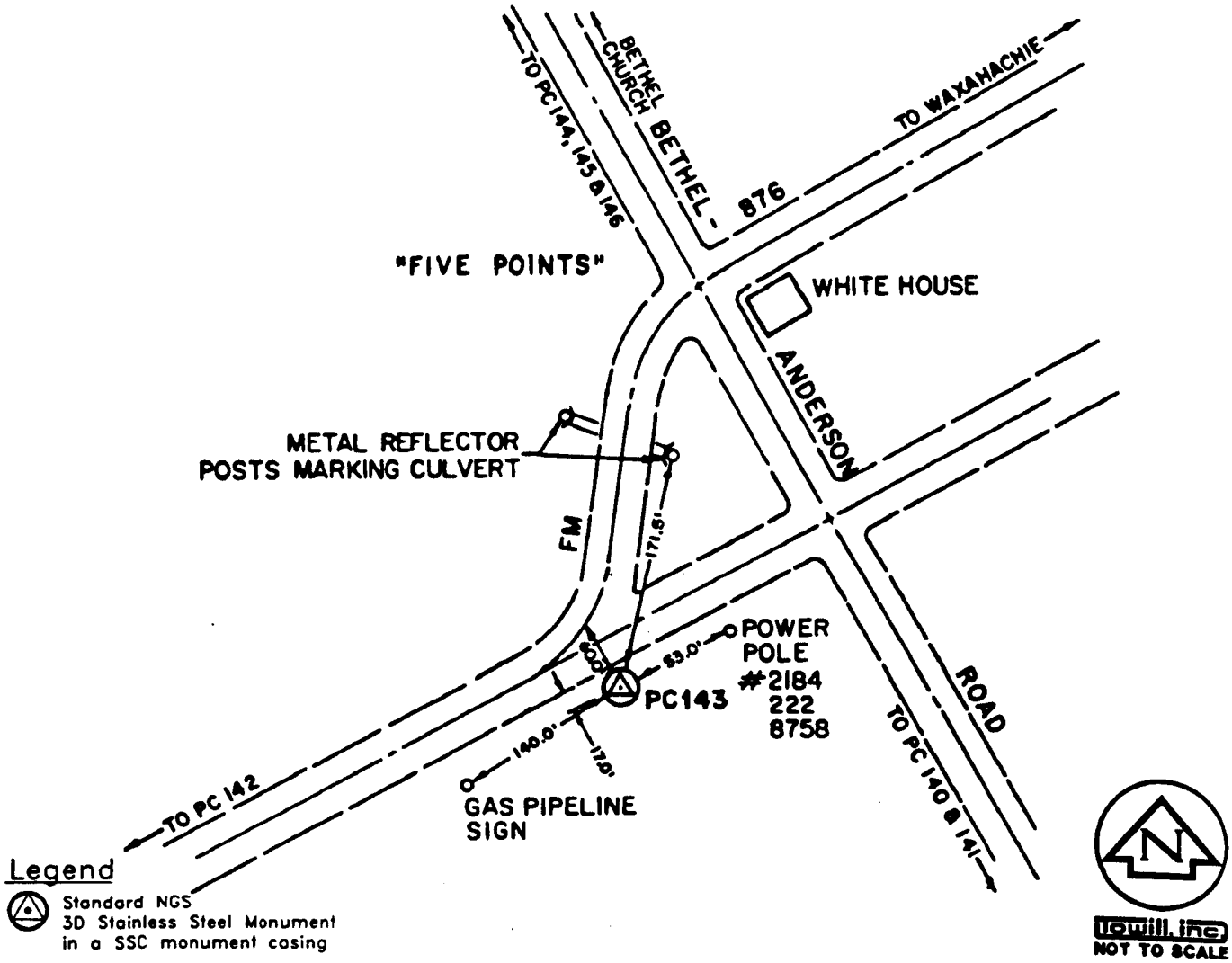
STATION		Point Grid Factor	SHEET
PC 143		0.99993867	1
N (ft)	E (ft)	Elev (ft)	OF
6787488.500	2462314.295	603.276	1

LATITUDE	32°16'37.35463" N
LONGITUDE	96°54'07.88834" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 142	208°04'10"	2426.147

DESCRIPTION, PLAT:

Southwest of Waxahachie. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go south-southwest on FM 876 for 4.87 miles to the community of Five Points and a 4-way intersection, continue 0.12 miles southwesterly on FM 876 to the station on the left on the southerly side of a frontage road south of FM 876.



SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

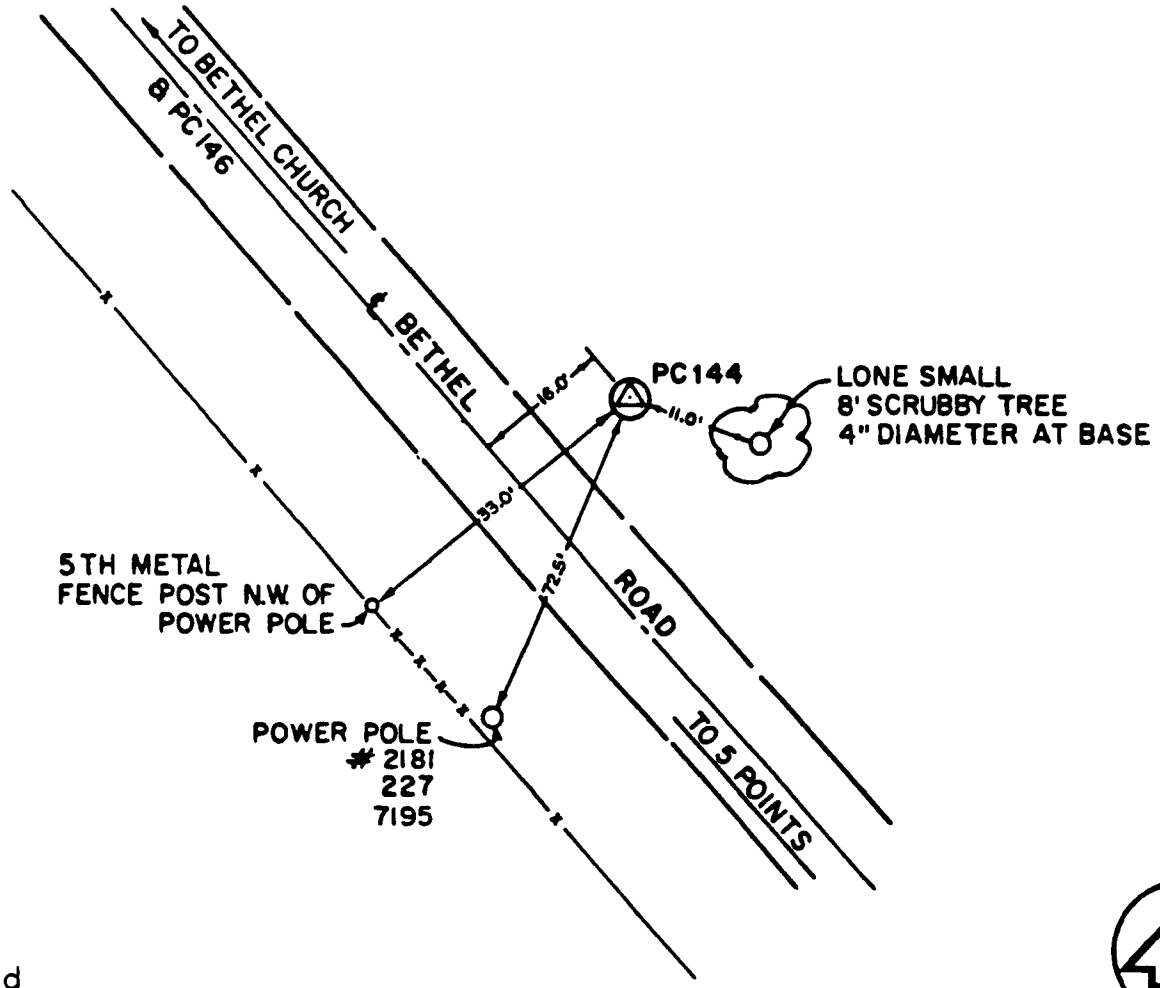
STATION		Point Grid Factor	SHEET
PC 144		0.99993561	1
N (ft) 6792998.804	E (ft) 2459123.368	Elev (ft) 593.390	OF 1

LATITUDE	32°17'32.35402" N
LONGITUDE	96°54'44.08163" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 145	220°34'22"	3345.043

DESCRIPTION, PLAT.

Southwest of Waxahachie. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go south-southwest on FM 876 for 4.87 miles to the community of Five Points and a 4-way intersection, turn right on Bethel Anderson Road (also known as Bethel Church Road) and go northerly for 1.11 miles to a crest and the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

lowill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

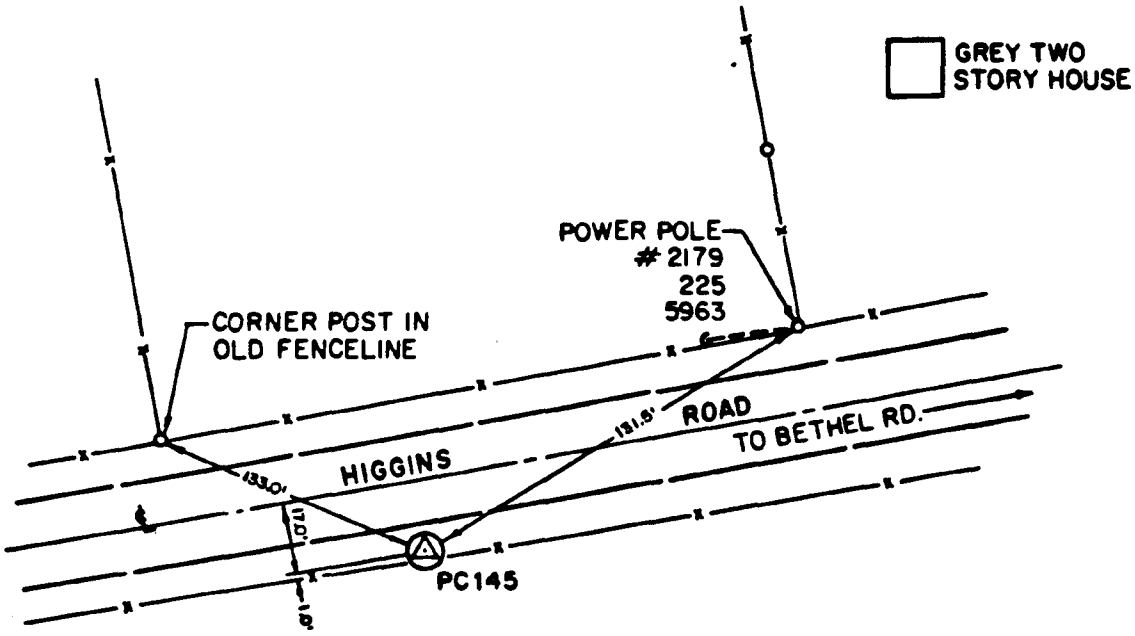
STATION		Point Grid Factor	SHEET
PC 145		0.99993722	1
N (ft) 6790457.978	E (ft) 2456947.704	Elev (ft)	OF 1

LATITUDE	32°17'07.53889" N
LONGITUDE	96°55'09.87030" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 144	40°34'22"	3345.043

DESCRIPTION, PLAT:

Southwest of Waxahachie. From the intersection of FM 876 and FM 14 approximately 2 miles southwest of FM 876 and I 35 E west of Waxahach go south-southwest on FM 876 for 4.87 miles to the community of I Points and a 4-way intersection, turn right on Bethel Anderson Road (a known as Bethel Church Road) and go northerly for 0.90 miles to a (road on the left. Go southwesterly on the dirt road, across two creeks, for 0.67 miles to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, Inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

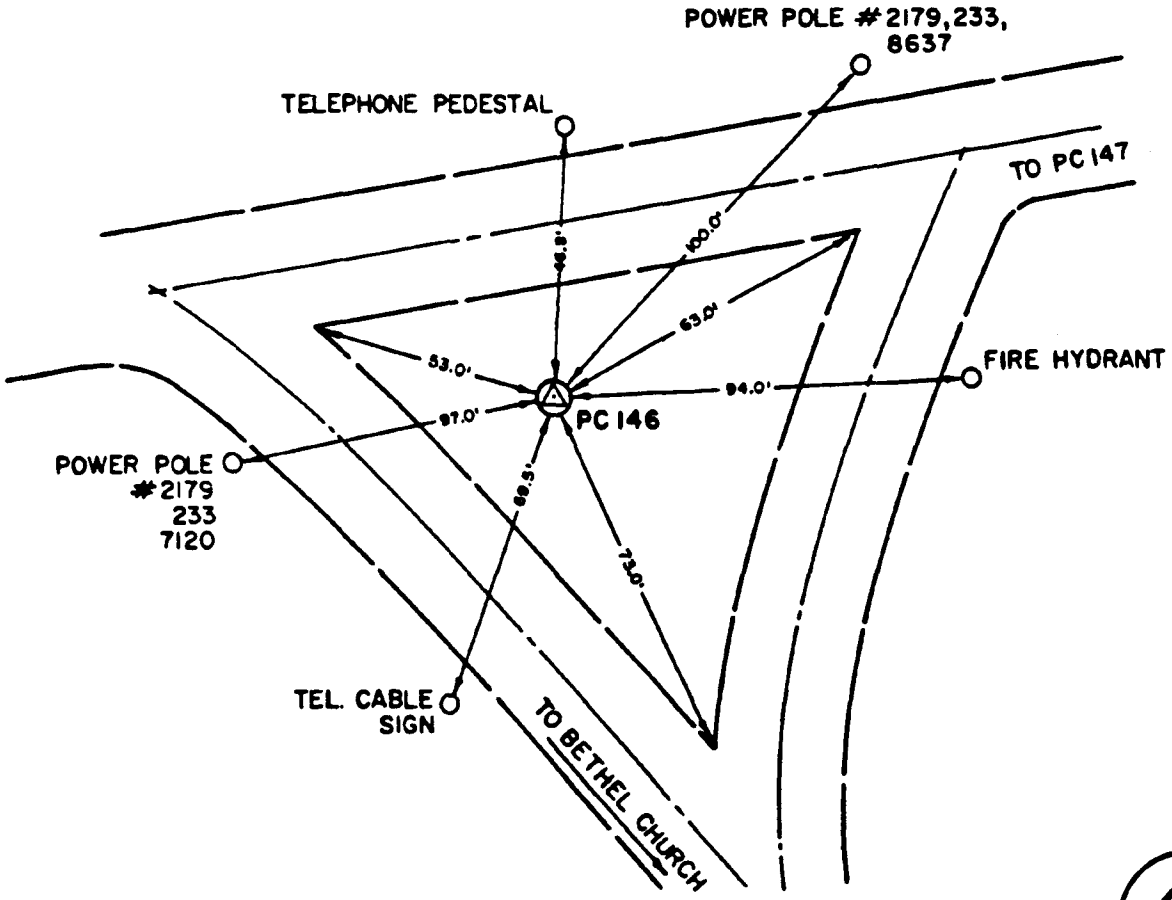
STATION		Point Grid Factor	SHEET
PC 146		0.99993040	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6798180.636	2457209.648	634.404	1

LATITUDE	32°18'23.91047" N
LONGITUDE	96°55'05.46476" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 147	19°59'03"	2566.284

DESCRIPTION, PLAT.

Southwest of Waxahachie. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go south-southwest on FM 876 for 4.87 miles to the community of Five Points and a 4-way intersection, turn right on Bethel Anderson Road (also known as Bethel Church Road) and go northerly for 2.25 miles to a "T" intersection with a large grass traffic island. PC 146 is located in the westerly portion of the triangle island.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

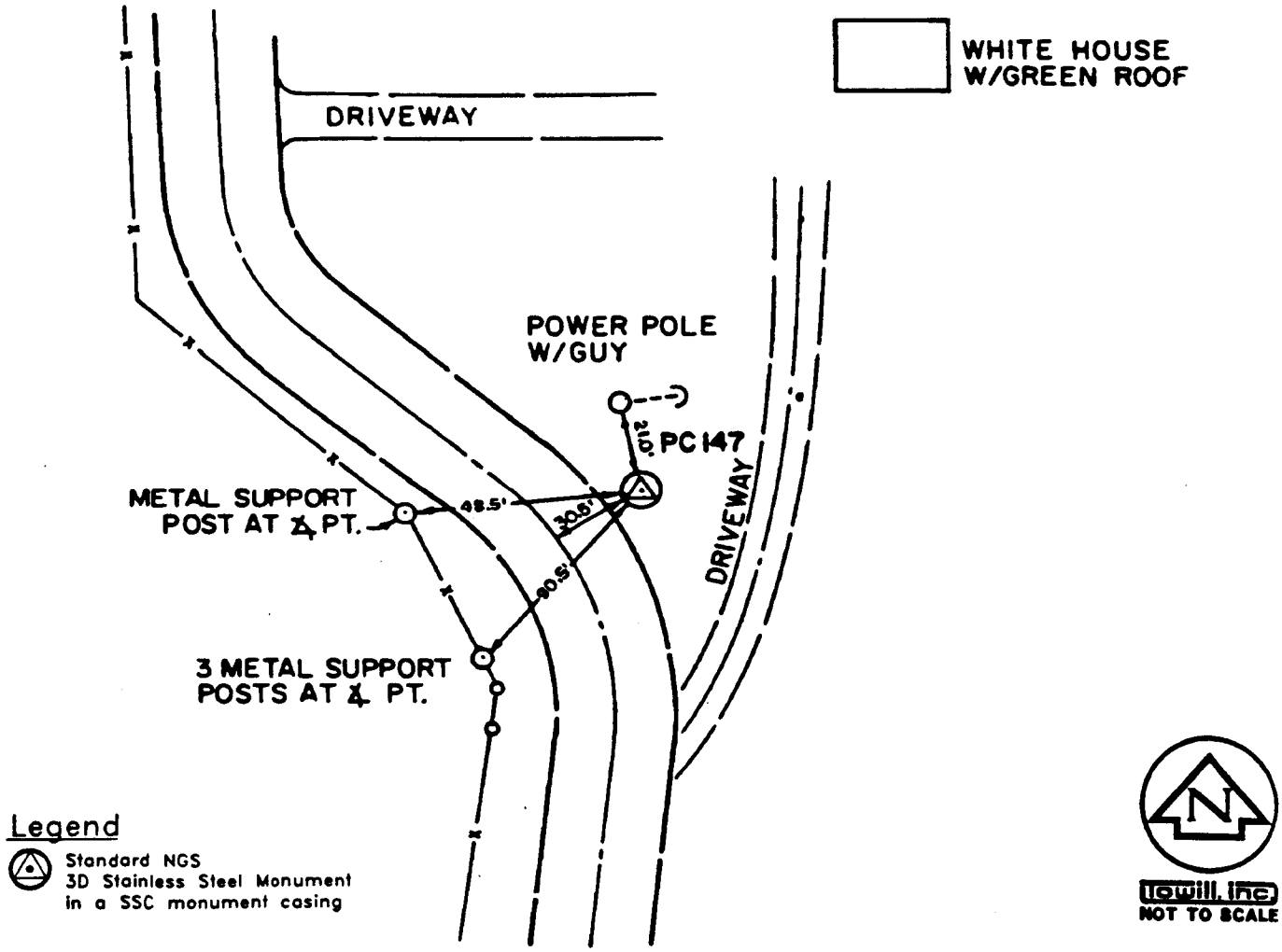
STATION		Point Grid Factor	SHEET
PC 147		0.99992773	1
N (ft) 6800592.395	E (ft) 2458086.707	Elev (ft) 659.287	OF 1

LATITUDE	32°18'47.64245" N
LONGITUDE	96°54'54.82276" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 8°00'00"	GRID DISTANCE IN FEET
PC 146	199°59'03"	2566.284

DESCRIPTION, PLAT.

Southwest of Waxahachie. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go southwesterly on FM 1493 for 2.25 miles to a 90-degree curve to the south and PC 149 on the right, go south for 0.19 miles to a 90-degree curve to the west. Go westerly for 1.01 miles to a white house on the right followed by a dirt road to the right and Bethel Road to the left. Turn left on Bethel Road and go south for 0.36 miles to a curve to the right, a power pole with a guy and the station on the left.



SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

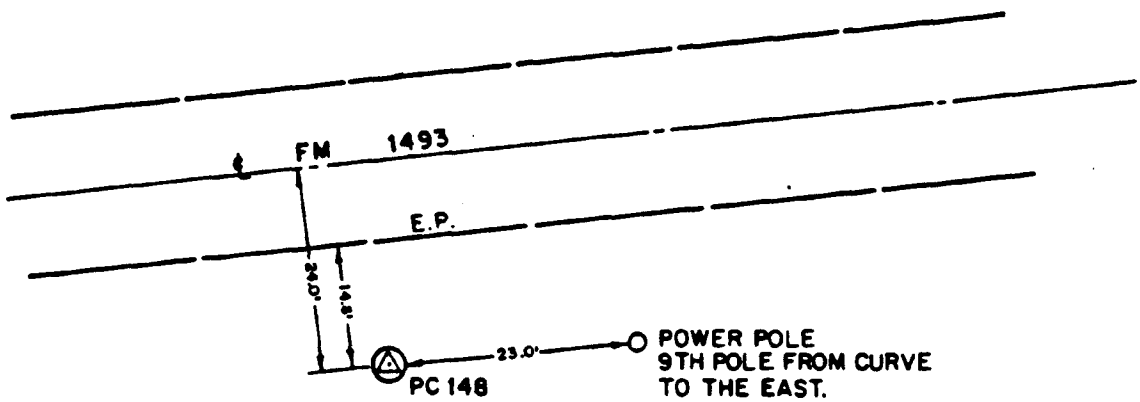
STATION		Point Grid Factor	SHEET
PC 148		0.99992634	1
N (ft) 6803594.112	E (ft) 2459148.302	Elev (ft) 650.182	OF 1

LATITUDE	32°19'17.18383" N
LONGITUDE	96°54'41.92500" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 149	43°10'52"	2769.867

DESCRIPTION, PLAT:

Southwest of Waxahachie. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go southwesterly on FM 1493 for 2.25 miles to a 90-degree curve to the south and PC 149 on the right, go south for 0.19 miles to a 90-degree curve to the west. Go west for 0.49 miles to the station on the left.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

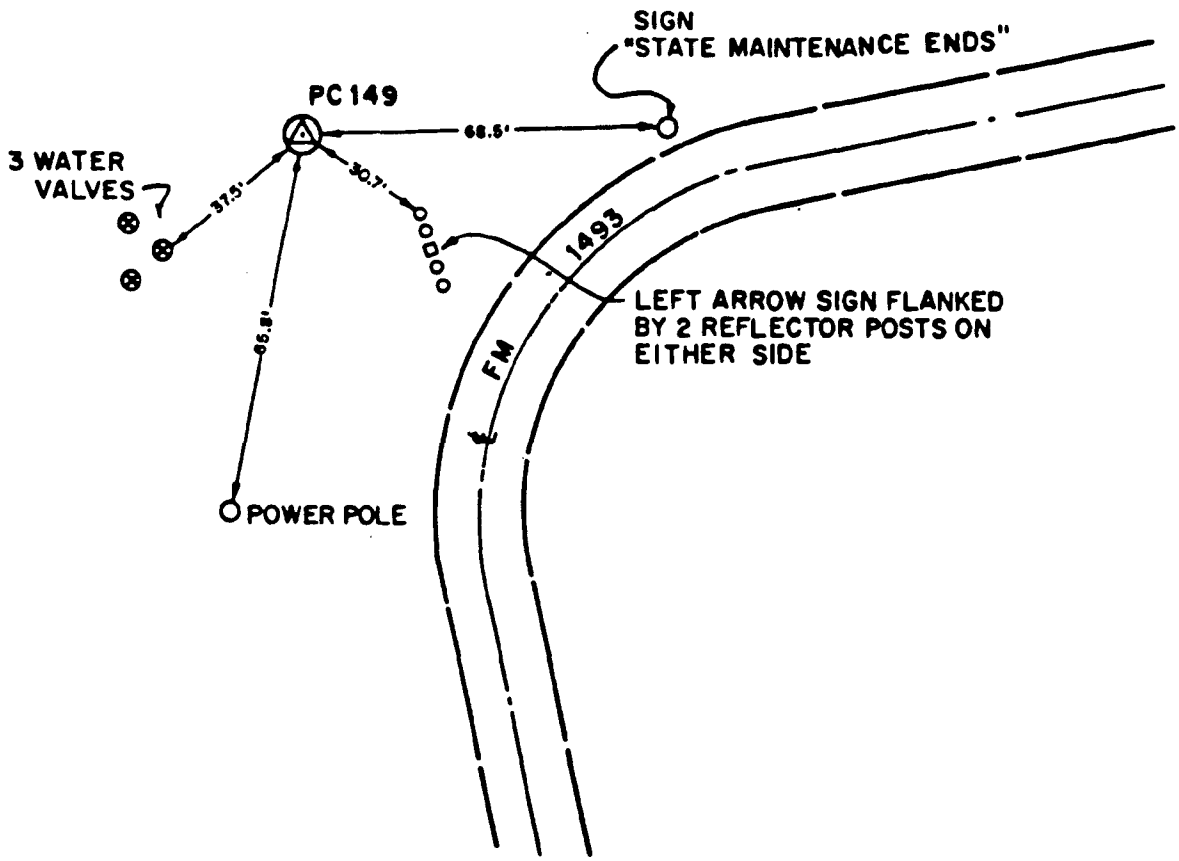
STATION		Point Grid Factor	SHEET
PC 149		0.99992435	1
N (ft) 6805613.885	E (ft) 2461043.738	Elev (ft)	OF 1

LATITUDE	32°19'36.88402" N
LONGITUDE	96°54'19.48148" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 148	223°10'52"	2769.867

DESCRIPTION, PLAT,

Southwest of Waxahachie. From the intersection of FM 876 and FM 1493, approximately 2 miles southwest of FM 876 and I 35 E west of Waxahachie, go southwesterly on FM 1493 for 2.25 miles to a 90-degree curve to the south and the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

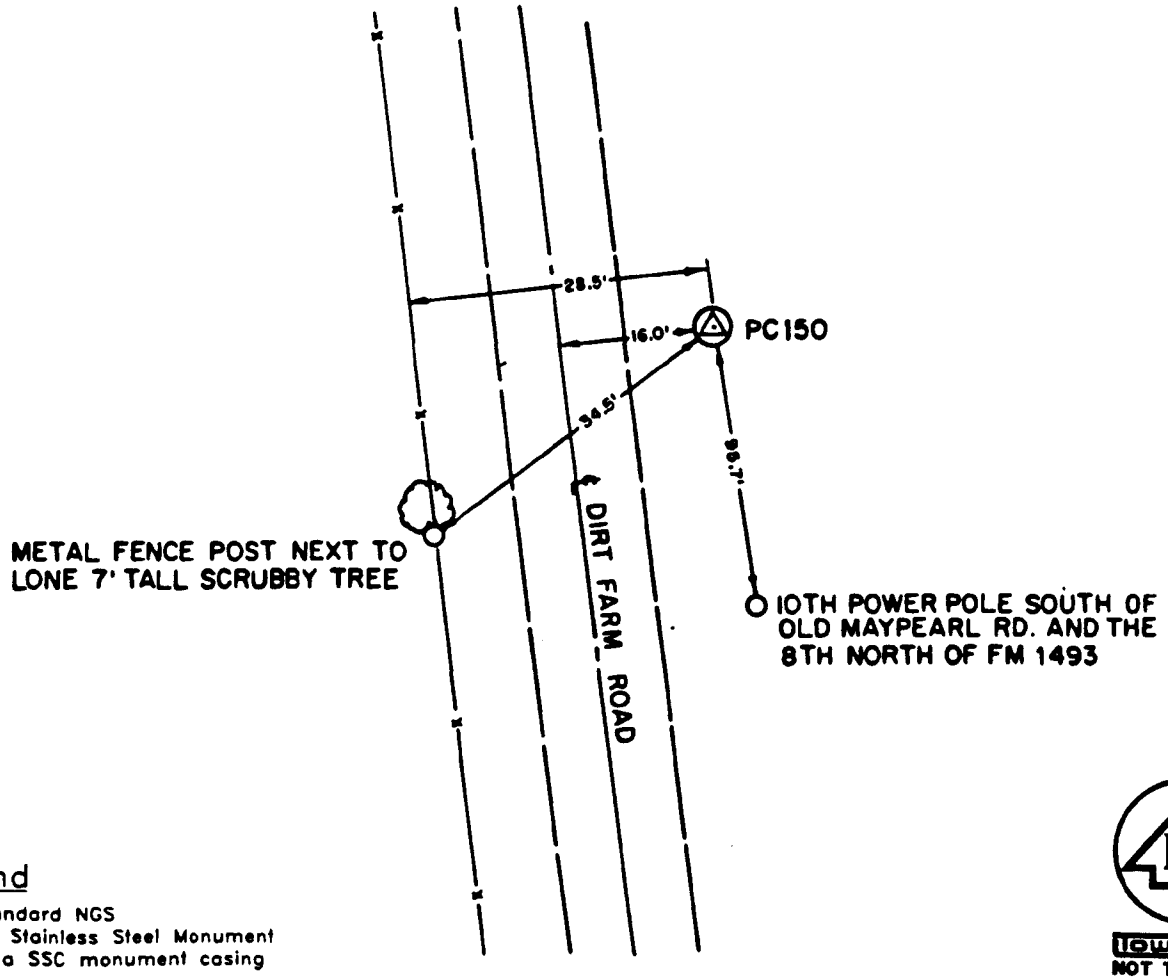
STATION		Point Grid Factor	SHEET
PC 150		0.99992452	1
N (ft) 6804196.977	E (ft) 2455798.573	Elev (ft)	OF 1

LATITUDE	32°19'23.64823" N
LONGITUDE	96°55'20.85176" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 151	281°48'19"	3698.325

DESCRIPTION, PLAT.

West of Waxahachie. From the center of the FM 66 overpass over I 35 E, go west for 4.56 miles on FM 66 to Arrowhead Road, a dirt road to the right and a paved road to the left. On the northeast corner are two (2) telephone pedestals and on the southeast corner is a group of four (4) mailboxes. Turn left and go in a southerly direction for 0.98 miles to a "T" intersection with Old Maypearl Road, turn right and go west for 0.10 miles to a dirt farm road on the left. Turn left and follow dirt road for 0.60 miles to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

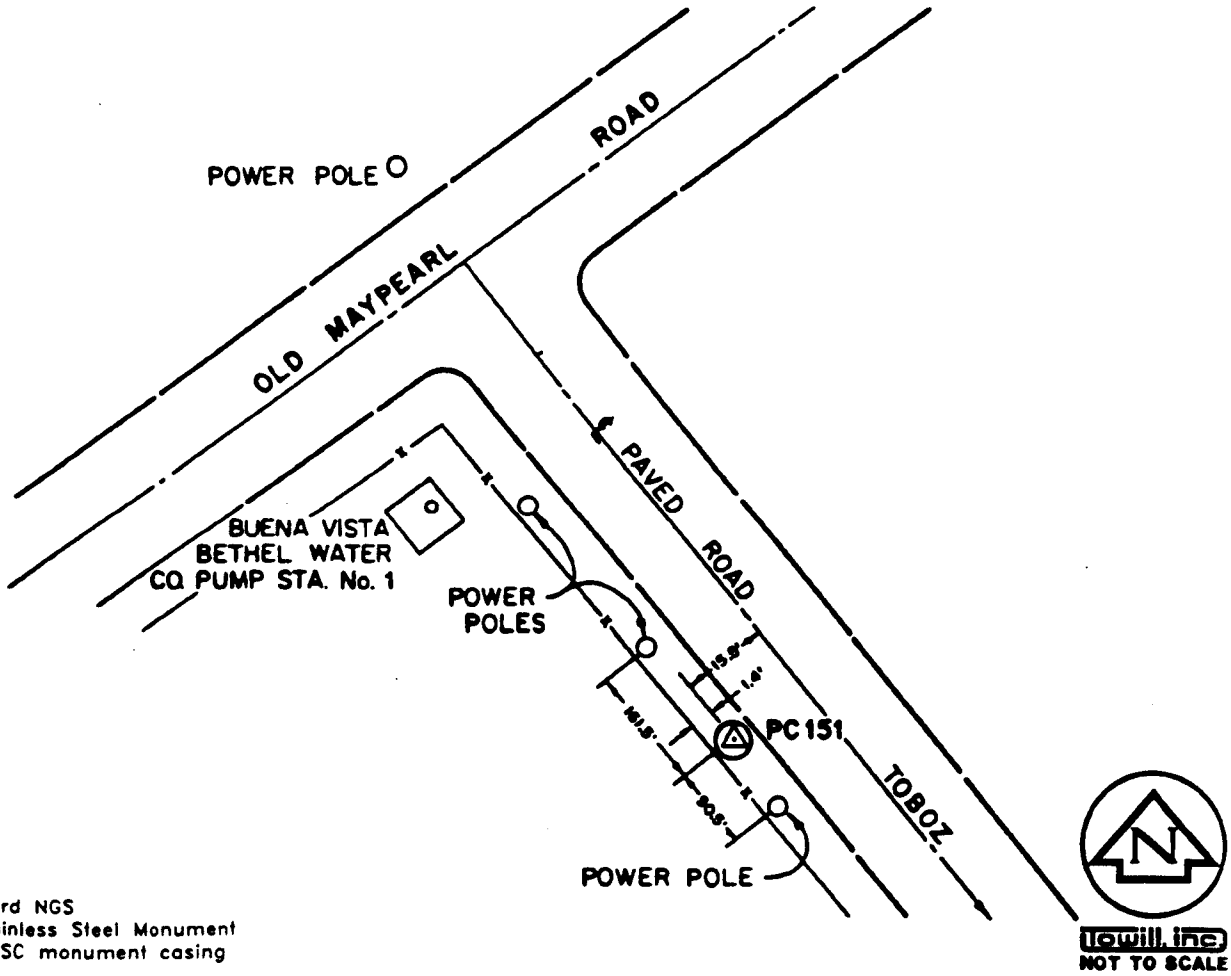
STATION		Point Grid Factor	SHEET
PC 151		0.99992397	1
N (ft) 6804953.612	E (ft) 2452178.475	Elev (ft) 681.526	OF 1

LATITUDE	32°19'31.67057" N
LONGITUDE	96°56'02.90395" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 150	101°48'19"	3698.325

DESCRIPTION, PLAT:

West of Waxahachie. From the center of the FM 66 overpass over I 35 E, go west for 4.56 miles on FM 66 to Arrowhead Road, a dirt road to the right and a paved road to the left. On the northeast corner are two (2) telephone pedestals and on the southeast corner is a group of four (4) mailboxes. Turn left and go in a southerly direction for 0.98 miles to a "T" intersection with Old Maypearl Road. Turn right and go southwest for 0.63 miles to a paved road on the left and a water tank/pump station on the southwest corner. Turn left and go southeast for 0.11 miles to the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

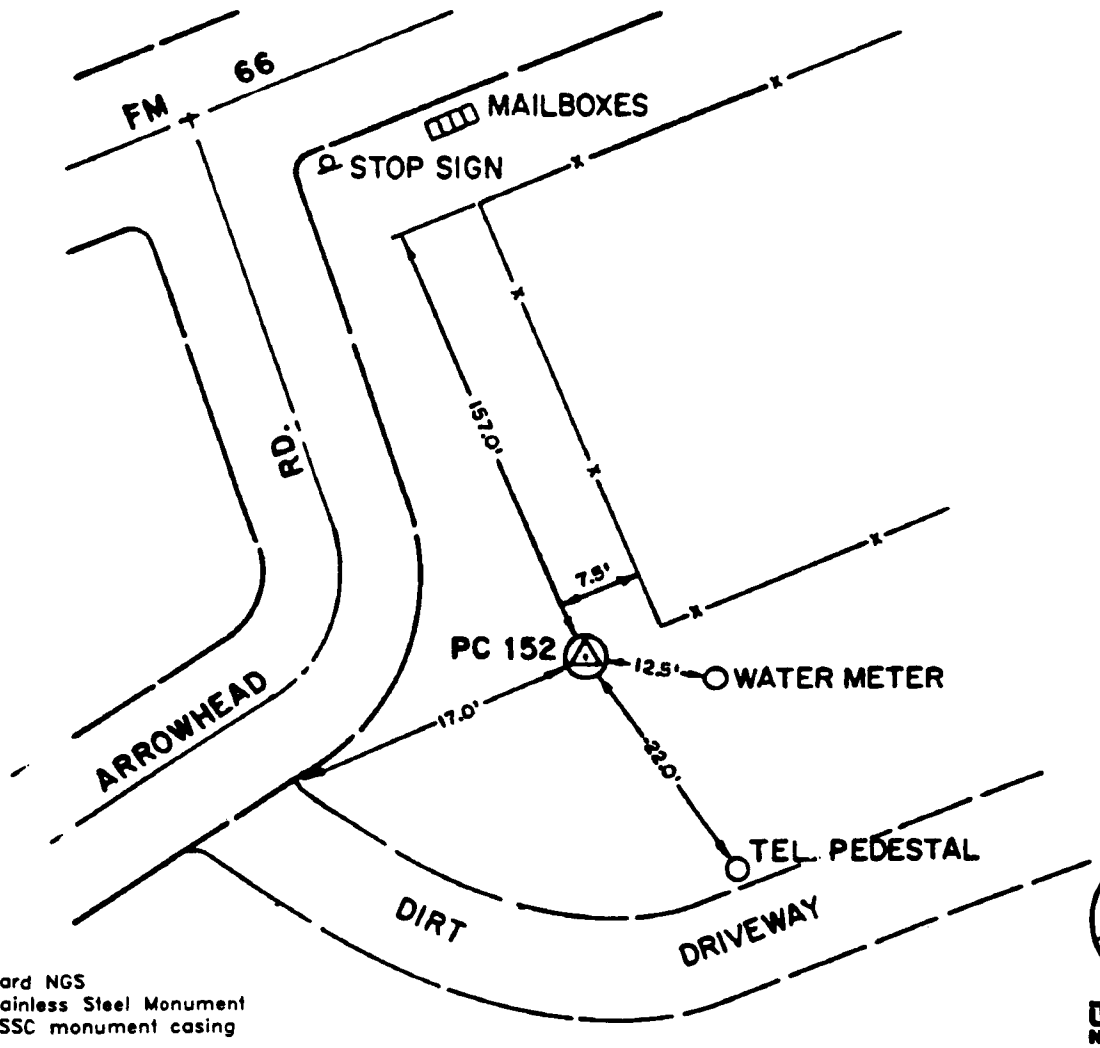
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 152		0.99991764	1
N (ft) 6811283.805	E (ft) 2452899.486	Elev (ft) 735.072	OF 1

LATITUDE	32°20'34.19749" N
LONGITUDE	96°55'53.40066" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 153	329°09'48"	2315.183

DESCRIPTION, PLAT:
West of Waxahachie. From the center of the FM 66 overpass over I 35 E, go west for 4.56 miles on FM 66 to Arrowhead Road, a dirt road to the right and a paved road to the left. On the northeast corner are two (2) telephone pedestals and on the southeast corner is a group of four (4) mailboxes. Turn left and go south for 225-feet to a curve to the right, a driveway on the left and the station on the left.



Legend
Standard NGS 3D Stainless Steel Monument in a SSC monument casing

NOT TO SCALE

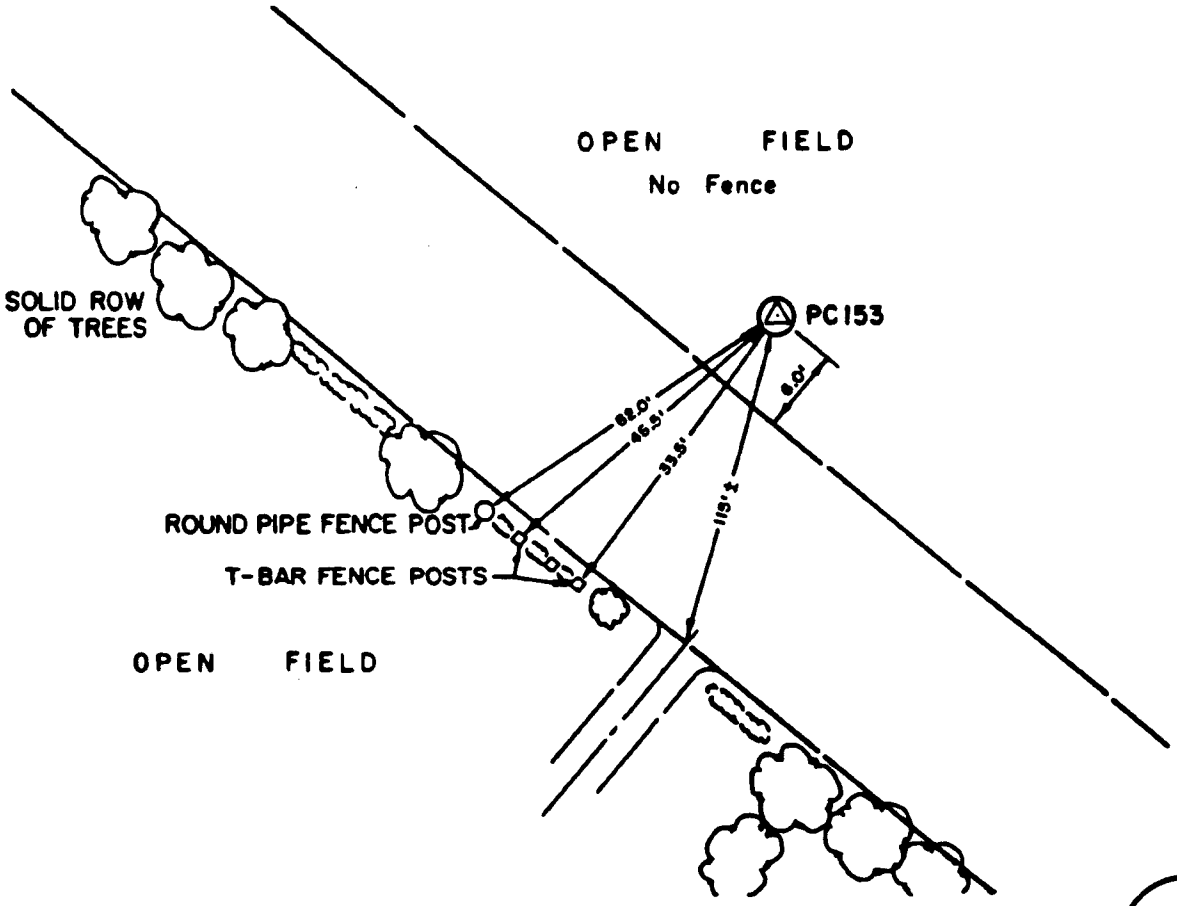
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 153		0.99991588	1
N (ft) 6813271.695	E (ft) 2451712.741	Elev (ft) 747.344	OF 1

LATITUDE	32°20'54.04157" N
LONGITUDE	96°56'06.88726" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 152	149°09'48"	2315.183

DESCRIPTION, PLAT:
West of Waxahachie. From the center of the FM 66 overpass over I 35 E, go west for 4.56 miles on FM 66 to Arrowhead Road, a dirt road to the right and a paved road to the left. On the northeast corner are two (2) telephone pedestals and on the southeast corner is a group of four (4) mailboxes. Turn right and follow the dirt road 0.39 miles to the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, Inc.
NOT TO SCALE

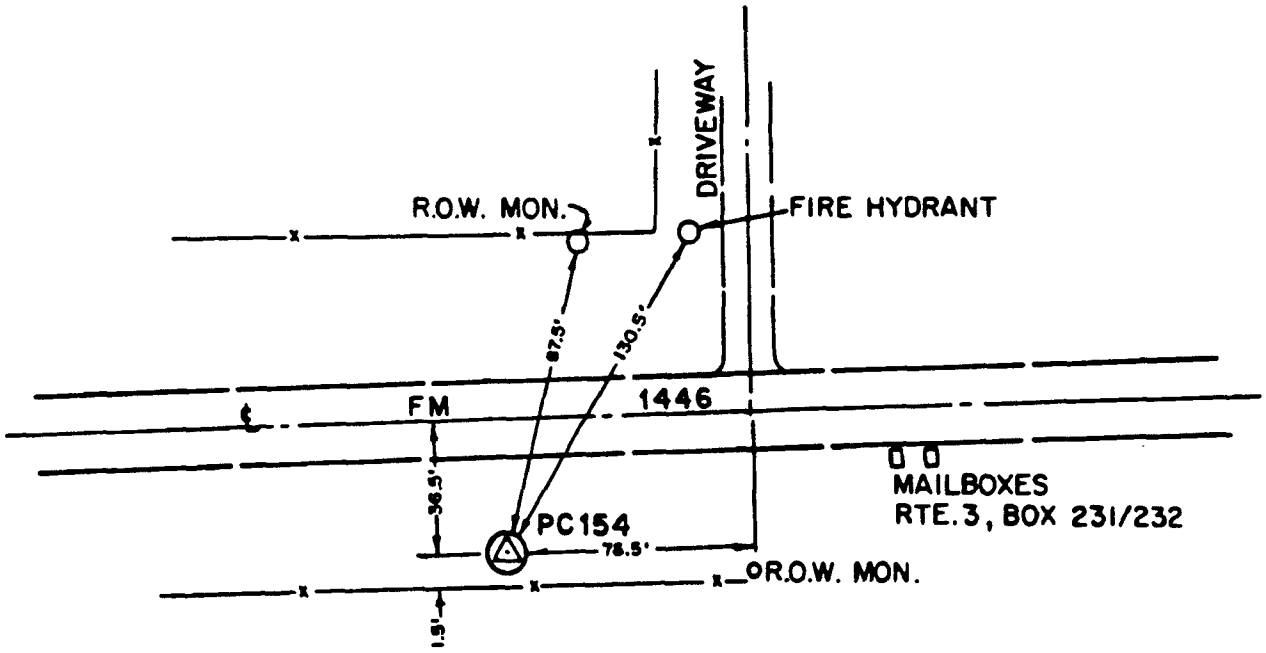
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 154		0.99991599	1
N (ft) 6822777.482	E (ft) 2459066.148	Elev (ft) 632.295	OF 1

LATITUDE	32°22'27.00327" N
LONGITUDE	96°54'39.50093" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 155	263°36'56"	3359.381

DESCRIPTION, PLAY:
West of Waxahachie. From the center of the FM 1446 (also known as Buena Vista Road) overpass over I 35 E, go west on FM 1446 2.62 miles to Lone Elm Road on the right. Continue west on FM 1446 0.10 miles to a slight rise and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

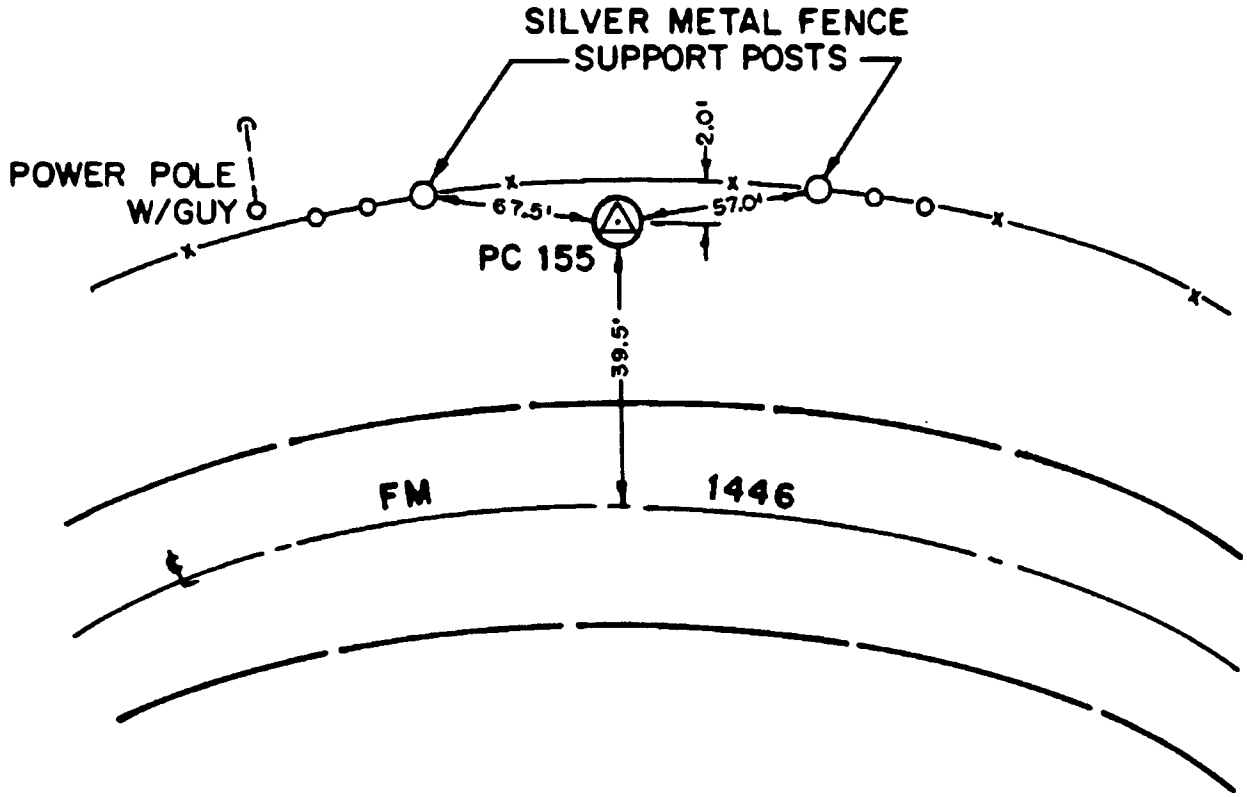
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 155		0.99991362	1
N (ft) 6822403.921	E (ft) 2455727.601	Elev (ft) 685.838	OF 1

LATITUDE	32°22'23.80510" N
LONGITUDE	96°55'18.49133" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 154	83°36'56"	3359.381

DESCRIPTION, PLAT:
West of Waxahachie. From the center of the FM 1446 (also known as Buena Vista Road) overpass over I 35 E, go west on FM 1446 2.62 miles to Lone Elm Road on the right, continue west on FM 1446 for 0.74 miles to a left bend and the station on the right.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

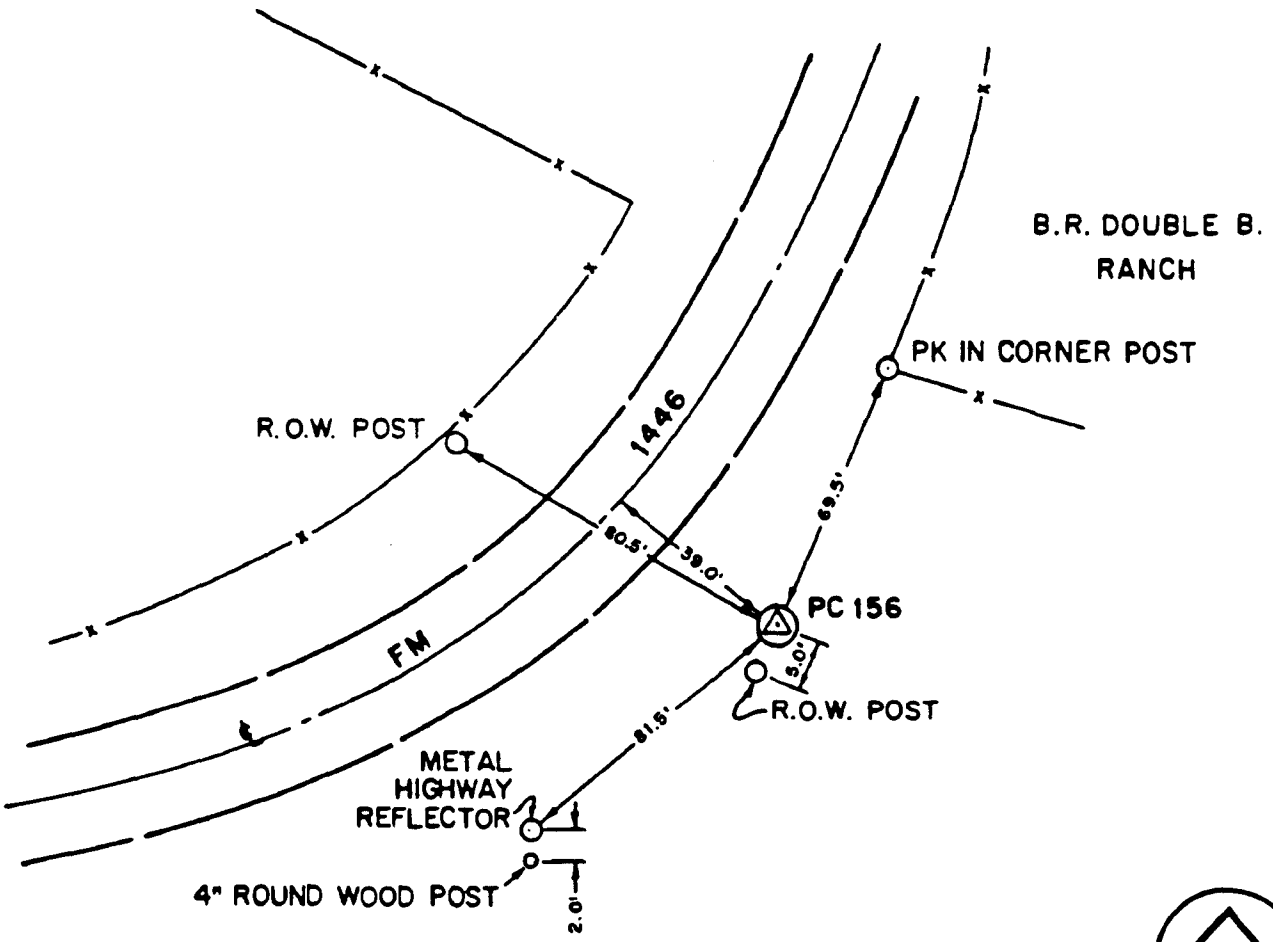
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 156		0.99991281	1
N (ft)	**E (ft)**	**Elev (ft)**	**OF**
6819240.990	2451600.992	739.602	1

LATITUDE	32°21'53.12061" N
LONGITUDE	96°56'07.15342" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 157	290°45'36"	2559.782

DESCRIPTION, PLAT:
West of Waxahachie. From the center of the FM 1446 (also known as Buena Vista Road) overpass over I 35 E, go west on FM 1446 2.62 miles to Lone Elm Road on the right, continue west on FM 1446 for 1.75 miles and the station on the left, on the outside of a right hand bend.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

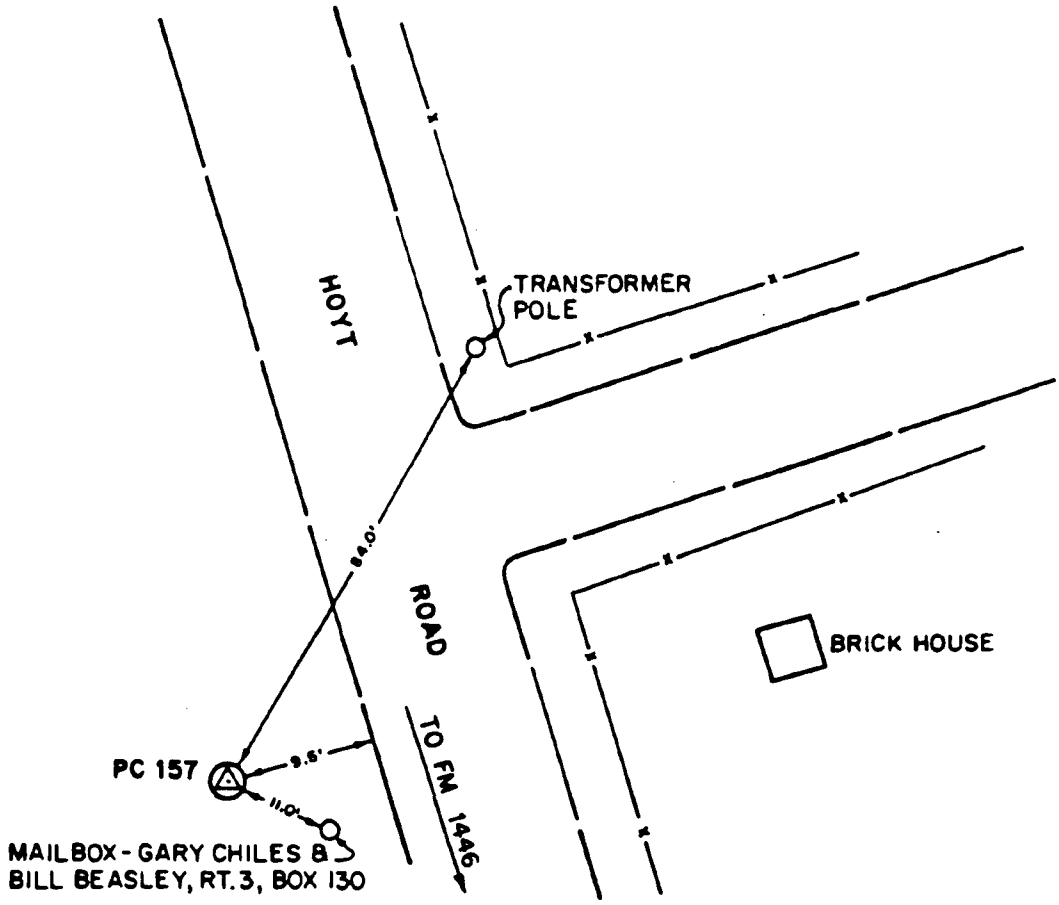
STATION		Point Grid Factor	SHEET
PC 157		0.99991126	1
N (ft) 6820148.310	E (ft) 2449207.406	Elev (ft) 760.763	OF 1

LATITUDE	32°22'02.44990" N
LONGITUDE	96°56'34.90121" W
INDEX SHEET (Quadrangle Sheet)	Boz
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 156	110°45'36"	2559.782

DESCRIPTION, PLAT:

West of Waxahachie. From the center of the FM 1446 (also known as Buena Vista Road) overpass over I 35 E, go west on FM 1446 2.62 miles to Lone Elm Road on the right, continue west on FM 1446 for 2.06 miles to Hoyt Road on the right. Turn right on Hoyt Road and go north for 0.37 miles to a one-story brick house on the right and a mailbox and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

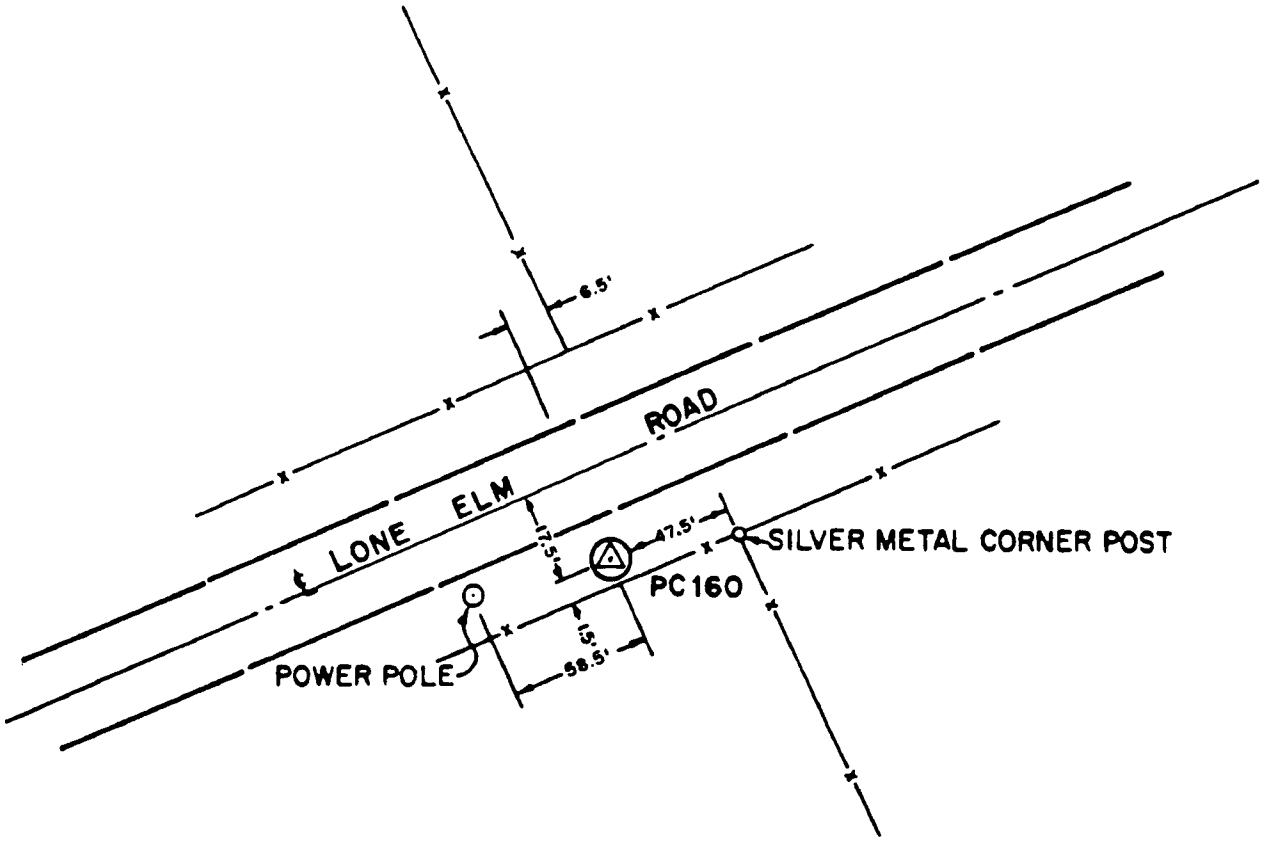
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 160		0.99990591	1
N (ft) 6832170.938	E (ft) 2450929.280	Elev (ft) 733.710	OF 1

LATITUDE	32°24'01.15378" N
LONGITUDE	96°56'12.74123" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 161	58°52'04"	1947.021

DESCRIPTION, PLAT:
West of Waxahachie. From the junction of FM 875 and Highway 287 Business, follow FM 875 west towards Venus for 2.28 miles to Lone Elm Road. Turn left on Lone Elm Road and continue for 1.06 miles to the station on the left, on the approximate extension of a fence line across the road.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

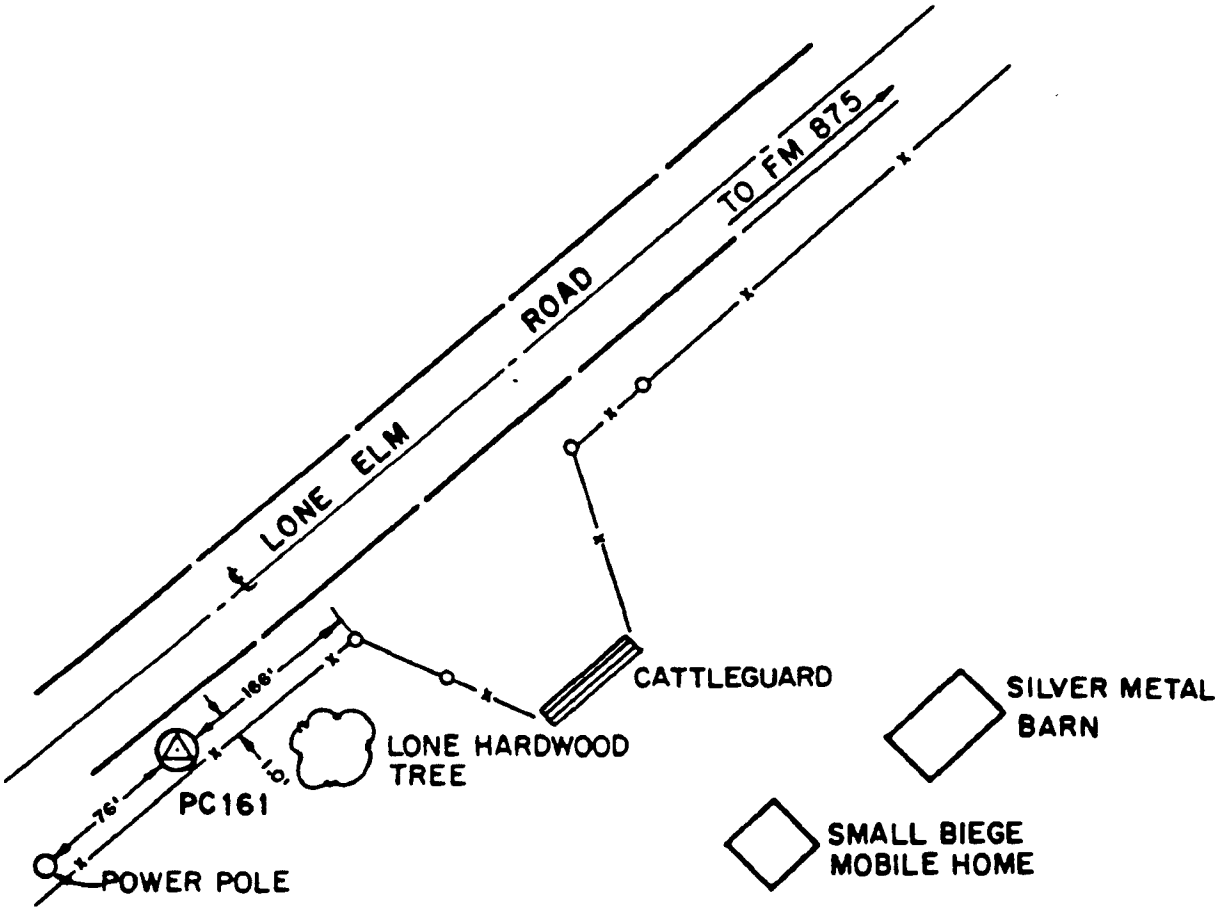
Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 161		0.99990515	1
N (ft) 6833177.573	E (ft) 2452595.886	Elev (ft) 738.325	OF 1

LATITUDE 32°24'10.86803" N		STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
LONGITUDE 96°55'53.12882" W		PC 160	238°52'04"	1947.021
INDEX SHEET (Quadrangle Sheet) Midlothian				
HORZ NAD 83	Order FIRST	Type GPS		
VERT NGVD 29	FIRST			

DESCRIPTION, PLAT:
West of Waxahachie. From the junction of FM 875 and Highway 287 Business, follow FM 875 west towards Venus for 2.28 miles to Lone Elm Road. Turn left on Lone Elm Road and continue for 0.68 miles to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

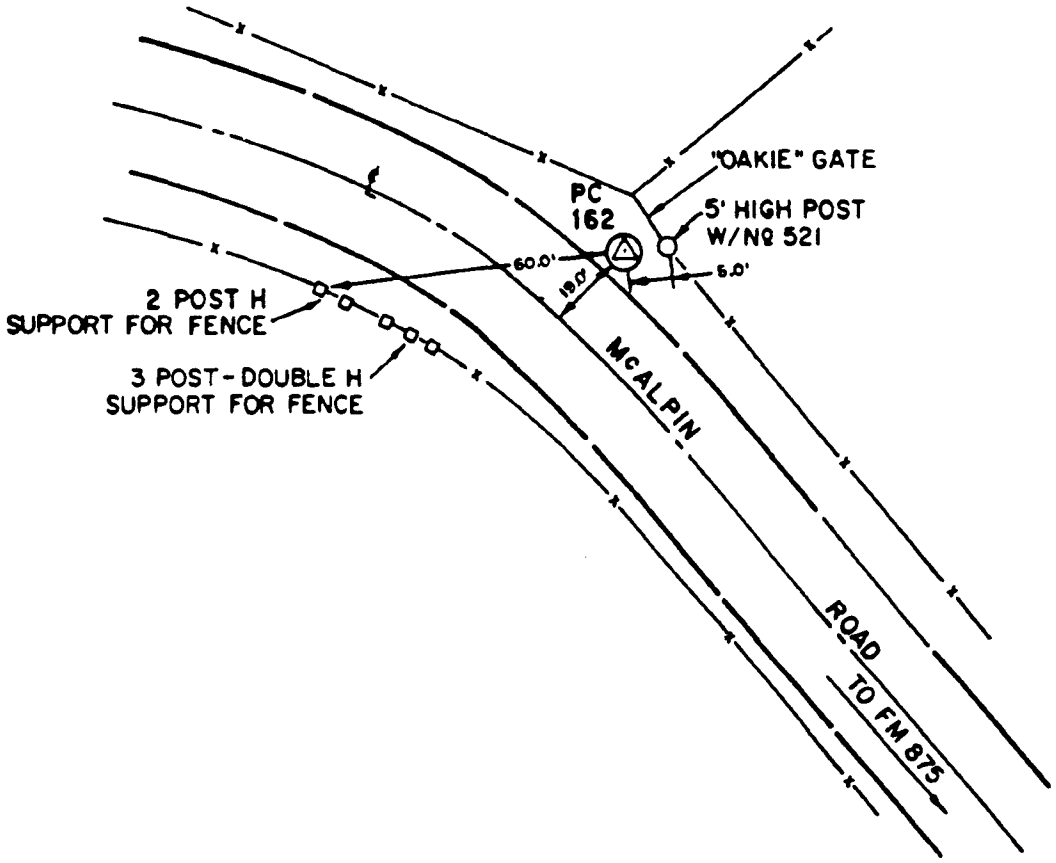
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 162		0.99990055	1
N (ft) 6838617.318	E (ft) 2443338.154	Elev (ft)	OF 1

LATITUDE	32°25'06.04607" N
LONGITUDE	96°57'40.17321" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 163	132°40'27"	3926.100

DESCRIPTION, PLAT:
West of Waxahachie. From the junction of Highway 287 Business and FM 875, follow 875 west towards Venus for 2.28 miles to Lone Elm Road, continue on FM 875 for 0.91 miles to a left hand bend and station PC 164 on the left, continue ahead on FM 875 1.10 miles to McAlpin Road on the right. Turn right and follow McAlpin Road for 0.68 miles to a left hand bend and the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

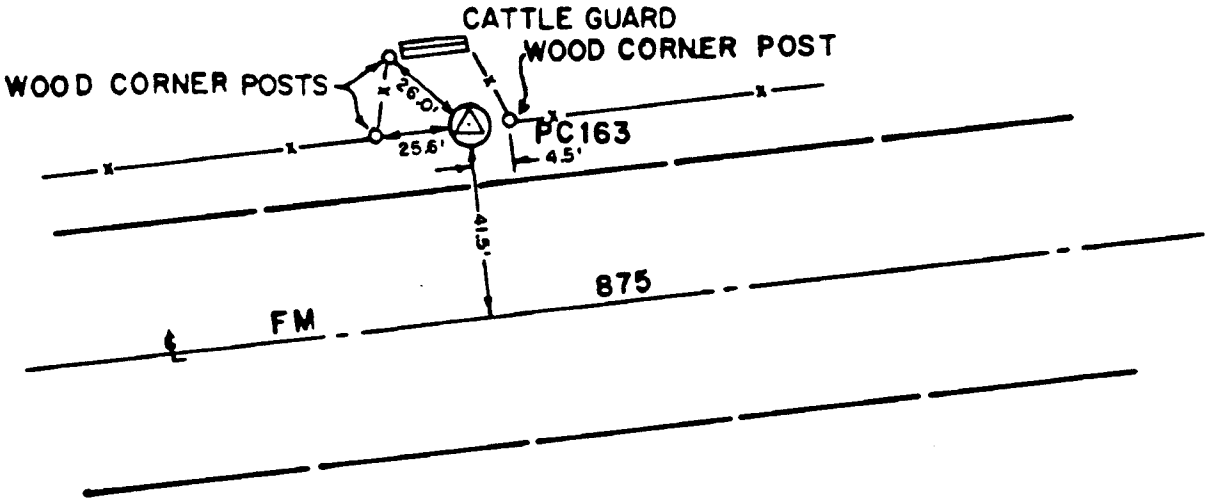
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 163		0.99990247	1
N (ft) 6835956.095	E (ft) 2446224.701	Elev (ft) 762.554	OF 1

LATITUDE	32°24'39.29509" N
LONGITUDE	96°57'06.95888" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 162	312°40'27"	3926.100

DESCRIPTION, PLAT:
West of Waxahachie. From the junction of Highway 287 Business and FM 875, follow 875 west towards Venus for 2.28 miles to Lone Elm Road, continue on FM 875 for 0.91 miles to a left hand bend and station PC 164 on the left, continue ahead on FM 875 0.89 miles to the station on the right at a cattle guard entrance to a pasture.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Towill, inc.
NOT TO SCALE

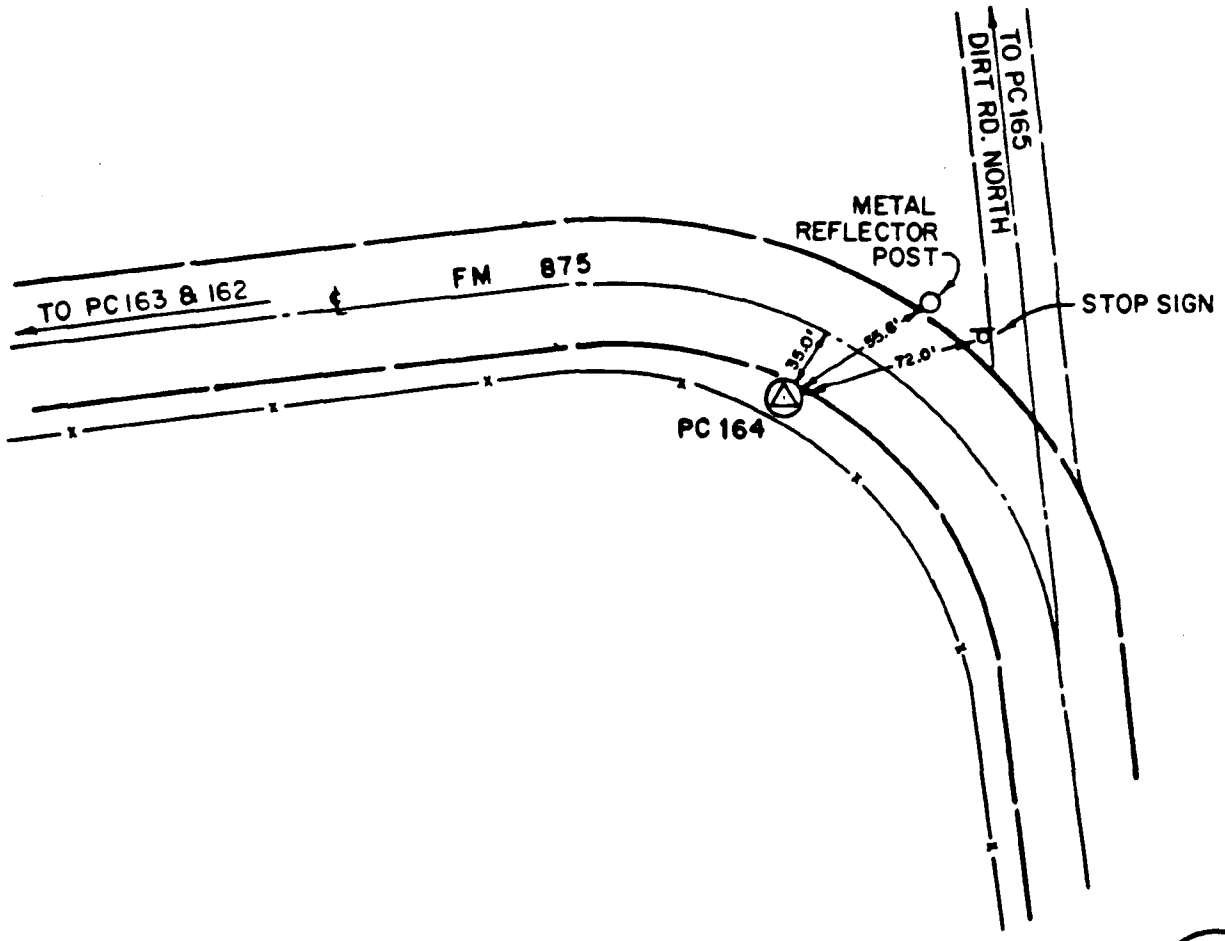
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 164		0.99990311	1
N (ft) 6837678.509	E (ft) 2450478.708	Elev (ft) 730.597	OF 1

LATITUDE	32°24'55.71433" N
LONGITUDE	96°56'17.04103" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 165	31°22'41"	6280.474

DESCRIPTION, PLAT:
West of Waxahachie. From the junction of Highway 287 Business and FM 875, follow 875 west towards Venus for 2.28 miles to Lone Elm Road, continue on FM 875 for 0.91 miles to a left hand bend and station PC 164 on the left.



Legend

Standard NGS
3D Stainless Steel Monument
in a SSC monument casing

Topwill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

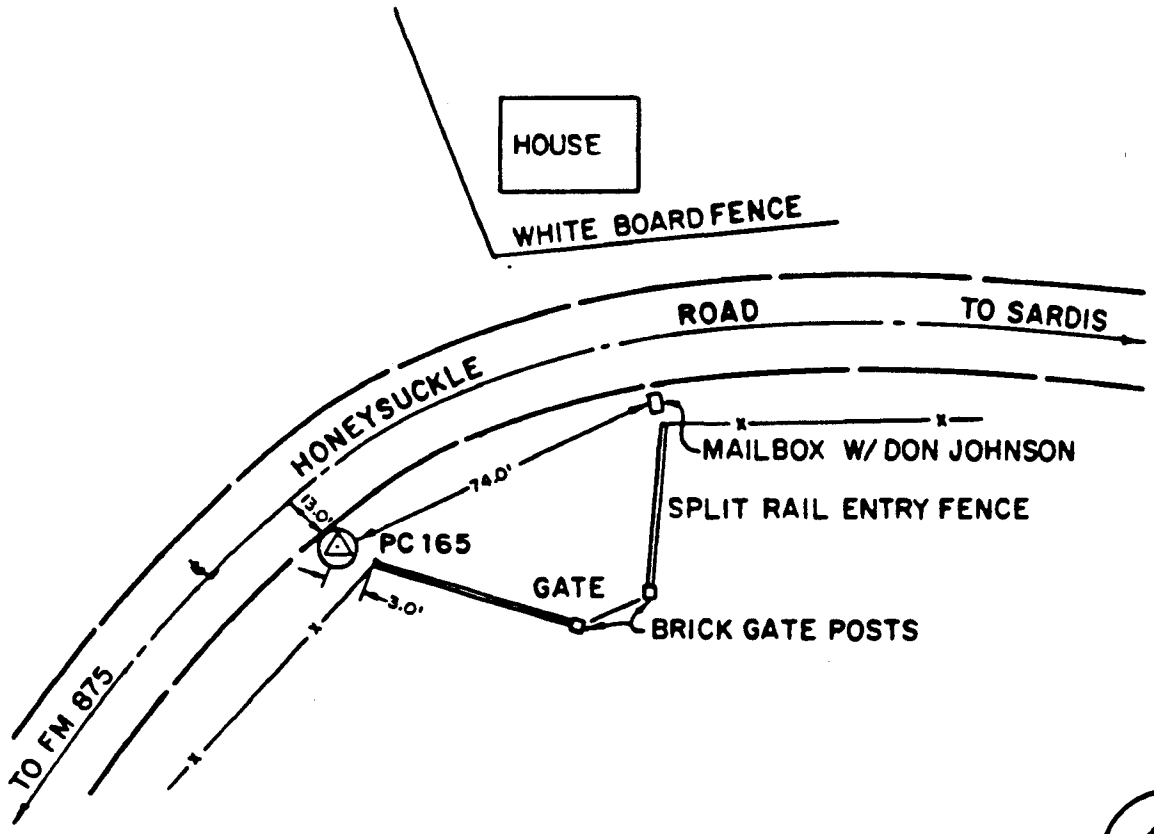
STATION		Point Grid Factor	SHEET
PC 165		0.99990230	1
N (ft) 6843040.471	E (ft) 2453748.833	Elev (ft) 689.474	OF 1

LATITUDE	32°25'48.28506" N
LONGITUDE	96°55'37.95966" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 164	211°22'41"	6280.474

DESCRIPTION, PLAT,

West of Waxahachie. From the junction of Highway 287 Business and FM 875, follow FM 875 west towards Venus for 2.28 miles to Lone Elm Road, continue on FM 875 for 0.91 miles to a left hand bend and station PC 164 on the left, and a dirt road continuing straight ahead. Continue straight ahead on the dirt road for 0.72 miles to another dirt road on the right. Turn right and follow this road for 1.18 miles to a house on the left with a white board fence, and a driveway to the right with brick gate posts and split rail fences. The station is on the extension of the southerly split rail entry fence 3-feet from the corner post.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

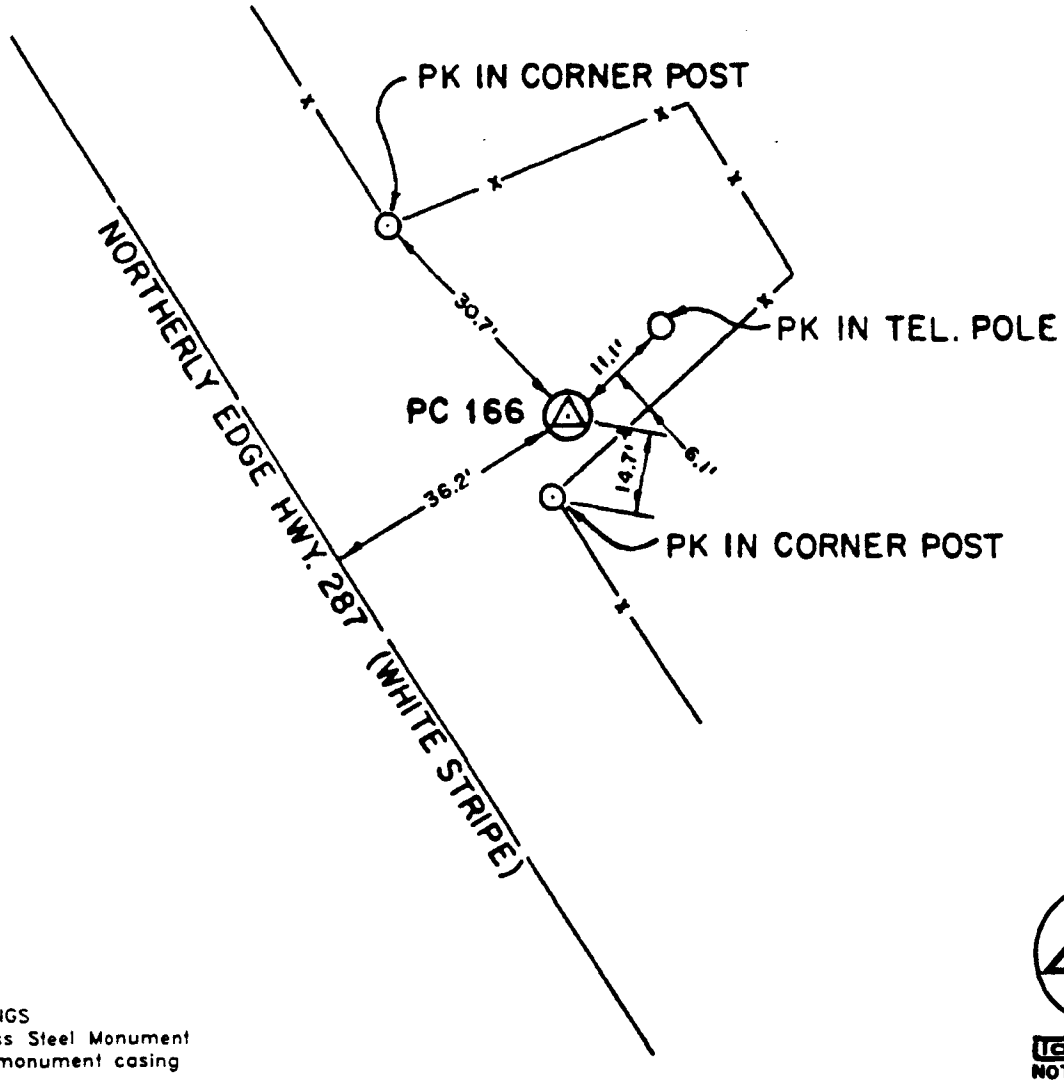
STATION		Point Grid Factor	SHEET
PC 166		0.99990349	1
N (ft) 6847513.616	E (ft) 2455935.537	Elev (ft) 616.967	OF 1

LATITUDE	32°26'32.21950" N
LONGITUDE	96°55'11.66334"W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
MM 007	307°49'51"	2558.316

DESCRIPTION, PLAT.

Northwest of Waxahachie. From the Sardis crossing on Highway 287 go northwesterly for 0.81 miles to the station on the right. The station is in the southerly side of an entrance to a cattle pasture.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

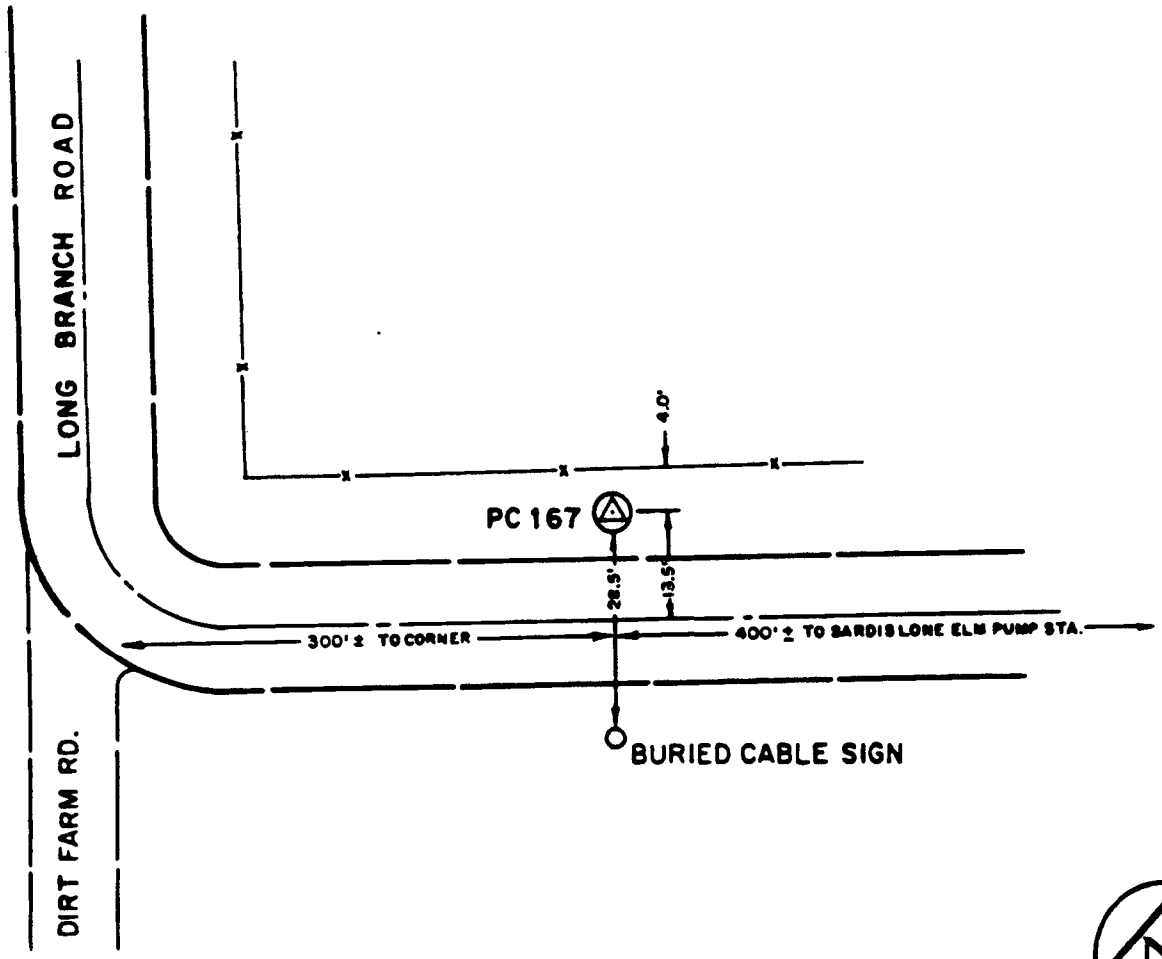
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 167		0.99989810	1
N (ft) 6850978.842	E (ft) 2459850.266	Elev (ft) 693.889	OF 1

LATITUDE	32°27'05.92083" N
LONGITUDE	96°54'25.37258" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 168	350°12'53"	2023.230

DESCRIPTION, PLAT:
Northwest of Waxahachie. To reach from the intersection of FM 664 and FM 1387, go west towards Midlothian 1.13 miles to Long Branch Road to the south, go south on Long Branch Road for 2.40 miles to a bend to the east, go east 300-feet, plus or minus, to the station on the left. The Sardis Lone Elm Pump Station No. 2 is 400-feet, plus or minus, to the east.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc
NOT TO SCALE

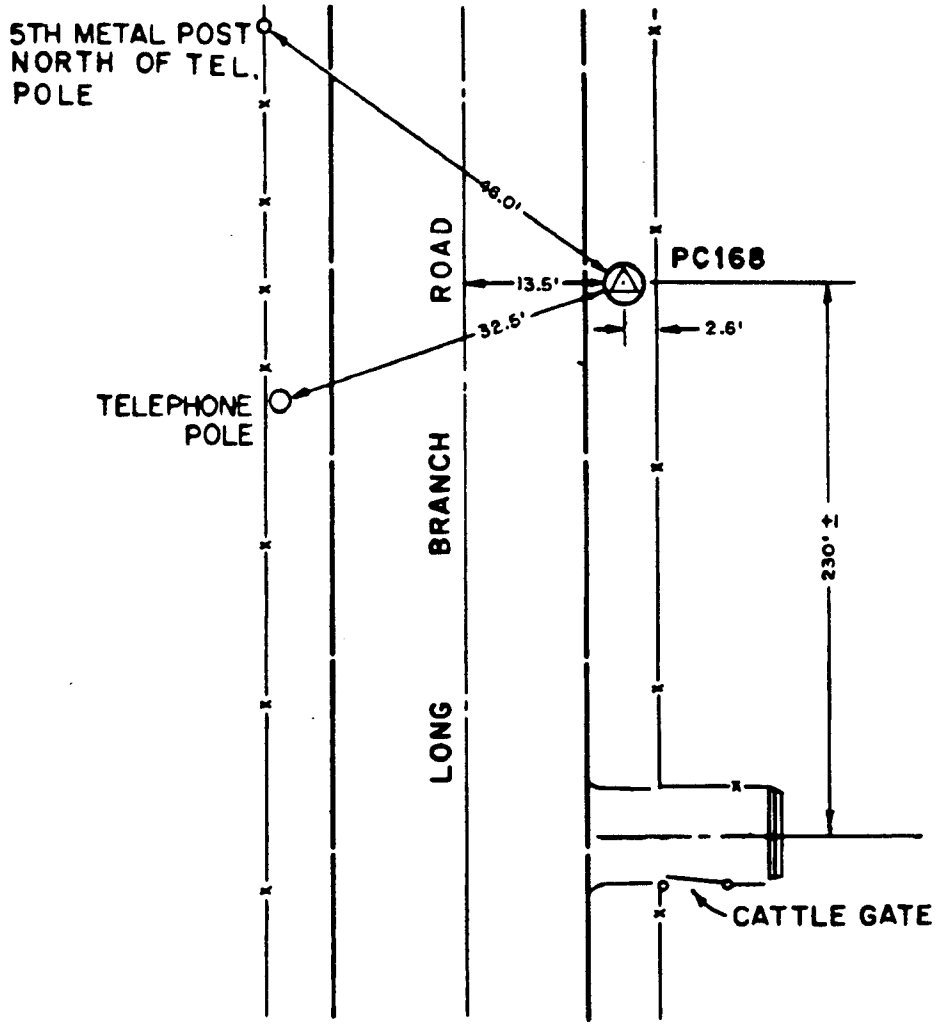
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 168		0.99989682	1
N (ft) 6852972.637	E (ft) 2459506.404	Elev (ft) 699.878	OF 1

LATITUDE	32°27'25.69980" N
LONGITUDE	96°54'29.03265" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 169	359°42'53"	2150.191
PC 167	170°12'53"	2023.230

DESCRIPTION, PLAT:
Northwest of Waxahachie. To reach from the intersection of FM 664 and FM 1387, go west towards Midlothian for 1.13 miles to Long Branch Road to the south, go south on Long Branch Road for 1.09 miles to PC 170 at 19th Avenue, continue south for 0.93 miles to the station of the left.



Legend
Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

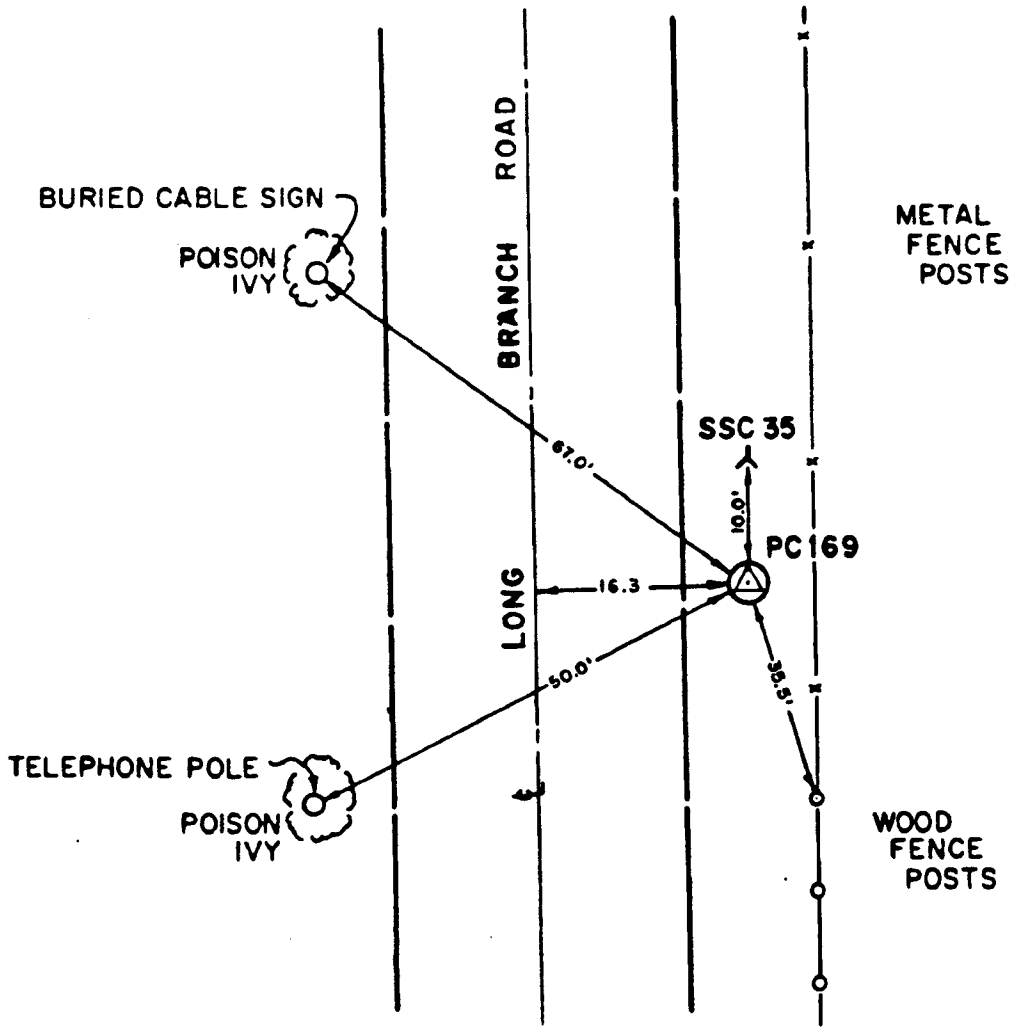
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 169		0.99989500	1
N (ft) 6855122.801	E (ft) 2459495.703	Elev (ft) 715.963	OF 1

LATITUDE	32°27'46.97598" N
LONGITUDE	96°54'28.77724" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 168	179°42'53"	2150.191
PC 170	358°24'08"	2705.782

DESCRIPTION, PLAT:
Northwest of Waxahachie. To reach from the intersection of FM 664 and FM 1387, go west towards Midlothian for 1.13 miles to Long Branch Road to the south, go south on Long Branch Road for 1.09 miles to PC 170 at 19th Avenue, continue south for 0.52 miles to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

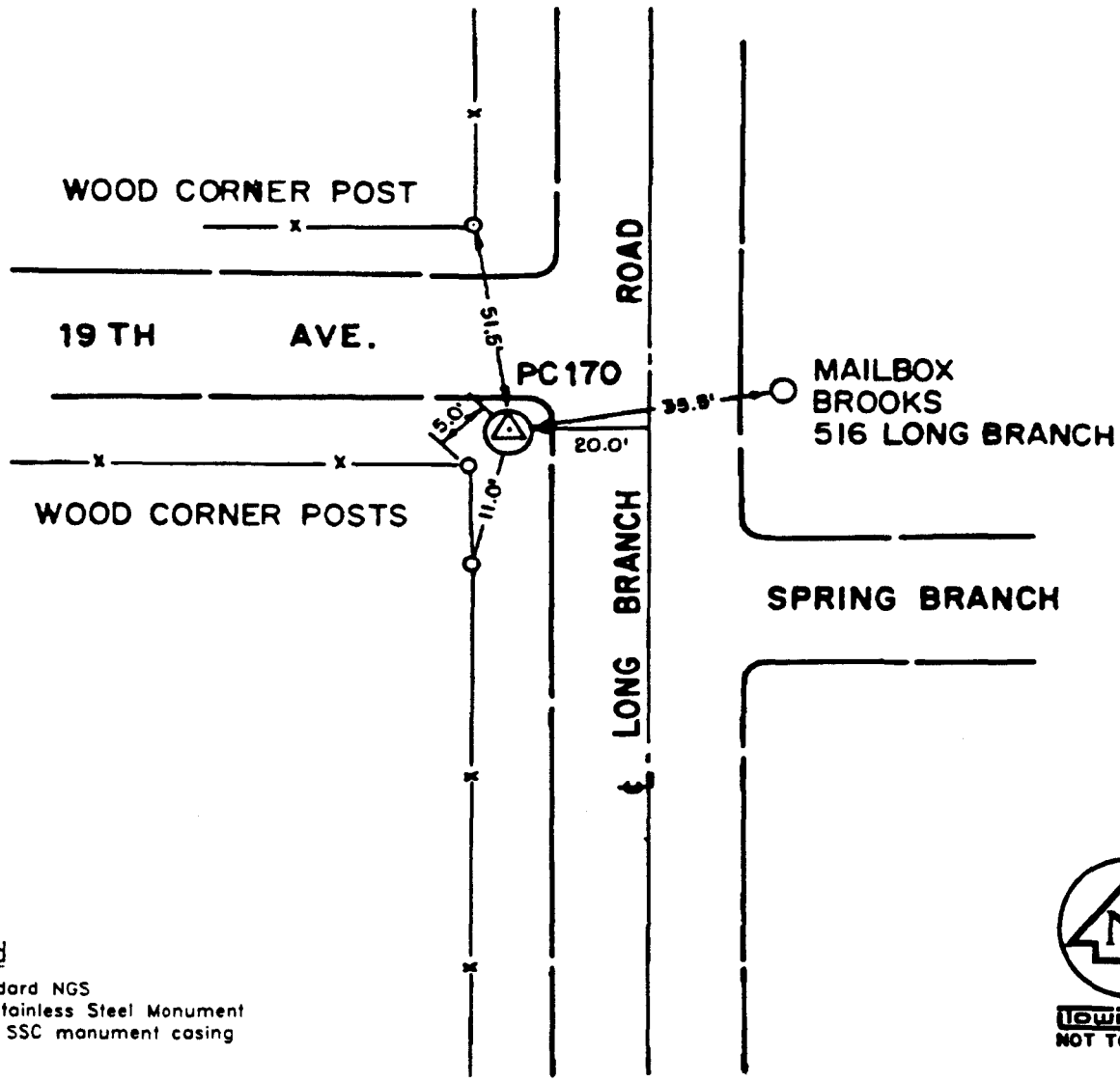
STATION		Point Grid Factor	SHEET
PC 170		0.99989351	1
N (ft) 6857827.531	E (ft) 2459420.256	Elev (ft) 719.593	OF 1

LATITUDE	32°28'13.74896" N
LONGITUDE	96°54'29.17940" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 28	FIRST

STATION	GRID NORTH 6°00'00"	GRID DISTANCE IN FEET
PC 169	178°24'08"	2705.782

DESCRIPTION, PLAT,

Northwest of Waxahachie. To reach from the intersection of FM 664 and FM 1387, go west towards Midlothian for 1.13 miles to Long Branch Road to the south, go south on Long Branch Road for 1.09 miles to 19th Avenue to the west and Spring Branch Road to the east and the station at the southwest corner of 19th Avenue and Long Branch Road.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Howill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

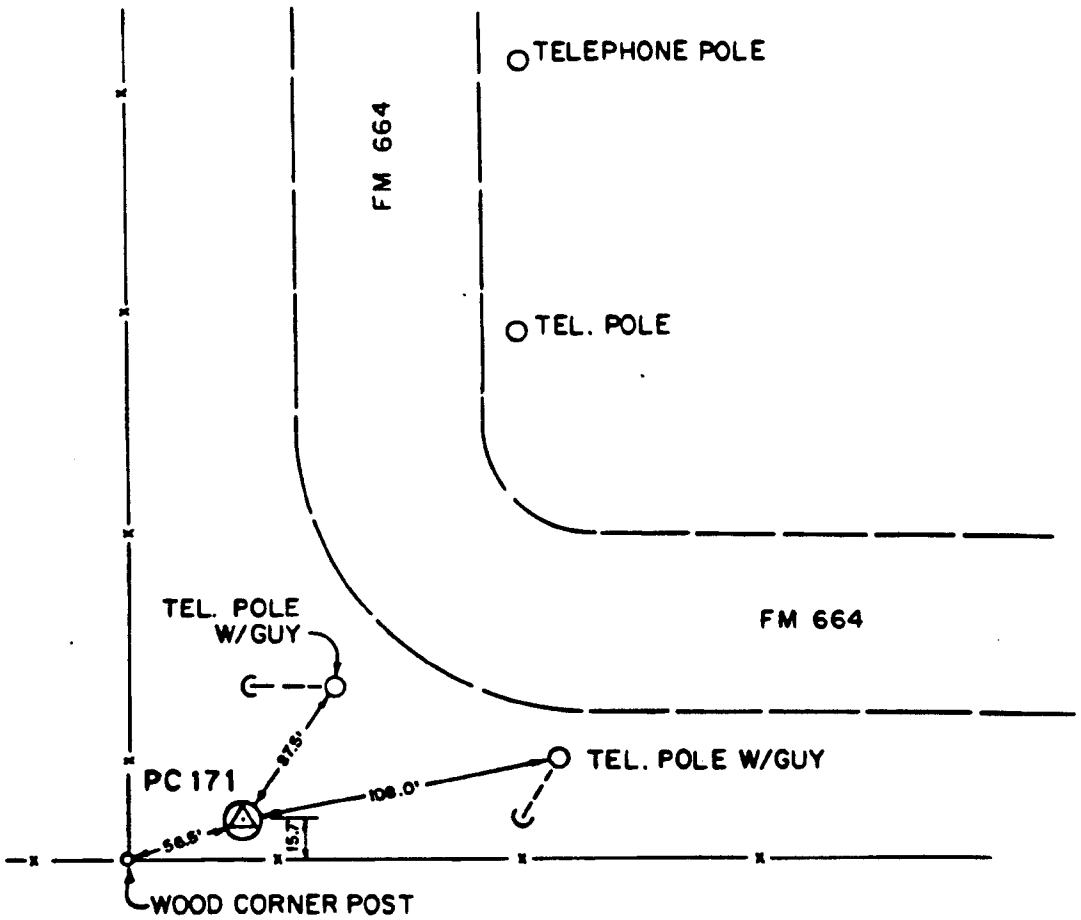
STATION		Point Grid Factor	SHEET
PC 171		0.99989427	1
N (ft) 6857571.851	E (ft) 2467809.149	Elev (ft)	OF 1

LATITUDE	32°28'09.95058" N
LONGITUDE	96°52'51.31195" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 172	357°54'14"	2722.738

DESCRIPTION, PLAT.

South of Ovilla. From the intersection of FM 664 and FM 1387 approximately 3 miles south of Ovilla, go south on FM 664 for 1.90 miles to the fifth 90-degree curve and the station on the right in the back of the right-of-way near the P.I. of the curve.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

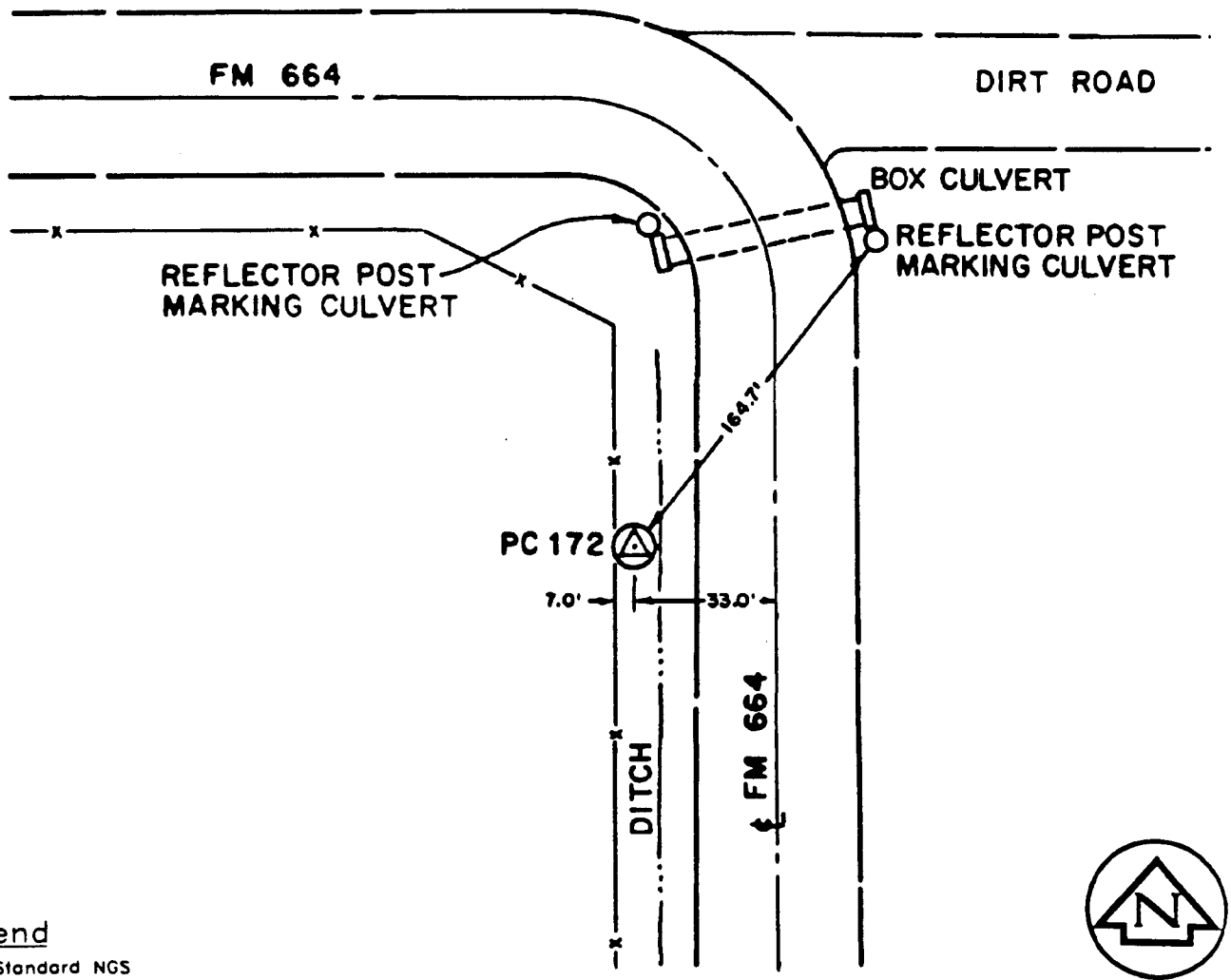
STATION		Point Grid Factor	SHEET
PC 172		0.99989363	1
N (ft) 6860292.767	E (ft) 2467709.567	Elev (ft) 693.484	OF 1

LATITUDE	32°28'36.88748" N
LONGITUDE	96°52'51.98481" W
INDEX SHEET (Quadrangle Sheet)	Midlothian
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 171	177°54'14"	2722.738

DESCRIPTION, PLAT:

South of Ovilla. From the intersection of FM 664 and FM 1387 approximately 3 miles south of Ovilla, go south on FM 664 for 1.36 miles to the fourth 90-degree curve. Continue south on FM 664 another 165-feet to the station on the right.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

BENCH MARKS GOING EAST CONTINUED:

BM Number 534 Elev.= 438.037'

Southeast of Alma. From the intersection of FM 1183 and the Southern Pacific Railroad crossing in Alma, go southeast on the road parallelling and northerly of the railroad tracks for 0.84 miles to a creek crossing and the station on the right. The station is located on the northerly corner of the railroad bridge abutment on the northwesterly side of the creek and 60-feet southwest of the road.

BM Number 535 Elev.= 467.590'

Southeast of Alma. From the intersection of FM 1183 and the Southern Pacific Railroad crossing in Alma, go southeasterly on the road paralleling and northerly of the railroad tracks for 1.98 miles to the station on the left. The station is 15-feet northerly of the road centerline and is in line with two (2) railroad signals and a telegraph pole.

BM Number 536 Elev.= 473.806'

Northwest of Rice. From the most northerly of three railroad crossings in Rice, go northwest on the road parallelling and easterly of the railroad tracks for 1.06 miles to a railroad crossing on the left and the station on the right. The station is 3-feet from a fence line and is centered opposite the railroad crossing.

BM Number 537 Elev.= 462.726'

In Rice. The station is located 5 ft north and 2 ft west of a fence corner in the northeast corner of the intersection formed by the most northerly of three Southern Pacific Railroad crossings, within the town of Rice, and the road paralleling and 60-feet east of the Southern Pacific Railroad tracks in Rice.

BM Number 538 Elev.= 442.554'

Southeast of Rice. From the intersection of Rusk Road and Dallas Road in Rice, go southwest on Rusk Road for 500-feet across the Southern Pacific Railroad tracks to road NW 0140 on the left, go southeast for 0.75 miles to a cattle road and the station on the right. The station is located 2-feet east of a fence and 25-feet north of the road intersection.

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

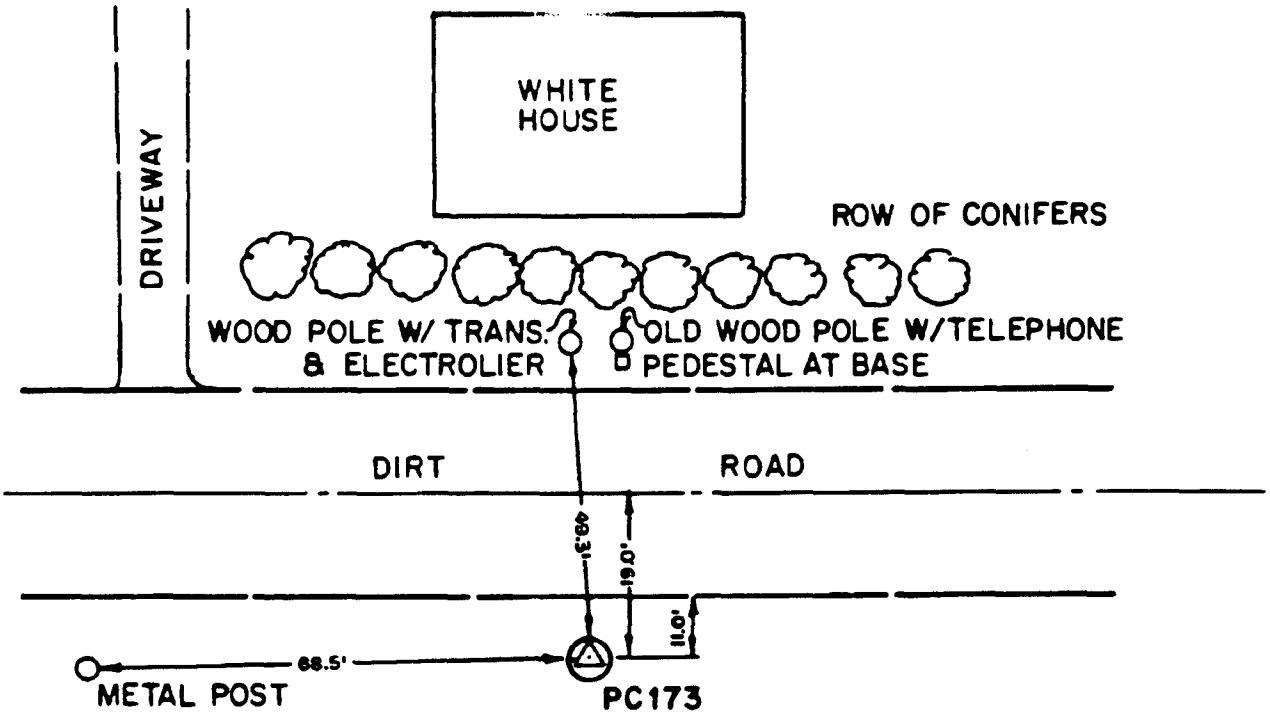
STATION		Point Grid Factor	SHEET
PC 173		0.99989209	1
N (ft) 6861788.716	E (ft) 2470968.194	Elev (ft) 711.141	OF 1

LATITUDE	32°28'51.19040" N
LONGITUDE	96°52'13.67722" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 174	47°51'09"	2267.360

DESCRIPTION, PLAT:

North of Waxahachie. To reach from the intersection of the Sterrett Road over-crossing of Highway I 35 E and the westerly access road paralleling Highway I 35 E, go south for 350-feet to Airport Road; turn right and go west for 0.11 miles; turn right and go north on Airport Road for 0.12 miles to Gun Club Road, also known as Sterrett Road, turn left and go west on Gun Club Road for 1.77 miles to a "T" junction at Patrick Road, turn right and go north on Patrick Road for 0.50 miles to a 125-foot tall white water tank on the left, turn left on the farm road and go west for 0.31 miles to a white house on the right and the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

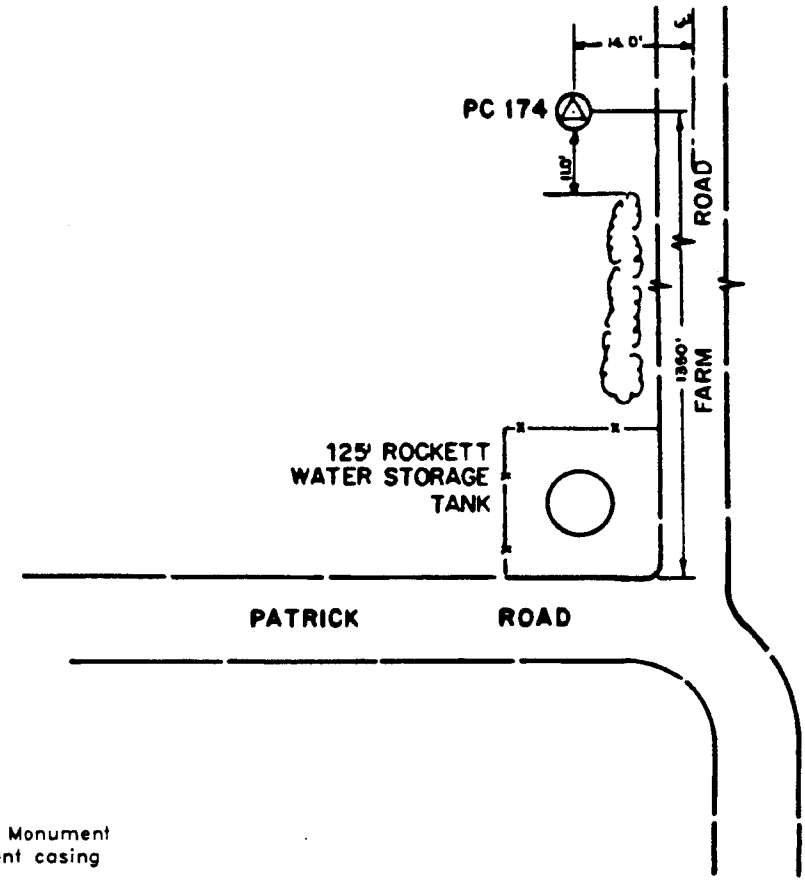
STATION		Point Grid Factor	SHEET
PC 174		0.99989231	1
N (ft) 6863310.207	E (ft) 2472649.261	Elev (ft) 691.792	OF 1

LATITUDE	32°29'05.98609" N
LONGITUDE	96°51'53.77746" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 28	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 173	227°51'09"	2267.360

DESCRIPTION, PLAT:

North of Waxahachie. To reach from the intersection of the Sterrett Road over-crossing of Highway I 35 E and the westerly access road paralleling Highway I 35 E, go south for 350-feet to Airport Road; turn right and go west for 0.11 miles; turn right and go north on Airport Road for 0.12 miles to Gun Club Road, also known as Sterrett Road, turn left and go west on Gun Club Road for 1.77 miles to a "T" junction at Patrick Road, turn right and go north on Patrick Road for 0.50 miles to a left bend, a farm road straight ahead and a 125-foot tall Rockett W.S. tank at the northwest corner. Continue north for 0.25 miles to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc
NOT TO SCALE

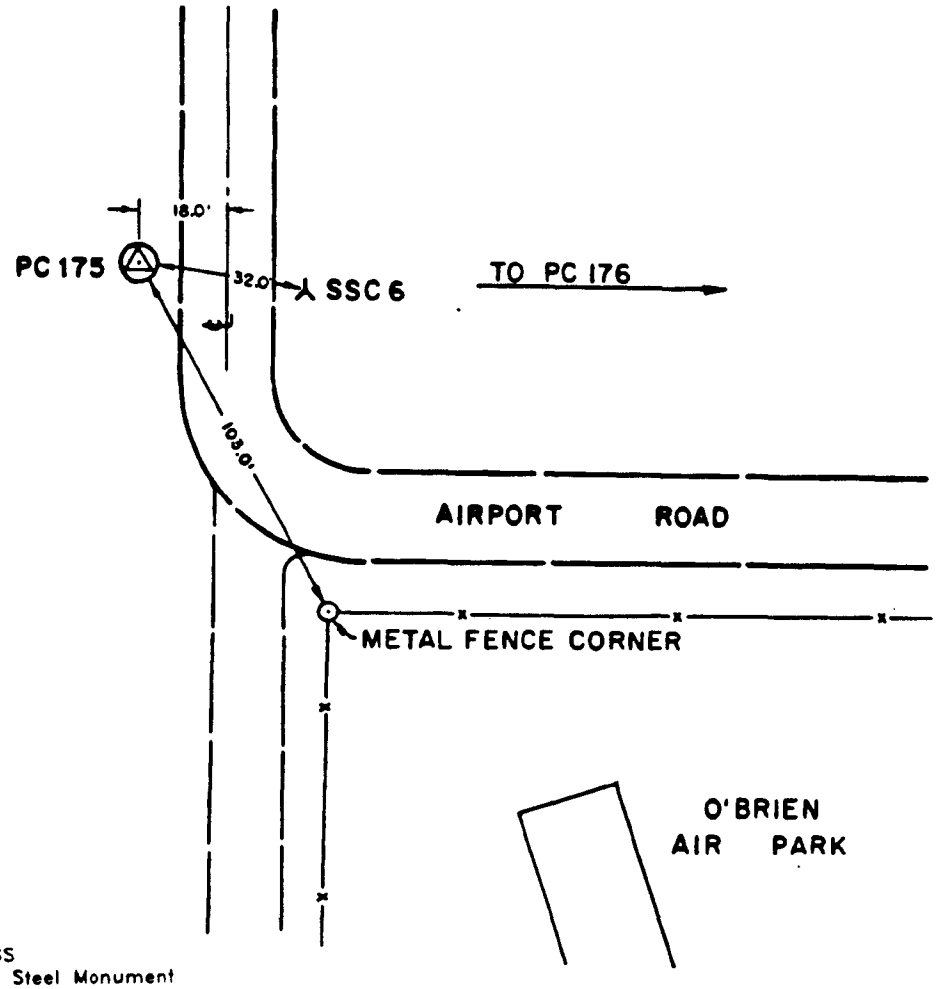
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 175		0.99989342	1
N (ft) 6865280.039	E (ft) 2477869.022	Elev (ft) 649.959	OF 1

LATITUDE	32°29'24.66818" N	STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
LONGITUDE	96°50'52.48219" W	PC 176	88°36'18"	2630.361
INDEX SHEET (Quadrangle Sheet)	Waxahachie			
HORZ NAD 83	Order FIRST	Type GPS		
VERT NGVD 28	FIRST			

DESCRIPTION, PLAT.

North of Waxahachie. To reach from the intersection of the Sterrett Road over-crossing of Highway I 35 E and the westerly access road paralleling Highway I 35 E, go south for 350-feet to Airport Road; turn right and go west for 0.11 miles; turn right and go north on Airport Road for 1.12 miles to a left bend on Airport Road west; turn left and go west along Airport Road for 0.52 miles to a bend to the north, turn right and go north for 100-feet to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

N

Towill, inc

NOT TO SCALE

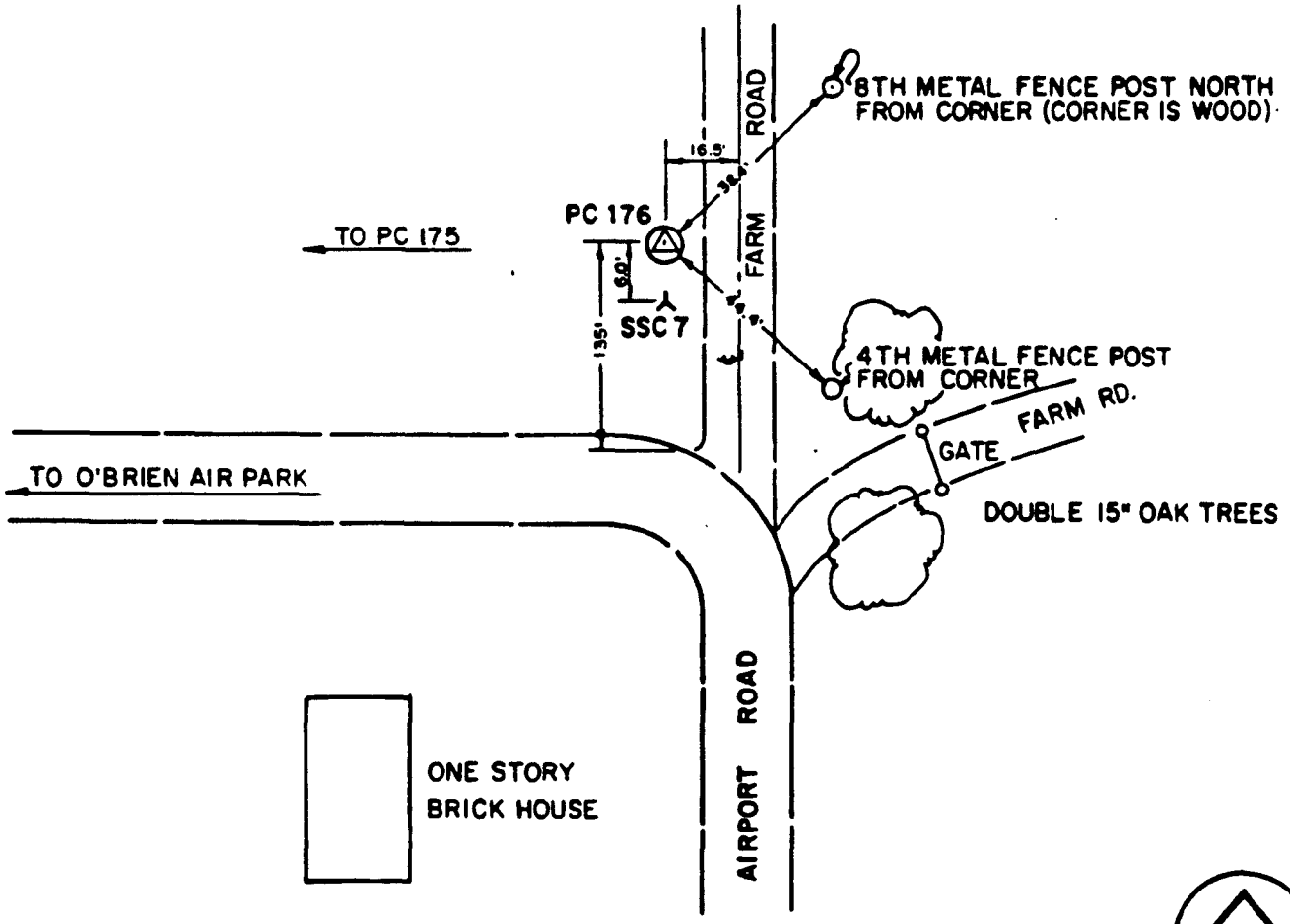
SSC SURVEY MONUMENT RECORD
TEXAS COORDINATE SYSTEM - NORTH CENTRAL ZONE

STATION		Point Grid Factor	SHEET
PC 176		0.99989388	1
N (ft) 6865344.073	E (ft) 2480498.603	Elev (ft) 640.077	OF 1

LATITUDE	32°29'24.89150" N
LONGITUDE	96°50'21.77185" W
INDEX SHEET (Quadrangle Sheet)	Waxahachie
HORZ NAD 83	Order FIRST Type GPS
VERT NGVD 29	FIRST

STATION	GRID NORTH 0°00'00"	GRID DISTANCE IN FEET
PC 175	268°36'18"	2630.361
MM 001	61°38'20"	5568.845

DESCRIPTION, PLAT:
North of Waxahachie. To reach from the intersection of the Sterrett Road over-crossing of Highway I 35 E and the westerly access road paralleling Highway I 35 E, go south for 350-feet to Airport Road; turn right and go west for 0.11 miles; turn right and go north on Airport Road for 1.12 miles where Airport Road turns west; continue north along a farm road for 135-feet to the station on the left.



Legend

Standard NGS 3D Stainless Steel Monument in a SSC monument casing

Towill, inc.
NOT TO SCALE

BENCH MARKS GOING NORTH

BM Number 500 Elev.= 553.931'

Southwesterly of Red Oak. The station is located 200-feet north of the intersection of Highway 342 and Possum Trot Lane in Red Oak. The station is on the west side of Highway 342 approximately 24-feet from the edge of the pavement.

BM Number 501 Elev.= 593.072'

In Red Oak. The station is located on the east side of Highway 342 at the Post Office in Red Oak. The station is 19.5-feet from the edge of the pavement and 50-feet north of Pierce Street.

BM Number 502 Elev.= 606.798'

Northeast of Red Oak. From the Post Office in Red Oak, go northeasterly on Highway 342 for 0.92 miles to the station on the right. The station is located 200-feet, plus or minus, northerly of the entrance to J & L Automotive and is opposite a power pole with a deadman, 16-feet in front of the pole, on the east side of the road. The station is 0.4 miles south of FM 664, also known as Ovilla Road.

BM Number 503 Elev.= 594.627'

Northeast of Red Oak. From the Post Office in Red Oak, go northeasterly on Highway 342 for 1.94 miles to Anderson Street on the right and the station on the left. The station is located on the west side of Highway 342 and the south side of a dirt road leading west. The station is 1-foot north of the northwest corner of a headwall and 22-feet west of the edge of pavement on Highway 342, and 0.6 miles north of FM 664.

BM Number 504 Elev.= 549.033'

Northeast of Red Oak. From the Post Office in Red Oak, go northeasterly on Highway 342 for 2.61 miles to a bridge over Bear Creek and the station on the right. The station is located on the outside of the guard rail in the northeast wingwall of the bridge.

BENCH MARKS GOING NORTH CONTINUED:

BM Number 505 Elev.= 583.042'

Northeast of Red Oak. From the post office in Red Oak, go northeasterly on Highway 342 for 3.57 miles to high tension lines on steel towers and the station under a high tension line on a double pole wooden system north of the steel tower supported lines. The station is on the east side of the road and opposite a pole with two deadman anchors. The station is 27-feet from the edge of pavement and 9-feet west of the pole.

BM Number 506 Elev.= 508.921'

Southwest of Lancaster. From the intersection of Highway 342 and Lancaster-Hutchins Road south of Lancaster, go southwest on Highway 342 for 0.68 miles to Delle Lane and the station on the left. The station is located 65-feet east of the edge of pavement of Highway 342; 23-feet north of the edge of pavement of Delle Lane, and 10-feet north of a service pole anchor.

BM Number 507 Elev.= 474.700'

South of Lancaster. The station is a USGS gaging station brass disk set in the northeast abutment of the Highway 342 bridge over Tenmile Creek, approximately 300-feet south of the intersection of Highway 342 and Lancaster-Hutchins Road.

BM Number 508 Elev.= 489.955'

South of Lancaster. The station is located on the northeast abutment of a bridge over Keller Branch Creek on Lancaster Hutchins Road approximately 200-feet north of State Street and 0.2 miles north of Beltline Road.

BM Number 509 Elev.= 537.767'

East side of Lancaster. The station is located in the northeast corner of the intersection of Lancaster-Hutchins Road and Pleasant Run Road, 2-feet east of a guard rail.

BM Number 510 Elev.= 574.381'

Northeast of Lancaster. From the junction of Pleasant Run and Lancaster-Hutchins Road in northeast Lancaster, go northeast on Lancaster-Hutchins Road for 1.10 miles to Cornell Road and the station on the right. The station is located in the southerly portion of the "Y" intersection formed by the two (2) roads and 2-feet northwest of an electrolier pole.

BENCH MARKS GOING NORTH CONTINUED:

BM Number 511 Elev.= 557.528'

Southwest of Hutchins. From the intersection of Lancaster-Hutchins and Main Street on the north side of Hutchins, go southeast on Lancaster-Hutchins Road 2.00 miles to a road on the right and the station on the left. The station is 7-feet west of a power pole and on the projection of the road centerline leading southwest.

BM Number 512 Elev.= 512.262'

Southwest of Hutchins. From the intersection of Lancaster-Hutchins and Main Street in north Hutchins, go southwest on Lancaster-Hutchins Road for 1.00-miles to a fire hydrant and the station on the left. The station is located near a fence corner and 30-feet from the edge of pavement and 10-feet west of the fire hydrant.

BM Number 513 Elev.= 453.349'

North of Hutchins. The station is located in a triangular divider 6-feet southwest of a power pole, on Lancaster-Hutchins Road at the intersection with Main Street on the north side of Hutchins.

BENCH MARKS GOING EAST

BM Number 525 Elev.= 480.545'

In Ennis. On the west side of Ennis, 200-feet west of the Yorkston and West Ennis Street intersection. On the south side of West Ennis Street, also known as Highway 287 and 25-feet west of the entrance to the "Minute Mart" and 9-feet from the northerly support for the Minute Mart sign.

BM Number 526 Elev.= 534.610'

In Ennis. On West Ennis Street/Highway 287, 300-feet, plus or minus, southwest of the junction of Highway 287 and Highway 437 spur, 20-feet west of the entrance to "Sears" at 707 West Ennis Street, 2-feet south of the curb, and 21-feet northwest of a 40-foot high "Family Dollar" sign.

BM Number 527 Elev.= 497.368'

In Ennis. On Highway 34, 550-feet northeast of Highway 437 spur, on the northeast corner of a concrete culvert headwall over Cummins Creek and 28-feet east of the edge of pavement of Highway 34.

BM Number 528 Elev.= 515.715'

In Ennis. From the intersection of Creechville Road (Creechville Road runs north from a 90° turn to the northwest in Highway 34) and the Southern Pacific Railroad tracks in southeast Ennis, go southeast on Old Alma Road (Old Alma Road is unmarked at this intersection) paralleling and 75-feet south of the Southern Pacific Railroad tracks for 0.26 miles to Industrial Road on the left and the station on the right between a power pole and a deadman.

BM Number 529 Elev.= 490.437'

Southeast of Ennis. From the intersection of Creechville Road (Creechville Road runs north from a 90° turn to the northwest in Highway 34) and the Southern Pacific Railroad tracks in southeast Ennis, go southeast on Old Alma Road (Old Alma Road is unmarked at this intersection) parallelling and 75-feet south of the Southern Pacific Railroad tracks for 1.15 miles to a concrete lift station structure and the station on the right. The station is a standard 3" disk set in the southeast corner of the 2-foot high structure.

BENCH MARKS GOING EAST CONTINUED:

BM Number 530 Elev.= 493.976'

Southeast of Ennis. From the intersection of Creechville Road (Creechville Road runs north from a 90° turn to the northwest in Highway 34) and the Southern Pacific Railroad tracks in southeast Ennis, go southeast on Old Alma Road (Old Alma Road is unmarked at this intersection) paralleling and 75-feet south of the Southern Pacific Railroad tracks for 2.03 miles to Rudd Road. Continue ahead 0.21 miles to a railroad spur crossing and the station on the right. The station is 20-feet north of the spur and 9-feet southwest of the edge of pavement.

BM Number 531 Elev.= 480.503'

Northwest of Alma. From the intersection of FM 1183 and the Southern Pacific Railroad tracks in Alma, go northwesterly on the road paralleling the railroad tracks on the northerly side for 1.16 miles to a "T" intersection. Turn left across the tracks and go northwest on the road paralleling the tracks on the southerly side for 0.35 miles to the station on the left (a point 2.4 ft north of the westerly end of a barbed wire fence running west to east), directly across the road from a concrete base for a removed railroad signal. The station is 1.2 miles southeast of BM 530 and 0.33 miles southeast of railroad mile post 227.

BM Number 532 Elev.= 476.641'

Northwest of Alma. From the intersection of FM 1183 and the Southern Pacific Railroad crossing in Alma, go northwest on the road parallelling and northerly of the railroad tracks for 0.75 miles to a fence intersection and the station on the right. The station is located opposite mile post 226.

BM Number 533 Elev.= 465.068'

Southeast of Alma. From the intersection of FM 1183 and the Southern Pacific Railroad crossing in Alma, go southeast on Old Alma Road, 75-feet northwest and parallel to the railroad for 0.34 miles to a railroad crossing on the right and the station on the left. The station is 30-feet northeast of the road on the extension of the centerline and 400-feet southeast of the railroad mile post 225.

BENCH MARKS GOING SOUTH

BM Number 550 Elev.= 477.238'

South of Forreston. From the intersection of Main Street and Highway 77 in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go South on Highway 77 for 2.13 miles to the station. The station is set in the southeast corner of a bridge.

BM Number 551 Elev.= 545.290'

South of Forreston. From the intersection of Main Street and Highway 77 in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go south on Highway 77 for 3.07 miles to the station. The station is 45-feet west of the centerline of Highway 77 at the extended intersection of a 2-inch white steel fence north and west.

BM Number 552 Elev.= 577.827'

North of Italy. From the intersection of FM 34 and Highway 77 in Italy, go north on Highway 77 for 1.40 miles to the station. The station is 42-feet west of a PK and shiner in the centerline of Highway 77, on the extension of a 6-foot chain link fence on the east side of the road; the fence is running in a northeasterly direction.

BM Number 553 Elev.= 554.076'

In Italy. From the intersection of FM 34 and Highway 77, go north on Highway 77 for 0.31 miles to the station. The station is on the northwest wingwall of the bridge over Houston Creek.

BM Number 554 Elev.= 598.320'

South of Italy. From the intersection of FM 34 and Highway 77, go south on Highway 77 for 0.70 miles to the station on the right. The station is 3-feet north of a highway right-of-way post at the remnants of an old fence corner and 185-feet south of a white wood frame house.

BM Number 555 Elev.= 583.895'

South of Italy. From the intersection of FM 34 and Highway 77, go south on Highway 77 for 1.46 miles to the station. The station is on the southwest headwall of the bridge over Hog Creek.

BENCH MARKS GOING SOUTH CONTINUED:

BM Number 556 Elev.= 627.910'

South of Italy. From the intersection of FM 34 and Highway 77, go south on Highway 77 for 2.45 miles to the station. The station is 33.5-feet west of the centerline of road, 3-feet from the fence on the westerly extension of the north face of CO-OP Fertilizer Headquarters Building on the east side of Highway 77.

BM Number 557 Elev.= 628.154'

South of Italy. From the intersection of FM 34 and Highway 77, go south on Highway 77 for 3.40 miles to the station. The station is at the northwest corner of the intersection with Dale Acres Road; 33.5-feet west of the centerline of Highway 77, and 67-feet north of the Dale Acres Road/Highway 77 sign/stop sign.

BM Number 558 Elev.= 576.718'

North of Milford. From the intersection of FM 308 north and Highway 77, go south on Highway 77 for 0.27 miles to the station. The station is on the southeast headwall of the bridge over Mill Creek.

BM Number 559 Elev.= 623.476'

In Milford. At the southwest corner of Dickson and South Main, opposite the entrance to 400 Dickson. The station is 17-feet west of the edge of pavement, 4-feet east of the sidewalk on the extension of the south EP of FM 308 to the southeast and 30-feet north of a fire hydrant.

BM Number 560 Elev.= 644.064'

South of Milford. From the intersection of FM 308 to the southeast, and Highway 77 in Milford, go south on Highway 77 for 0.89 miles to the station on the right. The station is 3-feet easterly of a fence corner post on the easterly extension of a property line a fence to the west.

BM Number 561 Elev.= 626.541'

South of Milford. From the intersection of FM 308 to the southeast, and Highway 77 in Milford, go south on Highway 77 for 1.90 miles to the station. The station is on the south end of the west headwall of a creek crossing and 0.95 miles north of FM 1243.

BENCH MARKS GOING SOUTH CONTINUED:

BM Number 562 Elev.= 711.289'

South of Milford. From the intersection of FM 1243 and Highway 77, located 2.9 miles south of Milford, go east 0.35 miles on FM 1243 to the station. The station is 27-feet south of the south EP opposite a gate to the property to the north.

BM Number 563 Elev.= 655.552'

South of Milford. From the intersection of FM 1243 and Highway 77, located 2.9 miles south of Milford, go east 1.41 miles on FM 1243 to the station on the right. The station is 26-feet south of the south EP on the southerly extension of the centerline of a gated farm road to the north and 12-feet east of the southerly extension of a property line fence and 0.25 miles southeast of a railroad crossing.

BENCH MARKS GOING WEST

BM Number 575 Elev.= 647.173'

East-southeast of Midlothian. From the intersection of Highway 287 and the Atchison Topeka and Santa Fe Railroad in Midlothian, go east along Highway 287 for 3.75 miles to the station. The station is 28-feet northeast of the northeast EP and 75 ft, more or less, east of a petroleum pipeline valve station marked "U11".

BM Number 576 Elev.= 671.647'

East-southeast of Midlothian. From the intersection of Highway 287 and the Atchison Topeka and Santa Fe Railroad in Midlothian, go east along Highway 287 for 2.72 miles to the station. The station is 10-feet northeast of the northeast EP and 110-feet northwest of a driveway to the Ellis County Paint and Body Shop, in the east corner of a headwall.

BM Number 577 Elev.= 676.402'

East-southeast of Midlothian. From the intersection of Highway 287 and the Atchison Topeka and Santa Fe Railroad in Midlothian, go east along Highway 287 for 1.83 miles to the station. The station is 37.5-feet north of the north EP; 42.5-feet north-northwest of a stop sign for a county maintenance yard and 50-feet northeast the east end of a guard rail on the north side of Highway 287.

BM Number 578 Elev.= 741.167'

In Midlothian. The station is in the center of a headwall on the south side of George Hopper Road at the east entrance to Midlothian Middle School.

BM Number 579 Elev.= 758.608'

In Midlothian. The station is at the northeast corner of Fifth Street and Walter Stephensen Road, in the east end of a headwall.

BM Number 580 Elev.= 687.108'

Southwest of Midlothian. From the intersection of Highway 287 and Business 67 south (5th Street) in Midlothian, go south and west along Business 67 south for 0.92 miles. The station is on the north side of Business 67 south, 130-feet east of a sign that reads Venus 6, Cleburne 25, 47-feet north of the centerline of road and 1-foot south of a right-of-way marker.

BENCH MARKS GOING WEST CONTINUED:

BM Number 581 Elev.= 665.802'

Southwest of Midlothian. From the intersection of Highway 287 and Business 67 south in Midlothian, go south and west along Business 67 south for 2.05 miles to the station. The station is on the northeast wingwall of a bridge over a small creek, 700-feet east of Ward Road.

BM Number 582 Elev.= 645.268'

Southwest of Midlothian. From the intersection of Highway 287 and Business 67 south in Midlothian, go south and west along Business 67 south and Highway 67 for 3.00 miles to the station on the right. The station is 250-feet northeast of a sign that reads Ward Spur, 50-feet north of the north EP of Highway 67, 25-feet east of a farm road to the north, 6-feet south of a fence corner on the extension of a north running fence and 5-feet from a right-of-way marker.

BM Number 583 Elev.= 622.648'

Southwest of Midlothian. From the intersection of Highway 287 and Business 67 south in Midlothian, go south and west along Business 67 south and Highway 67 for 4.02 miles to the station. The station is 42-feet north of the north EP of Highway 67 at the northeast corner of Highway 67 and Weatherford Road; 32.5-feet northwest of a sign that reads "Weatherford Road" and 22.5-feet east of the centerline of Weatherford Road.

BM Number 584 Elev.= 611.792'

Northeast of Venus. From the intersection of Highway 67 and FM 157 in Venus, go northeast 2.24 miles to Soap Creek and the station. The station is in the southwest abutment of the bridge over Soap Creek.

BM Number 585 Elev.= 620.216'

Northeast of Venus. From the intersection of Highway 67 and FM 157 in Venus, go northeast 1.07 miles to the Johnson County - Ellis County line and the station. The station is 23-feet north of the north EP of Highway 67 and 3-feet south of a service pole.

BM Number 586 Elev.= 658.259'

In Venus. At the southeast corner of Highway 67 and FM 157. That station is 2-feet northwest of a concrete drain, 12-feet west of a guy pole and 15-feet west-southwest of a yield sign.

BENCH MARKS GOING WEST CONTINUED:

BM Number 587 Elev.= 672.742'

West of Venus. From the intersection of Highway 67 and FM 157 in Venus, go west along Highway 67 for 0.99 miles to the station. The station is 39-feet north of the north EP of Highway 67 and 25-feet east of the centerline of the entrance to Brigadier Homes and 3-feet south of the right-of-way fence.

BM Number 588 Elev.= 689.406'

West of Venus. From the intersection of Highway 67 and FM 157 in Venus, go west along Highway 67 for 2.00 miles to the station. The station is on the southwest abutment of a bridge over a small creek.

BENCH MARKS ACROSS THE CENTER FROM SOUTH TO NORTH

BM Number 600 Elev.= 548.238'

North of Forreston. From the intersection of Highway 77 and Main Street in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go north along Highway 77 for 0.52 miles to the station. The station is in the center of the northeast wingwall of a box culvert on a small creek.

BM Number 601 Elev.= 592.217'

North of Forreston. From the intersection of Highway 77 and Main Street in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go north along Highway 77 for 1.61 miles to the station on the right. The station is 2-feet west of a highway right-of-way marker.

BM Number 602 Elev.= 591.820'

North of Forreston. From the intersection of Highway 77 and Main Street in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go north along Highway 77 for 2.65 miles to the station on the right. The station is 35-feet east of the east EP of Highway 77, 56 feet north-northeast of a 30-inch Pecan tree, 2-feet from the right-of-way and 75-feet north of the intersection of Roebuck Road and Highway 77.

BM Number 603 Elev.= 592.171'

North of Forreston. From the intersection of Highway 77 and Main Street in Forreston, which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go north along Highway 77 for 3.64 miles to the station. The station is at the south corner of a 20-foot headwall on the west side of Highway 77; 0.35 miles south of Butler Lane and at the northeast end of Jerry's Auto Yard.

BM Number 604 Elev.= 608.240'

North of Forreston. From the intersection of Highway 77 and Main Street in Forreston which is located 0.12 miles south of the intersection of Highway 77 and FM 329, go north along Highway 77 for 4.56 miles to the station. The station is at the south corner of a 14-foot headwall on the west side of Highway 77; 0.58 miles north of Butler Lane and 0.30 miles South of FM 55 to the east.

BENCH MARKS ACROSS THE CENTER FROM SOUTH TO NORTH CONTINUED:

BM Number 605 Elev.= 586.725'

South of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go south along Highway 77 for 3.50 miles to the station. The station is 35-feet west of Highway 77; 3-feet east of a right-of-way fence south produced northerly and 50-feet north of a paved road continuing to the west that goes under Highway I 35 E.

BM Number 606 Elev.= 565.230'

South of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go south along Highway 77 for 2.53 miles to the station on the left. The station is 41-feet east of the EP, 7.5-feet from the right-of-way fence and 15-feet southeast of a telephone pole.

BM Number 607 Elev.= 601.799'

South of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go south along Highway 77 for 1.48 miles to the station. The station is at the on-ramp of I 35 E, 4.8-feet west of junction I 35 E sign and 9-feet from the EP.

BM Number 608 Elev.= 550.425'

South of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go south along Highway 77 for 0.38 miles to the station. The station is a standard USC and GS bench mark stamped B-389, 1946, 1-foot north and 0.5-feet east of the southwest corner of a bridge over Waxahachie Creek and the Missouri Kansas Texas Railroad.

BENCH MARKS ACROSS THE CENTER FROM SOUTH TO NORTH CONTINUED:

BM Number 609 Elev.= 556.014'

In Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 0.16 miles to the station. The station is in an island at the southwest corner of Highway 77 and Monroe Street; 50-feet north of the Southern Pacific Railroad tracks and 2-feet southwest of a concrete curb on a curve.

BM Number 610 Elev.= 614.070'

In Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 1.08 miles to the station. The station is in an island at the southerly corner of Highway 77 and Bryson Street; 2-feet south of a concrete curb on a curve and 4-feet east of an electrolier pole.

BM Number 611 Elev.= 620.578'

In Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 2.06 miles to the station. The station is north of the north entrance to Waxahachie High School, 15-feet from a right-of-way post, 14-feet from a telephone pole, and 10-feet from a catch basin.

BM Number 612 Elev.= 620.199'

North of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 2.99 miles to the station. The station is 60-feet north of YMCA Road in the south corner of the east headwall over Mustang Creek.

BM Number 613 Elev.= 623.137'

North of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 3.97 miles to the station. The station is 3-feet east of the west right-of-way fence and 50-feet south and across Highway 77 from the southwest corner of the Houston Hill Pump Station property line fence.

BENCH MARKS ACROSS THE CENTER FROM SOUTH TO NORTH CONTINUED:

BM Number 614 Elev.= 604.357'

North of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 4.70 miles to the station. The station is in the center of the northeast abutment of the bridge over South Grove Creek.

BM Number 615 Elev.= 606.342'

North of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 5.36 miles to the station. The station is in the center of the northeast abutment of the bridge over North Grove Creek.

BM Number 616 Elev.= 618.932'

North of Waxahachie. From the intersection of Highway 77 - Ferris Street and Business Route 287 - Main Street in Waxahachie, go north along Highway 77 for 6.52 miles to the station. The station is in the center of the northeast abutment of the bridge over the Sanger Branch of Red Oak Creek and 0.84 miles south of the "Y" at FM 342.

BENCH MARKS ACROSS THE CENTER FROM EAST TO WEST

BM Number 650 Elev.= 450.415'

West of Ennis. From the intersection of Highway 287 and Business 45 in Ennis at the intersection of Kaufmann and East Ennis Street, go southwest on Highway 287 (East Ennis Street) for 1.98 miles to the start of a divided highway. Continue west for 1.96 miles to the west side of a bridge over Mustang Creek and the station on the left. The station is set in the top of the southwest wingwall on the westerly abutment of the westbound lanes.

BM Number 651 Elev.= 505.843'

West of Ennis. The station is located approximately 5 miles west of Ennis on Highway 287 at the Texas Motorplex. The station is 6.5-feet south of a right-of-way post and 70-feet, plus or minus, east-southeast of the 60-foot high Texas Motorplex sign on the north side of the highway.

BM Number 652 Elev.= 490.512'

West of Ennis. From the intersection of Old Boyce Road and Highway 287 located 900-feet west of the 60-foot high Texas Motorplex sign on Highway 287, approximately 5 miles west of Ennis, go west on Highway 287 for 0.45 miles to the station on the northeast corner of a headwall.

BM Number 653 Elev.= 492.406'

West of Ennis. From the intersection of Old Boyce Road and Highway 287 located 900-feet west of the 60-foot high Texas Motorplex sign on Highway 287, approximately 5-miles west of Ennis, go west on Highway 287 for 1.31 miles to a bridge and the station located on the northeast corner of the west bound lane abutment.

BM Number 654 Elev.= 507.607'

At Reagor Springs. From the intersection of Old Boyce Road and Highway 287 located 900-feet west of the 60-foot high sign at the Texas Motorplex on Highway 287, approximately 5-miles west of Ennis, go west on Highway 287 for 2.34 miles to the station, 100-feet southeast of the intersection of an un-named road to the south of Highway 287 (this same road on the north of Highway 287 is called Old Church Road), 35-feet southwest of the EP and 8-feet northeast of the right-of-way.

BENCH MARKS ACROSS THE CENTER FROM EAST TO WEST CONTINUED:

BM Number 655 Elev.= 495.746'

At Reagor Springs. From the intersection of the paved road located 900-feet west of the 60-foot high Texas Motorplex sign on Highway 287, approximately 5 miles west of Ennis, go west on Highway 287 for 3.27 miles to Parks School House Road. Continue west for 175-feet to a large box culvert on the right. The station is located in the east end of the northerly headwall.

BM Number 656 Elev.= 499.009'

Northwest of Reagor Springs. From the intersection of the paved road located 900-feet west of the 60-foot high Texas Motorplex sign on Highway 287, approximately 5 miles west of Ennis, go west on Highway 287 for 4.22 miles to a paved cross over and the station on the right. The station is located in the northerly headwall of a box culvert, at the west end, 22-feet north of the shoulder and 33-feet north of the white stripe.

BM Number 657 Elev.= 550.756'

Southeast of Waxahachie. From the courthouse in Waxahachie, go southeast on Main Street for 2.09 miles to the top of a hill and the station on the left. The station is located east of a dirt driveway heading to an equipment storage yard, 21-feet from the EP, 4-feet from the fence, and 11-feet from the angle point in the fence where it leads into the driveway.

BM Number 658 Elev.= 562.084'

In Waxahachie. The station is located 1.32 miles southeast of the courthouse in Waxahachie on the northerly side of Business 287, 25-feet plus or minus, southeast of the southeast corner of an abandoned grocery store, 16-feet northerly of the northerly EP and 4.5-feet from a silver metal pole.

BM Number 659 Elev.= 531.895'

In Waxahachie. The station is located at the easterly corner of the intersection of Wyatt and Main Streets (Main = Business 287). The station is 9.8-feet southeast of the southeasterly edge of Wyatt, 9.4-feet northeast of the northeasterly edge of Main and 2.9-feet northerly of a power pole.

BENCH MARKS ACROSS THE CENTER FROM EAST TO WEST CONTINUED:

BM Number 660 Elev.= 562.769'

In Waxahachie. From the junction of Highway 77 and Business 287 in Waxahachie, go northwest on Business 287 for 0.82 miles to a railroad crossing and the station on the left. The station is located in the headwall of a large box culvert on the southwest side of Business 287 and west of the railroad tracks by a railroad signal box.

BM Number 661 Elev.= 566.211'

In Waxahachie. From the junction of Highway 77 and Business 287 in Waxahachie, go northwest on Business 287 for 1.74 miles to a railroad bridge overhead and the station on the southwesterly abutment approximately 20-feet higher than the road.

BM Number 662 Elev.= 582.174'

Northwest of Waxahachie. From the junction of Highway 77 and Business 287 in Waxahachie, go northwest on Business 287 for 2.70 miles to a fence corner, power pole and right-of-way post on the right. The station is located 15-feet from the edge of pavement on the northerly side of the road by the right-of-way post and is approximately 200-feet northwest of the entrance to a trailer park.

BM Number 663 Elev.= 576.748'

Northwest of Waxahachie. From the junction of Highway 77 and Business 287 in Waxahachie, go northwest on Business 287 for 3.05 miles. The station is located approximately 200-feet southeast of the intersection of FM 875 and Business 287 on the northwest corner of the abutment of a bridge on Business 287 over Irving Branch Creek, approximately 3.3 miles from the courthouse in Waxahachie.

BM Number 664 Elev.= 592.584'

Northwest of Waxahachie. From the junction of FM 875 and Business 287 northwest of Waxahachie, go northwest on Business 287 for 0.68 miles to the station on the right. The station is located in a headwall on the northerly side of the road.

APPENDIX H

ANALYSIS OF SSC GEODETIC NETWORKS

Analysis of SSC Geodetic Networks

by
Alfred Leick
University of Maine
January, 1991

1. Introduction

In preparation for the construction of the Superconducting Super Collider (SSC), several geodetic networks were established using GPS and conventional leveling. The specifications call for two GPS networks, i.e. a Master Control Network adhering to FGCC specifications for Order B and a Primary Control Network following FGCC specifications for Order C (Class 1). The vertical references are to be established through conventional leveling following the rigorous NGS specifications for Class 1 leveling (first order). Both the GPS networks and the leveling network were observed by and adjusted at Towill, Inc. of San Francisco, California.

The purpose of this study is to provide quality control for Towill's adjustments, to analyze the adjustments, to combine GPS and leveling data, and to carry out an initial geoid study using gravimetric geoid undulations provided by Prof. Carlos Aiken from the University of Texas at Dallas. The MainePac program developed at the University of Maine is used for this analysis. The respective computer output files are submitted with this report and are referenced in this text (brackets []). Numeric station identifiers are used which are identical to those used by Towill, with the exception of V293(=999) and PRONG(=888).

2. Leveling Adjustment

In order to independently verify the level data, the adjustment of the level network was repeated with MainePac. The input for this adjustment includes the raw observations (differences in level rod reading). Correction for gravity and for tides, which are required for first order leveling, is not yet applied. The latter corrections will be applied in a separate adjustment carried out at NGS.

2.1 Minimal Constraint Solution

The minimal constraint adjustment contains 178 observations and 175 stations. The stochastic model is Sig[mm] = 4 SQRT(S[km]). The project reference bench mark USGS 389 was held fixed to the published orthometric height H=167.770 m.

The a-posteriori variance of unit weight is 0.22. If the standard deviations of the observations were computed by the model Sig[mm] = 1.9 SQRT(S[km]), then an a-posteriori variance of unit weight equal to 1 would result. No observations are flagged by the automatic blunder detection procedure. See computer file [LEVSOL.1]. This solution contains the corrected observations for line 153-156=2.35970 m, line 999(V293)-586=4.6075 m, and line 6-156=3.3498 m which were provided by Towill December 26, 1990. These corrected observations decrease the a-posteriori variance of unit weight from 0.51 to 0.22. The differences of approximate and adjusted coordinates, which are listed at

the end of the file [LEVSOL.1], show how the adjusted heights have changed due to these corrections. (The adjusted heights of the old solution were used as approximate parameters in the current solution). Note that the lines 999-586 and 6-156 are spur lines, i.e. they are not part of a loop, and thus have no impact on other stations.

The standard deviations for the adjusted heights are all smaller than 1 cm. Using variance - covariance propagation, the standard deviations of the adjusted height differences for the 67 km line from Station 12 to 14 (east - west) and the 60 km line from Station 11 to 563 (north - south,) are 0.015 m and 0.015 m respectively.

There are 77 uncontrolled observations as indicated by a zero redundancy number. See computer file [LEVSOL.1A]. The observations which are controlled show an internal reliability of 7-13 cm (delta factor = 4, probability of Type I error = 0.001, probability of type II error = 0.20).

This minimal constraint solution was carried out by Towill, Inc. as well. Towill's adjusted heights were reproduced exactly with MainePac. This is, of course, to be expected, because of the simplicity of the linear mathematical model and the same stochastic model used in both adjustments.

2.2 Over Constraint Solution

Towill provided four additional height references making external comparison possible.The values are given as (published, LEVSOL.1, difference): USGS 386 (114.525, 114.560, -25 mm), USGS 957 (146.838, 146.828, 10 mm), USGS W293(293) (187.624, 187.584, 40 mm), USGS V293(999) (205.263, 205.245, 18 mm). In the over constraint solution [LEVSOL.2], the published heights are held fixed. The a-posteriori variance of unit weight increases to 2.34, clearly indicating that the observations are not compatible with the constraints. Even for this over constraint solution, there are still 33 uncontrolled observations in the level network. See computer file [LEVSOL.2A].

2.3 Comments on the Leveling

As mentioned above the final adjustment of the leveling network will be carried out at NGS, taking all reductions (gravity, tides, etc) into consideration. The design of the leveling network is somewhat deficient, at least from the least squares point of view. There is a degree of freedom of only 4 which makes statistical analysis and blunder detection rather uncertain. It would be desirable to create three additional loops by observing, for example, the connections 8-111, 654-134, and 154-607. Also, it must be noted that absolutely no quality control is possible in those 33 segments having zero redundancy numbers.

3. GPS Vector Adjustments

The MainePac program uses a non-linear mathematical model for the combined adjustment of terrestrial and GPS vector observations. In the case of a non-linear mathematical model, initial approximate values are required for the parameters (station coordinates). The adjusted latitudes and longitudes obtained by Towill from their GPS vector adjustment are used to define the approximate horizontal position coordinates. Thus, any corrections to these approximate positions indicate disagreement with Towill's solution. The

"approximate heights" are obtained by translating the adjusted heights of the minimal constraint level network solution such that Station 8 is assigned the value of h(8)=140.041 m [LEVSOL.3]. This is precisely the ellipsoidal height for this station. Thus, the approximate height parameter values represent "translated orthometric heights" which describe the local (translated) geoid, on the one hand, and serve as approximate ellipsoidal heights for MainePac on the other hand. The corrections to these approximate heights, which are computed as part of the GPS vector adjustment, represent the difference between the ellipsoid and the geoid, centered to Station 8.

No distinction is made between trivial and non-trivial baselines. All baselines provided by Towill are used in the adjustments with MainePac. Trivial baselines are typically generated if more than two receivers observe during a session the same satellites at the same time and, in the subsequent vector adjustment, the correlations between the vectors are neglected. For example, if three receivers observe during a session, only two independent baselines are possible. The third baseline is dependent and is called a trivial baseline. The effect of trivial baselines is to reduce the value of the a-posteriori variance of unit weight. No other negative side effects are expected from the inclusion of trivial baselines. The proper method would be to use the full variance-covariance matrix of the session (session solution).

3.1 GPS Vector Adjustment of the Master Control Stations

The Order B network was adjusted at Towill using the session mode, i.e. the Trimvec program was used to generate a full variance-covariance matrix between the vectors of the same session. For the present computations with MainePac, the 3x3 variance-covariance matrices components were extracted from the OPT files provided by Towill, i.e. the GPS vectors are considered stochastically independent. An initial solution indicates that a scale factor of 100 is required to scale these variance-covariance submatrices to yield an a-posteriori variance of unit weight of 1. Such a scaling is expected because the correlations between the vectors are neglected.

The minimal constraint adjustment of the Order B network consists of 255 observations (=75 vectors) and 11 stations. The coordinates of Station 8 are held fixed. See computer file [GPSSOL.1]. The a-posteriori variance of unit weight is 0.99 using the scaled variance covariance submatrices. The automatic blunder detection procedure flagged vector 5-12; a residual in height of 70 mm is obtained for this particular vector. The de-weighting of this vector reduces the a-priori variance of unit weight to 0.81.

It is interesting to note that the latitudes and longitudes provided by Towill are reproduced precisely (only 2 coordinates differed by 1 mm), despite the fact that the correlations between the vectors were neglected. It is also well known that GPS gives horizontal positions more accurately than vertical positions. This fact is readily seen from the northing, easting and height residuals listed in Table 1. The residuals in the height component are larger than those in the horizontal components.

The standard deviations of the adjusted station coordinates are in the millimeter range. The high quality of this network is further confirmed by computing the standard deviations for the spatial distances and height differences for all adjusted vectors using variance covariance propagation. It is found that the standard deviations for the spatial distances are less than 2 mm; this includes the long line from Station 12 to Station 14. The height differences have standard deviations of 5 - 7 mm. The standard deviations were computed for each observed vector. The computed values were compared with FGCC specifications of Order B. See Appendix I for a detailed listing; the values listed in column FGCC are

computed from the expression listed in (FGCC, 1988, page 6). It is readily seen that FGCC specifications for Order B are fulfilled.

In order to gain additional insight into the Master Control network, several additional adjustments were performed. In one of the cases, the Station 12 was deleted in order to investigate the impact of observation 5-12 which has a height residual of 70 mm. The a-posteriori variance reduced to 0.70. The positions of the other stations remained unchanged with the exception of the heights, which in some cases changed by 1 to 2 mm. Similarly, little change is seen if only vector 5-12 is deleted rather than Station 12. In yet another experimental solution the vectors from Station 6 to 5 were deleted. Table 1 lists three vectors from Station 6 to Station 5, having residuals in the vertical of 5, 17, -17 mm respectively. Note that two of the residuals have the same magnitude but an opposite sign. No significant change was seen; the adjusted height of Station 6 changed by merely 1 mm.

3.2 GPS Vector Adjustment of Primary Network.

Towill provided the data for the primary network in the form of Trimble FIX files. The variance-covariance matrices are extracted from these files, but are not scaled. An initial minimal constraint solution indicated singularity caused by the disconnected baseline from Station 8 to Station 402. After removing this baseline, the minimal constraint solution contains 1065 (355 vectors) observations and 85 stations.

The solution is shown in [GPSSOL.2]. The a-posteriori variance of unit weight is 0.43. The residuals are all very small. Variance-covariance propagation for the observed vector distances is given in Appendix II. Note that the Order C (Class 1) FGCC specifications are clearly met.

The primary network resembles a closed traverse following the proposed accelerator track. Closed traverse types of networks do not exhibit good geometric network properties. This is true for classical surveying and for GPS surveying. Because of this weak geometry, the possible errors can "almost freely" distribute over the complete (linear) network. This is the reason why the a-posterior variance of unit weights and the residuals are small. The station spacing does not exceed 5 to 6 km.

The primary and the master network have 6 stations in common. For the current solution, the adjusted coordinates from the master control network were used as approximate parameters. Station 6 was held fixed. The computer file [GPSSOL.2] shows the following coordinate shifts of the primary network stations with respect to the master network stations: 1(-27, -21, 26), 3(-2, -34, 8), 4 (10, -25, -8), 5 (5, -15,-24), 6 (0, 0, 0), 7(-30, -9, -11). The values are given in millimeters for northing, easting, and height.

3.3 Combined GPS Vector Adjustment of Master and Primary Network.

This adjustment combines the observations of the primary (Order B) network with the remaining GPS vectors. The scaled variance-covariance submatrices of the primary solution are used. The other variance-covariance matrices are extracted from the FIX files provided by Towill, but are not scaled. The approximate latitude and longitude are those computed by Towill. The solution consists of 1323 (=441 vectors) observations and 91 stations.

For the minimal constraint solution [GPSSOL.3], the coordinates of Station 8 are held fixed. The a-posteriori variance of unit weight is 0.62. The blunder detection procedure

flagged the baselines 5-12 and 147-146. The latter baseline has received small residuals. Because it is a small baseline, the stochastic model is probably too optimistic. There is no cause for alarm regarding this baseline. The largest residuals are found, again, in the height component and are associated with Station 12. The standard deviations in northing and easting are all less than 5 mm; the same is true for most of the heights; no standard deviation in height exceeds 15 mm. Applying variance-covariance propagation to compute the standard deviations of the length of the adjusted vectors gives generally 1 mm and 2 mm, with only a handful of vectors showing standard deviations of 3 mm. Note that the horizontal positions computed by Towill are reproduced to within a couple of millimeters.

4. Preliminary Analysis of the Geoid

Recall the fundamental relationship of h=H+N, where h denotes the ellipsoidal heights, H are the orthometric heights, and N are the geoid undulations. The heights h are obtained from GPS, the heights H follow from leveling, and N can be computed from various techniques involving gravity. Thus, if all three types of data are available, the relationship of h=H+N provides an independent quality control. This is, indeed, a desirable form of quality control or redundancy, because the actual techniques of GPS, leveling, and gravimetric geoid determination depend largely upon different error sources.

4.1 Comparing GPS and Leveling

[GPSSOL.4] is a minimal constraint solution, just as is [GPSSOL.3], except that the heights of the leveling stations were taken from [LEVSOL.3]; i.e. the "approximate" heights are adjusted orthometric heights translated such that h(8)=140.41 m, which is precisely the ellipsoidal height of that station. The last 16 stations in [GPSSOL.4], starting with stations 10, are not part of the leveling network. These stations, consequently, are not used in the discussion below.

Figure 1 shows the differences between the adjusted and the approximate heights as listed at the end of [GPSSOL.4]. The differences are centered at Station 8; i.e. the local geoid is translated through Station 8. The units are in millimeters. The geoid has an upward slope in the direction of west to east. The slope amounts to about 600 mm across the accelerator track. Contouring in Figure 1 is done only approximately.

4.2 Comparing GPS, Leveling, and Gravimetric Geoid Undulations

Table 2 shows the gravimetric geoid undulations (column 2) as provided by Aiken of the University of Texas at Dallas; the values centered at Station 8 are seen in column 3. The undulations obtained from [GPSSOL.4] on the basis of the GPS and leveling are shown in column 4. The differences between both sets of undulations are given in column 5 and are graphically represented in Figure 2.

It is important to realize that the features seen in Figure 2 can result from errors in either the GPS survey, the leveling, or the gravimetric geoid determination. The features could, of course, be a result of errors and/or natural limitations in all three data sets. With perfect data (GPS, leveling, gravimetric geoid) the contours in Figure 2 would show a random pattern.

The spurs leading to Master Control Stations 12 and 14 exhibit significant slopes as seen from Figure 2. Because both of these spurs are controlled by published USGS heights, and because the discrepancies to the published heights are much smaller than the differences seen in Figure 2, it is concluded that the slopes on the spurs to Stations 12 and 14 represent unnodelled features in Aiken's gravimetric geoid.

4. 3 Solving for Rotation and Scale

The MainePac program is able to adjust simultaneously GPS vectors and classical terrestrial observations, and can solve for three rotations and one scale parameter to account for non-parallelism between the geoid and the ellipsoid. Thus, a combined adjustment including all GPS vectors and leveling observations is possible. However, since the leveling observations are already taken into account by virtue of using the adjusted heights of the leveling network as approximate values for the height parameter, it is only necessary to solve for the transformation parameters.

The minimal constraints for this combination solution are imposed by holding the latitude and longitude of Stations 8 and 14 and by holding the heights of Stations 1, 3, and 153 fixed to determine translation, rotation, and one scale factor.

The solution is documented in [GPSSOL.5]. The estimated transformation parameters are: -0.002+-0.03 arcsec (in azimuth), -6+-0.07 arcsec (around local meridian), 0.8+-0.05 arcsec (around local easting) and scale=-0.1+-0.1ppm. The rotation parameters indicate the average misalignment between the ellipsoidal surface and the geoid (as defined by the height stations 1, 3, 153) and can be interpreted as average deflection of the vertical values. The rotation in azimuth is not significant, because GPS positions are held fixed as opposed to NAD 83 network positions. The same is true for the scale parameter. The slope in the east west direction of 6 sec is confirmed (see Figure 1).

The discrepancies between the adjusted and the approximate heights (recall that the latter are the adjusted and translated level network heights), indicate that the deviation between the smooth ellipsoidal surface and the local geoid (as defined by the height stations) after the rotational component has been eliminated. These discrepancies are seen in Figure 3 and are listed in Table 3. Having perfect and sufficient GPS and leveling data, Figure 3 would show differences between the ellipsoid and the local geoid (as defined by the height stations with rotations eliminated). Suitable interpolation could be used, and GPS ellipsoidal heights and leveled orthometric heights could be related to each other. These differences vary systematically by about 70 mm along the planned accelerator track. Note that the stations 1,3, and 153 are located along the accelerator track, assuring that the undulating differences between ellipsoid and (translated) geoid average over the accelerator track.

It is readily seen that Figures 2 and 3 show the same features. (The absolute values for Stations 12 and 14 seen in Figure 3 depend on the selection of stations used to define the rotations.) The similarity of the features confirms, on the one hand, that the gravimetric geoid provided by Aiken is smooth and could be absorbed by the rotations, and on the other hand, that it still lacks the "micro" geoidal features.

5. Conclusion and Recommendations

It is concluded that the GPS surveys fulfill the respective requirements and specifications. This statement is based on the fact that no significant blunders in the observations could be detected and that variance covariance propagations for the observed vectors fulfill the part per million requirements. The same is true for the controlled portions of the leveling network.

It was found that the geoid fits a translated and rotated ellipsoidal surface to about 60 mm along the accelerator track. The deviations between both surfaces are systematic. It follows that the "fine structure" of the geoid shows topographical features of that magnitude. If the variations along the accelerator track shown in Figure 3 are beyond the permissible error for defining the vertical (in-plane) component of the accelerator, then an additional effort toward determining a more precise geoidal profile is required.

The next step, which is already in progress, is to apply gravity and tide corrections to the leveling data. It is doubtful that these corrections, even though theoretically important, will resolve the features seen in Figures 2 and 3. In future work, the GPS baselines related to Station 12 could possibly be recomputed using orbital relaxation techniques, and the residual could be re-examined for remaining cycle slips and possible trouble spots caused by the ionosphere and troposphere. Finally, the gravimetric geoid must be recomputed using new gravity observations which are already available but not yet incorporated into the present geoid solution.

This analysis shows, once again, the importance of having GPS vector observations, leveling observations, and precision geoid undulations to assure independent quality control in geodetic networks. All three observation types are required; the observations should, of course, be of the same accuracy. Adjusting GPS vectors or leveling separately may lead to acceptable a-posteriori variances of unit weight and good ratios in terms of parts per million, good variance-covariance propagation characteristics, etc. However, combining all three types (heterogeneous observations) constitutes a higher level of quality control, because each type depends on different error sources. The variations seen in Figures 2 and 3 are smooth and of a magnitude expected for the regional geoid. Thus, the absence of erratic jumps in Figure 3 reconfirms the high quality of the GPS survey and the leveling.

6. References

FGCC, 1989 (Preliminary Document). Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques.

Table 1: Residuals in Northing, Easting and Height

VECTOR ST	ST	DIST. (KM)	[GPSSOL.1] N (mm)	E (mm)	h (mm)	[GPSSOL.3] N (mm)	E (mm)	h (mm)
202	1	13.0	1	9	16	0	9	12
202	1	13.0	-2	-4	-5	-2	-4	-10
3	1	24.4	-2	7	17	0	6	14
3	1	24.4	-1	-4	-2	0	-5	-5
5	1	28.2	8	3	14	10	3	8
5	1	28.2	-5	-9	-10	-3	-9	-17
6	1	19.1	6	3	9	8	4	6
6	1	19.1	-1	-2	0	0	-1	-3
7	1	11.2	6	0	12	5	1	1
7	1	11.2	-2	0	-3	-4	1	-14
8	1	15.4	7	-2	15	8	-2	11
8	1	15.4	-2	3	-8	-1	3	-13
8	1	15.4	0	-2	-1	0	-2	-6
10	1	20.7	-4	1	-28	-3	1	-31
10	1	20.7	1	-3	12	2	-3	10
14	1	31.7	1	4	-12	1	4	-16
14	1	31.7	-2	1	2	-2	1	-2
202	3	13.9	3	3	0	0	3	-1
202	3	13.9	0	0	0	-2	1	-1
4	3	11.6	2	-1	3	3	-1	-1
5	3	21.4	-2	4	10	-3	5	6
5	3	21.4	0	6	19	0	7	16
5	3	21.4	-3	-6	-11	-3	-5	-14
5	3	21.4	-4	-6	11	-5	-5	7
8	3	13.6	6	3	18	5	4	17
8	3	13.6	2	1	-2	1	3	-4
10	3	38.2	2	1	12	1	2	12
12	3	20.8	0	1	-37	0	2	-39
3	4	11.6	5	2	1	4	2	4
5	4	12.3	1	6	9	0	7	10
5	4	12.3	0	-6	-10	-1	-5	-10
5	4	12.3	-8	-4	10	-9	-4	10
6	4	23.0	1	2	-20	-1	3	-16
8	4	14.2	-4	-2	-11	-6	-1	-9
12	4	24.9	0	2	17	-2	2	19
13	4	28.3	-1	0	2	-2	1	3
13	4	28.3	1	0	0	0	0	1
1	5	28.2	1	-2	-17	-1	-1	-11
1	5	28.2	2	-1	17	0	-1	23
202	5	27.5	2	-5	-14	0	-5	-12
202	5	27.5	3	5	5	1	5	7
6	5	14.2	-2	-1	-4	-2	0	-1
6	5	14.2	-1	-3	17	-1	-2	20
6	5	14.2	-4	7	-17	-4	8	-14
7	5	22.7	-2	-2	-3	-5	-1	-7
7	5	22.7	-1	-1	13	-4	0	8
8	5	14.2	6	-3	4	5	-3	6
8	5	14.2	-2	-6	6	-2	-6	7

8	5	14.2	-4	4	-6	-5	4	-4
8	5	14.2	6	7	8	5	8	10
5	12	37.2	4	0	70	3	0	69
13	5	21.5	3	0	-10	3	0	-9
13	5	21.5	0	6	8	0	6	8
14	5	32.4	2	1	-26	1	2	-24
7	6	9.8	0	-2	1	-3	-2	-7
8	6	13.3	0	-6	10	-1	-7	8
6	7	9.8	-1	-2	4	2	-2	12
8	7	15.0	1	-4	7	3	-5	14
14	7	21.1	0	-1	8	2	-1	14
202	8	13.6	-3	-1	-19	-5	-1	-19
202	8	13.6	-1	-2	0	-3	-2	0
3	8	13.6	1	-3	-4	2	-4	-3
4	8	14.2	-4	-5	-4	-2	-6	-6
5	8	14.2	-2	0	5	-2	0	3
5	8	14.2	2	0	-12	3	0	-13
6	8	13.3	1	-3	5	2	-2	7
7	8	15.0	1	-1	-2	-1	0	-8
10	8	34.5	1	0	15	0	0	17
12	8	34.2	6	4	32	6	4	31
13	8	35.7	-3	-6	-1	-3	-6	-2
13	8	35.7	4	2	17	5	2	16
14	8	33.3	2	-2	9	2	-2	9
202	10	24.3	-2	-1	-15	-3	-1	-16
14	10	48.1	4	2	21	4	2	20
202	12	32.4	2	2	40	0	2	40
3	12	20.8	2	6	-19	3	5	-17
4	12	24.9	-1	4	-20	0	4	-22
10	12	54.3	-13	8	-21	-14	8	-19
13	12	48.5	-2	3	-13	-1	3	-14
13	12	48.5	-5	-3	-4	-4	-3	-5
13	12	48.5	1	-2	-14	1	-2	-15
5	13	21.5	2	6	5	1	6	4
14	13	43.1	-1	2	-15	-2	3	-14
5	14	32.4	1	2	-14	2	2	-16
6	14	20.4	0	-1	-1	1	0	0
1	100	0.8				0	2	-4
113	400	1.6				3	-1	-3
174	100	4.0				1	-8	9
176	100	1.5				0	-4	6
100	101	1.9				0	-5	-5
100	101	1.9				1	-3	-1
101	1	1.9				-2	1	4
102	101	1.8				2	1	3
104	101	2.9				-4	3	2
149	401	1.6				-7	-4	1
154	401	3.9				10	-8	4
174	101	5.9				2	-11	9
175	1	2.4				1	-7	12
176	101	3.4				1	-7	4
400	202	3.0				-2	-1	0
100	102	3.5				-1	-3	-6
101	102	1.8				4	-4	-2
104	102	1.1				0	1	0
111	202	2.7				-3	0	-3
112	202	2.3				1	-4	-7
113	202	1.9				0	-2	-2

101	103	2.6	5	-4	-2
102	103	0.9	-1	-1	0
104	103	0.5	0	0	0
118	3	4.0	7	-5	7
119	3	3.3	9	-5	5
120	3	2.4	8	-6	1
121	3	1.6	1	2	-6
122	3	3.0	7	-3	8
123	3	1.1	1	1	-8
123	3	1.1	5	-3	4
127	3	4.9	-4	-1	-3
128	3	7.0	-5	0	-1
124	4	9.1	11	10	-24
129	4	2.8	3	1	1
129	4	2.8	2	8	-8
131	4	2.7	-5	-6	0
131	4	2.7	4	4	5
132	4	2.7	-1	-10	-1
133	4	4.4	0	-6	3
134	4	6.1	0	-9	2
135	4	6.3	0	-8	3
101	105	5.9	5	-10	-5
102	105	4.1	0	-5	-2
103	105	3.4	1	-5	-1
104	105	3.0	2	-5	1
139	5	0.9	1	0	-1
101	106	6.3	5	-11	-8
102	106	4.5	1	-5	-4
103	106	3.8	2	-6	-3
104	106	3.4	2	-5	-3
105	106	0.7	1	0	6
105	106	0.7	0	0	-3
153	6	1.6	0	3	3
154	6	3.6	4	7	3
155	6	2.7	2	3	1
156	6	1.1	2	3	0
157	6	0.9	3	2	0
403	7	0.0	-1	1	0
105	107	2.0	1	-1	2
106	107	1.9	0	-1	-4
108	107	0.6	0	0	1
162	7	4.5	-17	1	3
162	7	4.5	12	-1	-6
164	7	3.6	-9	1	-3
165	7	1.8	-4	2	-1
166	7	0.8	-4	4	-1
166	7	0.8	1	1	7
166	7	0.8	-1	-3	10
167	7	1.9	0	1	-2
168	7	2.1	0	3	6
168	7	2.1	3	-5	11
169	7	2.5	2	2	9
169	7	2.5	2	-4	8
170	7	3.2	-2	2	-1
170	7	3.2	5	-5	7
402	8	0.3	0	0	0
105	108	2.2	1	-1	2
106	108	1.9	0	-1	-3

202	109	1.9	-3	5	9
105	109	3.6	1	0	-2
106	109	3.4	1	-2	-7
107	109	1.6	0	0	-2
108	109	1.6	0	0	-3
110	109	0.7	-2	0	5
110	109	0.7	1	0	-8
111	109	3.0	-6	4	6
112	109	3.2	-3	1	4
113	109	3.7	-3	3	8
202	110	1.3	0	3	3
105	110	4.0	1	-4	1
106	110	3.8	2	-4	-1
107	110	2.1	0	-2	2
108	110	1.9	1	-2	1
111	110	3.0	-4	4	0
112	110	3.0	-1	1	-2
113	110	3.2	-1	2	1
202	111	2.7	-1	-1	-9
112	111	1.0	4	-4	-3
114	111	3.1	-7	3	2
115	111	3.5	-5	4	-5
202	112	2.3	3	-3	-7
111	112	1.0	3	-2	3
114	112	2.9	-5	0	3
115	112	3.1	-3	2	-1
202	113	1.9	1	0	1
111	113	2.8	-3	1	-2
112	113	1.8	0	-2	-5
202	114	5.1	6	-4	-6
115	114	0.7	-1	-4	-4
115	114	0.7	0	3	3
118	114	5.0	-5	-1	-7
400	115	4.6	17	8	-8
202	115	5.2	6	-6	-5
118	115	4.9	-2	2	-1
114	116	2.6	3	1	-2
115	116	2.6	1	-3	-8
117	116	0.8	0	-1	-2
118	116	2.4	-3	1	2
118	116	2.4	-1	-1	-8
119	116	3.0	-6	2	2
121	116	4.8	-5	1	3
114	117	2.9	3	1	3
115	117	2.6	0	-3	-5
118	117	2.3	-2	0	-4
120	118	1.7	0	-1	-5
122	118	3.7	0	2	3
123	118	3.6	-2	2	-2
118	119	0.7	4	-1	0
118	119	0.7	-2	0	1
120	119	1.0	-2	-1	-2
122	119	3.5	-3	3	3
123	119	3.0	-5	3	-1
116	120	4.0	5	-3	-6
118	120	1.7	4	-1	-2
119	120	1.0	0	-1	-2
121	120	0.8	0	-2	-1

118	121	2.5	1	0	-3
119	121	1.8	0	2	-2
123	121	1.8	1	-1	-2
3	122	3.0	-2	-3	16
120	122	3.2	1	-3	-8
121	122	3.1	-1	-1	8
123	122	1.8	0	-1	6
124	122	1.8	0	0	5
120	123	2.3	4	-3	-2
122	123	1.8	2	0	4
3	124	2.7	5	2	8
3	124	2.7	-2	-2	13
121	124	3.7	-2	0	6
123	124	2.0	0	-1	2
127	124	3.5	1	0	3
128	124	5.0	-1	1	3
129	124	6.7	-9	-1	15
3	125	2.5	5	2	13
3	125	2.5	-3	0	4
121	125	3.7	-2	1	1
122	125	2.3	0	1	-10
123	125	2.0	0	1	-6
124	125	0.6	-1	0	6
124	125	0.6	0	1	-6
126	125	2.5	1	1	4
127	125	3.1	2	0	5
128	125	4.8	0	2	7
3	126	4.5	9	3	2
124	126	2.9	3	-1	0
127	126	0.7	0	0	0
128	126	2.5	-3	0	8
4	128	5.1	-7	-3	1
127	128	2.3	3	-2	-9
129	128	2.3	-4	-3	2
131	128	7.7	-3	1	5
132	128	7.6	-4	5	10
131	129	5.4	1	4	2
4	130	0.9	-1	-1	-1
128	130	5.4	6	1	-4
129	130	3.2	2	0	-1
131	130	2.4	2	3	3
132	130	2.9	2	6	9
4	132	2.7	-3	-7	-10
129	132	5.3	0	-6	-9
131	132	1.6	-4	3	2
131	132	1.6	1	-3	-5
133	132	1.8	-1	2	2
135	132	3.7	0	0	-1
131	133	2.9	-3	0	-1
135	133	2.3	-5	5	27
135	133	2.3	1	-1	-1
136	133	5.0	-2	3	27
137	133	5.6	1	0	18
139	133	7.3	0	1	21
131	134	3.7	-4	2	1
132	134	3.7	-1	-1	-2
133	134	2.6	0	1	2
135	134	0.8	0	0	0

131	135	4.1	-4	2	0
135	136	2.9	-3	2	-9
135	137	3.7	-3	1	-10
136	137	0.8	0	0	-1
5	138	1.0	0	0	0
5	139	0.9	1	1	-2
135	139	5.8	-4	2	-14
136	139	3.3	-1	0	-5
137	139	2.5	-1	1	-5
138	139	1.0	0	-1	0
5	140	1.5	0	5	0
5	140	1.5	0	2	-3
5	140	1.5	-1	0	9
138	140	2.3	-1	5	0
139	140	2.4	0	5	-2
141	140	0.8	1	3	-3
141	140	0.8	0	-1	1
142	140	2.5	-1	-1	-3
143	140	2.8	4	-1	-1
5	141	2.3	-1	1	0
5	141	2.3	-2	0	9
5	142	3.9	-2	1	10
141	142	1.6	0	0	5
5	143	4.2	-4	4	0
141	143	2.0	-3	3	0
142	143	0.7	1	0	1
144	143	1.9	0	-2	-4
145	143	1.9	2	-1	-2
146	143	3.6	7	-1	2
401	144	5.4	-7	-1	13
142	144	2.4	2	1	6
146	144	1.7	0	0	-12
147	144	2.3	-2	0	2
152	144	5.9	-11	2	24
142	145	2.0	0	1	3
144	145	1.0	-1	-1	-4
401	146	4.1	-3	-2	14
142	146	4.1	-5	0	-1
144	146	1.7	-7	-1	-7
145	146	2.4	-5	0	-4
147	146	0.8	7	6	-11
147	146	0.8	-1	0	12
148	146	1.8	10	6	-7
149	146	2.5	12	3	-7
150	146	1.9	12	2	-8
152	146	4.2	-8	1	26
401	147	3.3	0	-2	-10
152	147	3.6	1	0	-21
147	148	1.0	2	2	0
147	148	1.0	-4	0	-3
147	149	1.8	-5	0	-3
148	149	0.8	-1	0	1
154	149	5.3	19	-5	1
147	150	1.3	1	-3	-4
147	150	1.3	1	1	-6
147	150	1.3	-6	3	-1
148	150	1.0	0	0	-8
148	150	1.0	-1	4	2

149	150	1.7	0	4	2
151	150	1.1	3	-1	0
151	150	1.1	2	0	-5
152	150	2.3	3	-2	2
147	151	2.2	-1	-1	0
401	152	2.9	3	-2	-4
151	152	1.9	-8	-1	2
152	151	1.9	1	0	5
153	152	0.7	-1	-1	-1
151	153	2.5	-9	0	3
154	153	3.7	3	5	-1
155	153	3.0	2	1	-1
156	153	1.8	1	0	0
157	153	2.2	2	0	-2
155	154	1.0	-1	-3	-1
156	154	2.5	-2	-4	-2
157	154	3.1	0	-5	-3
161	154	3.7	10	8	8
163	154	5.6	10	10	6
157	155	2.1	1	-2	-2
155	156	1.6	1	2	2
157	156	0.8	1	0	-1
160	157	3.7	18	7	-13
154	160	3.8	-10	-8	-8
161	160	0.6	1	1	-1
162	160	3.0	5	4	-4
163	160	1.8	2	2	-1
164	160	1.7	4	2	0
163	161	2.1	0	2	-3
403	162	4.5	15	-1	-3
154	162	6.8	-13	-11	-5
161	162	3.3	-4	-2	3
163	162	1.2	-3	-2	0
164	162	2.2	6	1	-5
164	162	2.2	-2	-2	2
168	162	6.6	-8	-6	19
157	163	4.9	-19	-7	9
160	163	1.8	-1	2	-8
403	164	3.6	8	-1	2
154	164	5.2	-13	-9	-7
161	164	1.5	-3	-2	0
163	164	1.4	-2	0	-3
403	165	1.8	3	-1	0
162	165	3.4	-13	-1	5
164	165	1.9	-6	0	-1
403	166	0.8	2	-4	2
162	166	4.7	-13	-4	5
162	166	4.7	10	4	-15
164	166	3.4	-6	-3	-1
165	166	1.5	0	-3	1
167	166	1.6	-2	2	-5
168	166	2.0	-1	5	4
168	166	2.0	3	-2	0
169	166	2.6	0	3	5
170	166	3.3	-3	4	-3
168	167	0.6	0	-1	-6
169	167	1.3	-1	0	-6
170	167	2.1	1	-2	-8

171	167	3.2	1	2	2
172	167	3.7	2	2	3
167	168	0.6	-1	-2	-5
162	169	7.0	6	5	-16
166	169	2.6	-3	1	3
167	169	1.3	-2	0	-8
168	169	0.7	-1	2	-1
168	169	0.7	0	-1	3
168	169	0.7	0	0	3
170	169	0.8	-3	0	-8
170	169	0.8	2	-1	1
170	169	0.8	2	-1	-2
171	169	2.6	2	2	12
172	169	3.0	2	4	12
162	170	7.6	6	5	-16
166	170	3.3	-4	2	3
167	170	2.1	3	-1	-1
168	170	1.5	3	2	8
168	170	1.5	-2	0	6
168	170	1.5	-2	0	4
171	170	2.6	-7	5	-16
171	170	2.6	0	4	10
172	170	2.6	-7	5	-15
172	170	2.6	0	4	9
174	170	4.4	-8	9	-15
168	171	2.9	-1	-3	-11
174	171	2.3	1	2	-1
168	172	3.4	-2	-5	-11
171	172	0.8	0	1	0
171	172	0.8	0	-1	-1
174	172	1.8	0	3	-3
170	173	3.7	8	-8	16
171	173	1.6	-1	-1	0
172	173	1.1	0	-3	2
174	173	0.7	0	1	-1
176	174	2.5	0	4	-4
100	175	2.3	0	8	-10
101	175	4.2	0	8	-5
170	175	6.1	8	-12	24
171	175	3.9	0	-5	9
172	175	3.4	0	-7	9
173	175	2.4	1	-5	8
174	175	1.7	0	-2	3
174	175	1.7	-1	-5	3
176	175	0.8	0	2	-2

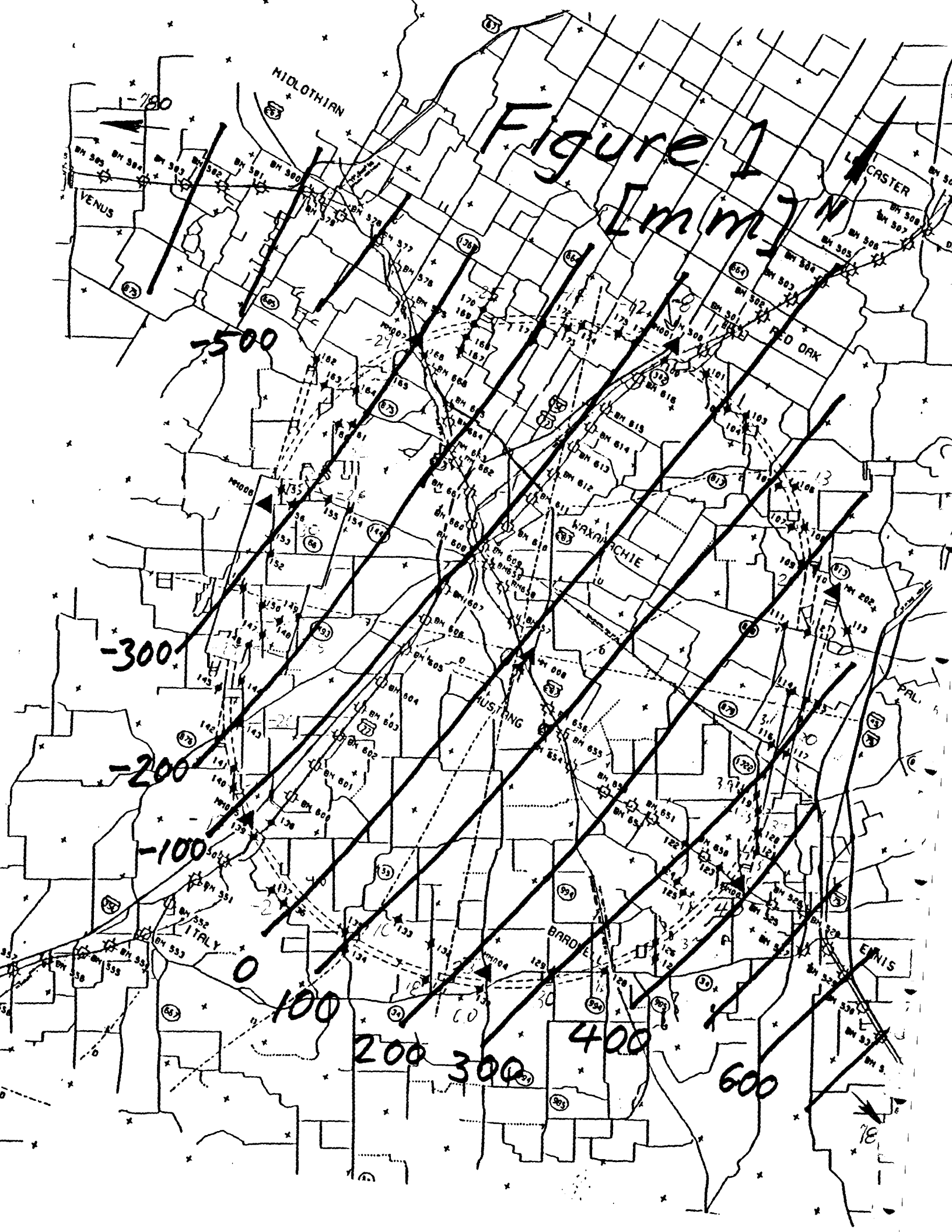


Figure 1
[mm]
N
MIDLOTHIAN
VENUS
LANCASTER
RED OAK
WAXAHACHIE
HUSTING
ITALY
BARDWELL
ENNIS
-700
-500
-300
-200
-100
0
100
200
300
400
600

Table 2: Comparing GPS/Leveling With Gravimetric Geoid Undulations

Station	N (gravity) (Aiken)	N + 25.73	GPS/Leveling [GPSSOL.4]	Difference (m)
1	-25.780	-0.050	-0.077	-0.027
3	-25.310	0.420	0.396	-0.024
4	-25.500	0.230	0.232	0.002
5	-25.880	-0.150	-0.133	0.017
6	-26.050	-0.320	-0.333	-0.013
7	-26.020	-0.290	-0.288	-0.002
8	-25.730	0.000	0.000	0.000
12	-24.840	0.890	0.776	-0.114
14	-26.460	-0.730	-0.776	-0.046
100	-25.780	-0.050	-0.075	-0.025
101	-25.730	0.000	-0.030	-0.030
102	-25.680	0.050	0.013	-0.037
103	-25.660	0.070	0.036	-0.034
104	-25.650	0.080	0.047	-0.033
105	-25.590	0.140	0.115	-0.025
106	-25.560	0.170	0.131	-0.039
107	-25.550	0.180	0.153	-0.027
108	-25.530	0.200	0.168	-0.038
109	-25.520	0.210	0.196	-0.014
110	-25.500	0.230	0.208	-0.022
111	-25.480	0.250	0.218	-0.032
112	-25.460	0.270	0.245	-0.025
113	-25.410	0.320	0.278	-0.042
114	-25.430	0.300	0.269	-0.031
116	-25.400	0.330	0.305	-0.025
118	-25.370	0.360	0.333	-0.027
119	-25.350	0.380	0.348	-0.032
120	-25.330	0.400	0.373	-0.027
121	-25.320	0.410	0.385	-0.025
122	-25.400	0.330	0.306	-0.024
123	-25.340	0.390	0.358	-0.032
124	-25.370	0.360	0.325	-0.035
125	-25.360	0.370	0.342	-0.028
126	-25.340	0.390	0.373	-0.017
127	-25.320	0.410	0.383	-0.027
128	-25.360	0.370	0.348	-0.022
129	-25.420	0.310	0.296	-0.004
130	-25.480	0.250	0.245	-0.005
131	-25.550	0.180	0.188	0.008
132	-25.590	0.140	0.151	0.011
133	-25.650	0.080	0.102	0.022
135	-25.690	0.040	0.062	0.022
136	-25.780	-0.050	-0.024	0.026
137	-25.800	-0.070	-0.044	0.026
138	-25.850	-0.120	-0.101	0.021
139	-25.860	-0.130	-0.107	0.023
140	-25.920	-0.190	-0.173	0.017
141	-25.930	-0.200	-0.182	0.018
143	-25.960	-0.230	-0.212	0.018
144	-25.980	-0.250	-0.251	-0.001

146	-26.000	-0.270	-0.270	0.000
147	-25.990	-0.260	-0.261	-0.001
148	-25.980	-0.250	-0.252	-0.002
151	-26.030	-0.300	-0.302	-0.002
152	-26.020	-0.290	-0.287	0.003
153	-26.030	-0.300	-0.304	-0.004
154	-25.970	-0.240	-0.249	-0.009
155	-25.990	-0.260	-0.281	-0.021
156	-26.030	-0.300	-0.311	-0.011
157	-26.040	-0.310	-0.325	-0.015
160	-26.030	-0.300	-0.320	-0.020
161	-26.020	-0.290	-0.309	-0.019
163	-26.070	-0.340	-0.350	-0.010
164	-26.040	-0.310	-0.325	-0.015
165	-26.020	-0.290	-0.300	-0.010
166	-26.000	-0.270	-0.258	0.012
167	-25.980	-0.250	-0.250	0.000
168	-25.980	-0.250	-0.248	0.002
169	-25.980	-0.250	-0.249	0.001
170	-25.980	-0.250	-0.252	-0.002
172	-25.910	-0.180	-0.187	-0.007
173	-25.890	-0.160	-0.165	-0.005
174	-25.880	-0.150	-0.157	-0.007
175	-25.830	-0.100	-0.121	-0.021
176	-25.810	-0.080	-0.102	-0.022

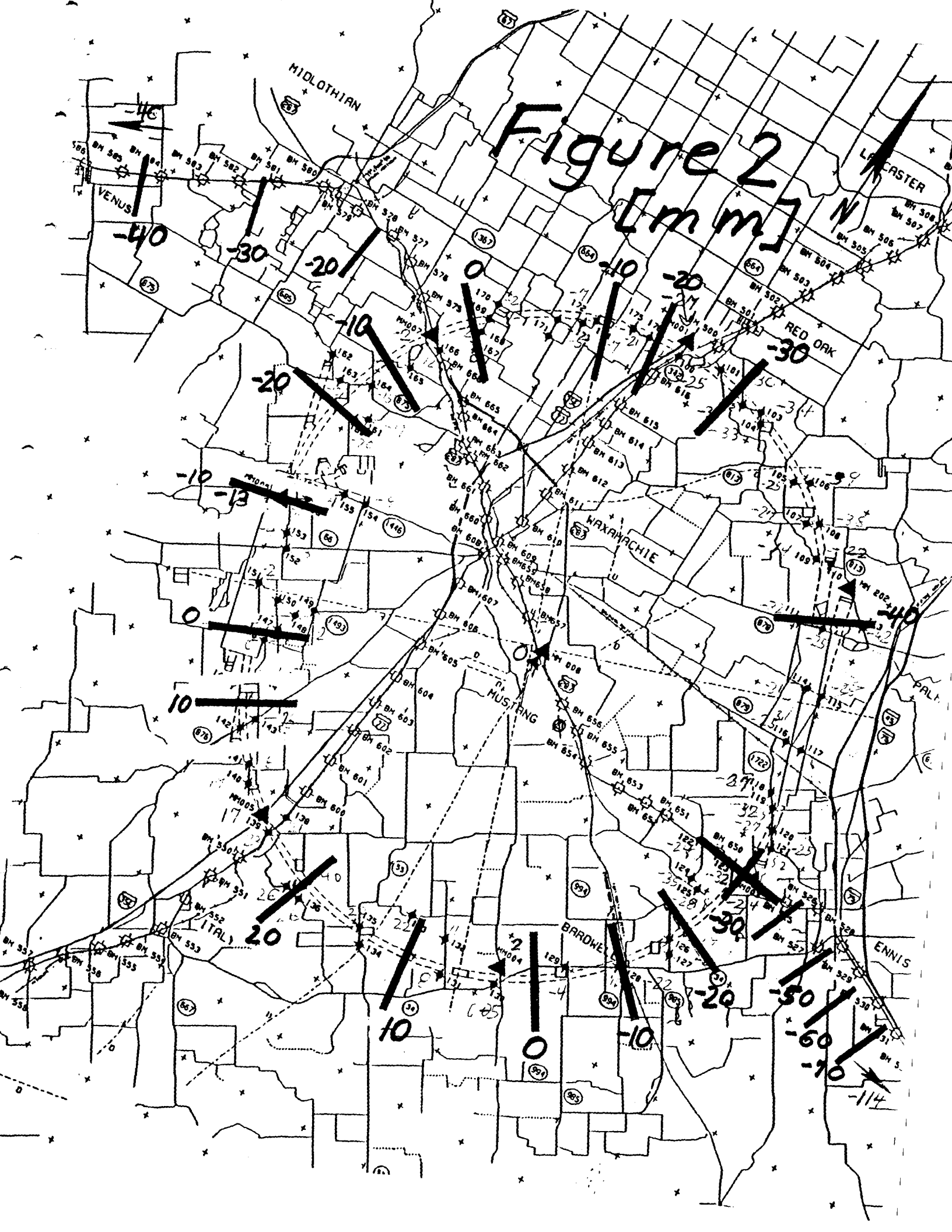


Figure 2
[mm]
N
MIDLOTHIAN
VENUS
LANCASTER
RED OAK
WAXAHACHIE
MUSTANG
BARDWELL
ENNIS
-40
-30
-20
0
-10
-20
-30
-10
-13
0
-40
10
20
10
0
-10
-20
-30
-50
-60
-70
-114

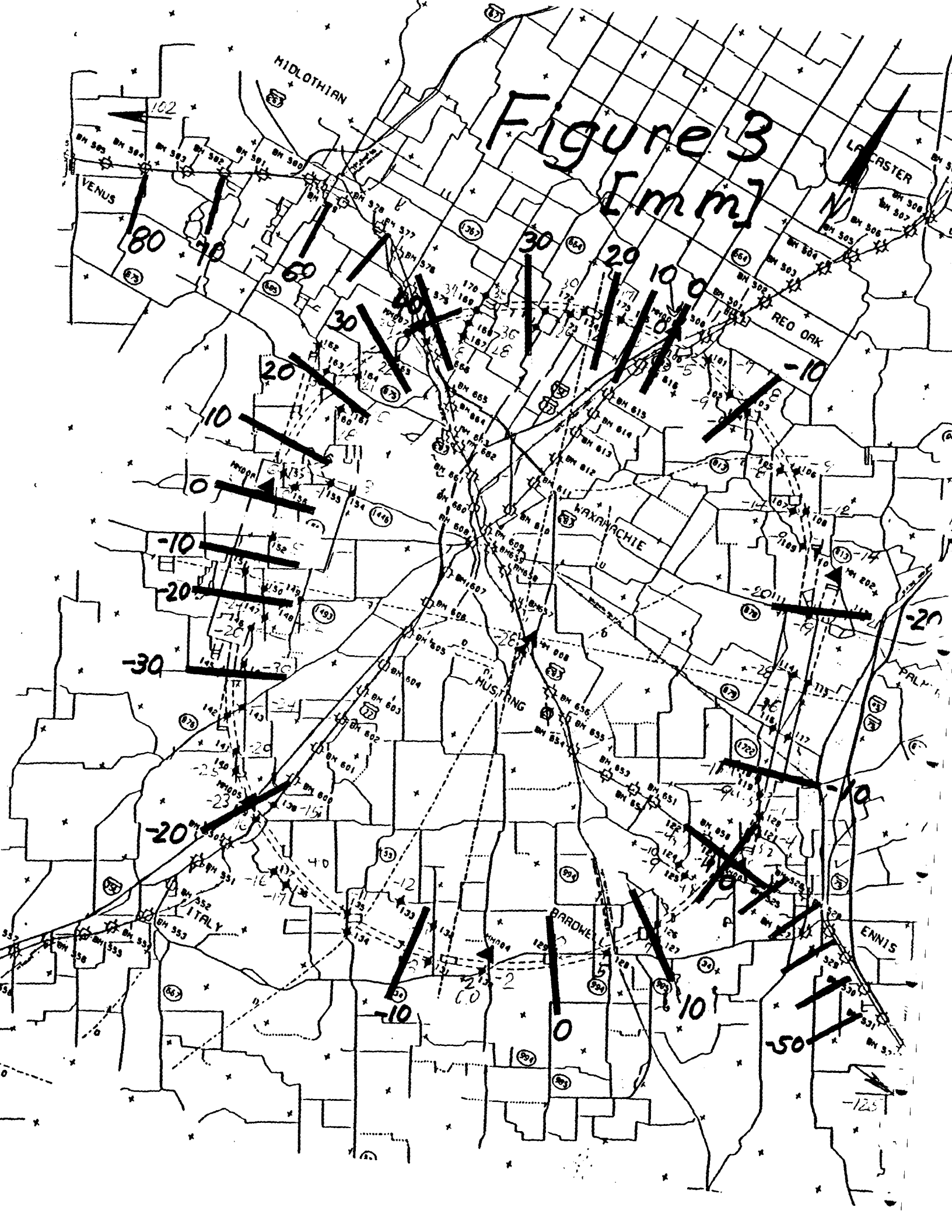


Figure 3
[mm]
MIDLOTHIAN
VENUS
LANCASTER
RED OAK
MAXWELL
HUSTING
ITALY
BARDWELL
ENNIS

Table 3: Comparing Ellipsoidal Surface and Local Geoid

Adjusted minus Approximate Coordinates (M)

	NORTHING	EASTING	HEIGHT
1	0.001	-0.001	0.000
3	0.003	-0.002	0.000
4	0.006	-0.003	-0.002
5	-0.001	-0.001	-0.023
6	-0.001	0.004	0.001
7	-0.005	0.003	0.039
8	0.000	0.000	-0.028
12	-0.002	0.004	-0.125
14	0.000	0.000	0.102
100	0.001	0.004	-0.005
101	0.001	0.002	-0.007
102	0.000	0.002	-0.009
103	-0.001	0.002	-0.008
104	-0.001	0.002	-0.005
105	-0.003	0.002	-0.008
106	-0.003	0.001	-0.009
107	-0.003	0.001	-0.014
108	-0.003	0.001	-0.012
109	-0.003	0.001	-0.009
110	-0.003	0.002	-0.014
111	-0.002	0.001	-0.020
112	-0.001	0.000	-0.019
113	-0.004	0.001	-0.021
114	0.001	0.000	-0.028
116	0.002	0.000	-0.016
118	0.003	-0.001	-0.011
119	0.002	-0.001	-0.009
120	0.002	-0.001	0.000
121	0.004	-0.002	-0.001
122	0.004	-0.003	-0.004
123	0.004	-0.003	-0.004
124	0.004	-0.003	-0.010
125	0.005	-0.002	-0.009
126	0.004	-0.003	0.008
127	0.004	-0.003	0.007
128	0.006	-0.004	0.005
129	0.007	-0.002	0.000
130	0.005	-0.004	0.002
131	0.005	-0.004	0.003
132	0.006	-0.004	-0.011
133	0.005	-0.004	-0.012
135	0.005	-0.004	-0.011
136	0.001	-0.002	-0.017
137	0.001	-0.002	-0.016
138	-0.001	-0.001	-0.015
139	0.000	-0.001	-0.016
140	-0.001	-0.002	-0.025
141	-0.001	-0.001	-0.020
143	-0.001	-0.001	-0.024
144	0.000	0.000	-0.030
146	0.000	0.000	-0.026
147	0.001	0.001	-0.024
148	0.002	0.002	-0.022
151	0.002	0.002	-0.011
152	0.001	0.002	0.005
153	-0.001	0.003	0.000
154	-0.004	0.003	0.003

155	-0.003	0.003	-0.001
156	-0.001	0.004	0.000
157	-0.001	0.004	0.006
160	-0.005	0.004	0.018
161	-0.005	0.004	0.016
163	-0.007	0.003	0.030
164	-0.003	0.005	0.021
165	-0.005	0.004	0.022
166	-0.006	0.004	0.048
167	-0.004	0.004	0.028
168	-0.005	0.004	0.036
169	-0.005	0.004	0.037
170	-0.005	0.004	0.038
172	-0.005	0.002	0.030
173	-0.005	0.002	0.026
174	-0.004	0.002	0.023
175	-0.002	0.002	0.017
176	-0.001	0.002	0.013
10	0.004	-0.002	0.073
13	-0.001	-0.005	0.267
202	-0.003	0.002	-0.258
115	0.001	0.000	-0.319
117	0.001	0.000	-0.343
134	0.005	-0.003	-0.084
142	-0.001	-0.001	0.199
145	0.000	0.000	0.240
149	0.003	0.004	0.215
150	0.003	0.002	0.258
162	-0.006	0.003	0.408
171	-0.006	0.002	0.213
400	0.003	0.005	-0.337
401	-0.004	-0.004	0.209
402	0.000	0.000	-0.026
403	0.014	-0.006	0.330

APPENDIX II(A)

Primary Control Network

Adjusted Distances (MARK TO MARK)
and their Standard Deviations/FGCC Specifications

ORDER C 1

			ST.DEV	FGCC
1	100	841.8500	0.001	0.007
113	400	1626.8297	0.002	0.010
174	100	3978.6084	0.002	0.021
176	100	1542.8366	0.002	0.009
100	101	1903.7012	0.001	0.011
100	101	1903.7012	0.001	0.011
101	1	1925.8708	0.002	0.011
102	101	1818.1382	0.001	0.011
104	101	2941.7151	0.002	0.016
149	401	1551.6858	0.002	0.009
154	401	3889.6869	0.002	0.020
174	101	5875.0879	0.002	0.030
175	1	2439.4922	0.002	0.013
176	101	3414.1708	0.002	0.018
400	202	2968.7404	0.003	0.016
100	102	3482.5461	0.002	0.018
101	102	1818.1382	0.001	0.011
104	102	1136.5918	0.001	0.008
111	202	2729.4680	0.001	0.015
112	202	2258.4652	0.001	0.013
113	202	1893.7116	0.002	0.011
101	103	2550.6626	0.002	0.014
102	103	854.7208	0.001	0.007
104	103	529.9987	0.001	0.006
118	3	3960.7706	0.001	0.021
119	3	3302.3377	0.001	0.018
120	3	2381.8011	0.001	0.013
121	3	1619.2206	0.001	0.010
122	3	2956.7081	0.001	0.016
123	3	1125.8899	0.001	0.008
123	3	1125.8899	0.001	0.008
127	3	4913.6072	0.001	0.026
128	3	7003.1063	0.002	0.036
124	4	9094.4212	0.003	0.047
129	4	2787.7350	0.002	0.015
129	4	2787.7350	0.002	0.015
131	4	2656.4451	0.002	0.014
131	4	2656.4451	0.002	0.014
132	4	2661.5229	0.002	0.015
133	4	4418.4010	0.002	0.023
134	4	6135.7014	0.002	0.032
135	4	6300.5954	0.002	0.033
101	105	5882.1745	0.002	0.030
102	105	4064.2507	0.002	0.021
103	105	3413.3696	0.002	0.018
104	105	2951.5459	0.002	0.016
139	5	859.5088	0.001	0.007
101	106	6320.0213	0.002	0.033
102	106	4516.0307	0.002	0.024
103	106	3790.4365	0.002	0.020
104	106	3380.9994	0.002	0.018
105	106	714.6716	0.001	0.006
105	106	714.6716	0.001	0.006
153	6	1624.2131	0.002	0.010

154	6	3646.5968	0.002	0.019
155	6	2708.7677	0.002	0.015
156	6	1130.3617	0.001	0.008
157	6	869.6271	0.001	0.007
403	7	3.5252	0.000	0.005
105	107	1952.0111	0.001	0.011
106	107	1851.5468	0.001	0.011
108	107	562.0961	0.001	0.006
162	7	4535.8598	0.001	0.024
162	7	4535.8598	0.001	0.024
164	7	3630.8486	0.001	0.019
165	7	1842.6438	0.001	0.011
166	7	779.8615	0.001	0.006
166	7	779.8615	0.001	0.006
166	7	779.8615	0.001	0.006
167	7	1899.4650	0.001	0.011
168	7	2076.4646	0.001	0.012
168	7	2076.4646	0.001	0.012
169	7	2506.9581	0.001	0.014
169	7	2506.9581	0.001	0.014
170	7	3150.0917	0.001	0.017
170	7	3150.0917	0.001	0.017
105	108	2178.8345	0.001	0.012
106	108	1887.4259	0.001	0.011
202	109	1925.1786	0.001	0.011
105	109	3589.1408	0.001	0.019
106	109	3431.3805	0.001	0.018
107	109	1637.1794	0.001	0.010
108	109	1579.2720	0.001	0.010
110	109	669.2069	0.001	0.006
110	109	669.2069	0.001	0.006
111	109	2990.3556	0.002	0.016
112	109	3192.9990	0.002	0.017
113	109	3677.0257	0.002	0.019
202	110	1320.3063	0.002	0.008
105	110	4017.0939	0.001	0.021
106	110	3757.2051	0.001	0.020
107	110	2097.2613	0.001	0.012
108	110	1871.7659	0.001	0.011
111	110	2993.2172	0.002	0.016
112	110	2972.1228	0.002	0.016
113	110	3161.7707	0.002	0.017
202	111	2729.4680	0.001	0.015
112	111	1033.3430	0.001	0.007
114	111	3064.2365	0.002	0.016
115	111	3546.7617	0.002	0.019
202	112	2258.4652	0.001	0.013
111	112	1033.3430	0.001	0.007
114	112	2858.1780	0.002	0.015
115	112	3145.1601	0.002	0.017
202	113	1893.7116	0.002	0.011
111	113	2764.3086	0.001	0.015
112	113	1769.0112	0.001	0.010
202	114	5058.4714	0.002	0.026
115	114	734.5524	0.001	0.006
115	114	734.5524	0.001	0.006
118	114	4958.1219	0.001	0.026
400	115	4617.0356	0.002	0.024
202	115	5220.1788	0.002	0.027
118	115	4855.3075	0.001	0.025
114	116	2597.1864	0.001	0.014
115	116	2575.6705	0.001	0.014
117	116	784.6429	0.001	0.006

APPENDIX I(B)

Master Control Network

Adjusted Distances (MARK TO MARK)
and their Standard Deviations (PARTS PER MILLION)

			ST.DEV	PPM
202	1	13020.7102	0.001	0.111
202	1	13020.7102	0.001	0.111
3	1	24423.1480	0.002	0.062
3	1	24423.1480	0.002	0.062
5	1	28241.9523	0.001	0.040
5	1	28241.9523	0.001	0.040
6	1	19105.6127	0.001	0.059
6	1	19105.6127	0.001	0.059
7	1	11194.8904	0.001	0.099
7	1	11194.8904	0.001	0.099
8	1	15382.8048	0.001	0.081
8	1	15382.8048	0.001	0.081
8	1	15382.8048	0.001	0.081
10	1	20694.8096	0.002	0.094
10	1	20694.8096	0.002	0.094
14	1	31685.4167	0.001	0.037
14	1	31685.4167	0.001	0.037
202	3	13941.3623	0.002	0.119
202	3	13941.3623	0.002	0.119
4	3	11563.1553	0.001	0.118
5	3	21408.4959	0.001	0.048
5	3	21408.4959	0.001	0.048
5	3	21408.4959	0.001	0.048
5	3	21408.4959	0.001	0.048
8	3	13618.0637	0.001	0.090
8	3	13618.0637	0.001	0.090
10	3	38201.1174	0.002	0.060
12	3	20847.8767	0.002	0.083
3	4	11563.1553	0.001	0.118
5	4	12331.2558	0.001	0.105
5	4	12331.2558	0.001	0.105
5	4	12331.2558	0.001	0.105
6	4	22997.6290	0.002	0.076
8	4	14205.4257	0.002	0.111
12	4	24875.0023	0.002	0.066
13	4	28335.5347	0.001	0.049
13	4	28335.5347	0.001	0.049
1	5	28241.9523	0.001	0.040
1	5	28241.9523	0.001	0.040
202	5	27487.7710	0.001	0.047
202	5	27487.7710	0.001	0.047
6	5	14184.3759	0.001	0.105
6	5	14184.3759	0.001	0.105
6	5	14184.3759	0.001	0.105
7	5	22691.2743	0.002	0.071
7	5	22691.2743	0.002	0.071
8	5	14231.8363	0.001	0.065
8	5	14231.8363	0.001	0.065
8	5	14231.8363	0.001	0.065
8	5	14231.8363	0.001	0.065
5	12	37189.0944	0.002	0.044
13	5	21485.5170	0.002	0.070
13	5	21485.5170	0.002	0.070
14	5	32440.2823	0.002	0.049

7	6	9798.3214	0.002	0.162
8	6	13328.7853	0.001	0.082
6	7	9798.3214	0.002	0.162
8	7	15012.2795	0.002	0.106
14	7	21106.1248	0.001	0.069
202	8	13595.0632	0.001	0.088
202	8	13595.0632	0.001	0.088
3	8	13618.0637	0.001	0.090
4	8	14205.4257	0.002	0.111
5	8	14231.8363	0.001	0.065
5	8	14231.8363	0.001	0.065
6	8	13328.7853	0.001	0.082
7	8	15012.2795	0.002	0.106
10	8	34529.1885	0.002	0.061
12	8	34150.2615	0.002	0.050
13	8	35686.2078	0.002	0.043
13	8	35686.2078	0.002	0.043
14	8	33259.7959	0.001	0.042
202	10	24347.1597	0.002	0.095
14	10	48059.7279	0.002	0.041
202	12	32443.2233	0.002	0.059
3	12	20847.8767	0.002	0.083
4	12	24875.0023	0.002	0.066
10	12	54338.1278	0.003	0.047
13	12	48480.9413	0.002	0.033
13	12	48480.9413	0.002	0.033
13	12	48480.9413	0.002	0.033
5	13	21485.5170	0.002	0.070
14	13	43068.3702	0.002	0.049
5	14	32440.2823	0.002	0.049
6	14	20446.8105	0.002	0.079

APPENDIX I(A)

Master Control Network

Adjusted Distances (MARK TO MARK)
and their Standard Deviations/FGCC Specifications

ORDER B

			ST.DEV	FGCC
202	1	13020.7102	0.001	0.008
202	1	13020.7102	0.001	0.008
3	1	24423.1480	0.002	0.013
3	1	24423.1480	0.002	0.013
5	1	28241.9523	0.001	0.015
5	1	28241.9523	0.001	0.015
6	1	19105.6127	0.001	0.011
6	1	19105.6127	0.001	0.011
7	1	11194.8904	0.001	0.007
7	1	11194.8904	0.001	0.007
8	1	15382.8048	0.001	0.009
8	1	15382.8048	0.001	0.009
8	1	15382.8048	0.001	0.009
10	1	20694.8096	0.002	0.011
10	1	20694.8096	0.002	0.011
14	1	31685.4167	0.001	0.017
14	1	31685.4167	0.001	0.017
202	3	13941.3623	0.002	0.008
202	3	13941.3623	0.002	0.008
4	3	11563.1553	0.001	0.007
5	3	21408.4959	0.001	0.012
5	3	21408.4959	0.001	0.012
5	3	21408.4959	0.001	0.012
5	3	21408.4959	0.001	0.012
8	3	13618.0637	0.001	0.008
8	3	13618.0637	0.001	0.008
10	3	38201.1174	0.002	0.020
12	3	20847.8767	0.002	0.011
3	4	11563.1553	0.001	0.007
5	4	12331.2558	0.001	0.007
5	4	12331.2558	0.001	0.007
5	4	12331.2558	0.001	0.007
6	4	22997.6290	0.002	0.012
8	4	14205.4257	0.002	0.008
12	4	24875.0023	0.002	0.013
13	4	28335.5347	0.001	0.015
13	4	28335.5347	0.001	0.015
1	5	28241.9523	0.001	0.015
1	5	28241.9523	0.001	0.015
202	5	27487.7710	0.001	0.015
202	5	27487.7710	0.001	0.015
6	5	14184.3759	0.001	0.008
6	5	14184.3759	0.001	0.008
6	5	14184.3759	0.001	0.008
7	5	22691.2743	0.002	0.012
7	5	22691.2743	0.002	0.012
8	5	14231.8363	0.001	0.008
8	5	14231.8363	0.001	0.008
8	5	14231.8363	0.001	0.008
8	5	14231.8363	0.001	0.008
5	12	37189.0944	0.002	0.019
13	5	21485.5170	0.002	0.012
13	5	21485.5170	0.002	0.012
14	5	32440.2823	0.002	0.017

7	6	9798.3214	0.002	0.006
8	6	13328.7853	0.001	0.008
6	7	9798.3214	0.002	0.006
8	7	15012.2795	0.002	0.009
14	7	21106.1248	0.001	0.012
202	8	13595.0632	0.001	0.008
202	8	13595.0632	0.001	0.008
3	8	13618.0637	0.001	0.008
4	8	14205.4257	0.002	0.008
5	8	14231.8363	0.001	0.008
5	8	14231.8363	0.001	0.008
6	8	13328.7853	0.001	0.008
7	8	15012.2795	0.002	0.009
10	8	34529.1885	0.002	0.018
12	8	34150.2615	0.002	0.018
13	8	35686.2078	0.002	0.019
13	8	35686.2078	0.002	0.019
14	8	33259.7959	0.001	0.017
202	10	24347.1597	0.002	0.013
14	10	48059.7279	0.002	0.025
202	12	32443.2233	0.002	0.017
3	12	20847.8767	0.002	0.011
4	12	24875.0023	0.002	0.013
10	12	54338.1278	0.003	0.028
13	12	48480.9413	0.002	0.025
13	12	48480.9413	0.002	0.025
13	12	48480.9413	0.002	0.025
5	13	21485.5170	0.002	0.012
14	13	43068.3702	0.002	0.022
5	14	32440.2823	0.002	0.017
6	14	20446.8105	0.002	0.011

147	148	970.5329	0.001	0.007
147	149	1776.3494	0.001	0.010
148	149	844.3357	0.001	0.007
154	149	5266.5101	0.002	0.027
147	150	1301.4551	0.001	0.008
147	150	1301.4551	0.001	0.008
147	150	1301.4551	0.001	0.008
148	150	1037.5196	0.001	0.007
148	150	1037.5196	0.001	0.007
149	150	1656.1649	0.001	0.010
151	150	1127.3360	0.001	0.008
151	150	1127.3360	0.001	0.008
152	150	2334.0654	0.001	0.013
147	151	2238.4860	0.001	0.013
401	152	2938.0754	0.001	0.016
151	152	1942.1449	0.001	0.011
152	151	1942.1449	0.001	0.011
153	152	705.7362	0.001	0.006
151	153	2539.6102	0.002	0.014
154	153	3663.5675	0.002	0.019
155	153	3040.9455	0.002	0.016
156	153	1819.9193	0.002	0.011
157	153	2230.9616	0.002	0.012
155	154	1024.1564	0.002	0.007
156	154	2518.2184	0.002	0.014
157	154	3110.4822	0.002	0.017
161	154	3733.8194	0.002	0.020
163	154	5609.1269	0.002	0.029
157	155	2103.2250	0.002	0.012
155	156	1584.9790	0.002	0.010
157	156	780.3175	0.001	0.006
160	157	3702.2274	0.002	0.020
154	160	3788.4003	0.002	0.020
161	160	593.5100	0.001	0.006
162	160	3035.8140	0.002	0.016
163	160	1840.6595	0.001	0.011
164	160	1684.4769	0.001	0.010
163	161	2118.7929	0.001	0.012
403	162	4532.3501	0.001	0.024
154	162	6804.4983	0.002	0.035
161	162	3273.1657	0.002	0.017
163	162	1196.7980	0.001	0.008
164	162	2195.4280	0.001	0.012
164	162	2195.4280	0.001	0.012
168	162	6590.9357	0.001	0.034
157	163	4903.6840	0.002	0.026
160	163	1840.6595	0.001	0.011
403	164	3627.6192	0.002	0.019
154	164	5242.6282	0.002	0.027
161	164	1516.2290	0.001	0.009
163	164	1399.0430	0.001	0.009
403	165	1839.8970	0.001	0.011
162	165	3448.1364	0.001	0.018
164	165	1914.5156	0.001	0.011
403	166	780.0231	0.001	0.006
162	166	4701.3324	0.001	0.025
162	166	4701.3324	0.001	0.025
164	166	3428.7464	0.001	0.018
165	166	1517.9168	0.001	0.009
167	166	1593.8559	0.001	0.010
168	166	1988.6321	0.001	0.011
168	166	1988.6321	0.001	0.011
169	166	2561.0245	0.001	0.014

170	166	3318.7561	0.001	0.018
168	167	616.7474	0.000	0.006
169	167	1267.8446	0.000	0.008
170	167	2091.8273	0.000	0.012
171	167	3150.4336	0.001	0.017
172	167	3714.9264	0.001	0.020
167	168	616.7474	0.000	0.006
162	169	7040.8886	0.001	0.036
166	169	2561.0245	0.001	0.014
167	169	1267.8446	0.000	0.008
168	169	655.4658	0.000	0.006
168	169	655.4658	0.000	0.006
168	169	655.4658	0.000	0.006
170	169	824.8119	0.000	0.007
170	169	824.8119	0.000	0.007
170	169	824.8119	0.000	0.007
171	169	2641.8862	0.001	0.014
172	169	2958.5523	0.001	0.016
162	170	7637.0515	0.001	0.039
166	170	3318.7561	0.001	0.018
167	170	2091.8273	0.000	0.012
168	170	1480.1747	0.000	0.009
168	170	1480.1747	0.000	0.009
168	170	1480.1747	0.000	0.009
171	170	2558.4006	0.001	0.014
171	170	2558.4006	0.001	0.014
172	170	2636.2456	0.001	0.014
172	170	2636.2456	0.001	0.014
174	170	4365.2596	0.002	0.023
168	171	2893.3140	0.001	0.016
174	171	2288.3939	0.001	0.013
168	172	3351.4422	0.001	0.018
171	172	829.9911	0.001	0.007
171	172	829.9911	0.001	0.007
174	172	1764.4939	0.001	0.010
170	173	3721.5362	0.002	0.020
171	173	1606.1416	0.001	0.010
172	173	1093.0219	0.001	0.008
174	173	691.1918	0.001	0.006
176	174	2471.8055	0.002	0.014
100	175	2344.0611	0.002	0.013
101	175	4212.3456	0.002	0.022
170	175	6065.3445	0.002	0.031
171	175	3863.3331	0.002	0.020
172	175	3449.9921	0.002	0.018
173	175	2357.5736	0.002	0.013
174	175	1700.7356	0.001	0.010
174	175	1700.7356	0.001	0.010
176	175	801.8245	0.001	0.007

118	116	2365.9506	0.001	0.013
118	116	2365.9506	0.001	0.013
119	116	3024.7533	0.001	0.016
121	116	4790.6665	0.002	0.025
114	117	2860.5198	0.001	0.015
115	117	2630.4277	0.001	0.014
118	117	2267.5427	0.001	0.013
120	118	1650.0921	0.001	0.010
122	118	3732.4899	0.002	0.020
123	118	3558.9004	0.001	0.019
118	119	693.0852	0.001	0.006
118	119	693.0852	0.001	0.006
120	119	959.3467	0.001	0.007
122	119	3457.4778	0.001	0.018
123	119	2998.8230	0.001	0.016
116	120	3973.5412	0.001	0.021
118	120	1650.0921	0.001	0.010
119	120	959.3467	0.001	0.007
121	120	820.5721	0.001	0.007
118	121	2469.1336	0.001	0.014
119	121	1779.7049	0.001	0.010
123	121	1787.9602	0.001	0.010
3	122	2956.7081	0.001	0.016
120	122	3183.9023	0.001	0.017
121	122	3145.3770	0.001	0.017
123	122	1832.1394	0.001	0.011
124	122	1801.1710	0.001	0.011
120	123	2263.5919	0.001	0.013
122	123	1832.1394	0.001	0.011
3	124	2699.2596	0.001	0.015
3	124	2699.2596	0.001	0.015
121	124	3742.2964	0.001	0.020
123	124	1955.3881	0.001	0.011
127	124	3532.7797	0.001	0.019
128	124	5047.7276	0.002	0.026
129	124	6720.9071	0.003	0.035
3	125	2482.0709	0.001	0.014
3	125	2482.0709	0.001	0.014
121	125	3730.3595	0.001	0.020
122	125	2276.2601	0.001	0.013
123	125	1970.7362	0.001	0.011
124	125	572.1872	0.001	0.006
124	125	572.1872	0.001	0.006
126	125	2501.2859	0.001	0.014
127	125	3125.9707	0.001	0.017
128	125	4831.2946	0.001	0.025
3	126	4478.3806	0.001	0.023
124	126	2873.1354	0.001	0.016
127	126	690.2408	0.001	0.006
128	126	2536.9976	0.001	0.014
4	128	5082.5699	0.003	0.026
127	128	2287.2594	0.001	0.013
129	128	2295.2213	0.003	0.013
131	128	7711.4672	0.003	0.040
132	128	7569.6703	0.003	0.039
131	129	5419.9406	0.002	0.028
4	130	895.1330	0.001	0.007
128	130	5429.4913	0.003	0.028
129	130	3175.0682	0.002	0.017
131	130	2365.4418	0.002	0.013
132	130	2915.9499	0.002	0.016
4	132	2661.5229	0.002	0.015
129	132	5319.7368	0.002	0.028

131	132	1637.1910	0.001	0.010
131	132	1637.1910	0.001	0.010
133	132	1775.4557	0.002	0.010
135	132	3713.2779	0.002	0.020
131	133	2938.3307	0.002	0.016
135	133	2312.5240	0.001	0.013
135	133	2312.5240	0.001	0.013
136	133	4959.6761	0.002	0.026
137	133	5592.3658	0.003	0.029
139	133	7283.4118	0.003	0.038
131	134	3702.4640	0.002	0.020
132	134	3692.7906	0.002	0.020
133	134	2632.9823	0.002	0.014
135	134	826.6926	0.001	0.007
131	135	4067.4010	0.002	0.021
135	136	2932.3435	0.002	0.016
135	137	3670.8032	0.003	0.019
136	137	783.7023	0.001	0.006
5	138	1007.2649	0.001	0.007
5	139	859.5088	0.001	0.007
135	139	5831.3904	0.003	0.030
136	139	3275.4070	0.002	0.017
137	139	2542.6492	0.002	0.014
138	139	1011.1845	0.001	0.007
5	140	1519.2833	0.001	0.009
5	140	1519.2833	0.001	0.009
5	140	1519.2833	0.001	0.009
138	140	2261.0022	0.001	0.013
139	140	2369.0067	0.001	0.013
141	140	848.2317	0.001	0.007
141	140	848.2317	0.001	0.007
142	140	2454.4411	0.001	0.014
143	140	2813.2647	0.001	0.015
5	141	2305.9965	0.001	0.013
5	141	2305.9965	0.001	0.013
5	142	3930.3978	0.001	0.021
141	142	1625.3611	0.001	0.010
5	143	4184.0216	0.001	0.022
141	143	1968.3672	0.001	0.011
142	143	739.5936	0.001	0.006
144	143	1940.9507	0.001	0.011
145	143	1869.5684	0.001	0.011
146	143	3611.5768	0.001	0.019
401	144	5430.4998	0.001	0.028
142	144	2414.4140	0.001	0.013
146	144	1683.8527	0.001	0.010
147	144	2336.2448	0.001	0.013
152	144	5887.8807	0.001	0.030
142	145	2021.1489	0.001	0.012
144	145	1019.6365	0.001	0.007
401	146	4084.6738	0.001	0.021
142	146	4094.0526	0.001	0.022
144	146	1683.8527	0.001	0.010
145	146	2355.4138	0.001	0.013
147	146	782.2977	0.001	0.006
147	146	782.2977	0.001	0.006
148	146	1752.7787	0.001	0.010
149	146	2549.5018	0.001	0.014
150	146	1883.7347	0.001	0.011
152	146	4204.8066	0.001	0.022
401	147	3303.9793	0.001	0.018
152	147	3622.3981	0.001	0.019
147	148	970.5329	0.001	0.007

APPENDIX I

DISTRIBUTION LIST

DISTRIBUTION LIST

Carlos L.V. Aiken, Ph.D.
The University of Texas at Dallas
P.O. Box 830688, F02.1
Richardson, TX 75083

Ellis County Department of Public Works
Ellis County Records Building
2nd Floor
Waxahachie, TX 75165
Attn: Mr. Jimmy M. Reavis

Ellis County Road Commissioner - Precinct 1
P.O. Box 536
Palmer, TX 55151
Attn: Mr. James Palmer

Ellis County Road Commissioner - Precinct 2
1400 Oak Grove Road
Ennis, TX 75119
Attn: Mr. Ron Gilespie

Ellis County Road Commissioner - Precinct 3
P.O. Box 396
Italy, TX 76651
Attn: Mr. Del McLane

Ellis County Road Commissioner - Precinct 4
248 Eastgate Road
Midlothian, TX 76065
Attn: Mr. Cliff Wammack

City of Ennis
Director of Public Works
P.O. Box 220
Ennis, TX 75120
Attn: Mr. Roy Callahan

Larry Hothem
USGS
Geometronics Branch
521 National Center
Reston, VA 22092

City of Hutchins
P.O. Box 500
Hutchins, TX 75141
Attn: Ms. Jackie Denman, City Secretary

Kimley-Horn and Associates
12660 Coit Road, Suite 200
Dallas, TX 75251
Attn: Mr. Paul Hubert

City of Lancaster
Department of Public Works
P.O. Box 940
Lancaster, TX 75146
Attn: Mr. Robert Foster, Director

Alfred Leick, Ph.D.
Department of Surveying
University of Maine at Orono
Orono, ME 04469

City Engineer
City of Midlothian
235 North 8th Street
Midlothian, TX 76065
Attn: Mr. Duane Hill

City of Milford
Water and Sanitation Department
P.O. Box 538
Milford, TX 76670
Attn: Mr. Othel Smith

NGS, NOAA
N/CG 144
Rockwall 306
Rockville, MD 20852
Attn: Mr. John Love

Oceanics, Inc.
16223 Polk Road, Suite 150
Houston, TX 77084
Attn: Mr. George Loy

City of Palmer
P.O. Box 489
Palmer, TX 75152
Attn: Mr. James Gowin

Bob Schutz, Ph.D.
Center for Space Research
University of Texas
Austin, TX 78712

Texas Department of Highways and Public Transportation
Division of Automation - D-19
11th and Brazols Streets
Austin, Texas 78701
Attn: Mr. Roger Merrell

Texas State Department of Highways
P.O. Box 903
Waxahachie, TX 75165
Attn: Mr. Al Barton

Texas National Research Laboratory Commission
1801 North Hampton, Suite 400
DeSoto, TX 75115
Attn: Mr. John Slonaker

City of Waxahachie
Department of Public Works
P.O. Box 757
Waxahachie, TX 75165
Attn: Mr. Frank Davis