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The Series

THE ENGINEERING FIELD NOTES SERIES is published periodically as a means of exchanging engineering-related ideas and information on activities, problems encountered and solutions developed, or other data that may be of value to Engineers Service-wide.

Submittals

Field personnel should send material through their Regional Information Coordinator for review by the Regional Office to ensure inclusion of information that is accurate, timely, and of interest Service-wide.

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Honors Go to Two Regional Engineers

Both John Pruitt, Region 3 Director of Engineering, and Jim Wolfe, Region 10 Director of Engineering & Aviation Management, were recently honored as outstanding alumni by the New Mexico State University (NMSU) College of Engineering. The two, along with 98 other 1923–1973 honored graduates of the NMSU College of Engineering, were recognized in the College of Engineering's centennial book with a photograph and an impressive writeup (see below).

Pruitt, who was able to attend the school's centennial celebration, was presented an award by the university's president on stage at the school. The award included a certificate, a plaque, and a copy of the centennial book.

Pruitt: B.S., Civil Engineering, 1960. John Pruitt is Regional Engineer for the Southwestern Region of the Forest Service. He was a part-time employee of the Forest Service while a student at NMSU and accepted a position with the Forest Service in the Albuquerque Office when he graduated.

After 3 years of active duty in the Air Force, Pruitt returned to New Mexico and the Forest Service. His 26 years of employment with the Forest Service have included assignments as Preconstruction Engineer in San Francisco; Assistant Regional Engineer, Technical Services in Ogden, Utah; and Assistant Regional Engineer for Transportation in Portland, Oregon. Pruitt was Chief Transportation Planner for the Forest Service in Washington, D.C., for 2 years. In 1986, he was promoted to his present position in the Southwestern Region, which comprises Arizona, New Mexico, and the western portions of Oklahoma and Texas.

Pruitt was selected as the Forest Service Employee of the Year in Portland, Oregon, in 1981, for his leadership in evaluating the resource damage caused by the eruption of Mt. St. Helens.

Pruitt is a member of the WASHTO Highway Maintenance Committee and the Transportation Research Board's steering committee on low-volume roads.

Wolfe: B.S., Civil Engineering, 1965. Jim Wolfe is Director of Engineering and Aviation Management for the Alaska Region of the Forest Service in Juneau, Alaska. He has been with the Forest Service since 1971. He was Assistant Director for Technical Engineering for the Alaska Region prior to being named Director in 1984. Earlier, Wolfe was assigned to the Washington, D.C., Office as Chief Hydraulics and Dams Engineer, and he worked with the Interagency Committee on Dam Safety. He received a commendation from the Federal Coordinating Council for Science Engineering and Technology for his work on dam safety.

Wolfe was employed by the Corps of Engineers and the U.S. Department of the Interior from 1965 to 1971 and was involved in the design of flood control and related hydraulic structures.

He has published technical papers on safety inspection and maintenance of dams and is an active member of the American Society of Civil Engineers and the U.S. Committee of the International Commission on Large Dams. He is also a registered professional engineer in the States of Alaska, New Mexico, and Virginia.

The College of Engineering at NMSU recognizes James A. Wolfe for his contributions to the engineering profession through his service to the Forest Service.

Employee Suggestion Bulletin

(Last minute insert to EFN while on its way to printer)

United States Department of Agriculture | Forest Service | WO

Reply to: 1340-1

Date: JUL 06 1988

Subject: Employee Suggestion Bulletin

To: Regional Foresters, Station Directors, Area Director, and WO Staff

Our efforts for developing a brief flyer listing adopted suggestions on the Data General was well received. We thank each of you for your favorable comments.

At this time, we are enclosing the second flyer including adopted suggestions from March 25 until now. The next flyer will be forwarded to you the end of September.

After this flyer is distributed hard copy, it will be moved to the public file in Public Drawer: 1300 Management, Folder: 1340-1 Employee Suggestion.

James E. Webb

JAMES E. WEBB
ASSOCIATE DEPUTY CHIEF

****

7160--Signs and Posters

Jeff Meiner 6310 (R3-87-60/09-88-02)

Location: Prescott National Forest, Bradshaw Ranger District — Adopted: Service-wide.

Implementation of a new bumper sticker for "Federal Lands Clean Up Day" for volunteers who participate.

****

Doyle V. Ward 6314 (R6-1125)

Location: Okanogan National Forest, Tonasket Ranger District — Adopted: Service-wide.

Bumper sticker for internal/external use. I "Heart" my National Forest.

****

7700--Transportation System

Rick Elliott 6304 (R6-1105)

Location: Fremont National Forest, Lakeview Ranger District — Adopted: Optional Service-wide.

Power roller, attached to a tractor with 3-point hitch and powered by the PTO system of the tractor.

Road Program Costs—Continuing Efforts Addressing the Issue

James B. Heck
Civil Engineer
Willamette National Forest, Region 6

STARS to ROADS Data Conversion

It seems there is a never-ending demand for information. There are data base systems for almost any conceivable collection of data. Two important systems in the Forest Service are STARS (Sales Tracking and Reporting System) and ROADS (ROads Analysis and Display System). STARS, recently implemented, tracks timber sale information up to award of the sale contract. ROADS, an even newer system, analyzes and monitors the Forest Roads Program and helps present the program to others, including Congress (see Road Program Costs: Continuing Efforts Addressing the Issue, *Engineering Field Notes*, Volume 20, March-April 1988). These two national data base systems contain specific road data, such as road number, length, cost, and funding. Both require a considerable amount of data collection and computer input time.

The Willamette National Forest has created a process to reduce the time needed to use these two systems. First, they are using STARS as their primary data base. Second, they are developing a data transfer process that takes the data from STARS and electronically duplicates them into the ROADS Project Listing data base. This process substantially reduces input time.

STARS

The seven districts of the Willamette National Forest maintain a moving 5-year data base of sale information (current year plus 4 future years). This data base is updated every fiscal quarter. The road data consist of information gathered on the Facilities Estimate screen. The particular data fields are:

C1410 Facility (Road or Bridge number)
C1415 Work Class (Construction, Reconstruction, etc.)
C1435 Miles/Units
C1445 Contributed (FRP Funding)
C1446 Supplemental (FRP Funding)
C1447 Purchaser Credit (PCP Funding)
C1448 Pre-Road (FRP Funding)
C1443 Functional Class (Arterial, Collector, or Local)
C1444 Closure Status (Yes or No)
RARE II Access Acres (M-Acres)

The same information is required on the ROADS Project Listing.

To begin the data transfer process, a System 2000 (S2K) query is run at the National Computer Center at Fort Collins (NCC-FC). This query brings the information from NCC-FC and stores it as files in the Forest's Data General computer.

ROADS

The ROADS Project Listing data base contains three data files: District, Project, and Road. Information from the STARS query is inserted only into the Project and Road files. The District file contains only the Region, Forest, and District numbers and the Total District RARE II Released Acres. This released acreage is a constant and will change only with further legislation or by completion of Forest Plans. The District file information is input manually and takes little time. Capital Investment Program projects must also be entered manually.

The STARS data, stored by the S2K query in the "FCCC.Proj" and "FCCC.Road" files, is transferred into the ROADS Project and Road files, respectively, by using a macro written by Nora Holmquist of Management Systems.

The entire process takes about 20 minutes, compared to the many hours it takes to input information directly into the ROADS program for a Forest the size of the Willamette. The process is not necessarily user-friendly but can be learned by someone with basic computer skills.

Commitment

The data transfer process is easy and saves the Forest time and money in data input. What is difficult is getting the commitment from the Forest, and especially the Districts, to maintain and update the STARS data base so that accurate and timely information can be retrieved and presented. Through the efforts of Fred Harris, Operations Engineer, this commitment is being developed on the Willamette National Forest.

The STARS and ROADS Data Transfer Package was used to produce the Willamette's FY88 Final Allocation and FY89 President's Budget Project Listings. The program was ready for distribution earlier this summer.

For information regarding the process, contact Fred Harris, FTS 425-6514, COM 687-6514, DG Address: R06F18A, or Jim Heck, FTS 425-6828, COM 687-6828, DG Address: R06F18A. EFN

Generator-Powered Water System for a Remote Campground

Rochelle L. Liggins
Student Engineer
Mark Twain National Forest, Region 9

Introduction

Wild Boar Ridge Campground is a remote site within the Council Bluff Lake Recreation Area. The reservoir and recreation area are located along the Big River near Belgrade, Missouri, on the Mark Twain National Forest. The campground consists of 55 single and multiple camping units spread over a 1-mile length. Electricity terminates several miles from the site, and powerlines would have to be brought in underground to provide electricity.

The criteria indicated that a pressurized distribution system would be needed to meet the water demands of the campground. The system had to be cost-effective, automated, and nearly maintenance-free. Several options were considered before the final system was selected. Providing electricity to the site was the first consideration, but the cost of underground power was prohibitive. Other options to underground power included a direct-current pump with electricity provided by batteries that are recharged by solar cells, a wind turbine with a storage tank, and a storage tank supplied by a generator-electrified pump. The most economic and maintenance-free system was a pressurized system with a submersible pump powered by a generator fueled by liquefied petroleum gas (LPG).

The esthetics of the site dictated a low-profile, unobtrusive installation. The selected distribution system was underground and automated and meets the water demands of a major developed campground. The unit also can be modified to accept commercial power if the distribution lines are brought closer to the site.

Design

The Wild Boar water system is designed to meet a supply need of 15,400 gallons per day. The submersible pump is capable of pumping 15 gallons per minute against a total dynamic head of 540 feet of water. The distribution system has 12 hydrants and is pressurized by 10 hydropneumatic tanks. Each tank has a minimum drawdown capacity of 22 gallons.

The generator selected to power the system is an air-cooled 60-cycle-unit set for LPG operation. It has a minimum rated output of 12.5 kilowatts and an engine speed of 1,800 revolutions per minute; it also recharges the 12-volt battery that provides electricity for the DC light system in the well house. Two of the special attributes of the generator are a solenoid valve that shuts off the LPG supply when the unit is not running and an automatic load demand control to start and stop power at water pressures of 30 and 50 pounds per square inch, respectively. The generator also can be operated manually.

The LPG tank is located about 50 feet from the pumphouse/generator in an area difficult to see from the closest camping unit. However, a propane truck can easily service the 350-gallon tank, which is set on a concrete pad.

Operating Experience

The system has been operational since May 1987 and has performed well. There have been no problems with the sensing unit or the generator. The batteries appeared to have a bad cell, but their replacements have operated well. The only maintenance has been ensuring that the propane tank is full and cleaning the leaves from the generator area. One tank of propane ran the system for the summer.

Conclusion

The Wild Boar water system has several unique qualities. For instance, the automation of the system is atypical. The electric generator is started based on water system pressure. In addition, the generator is efficient and is expected to last for many years with little maintenance. The use of LPG minimizes air pollution, while the muffler and the location of the water system help keep noise levels low. The design of the well house and location of the generator and propane tank camouflage the water supply operation. This shows how a water system can be designed to have little visual impact. Esthetic considerations required innovation to provide a water system that did not require an overhead powerline.

Developing the system required expertise in design and a familiarity with remote systems. Harry Kringler, Zone Environmental Engineer on the Gallatin National Forest in Region 1, designed and assisted with the initial startup. There is a great deal of engineering expertise Service-wide, and this project is a good example of how technology can be shared among the National Forests. EFN

Rottne Logging Equipment on the Black Hills National Forest

Gregory M. Bohls
Civil Engineering Technician
Black Hills National Forest, Region 2

Introduction

Equipment and technology are rapidly changing. The logging industry is one of the areas where this change is taking place. The Rottne series of logging equipment is a new design that the Black Hills National Forest is currently using.

History of Use

Rottne equipment has been manufactured for approximately 30 years in Sweden, where Rottne is a well-respected name. In 1982, the United States began using Rottne logging equipment. The first 18 months were devoted to testing. Approximately 100 units (processors and forwarders) are now operating throughout the United States. However, there are no Rottnes operating in the Southwest Region.

A local logging contractor for Pope and Talbot, Inc. began using a Rottne unit in February 1986. Since then, three more units have been added. The Black Hills National Forest currently operates four units. The only other operation in Region 2 is along the Wyoming-Colorado border.

Equipment

The two machines that make up a unit are the processor and the forwarder (figure 1). Each machine has a Ford-manufactured tractor-body with a 4-cylinder, 98-horsepower turbo diesel. The tractor pulls and powers each machine. Visibility is excellent inside the tractor cabin, which provides a safe, comfortable working environment for the operator. Standard equipment in the cabin includes heating, air conditioning, windshield wipers, radio, fire extinguishers, and tools. Lights are mounted outside the cabin for nighttime operation. Each machine requires only one operator.

The machines are articulated, which allows them to move softly and with extreme flexibility, thus reducing the risk of damage to trees, ground, and machine. The machines are both 6-wheel drive. An 8-wheel-drive machine is in the development stage.

Processor

A trailer behind the tractor of the processor contains several types of machines—the crane; felling, limbing, and feeding tools; length-measuring device; and cutting tool (figure 2).

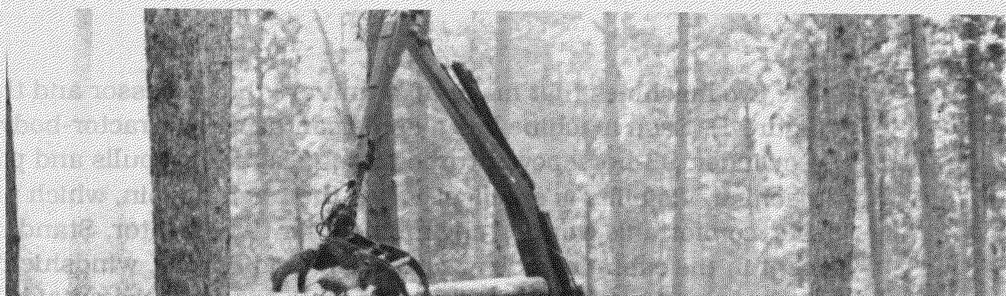

Figure 1.—The processor (top) and forwarder machines.

Figure 2.—Rear view of the processor unit.

After the processor drives to the tree, the crane swings the felling tool and grapple-holding device to the tree. The grapple holds the tree, while the felling tool, a hydraulic chainsaw, cuts the tree from the stump. The grapple and crane return the tree to the feeding tool, which forces the tree into the limbing tool (figure 3). The limbing tool removes and scatters the limbs.

Following the limbing operation, the log enters the measuring area, which breaks an electronic beam. Breaking the beam starts the free-running measuring wheel located under the log. An electronic reading is transmitted to the operator in the cabin.

The final step after the log is measured is to buck it into desired lengths and remove the top with the cutting tool, which is also a hydraulic chainsaw (figure 4). The cycle time for the complete process under average working conditions is about 1 minute. Then, the processor moves to the next tree to perform the same operation.

Figure 3.—Limbs are being removed from the tree by the limbing tool.

Figure 4.—After limbing, the log is measured and bucked into desired lengths by a hydraulic chainsaw.

Forwarder

The second machine is the forwarder. The forwarder contains a loading crane with grapple to load the bucked logs and transport finished logs to the landing (figure 5). The forwarder uses the slash alleys that the processor creates and deposits them approximately 50 to 75 feet apart. This serves several purposes—to break down the slash, to eliminate hand-slashing, and to reduce soil damage. Using the broad tracks over the bogie wheels and driving on the slash alleys allow field operation to continue even during spring breakup (figure 6).

The forwarder makes approximately 2.5 loaded trips to fill the truck and trailer. The forwarder unloads at an easy-access truck landing. Unloading directly to truck trailers would improve production (figure 7).

Costs

The approximate cost for the 6-wheel-drive unit is $350,000. The anticipated cost for the 8-wheel-drive model is $500,000.

Production

Production rates indicate that by using two 8-hour shifts (day and night), the machines can produce between 380 and 460 trees in open flat areas, which would equal approximately eight truckloads in 16 hours. It would take two crews of four cutters, one skidder with operator, and one bucker at the landing to produce the same results.

There are places where these machines perform well and other places where they do not. They do not perform well on steep, rocky ground with thick

Figure 5.—Loading bucked logs onto the forwarder. The operation is being controlled from inside the cab.

Figure 6.—The empty forwarder is returning for another load of logs. Note the heavy chains and broad tracks on the tires.

Figure 7.—Logs are being unloaded at the landing.

stands of large-diameter trees. They also are limited to trees with a diameter of approximately 18 to 20 feet.

The following are advantages of Rottne logging equipment:

(1) The equipment uses slash lanes to reduce soil damage and slash costs.

(2) The equipment provides for additional operating time during spring breakup periods.

(3) There is less need to have a large inventory of logs at the mill if operation continues during spring breakup.

(4) The cull material may be left in the field instead of at the landing and later burned by Forest Service crews.

(5) There is less damage (broken tops and skinned trees) to residual stands.

(6) The equipment increases production per staff-hour.

(7) There is increased safety and a reduction in workman's compensation costs.

Summary

Logging operations are changing because of such technological improvements as the Rottne unit. If operated properly and in the correct locations, this efficient machinery can serve a useful purpose for the logging industry, both today and in the future.

For further information or for copies of the technical machine specifications, contact the Black Hills National Forest, Spearfish Ranger District, 320 Ryan Road, Spearfish, South Dakota 57783, or call (605) 642-4622.

Remote Water-Level Monitor

Mary Denise Little
Student Engineer
Mark Twain National Forest, Region 9

WO Note

The Federal Guidelines for Dam Safety require that Emergency Action Plans for high-hazard dams consider early failure indicators and define emergency situations that require immediate notification of officials. The Council Bluff earthfill dam could fail by overtopping, slumping, or piping—all indicated by the nature of water-level fluctuation. The remote water-level monitor described in this article can provide an excellent warning system for these potential failure modes.

Introduction

The Mark Twain National Forest has encountered several firsts during the Council Bluff Dam project. The dam stands at 124 feet, making it one of the largest earthfill dams constructed by the Forest Service. Inundation maps of the floodplain indicate that several structures would be flooded in a dam failure. This identified the need to monitor surface-water fluctuations that are associated with unregulated releases. The device chosen for this project was the 560A Hydromet Data Acquisition System, which is manufactured by Handar Inc. The instrument package for this system is located on the dam intake tower and consists of a water-level sensor, recorder, transmitter, battery pack, solar cells, and charging unit.

Design

Developing a monitoring system that can distinguish significant water-level fluctuations is difficult. The 560A Hydromet Data Acquisition System is expandable and capable of operating as a data logger and remote data collection system that telemeters data using the Geostationary Operational Environmental Satellite, VHF/UHF radio, or telephone.

The system is an adaptation of a remote automated weather station, consisting of a data collection platform and incremental shaft encoder. The encoder was configured to operate as a stand-alone water-level monitor. The system is portable and can be installed in 1 day by two people.

The telemetry option chosen for this system is a VHF two-way radio with a Yagi antenna. A 12-volt battery recharged by a 9-watt solar system furnishes the power. The unit has been installed on the intake tower as shown in figure 1. The data are transmitted by radio wave on the Forest radio system to a base station transceiver that forwards them to a personal computer (PC) for storage and processing. The data also can be placed on a floppy or hard

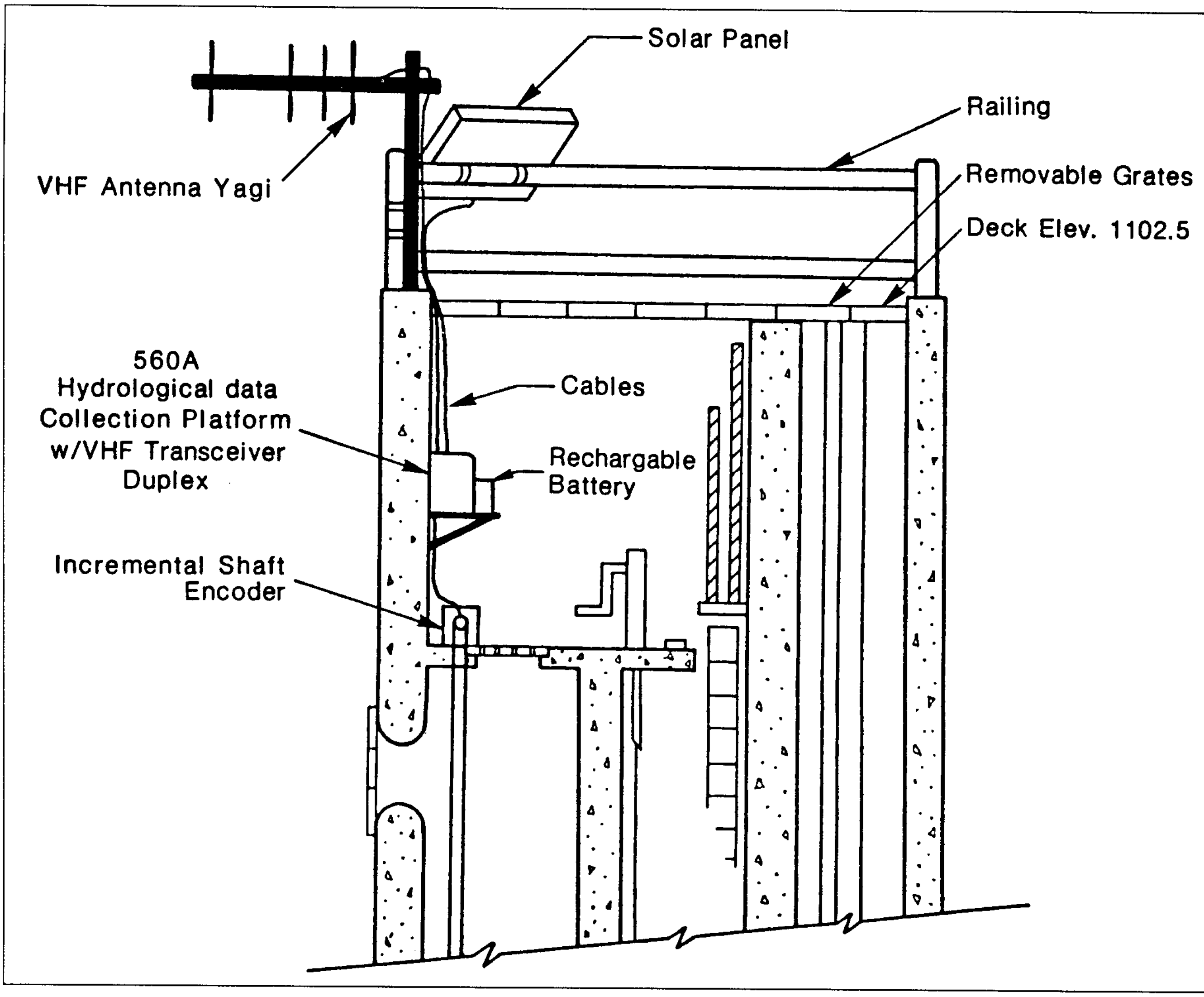

Figure 1.—This is a section of the upper 20 feet of the dam intake tower. The configuration of the monitoring system is shown.

disk. The transceiver, PC, and base station are located in the Potosi Ranger Station approximately 25 miles from the dam.

Performance

The system was installed in April 1987. The readings were stored while the Forest radio system was modified to allow better transmission of the data. Initially, a mountaintop base link was to be used to relay the data from the dam site to the Potosi Ranger Station. However, there were problems getting the data through the link, and they are now being forwarded through a repeater.

Once the data are cleanly received at Potosi, the PC will store and manipulate the information. The PC will be interconnected with the Data General equipment, and information will be sent to a mailing list in CEO. Personnel in a variety of locations will receive the water-level readings. If a substantial water-level change occurs, an URGENT message will be transmitted.

The system is easy to set up as a water-level monitor. The difficult part is transmitting the data on the radio system and interfacing the PC receiver with the Data General equipment. The technology is available to perform all necessary tasks. However, it has taken some time to get the system to function as intended, and additional time is needed to evaluate the final product.

Conclusion

A monitoring device should be considered for any dam that is rated as a high hazard. This system was developed because it uses existing technology and is cost-effective. Power and telephone lines stop 2 miles from the dam site. The system is automated and capable of transmitting data both at intervals and when changes occur. Adapting this type of system for dam monitoring has excellent potential. (EFN)

New Reinforced Soil Walls & Fills

Michael Burke
Geotechnical Engineer
San Juan National Forest, Region 2

During the last few years, we have developed several new methods for protecting the face of reinforced soil fills and walls. Our motive has been to develop systems that are cheap, easily adaptable to differing site conditions, and esthetically pleasing. Figures 1 through 5 are excerpts from construction plans and photos of three designs that have proven successful or show promise.

Treated Timber-Faced Reinforced Soil Wall

The treated timber face is constructed out of precut and predrilled 8-inch-square timbers in lifts as the fill is constructed. Geogrids, held in place by the weight of the timber face and staples, reinforce the compacted backfill. The lattice structure should save on materials as well as create a pleasing appearance. Five of these walls were built on a Forest Service road visible from a major ski area. The cost for the walls under a public works contract is approximately $14 per square facial foot. This price includes materials, installation, excavation, and placement of backfill under moderately difficult conditions (a significant amount of blasting was required).

Straw-, Soil-, Manure-, & Seed-Faced Reinforced Fill

The face of this .5H:1V (the fill in the photos) geogrid-reinforced fill was constructed by windrowing and compacting a mixture of straw, clay, cow manure, and seed along the outer edge of each 1-foot lift of embankment. The straw gives the soil enough tensile reinforcement so that the required steep slope can be obtained without using external forms and also serves as erosion protection until the seed germinates and vegetation establishes itself. The manure enriches the soil and replaces nutrients that are leached out by the straw. For this design to work, the soil must have some plasticity and be on the wet side of optimum. We have built four of these reinforced fills with a maximum height of 11 feet. The fill shown on the drawings is currently under contract and will be built this summer. The cost for these fills under public works contracts is approximately $9.50 per square facial foot, including materials, installation, excavation, and placement of backfill.

Fiberglass-Reinforced Fill

The face of this reinforced fill is formed by mixing very fine strands of fiberglass shot from an air gun with loose soil falling from a backhoe bucket. The fiberglass strands, like the straw in the previous design, provide the tensile reinforcement necessary to construct the .75H:1V fill slope. On the fill

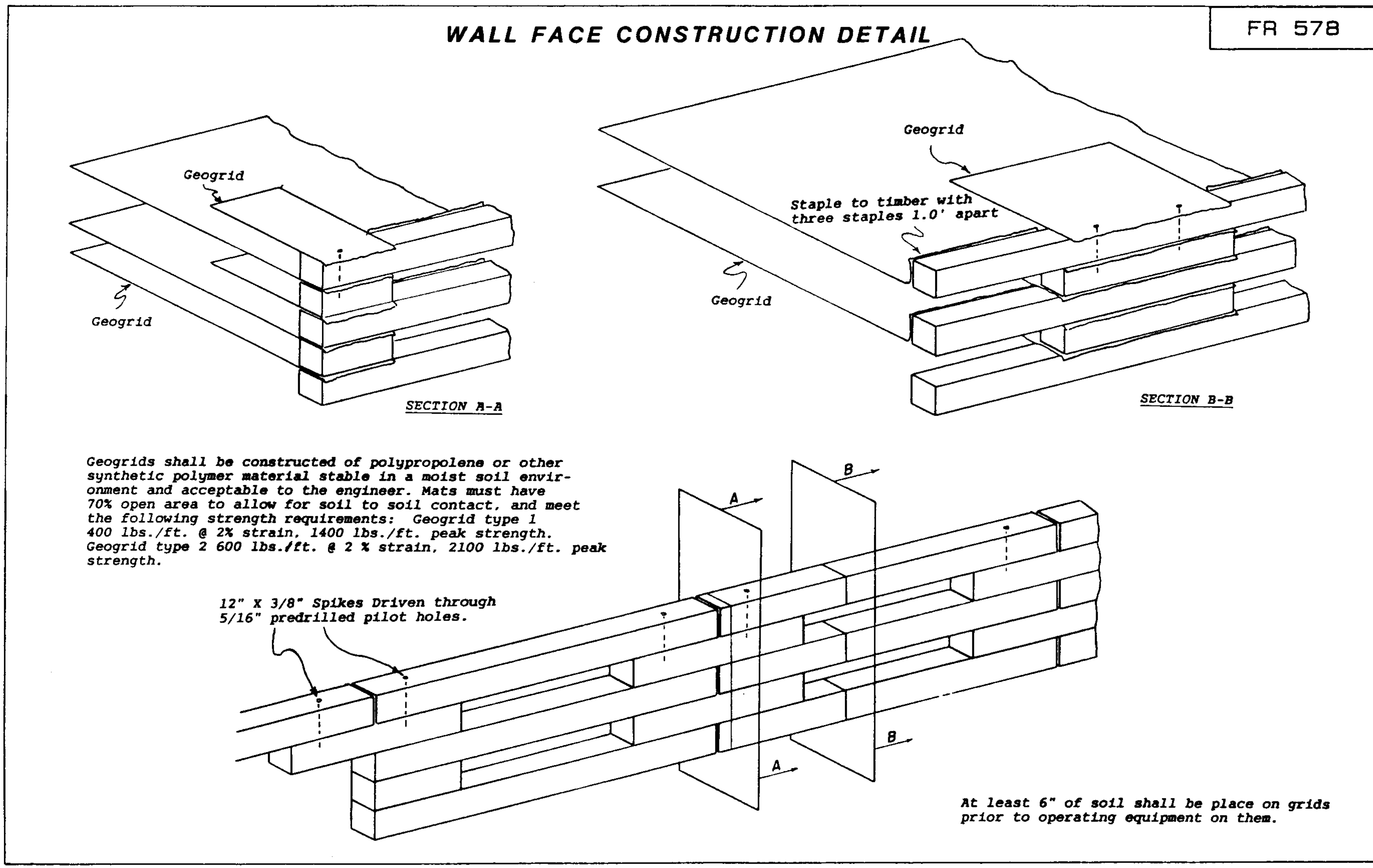

Figure 1.—Wall face construction detail.

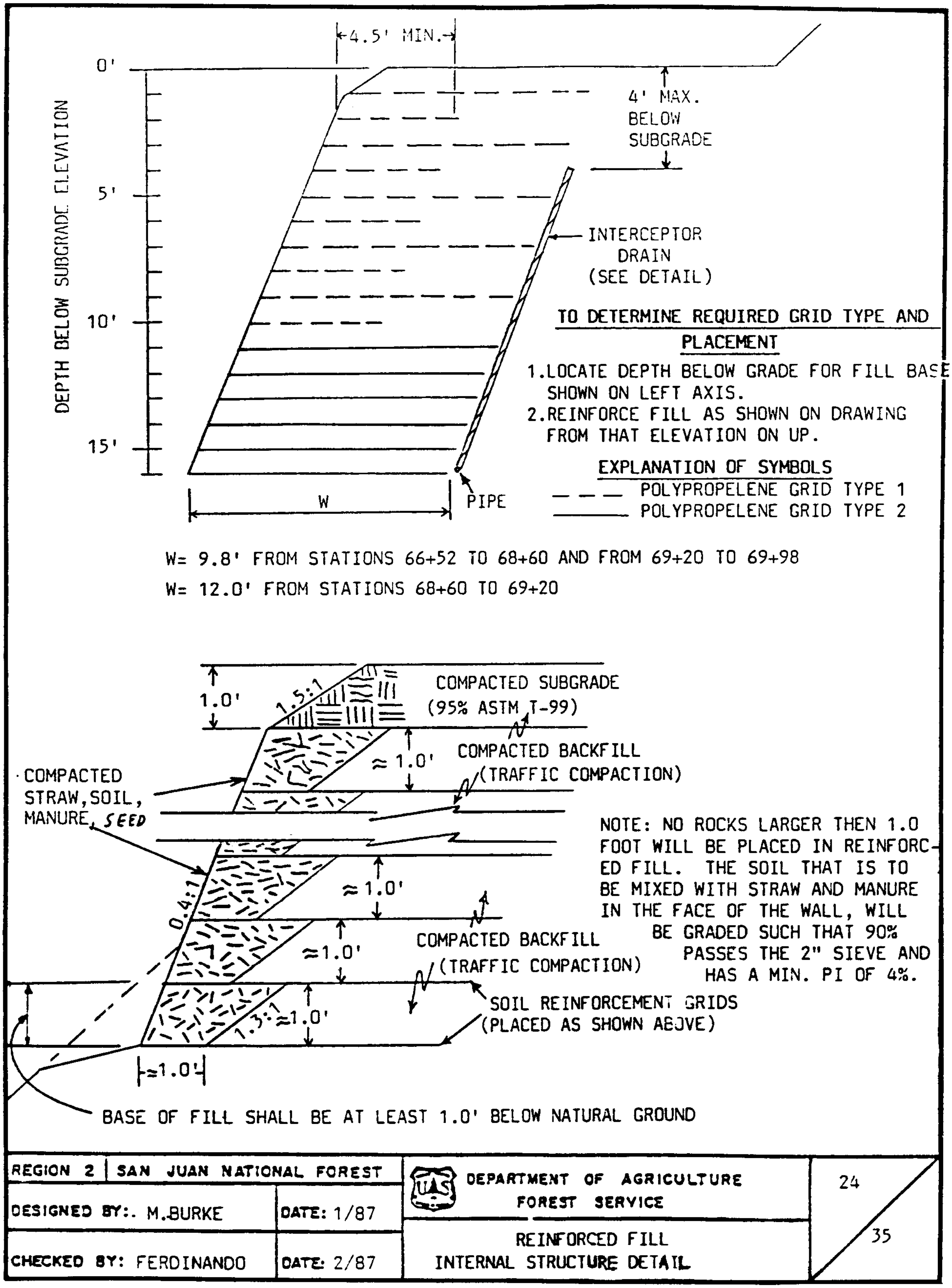

Figure 2.—Reinforced fill internal structure detail.

shown in the photos, the soil was too dry to achieve the .5H:1V slope originally intended. If the broadcasted seed does not take, we will hydromulch the slope this summer. The fiberglass should provide a good anchor for the hydromulch mat. This example (the only one to date) is 40 feet long and 8-1/2 feet high and was constructed force account by one backhoe operator and one laborer in a single 10-hour day. We placed horizontal layers of geogrid every 1-1/2 feet. However, with more experience and testing, this may prove an unnecessary precaution. Our total cost, including materials, installation, excavation, and placement of backfill was about $3.50 per square facial foot. This type of fill may turn out to be very useful for maintenance as well as for new construction on steep side slopes.

For additional information, contact Michael Burke at (303) 247-4874 or by DG: RO2F13A.

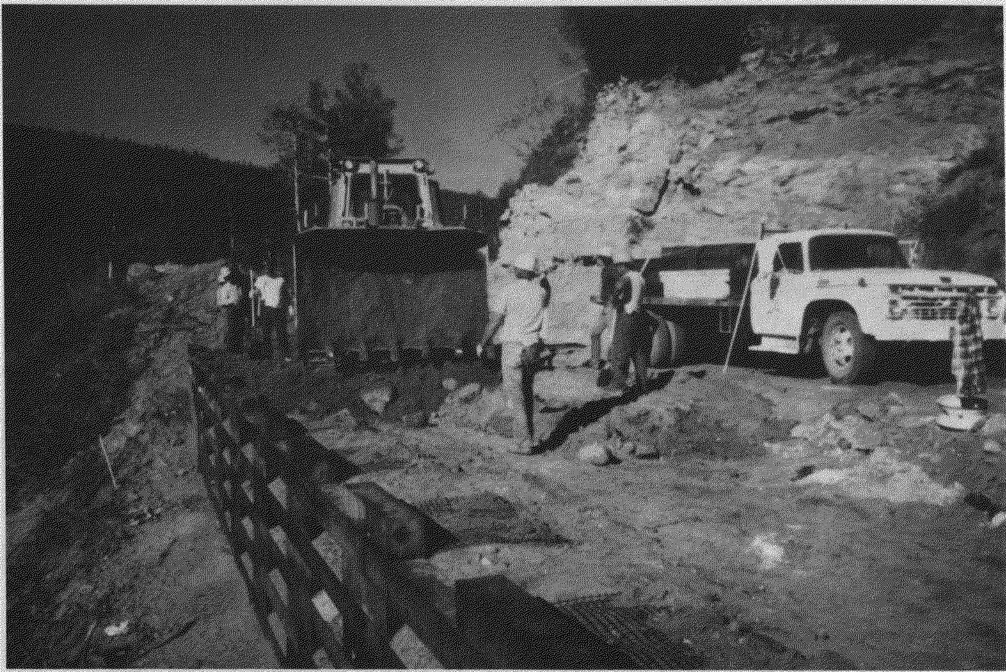

Figure 3.—Treated timber-faced reinforced soil retaining wall under construction (top). Alternate layers of geogrid reinforcement (hidden from view) extend the full length of wall and are 10 feet wide. Completed timber-faced wall (bottom). Note the lattice structure and loose soil in the openings.

Figure 4.—Soil-, straw-, manure-, and seed-faced, geogrid-reinforced fill just after completion (top). The middle portion of the fill is .5H:1V. The same reinforced fill after two growing seasons (bottom).

Figure 5.—Fiberglass-reinforced soil-faced, geogrid-reinforced fill under construction, .75H:1V (top). The fiberglass is broken up into very fine strands and mixed into the falling soil by a compressor powered air gun. Same fill after completion (bottom). Face may be hydromulched if broadcasted seed does not take.

Electronic Notebook Program for the HP-71B Computer

Richard A. Rasmussen
Civil Engineering Technician
Bighorn National Forest, Region 2

Introduction

The purpose of this article is to introduce a computer program that serves as an electronic fieldbook for use with the HP-71B handheld computer. To streamline road surveying, note keeping, and design practices, Engineering personnel of the Bighorn National Forest wrote the Electronic Notebook Program during the fall of 1986.

We already had an MSI Data Corporation electronic notebook available but were dissatisfied because data had to be coded before they could be put into the unit. Remark statements had to be put on another page or file in the electronic notebook, which made keeping track of the different files confusing. It was difficult to see the LED display in bright light. In addition, errors were hard to detect because of the coding, and they were not usually discovered until the data were dumped to the computer and a hard copy was made. If the electronic notebook could be set up so the survey data were entered using the same steps and language used with the regular fieldbook, then a great number of the errors could be avoided; they could be caught and corrected more easily when they did occur.

In the spring of 1986, we purchased two HP-71B computers to create the easy-to-use Electronic Notebook Program that could be used with our HP-150 and the HANS_ON road design system.

Program Description

The Electronic Notebook Program was designed for use with the HP-71B computer; it uses plain text entry exactly as if the data were being entered into a standard fieldbook. Data entered into the program are stored in a series of one- and two-dimension arrays. The program offers full editing capabilities, inputting or dumping of data to or from magnetic cards, cassette tapes, or disks, and printing of the survey data. The program currently is set up to accept a maximum of 200 sections or survey points—a very good day's work for a survey crew working under our field conditions.

When the program is run, the operator is asked for the same standard information—date, weather, temperature, party chief 's name, and road name and number—that normally would be put into a fieldbook. The entries are then displayed for verification, and if correct, the program proceeds to the actual survey information.

The operator is then prompted for the section number, left cross sections, right cross sections, remarks, slope distance ahead, percent slope ahead, and azimuth ahead. The cross sections have a limit of 45 characters per side in the form of ##/##,##/##. The positive sign (+) is assumed while the negative sign (-) must be shown. Cross sections must be input from left to right. This must be done for both the left sides before doing the right sides. The remarks also have a limit of 45 characters, so some abbreviations should be used. The slope distance ahead will accept a decimal if desired. Percent slope ahead will accept a negative sign while the positive sign is assumed. At this time, percent slope input is the only type of notation accepted. The program will accept azimuths but not bearings.

The data for each section number are then displayed for verification. If all data are correct, the program then prompts the operator with the data for the next section. This sequence of steps is repeated until the end of the day or the end of that particular road segment.

At the end of the day, the HP-71B is connected to the printer, and a copy of the survey data is printed out. If an error is detected, it can be corrected and reprinted. The day's work is then dumped to magnetic cards, cassette tapes, or disks. The cards, tapes, or disks can then be brought to the office where they are reloaded into an HP-71B and then dumped to the HP-150. HANS_ON Version 7.0 will load the data directly from the B drive, and no keypunch time is required. Hooking up the HP-71B and the HP-150 and dumping the day's survey data to disk require little time.

Equipment

The HP-71B computer will need to be upgraded from its original configuration with an IL Interface, a card reader (if using magnetic cards), a cassette drive, or a 3.5-inch disk drive. Additional random access memory (RAM) also is needed. We were not sure how much RAM would be needed, so we installed two 32K RAM chips in ports 1 and 2. The two chips seem to be more than adequate, and we can now put an entire day's survey into the 80K RAM. To print a hard copy of the survey, which can be checked for accuracy and kept as a backup, a Think-Jet printer with IL Interface can be purchased. We also purchased an HP-150 extended I/O accessory board and the HP-IL Link software package to complete the transfer of data from the HP-71B to the HP-150.

Savings

It requires 1 to 2 hours to input by hand a mile of survey data from a fieldbook to the HP-150. The same data can be transmitted to the HP-150 in a matter of seconds using the Electronic Notebook Program with the HP-71B. There is no appreciable savings during the survey because the time it takes to keypunch the data into the HP-71B is about the same as recording them in the fieldbook. Additional savings can be realized during the first part of the design process by using the EDLIN editor instead of making changes in the HANS_ON program.

For additional information, contact Richard Rasmussen at (307) 672-0751, or by DG at D.RASMUSSEN:R02F02A. EFN

Lowered-Pressure Off-Highway Tires for Road Construction

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Introduction

Some timber-harvest areas on the Tongass National Forest have only marginal- to poor-quality rock-borrow material available for road construction. Importing good-quality rock to these areas can be very expensive. This article describes how using lowered tire pressure for hauling over marginal-quality rock provided significant savings over using conventional-pressure tires and importing good-quality rock. While conditions described here are representative of southeast Alaska, they may apply in other areas.

Most of the native subgrade materials are saturated organic and sensitive, fine-grained, silty soils that tend to slough when wet. Generally, the subgrade is prepared with a hydraulic backhoe that levels the ground surface to the pioneer-grade elevation. The excavated material is wasted along the roadside because the frequency of rain makes drying it impractical. Clearing debris, such as limbs, tops, cull logs, and stumps, is placed on the subgrade as a mat.

The road is constructed by end-dumping pit-run shot-rock on the debris mat and spreading it with a bulldozer. The depth of rock on the finished road is approximately 30 inches. Road failures are usually caused by either the soft, saturated condition of the subgrade or the degradation of the borrow material.

Toncan Timber Sale

Work began on the preliminary layout of the Toncan Timber Sale in 1983. Because of previous experience with poor-quality materials in the vicinity, an intense geotechnical field evaluation was done. The evaluation identified the better-quality sources along the proposed road. However, the rock from these sources was considered marginal. When the sale was prepared, the best of the marginal-quality rock sources were designated in the contract.

The Toncan Sale was awarded in the spring of 1986. Road construction started in March 1987 and continued throughout the summer. Pit No. 3 was developed in July, and tests confirmed that the material from the pit was marginal in quality. This quarry was naturally highly fractured and, when blasted, yielded approximately 2-inch minus material. When placed on the roadway, 17 percent of the shot-rock material was sand size or smaller. After 6 or 7 days of rock haul, the road prism was resampled. The rock had degraded under traffic to the extent that 30 to 50 percent of the material was sand size or smaller, with 13 to 18 percent passing the #200 sieve.

Initial Road Construction

During the initial road construction from this pit, the weather was exceptionally dry, and the material performed satisfactorily. However, because of the amount of fines being produced, it was obvious that problems would develop when the normal fall rains began. The annual average rainfall in this part of southeast Alaska is 106 inches, with 30 percent occurring during the fall construction season. The rain started in early September, and the road began to deteriorate almost immediately. Constant grader maintenance and patching of the running surface were necessary, and ruts developed to a depth of 18 inches.

The only source of competent rock was down the existing road and would require an additional 9.25 miles of haul. Approximately 100,000 tons of shot-rock was needed to construct the remaining road. The additional cost of obtaining this rock from the alternate source was estimated at $274,300. In addition, the existing haul roads, which were built with marginal material, would require some reconstruction and rock replacement to accommodate the heavy rock-haul traffic. The estimated cost of this reconstruction and resurfacing was $303,000. The total cost of the design change using conventional haul methods would have been $577,300.

Because the authors had attended a meeting on central tire inflation (CTI) in San Dimas, they were knowledgeable about lowered tire pressures for log haul. Even though this technology was still in the experimental stage and had never been tried on off-highway trucks, it might be an alternative solution to the traditional method of changing rock sources.

Design Changes

The Forest, with the concurrence of the Regional Office, negotiated a design change with the purchaser for new steel-belted radial tires for four of the rock-haul trucks. This design change included additional borrow and haul as well as new tires, tubes, and rims for the trucks. The total cost of the design change was $123,800 ($49,400 for tires, tubes, and wheels), resulting in an initial savings of $453,500 to the Government.

In early December 1987, trucks equipped with steel-belted radial tires began hauling from Pit No. 3. The rock-haul trucks were three-axle off-highway Hayes and Mack trucks with gross vehicle weights of up to 100,000 pounds. Tire pressures were adjusted so that the deflection of the tires on the loaded trucks was 20 to 23 percent. No adjustment of pressure was made for the empty return trips. To achieve the desired deflection, tire pressures were 62 pounds per square inch (psi) on the front axles and 52 psi on the rear axles of the Mack trucks and 48 psi on the front axles and 42 psi on the rear axles of the Hayes trucks.

Prior to initiating lowered tire pressures on this project, the authors met with the truck drivers to discuss the concept of lowered tire pressure and the expected results. The drivers were very vocal and expressed their opinion that the trucks would be unsafe and hard to handle. During the first couple of haul days, the drivers expressed this same concern. However, as the drivers got used to the handling of the trucks, their resistance to the concept ceased.

Benefits

After 5 days of haul with about 60 loaded passes per day (120 loaded and empty passes), the road surface was in much better condition than after a high-pressure haul. For instance, in areas where severe rutting of up to 18 inches had occurred after a high-pressure haul, only minor rutting of 4 inches was evident, and where constant road blading was necessary before, no maintenance was required. Heavy rains continued and road construction progressed without problems until freezing weather and snow caused shutdown for the winter.

The purchaser resumed limited road construction in March 1988 using the same trucks. Sections of the road began to degrade similarly to when the trucks were run with the bias-ply tires. Frost in the road prism was suspected as the cause of the problem, and a work shutdown order was considered. However, a check of the tire air pressures revealed that one of the Hayes trucks was running with 90 psi in the front tires. The front-axle tire pressure was dropped to 48 psi on this truck, consistent with the other Hayes trucks, and the road immediately began to heal.

The purchaser has been very pleased with the results of lowered tire pressures on this project and estimates that the downtime for the rock trucks has been reduced by 10 percent, even though the concept has been used for only a short time. In addition, road maintenance has been reduced from daily grading to a weekly pass with the grader.

The use of bias-ply tires on these trucks under identical construction conditions indicates a tire life of 3,000 to 5,000 miles. In contrast, the radial tires in use on this project have approximately 2,500 miles on them and show absolutely no wear. The purchaser has expressed intent to equip all the logging trucks with radial tires and operate them at lowered tire pressures.

However, caution must be used in the application of the lowered-tire-pressure concept in spite of all the indicated benefits. Purchasers should not buy radial tires and randomly lower the pressure, because if pressures are lowered too much, tire failure can occur through sidewall damage or heat buildup.

An interim tire standard has been issued by the Tire and Rim Association for reduced tire pressures using 11R22.5 and 11R24.5 tires. This is the only approved standard allowing reductions below recommended highway pressures. Pressure for other sizes of radial tires (and a few bias-ply tires) can be lowered only under special agreements with the specific tire manufacturer. All projects using tire pressures below those recommended by the Tire and

Rim Association must be accomplished under the National CTI Program administered by the San Dimas Technology & Development Center (WO Engineering).

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Four Years of Using GPS

Vic Hedman
Land Surveyor
Region 9

Introduction

NAVSTAR GPS is the acronym for Navigation Satellite Timing and Ranging Global Positioning System. GPS has become the common term. The accuracy of precise relative positioning by GPS is making a significant impression on the system users.

As reported in the *Proceedings of the First International Symposium on Precise Positioning with the Global Positioning System—1985*, the current Block I of GPS satellites was launched from 1978 through 1984. In 1983, the Federal Geodetic Control Committee (FGCC) conducted tests of GPS receivers on a National Geodetic Survey (NGS) horizontal control network near Washington, D.C. The baselines of this network ranged from 8 to 42 kilometers. The comparison of these baseline lengths with GPS showed mean positional differences ranging from 1.7 to 11.1 centimeters, or a mean of 2.2 parts per million. This well exceeds current NGS first-order accuracy requirements.

To ensure quality control and comparable first-order accuracies, GPS equipment should be certified by the FGCC from test-range results. Observing time should be for a minimum of 30 minutes and should be simultaneous on four satellites using three receivers.

All of Region 9's GPS contracting has required baseline accuracies to be within 10 centimeters relative to the NGS master horizontal control station selected for each project area. Testing the accuracy of GPS coordinates has been accomplished by aerotriangulation and by traverse. The Region has placed GPS control on nine project areas as of January 1988 (figure 1).

FGCC is proposing to raise the accuracy standards to 1 part in 1 million for the primary National Geodetic Reference System and not less than the current 1 part in 100,000 first-order accuracies for densification within the primary network. The proposed new standards reflect the major impact of GPS positional accuracies.

Recently, the users of the national horizontal control network have been subjected to a major change: the North American Datum (NAD-27) has been replaced by NAD-83. This change is the result of the volume of additional and more accurate data observed since 1927. These new data have caused the revision of the earth's geocenter and radii. Positional changes from a few feet to over 100 feet have resulted from the readjustment of the national

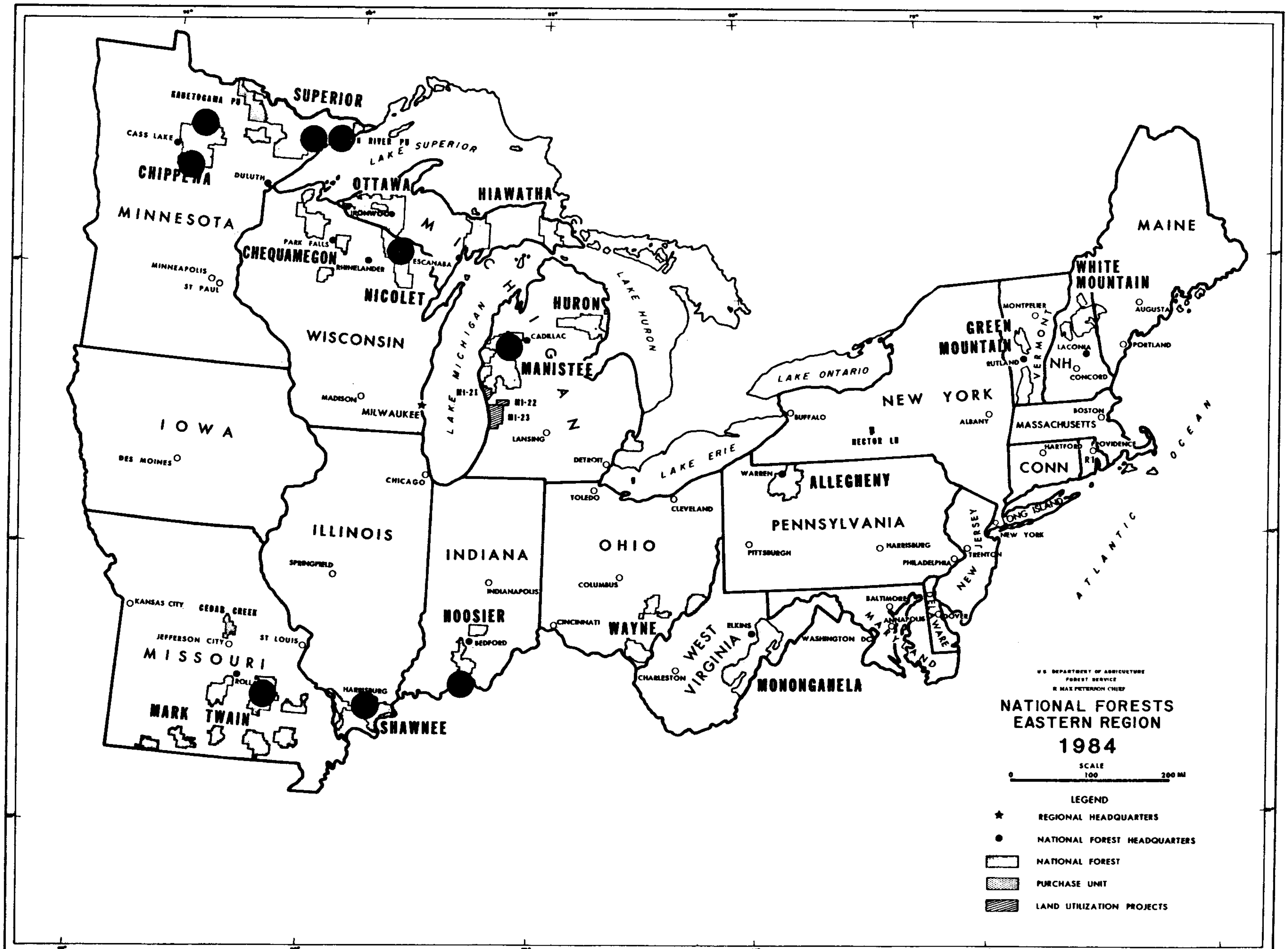

Figure 1.—GPS project areas.

network. The published data of NAD-83 were not received until 1987 because of the major task required to make the nationwide conversion. GPS projects prior to 1987 were referenced to NAD-27. A long and costly conversion will be needed for the 60 years that NAD-27 has been used as the standard of reference.

Planning for GPS Control

Planning for a GPS Control Project requires a time-elevation-azimuth ephemeris for the dates of the satellite observations. The ephemeris will show when and where not less than four satellites are available for simultaneous observations and the clearing required to make these observations. Generally, no clearing is required in the southeast quadrant for observations in the Midwest. When the full complement of Block II satellites is in place, clearing will be required in all four quadrants. We have limited clearing to 30 degrees above the horizon, which does reduce the observing time available.

Locating points for GPS coordinates has required vehicle accessibility to transport the equipment. On township projects designed for aerotriangulation, nine GPS points properly placed will control 1 part in 12,000 scale photography (figure 2). If the township requires extensive traverse and retracement for corner evidence, GPS points are placed as control near the corner of four section blocks that is easily accessible by motor vehicle (figure 3).

GPS projects are planned for the fall, when advantage can be taken of daylight field operations. When all Block II satellites are in orbit, the time of the year will no longer be a consideration. Field reconnaissance is scheduled in April or May to locate NGS master stations and GPS points. The GPS points are monumented and cleared for observation by September and the contracts awarded in September.

Each GPS point is marked with a substantial brass-capped monument stamped to identify the point and the year of placement. Each Forest has its own sequence of numbers, such as GPS-1, GPS-2, GPS-3. No reference or azimuth monuments are placed. A marker post and sign are set by each GPS monument to provide a limited degree of protection. The majority of the GPS points are placed on Government lands.

GPS 1984 to 1987

1984

The Region's first GPS project on the Superior National Forest in Minnesota was reported in the May-June 1985 issue of *Engineering Field Notes*. The project was a combination GPS-traverse-aerotriangulation control for a township. It was a learning project for the Region. We were aware of the problems of clearing, access, and not getting GPS points at the best locations for aerotriangulation, but we were not aware of any inconsistencies within NAD-27.

1985

In 1985, a GPS-aerotriangulation township project was established on the Nicolet National Forest in Wisconsin. Two NAD-27 first-order horizontal control stations within the same arc of triangulation were selected for relative

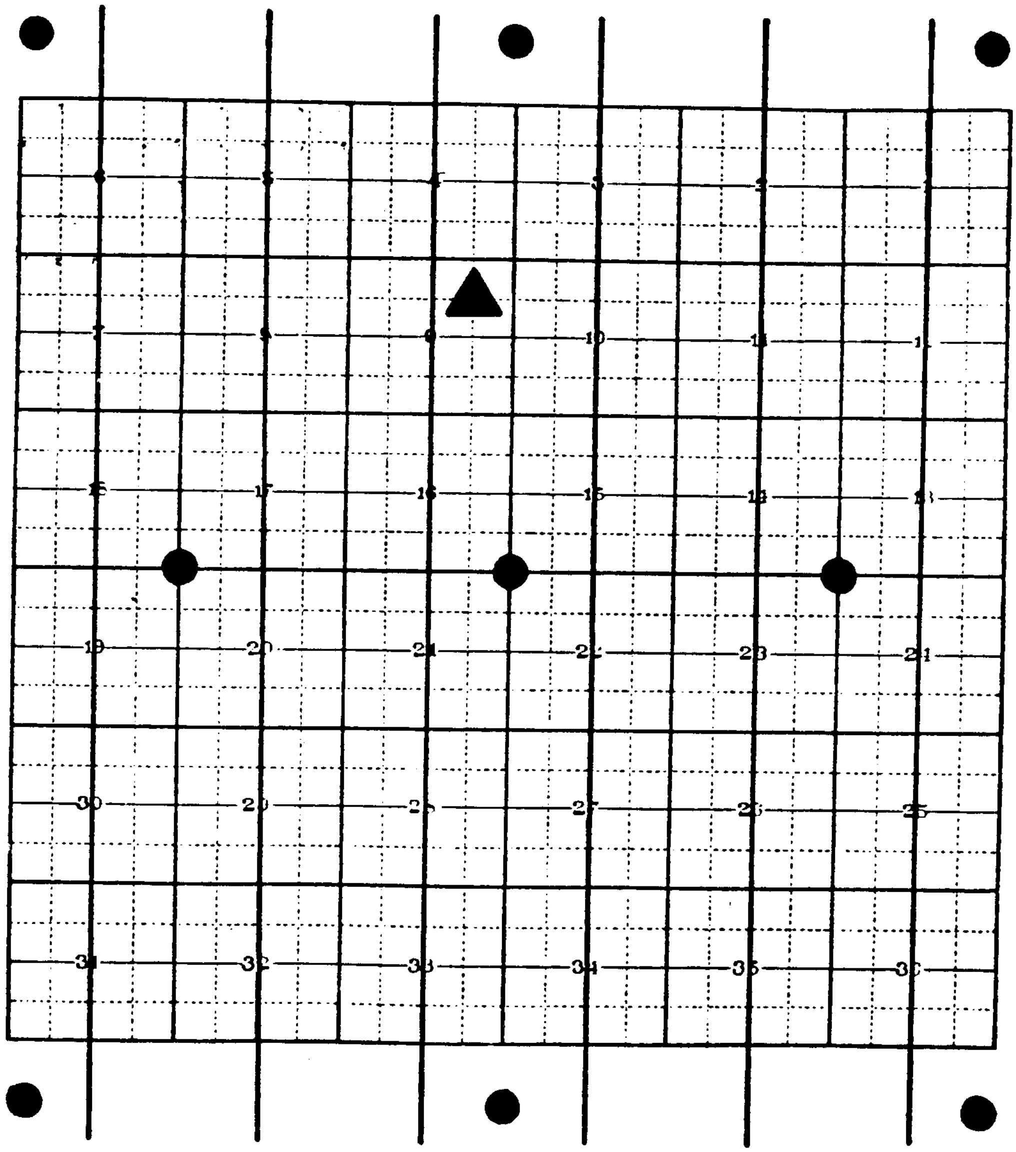

Figure 2.—GPS control for aerotriangulation.

GPS positioning and as control for coordinate establishment of photo targets. We were in for an unexpected surprise (figure 4).

Station Tauno, 6 miles north of the project area, is 48.7 miles away from Station Archibald, the second NGS Station south of the project township. The contractor, using codeless receivers, advised us that the closing on Archibald in relation to Tauno misclosed by about 1 meter in latitude and about 2 meters in longitude. A planned constrained adjustment between Tauno and Archibald was dropped, and the decision was made to hold to Tauno as the master station in the final solution.

When the NAD-83 coordinate values for Stations Tauno and Archibald became available, the comparisons with NAD-27 coordinates become quite enlightening (table 1). GPS indicated that there was a 3.4-foot relative error (14.9 – 11.5) in latitude and a 6.3-foot error (33.2 – 26.9) in longitude between Tauno and Archibald, as published under NAD-27.

The consideration on future projects involving Archibald is whether to use Archibald-83 or Archibald-GPS with the nearly 1-foot difference in latitude. The GPS equipment used was a codeless, single-frequency carrier-phase receiver that may have been at the limits (48.7 miles) for effects of ionosphere refraction. A check will be needed using either code- or dual-frequency carrier-phase receivers. Without a check, the tendency will be to hold to Archibald-GPS based on the exceptional accuracies of GPS.

One test of GPS accuracy is the internal consistencies of observed and processed data of reoccupied points in a loop traverse (figure 4). Points 4-6-9 have a 3- to 5-millimeter misclosure in latitude and a 2- to 3-millimeter misclosure in longitude. The closing back on Tauno varied by 0.6 millimeter in latitude and 1 millimeter in longitude. Thus, the internal proportional accuracies of the loop traverse were in the order of 1 part in 1 million.

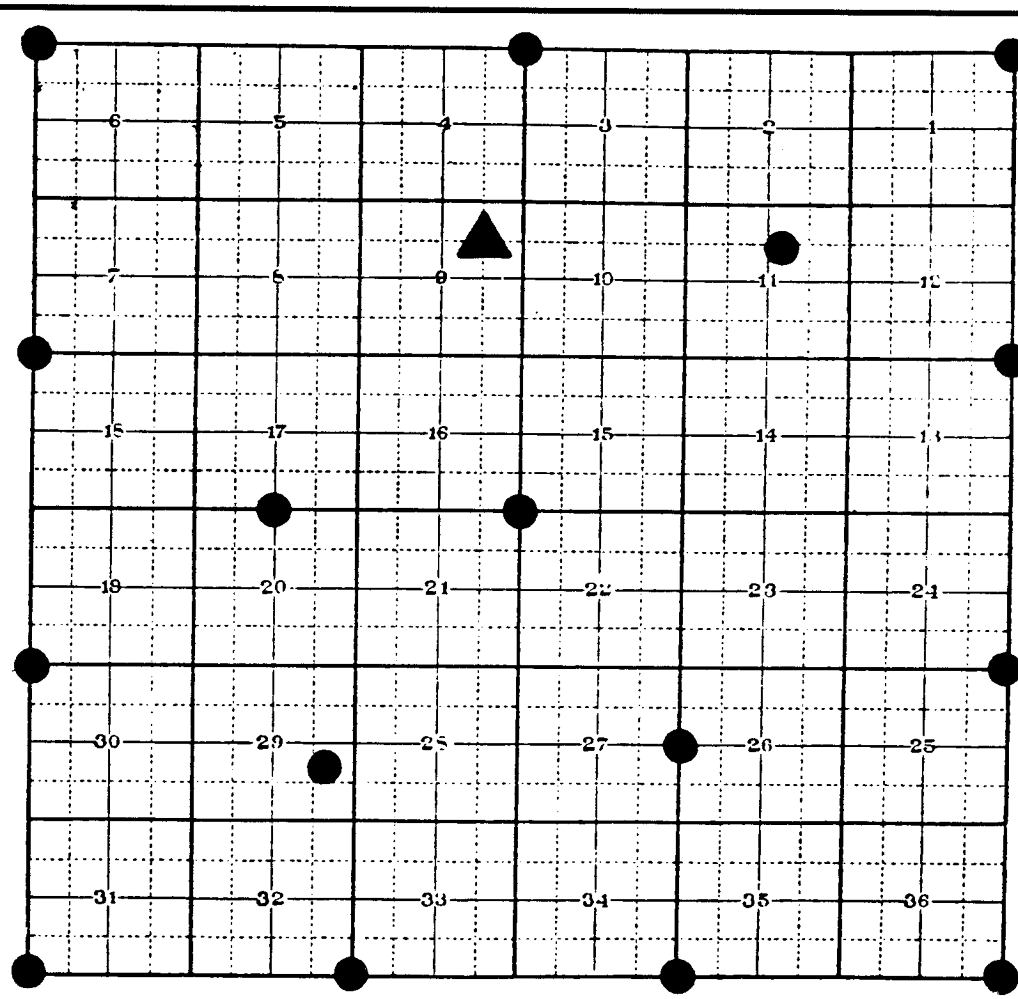

Figure 3.—GPS control for traverse.

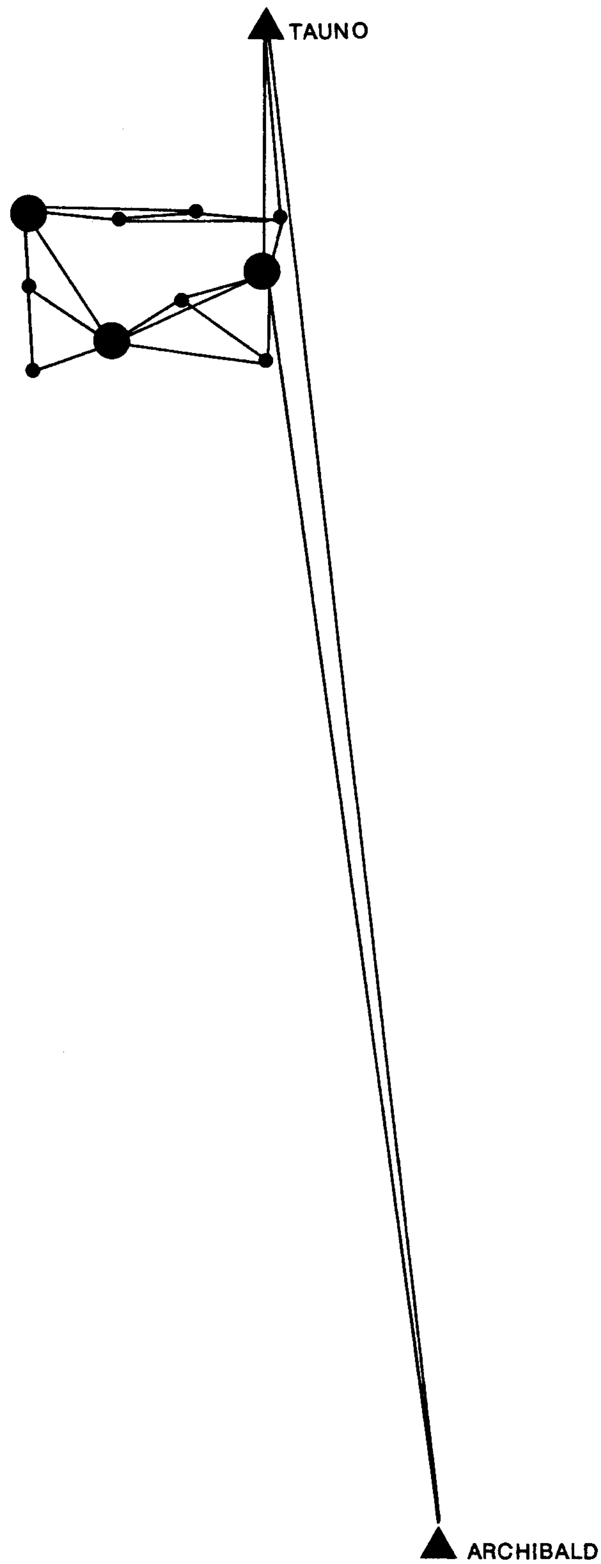

Figure 4.—GPS-aerotriangulation project: Station Tauno and Station Archibald.

Table 1.—Comparison of NAD-83 and NAD-27 coordinate values for Stations Tauno and Archibald.

Station[a]	Latitude	Longitude
(M) Tauno-27	45-57-59.015	88-39-06.313
(M) Tauno-83	45-57-58.868	88-38-06.787
Difference	0.147 arcsecond	0.474 arcsecond
Difference	14.9 feet	33.2 feet
(S) Archibald-27	45-15-46.465	88-35-12.695
(S) Archibald-83	45-15-46.351	88-35-13.079
Difference	0.114 arcsecond	0.384 arcsecond
Difference	11.5 feet	26.9 feet
(S) Archibald-83	45-15-46.351	88-35-13.079
(S) Archibald-GPS	45-15-46.360	88-35-13.080
Difference	0.009 arcsecond	0.001 arcsecond
Difference	0.9 foot	0.1 foot

[a]M indicates master control stations; S indicates secondary control station.

The field test for using GPS-aerotriangulation-traverse control is the angular and linear closure between known GPS or aerotriangulation coordinates of controlling targets and monumented corner positions. The weak linkage is extending the inverse bearing and distance from the point of beginning to the corner to be closed on as affected by clearing, topography, and methodology. Reference-azimuth orientation at the point of beginning must be in the order of 15 arcseconds or less to attain good closures. Closures on the Nicolet National Forest township project averaged 0.5 foot and did not exceed 1 foot between controlling corners for the 65 miles of boundary within the project area (figure 5).

The cost advantage of GPS-aerotriangulation-traverse township projects is substantial compared to conventional traverse of single-section and multi-section project areas. The 65 miles of boundary were located and marked at an average cost of $2,392 per mile compared to $3,300 per mile for the 900 miles of boundary completed to date on the Forest using conventional control traverse.

1986

A contract was awarded for 59 GPS points on four National Forests within Minnesota, Missouri, and Indiana—all under NAD-27. The coordinates were converted to NAD-83 in 1987. It was our first use of code receivers, and the results compared with the accuracies of the 1985 codeless receiver project.

Three project areas in Minnesota and one project area in Missouri brought out strengths and weaknesses in NAD-27 and NAD-83, compared to GPS. It emphasized use of NGS first-order horizontal control stations as the master stations for relative GPS positioning.

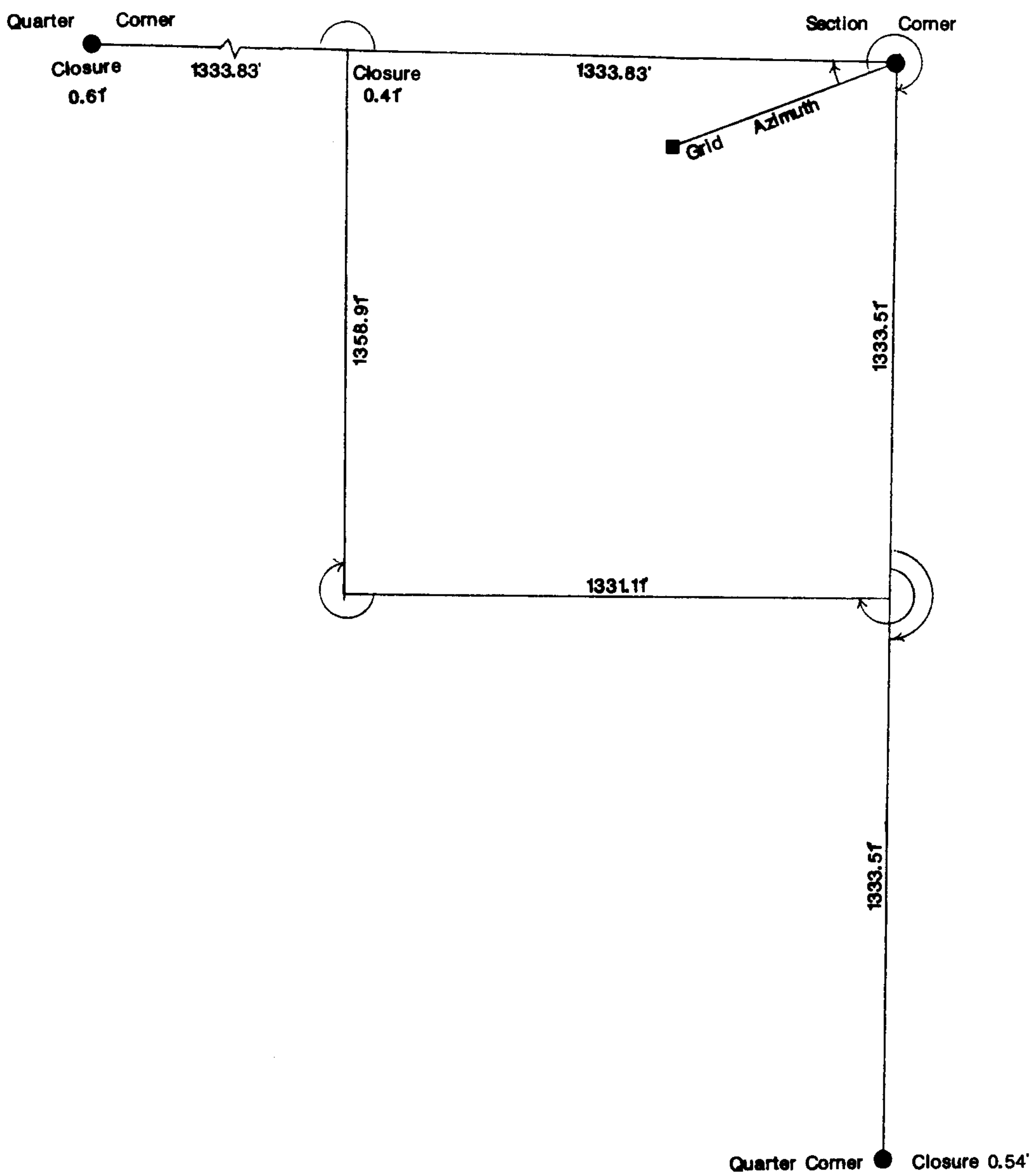

Figure 5.—Nicolet National Forest township project.

One project area on the Chippewa National Forest in Minnesota required placement of 19 GPS points within the southern half of three adjoining townships. It was an aerotriangulation project and included targeting each of the 19 monumented GPS points. A relative positional check was made of these points using a US-2 analytical stereoplotter and the Mapp/Pal/Albany adjustment program. Of the 19 points, 15 fell within 10 centimeters, and the remaining 4 did not exceed 12 centimeters (figure 6). Approximately half of the residual closures are accountable to aerotriangulation, leaving a net average GPS residual of approximately 5 centimeters. The master and secondary NGS first-order horizontal control stations selected for this project showed a relative closure of 4.3 feet under NAD-27 and a relative closure of 0.3 foot under NAD-83 over a 21-mile separation.

The second project area for a fractional township on the Superior National Forest in Minnesota showed a relative closure of 6.2 feet under NAD-27 and a relative closure of 1.9 feet under NAD-83 over a 16.7-mile separation. The comparisons are between two NGS second-order stations. One comparison of the relative positioning of second-order stations is not conclusive but does indicate that caution is needed in selecting second-order stations as master stations for relative positioning.

The project on the Mark Twain National Forest in Missouri was planned for 14 GPS points to control a conventional traverse survey of a township. The township required considerable retracement for corner evidence, which

	Intersection Residuals		Least Squares Residuals	
	In Feet			
	X	Y	X	Y
GPS-1	-0.06	0.12	-0.04	0.24
2	0.42	0.62	0.14	-0.03
3	0.45	0.04	0.38	0.07
4	0.23	-0.05	0.16	-0.20
5	-0.13	0.34	-0.10	0.18
6	0.10	0.72	0.10	0.35
7	0.31	0.43	0.26	0.28
8	0.16	-0.58	0.15	-0.31
9	-0.42	-0.17	•0.37	-0.12
10	-0.04	-0.44	0.00	-0.20
11	-0.11	-0.09	-0.10	-0.06
12	0.03	0.04	0.08	-0.08
13	-0.18	-0.07	-0.13	-0.02
14	-0.10	-0.01	-0.09	-0.01
15	-0.17	-0.42	-0.18	-0.14
16	-0.11	-0.24	-0.01	0.06
17	-0.16	-0.03	-0.14	-0.03
18	-0.12	0.30	-0.11	0.25
19	-0.12	-0.17	-0.01	-0.25

Figure 6.—Relative positional check of one project area on the Chippewa National Forest.

limits the method of control to be used. The two NGS first-order horizontal control stations selected for this project showed a relative closure of 1.0 foot under NAD-227 and a relative closure of 0.1 foot under NAD-83 over a 11.3-mile separation.

The project on the Wayne-Hoosier National Forest in Indiana established the minimum of 7 GPS points limited by clearing restrictions. It was the first project where one of the NGS first-order control monuments had been removed and the second selected first-order station required an eccentric location and an eccentric geographic position that was established to an accuracy of within 1 centimeter (figure 7).

1987

Two project areas were selected for 1987 GPS using dual-frequency codeless equipment. On the Huron-Manistee National Forest in Michigan, a four-section project of 12 GPS points was selected for direct coordinate positioning of monumented land corners (figure 8). The purpose is for the direct subdivision control of small aliquot parcels typical on this forest. It also was an opportunity to check for GPS scale and orientation bias between intervisible GPS points. Astronomical orientation between GPS points agreed within 5 arcseconds (without deflection of vertical corrections), and distances agreed within a tenth of a foot, proving a minor bias of using a single NGS first-order horizontal control station as the master station from relative positioning. The station is 18 miles from the project area.

The second project area in Illinois, on the Shawnee National Forest, was a test to use minimum GPS control. GPS points were established near the township corners of two adjoining townships plus 1 interim point for a total of 7 GPS points (figure 9). Closures between the 6-mile interval between GPS points will require calibration of Electronic Distance Measuring (EDM) traverse measurements and astronomical azimuth checks at not less than 2-mile intervals. The early conclusion based on one traverse run is not to exceed 3-mile intervals between GPS points. An eccentric point had to be established for first-order horizontal control station Trigg. Establishment of eccentric points is not desirable or recommended if there are alternate, recoverable, first-order horizontal control stations to serve the project area.

GPS Elevations

Any GPS project requires a minimum of one vertical elevation based on the NAD-27 national vertical control datum. It may be established on the NGS master horizontal control station or on any one of the GPS control monuments nearest an existing level line. This one elevation shows the relation of the ellipsoid to the geoid (mean sea level). The ellipsoid and the geoid do not have parallel surfaces of reference. Thus, all elevations established by GPS as the Z coordinate will be approximate. Obtaining accurate GPS elevations requires establishing known elevations along the perimeter of the project area, such as the four corners. This will give accurate vertical differences between the ellipsoid and the geoid.

GPS Network

It seems that GPS control for National Forests will not be part of a statewide network of NGS master horizontal control stations. Our initial GPS projects

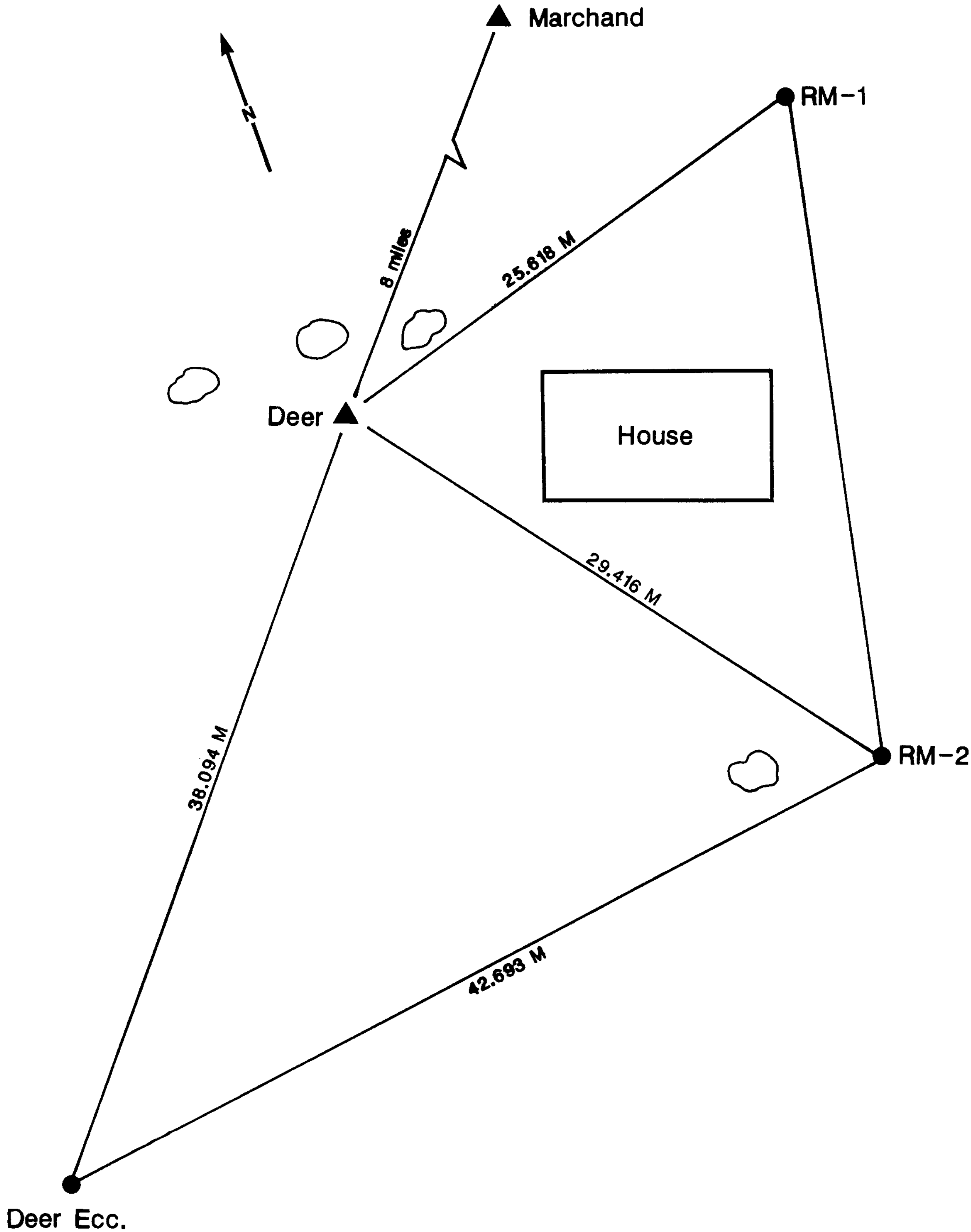

Figure 7.—Wayne-Hoosier National Forest project.

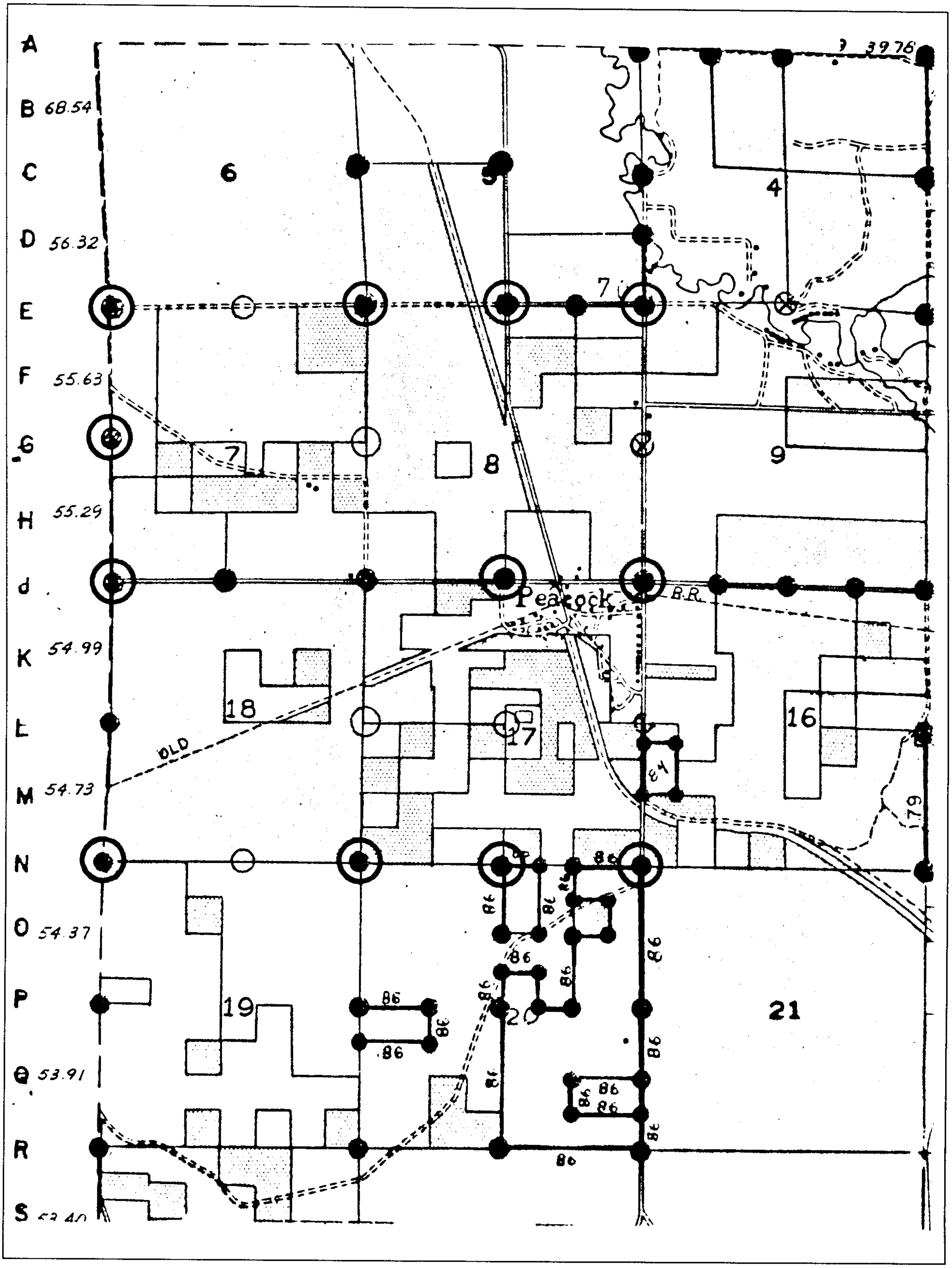

Figure 8.—Huron-Manistee National Forest: section subdivision control using GPS.

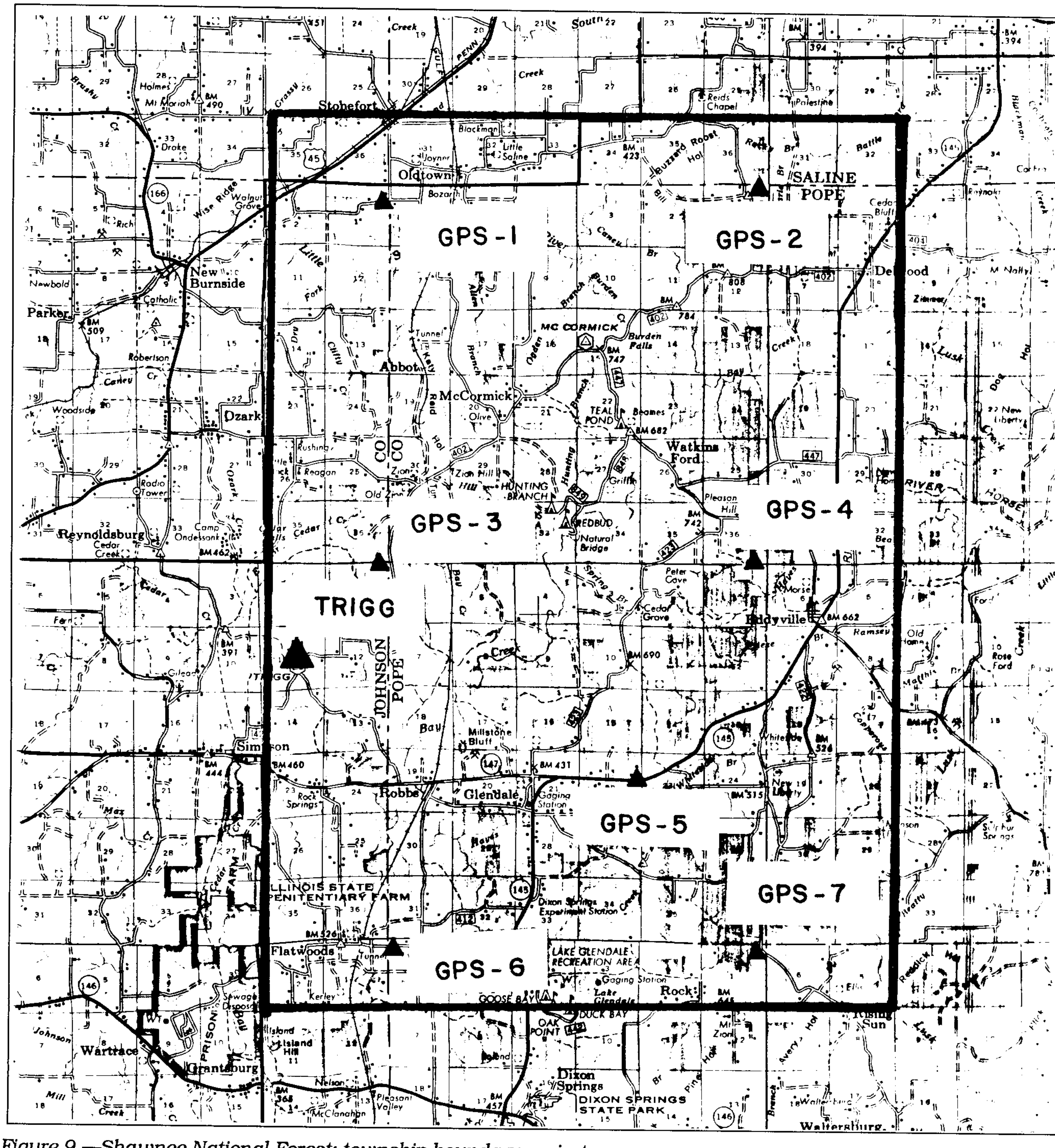

Figure 9.—Shawnee National Forest: township boundary project.

were to locate the nearest NGS first-order horizontal control station as the master station. Using code- and dual-frequency codeless receivers, the maximum radius of operations seems to be 60 miles or more without differential refraction effects of the ionosphere. On some Forests, a single master station can control the entire Forest (figure 10). Where there are two NGS first-order stations, constrained adjustment can be considered (figure 11). It may be desirable to have three NGS or GPS master stations per Forest for incorporation into a statewide network whenever that may develop.

The recommendation is to have two NGS master stations per Forest in case one is destroyed. The relative accuracy between these stations should be established to a probable accuracy of 1 part in 1 million for stations separated by at least 40 miles and not less than 1 part in 250,000 for stations 10 miles apart.

GPS has changed concepts of first-order accuracies. With FGCC proposing standards of 1 part in 10 million for Regional areas and 1 part in 1 million for a local primary network, we are entering a new era of control measurements.

Conclusions

The following can be concluded:

(1) GPS no longer needs testing. GPS is a very accurate control method. Use has proven its accuracy.

(2) Use only NGS (NAD-83) first-order horizontal control stations as the master stations for relative positioning.

(3) Select one and preferably two NGS master horizontal control stations for permanent reference on each Forest.

(4) Use of GPS is more cost-effective for township-size projects at current costs per point established.

(5) When the planned 21 Block II satellites are in orbit, daylight operations can be made at any time during the year.

(6) Planned GPS point locations will remain selective as controlled by portability of equipment and satellite clearance requirements.

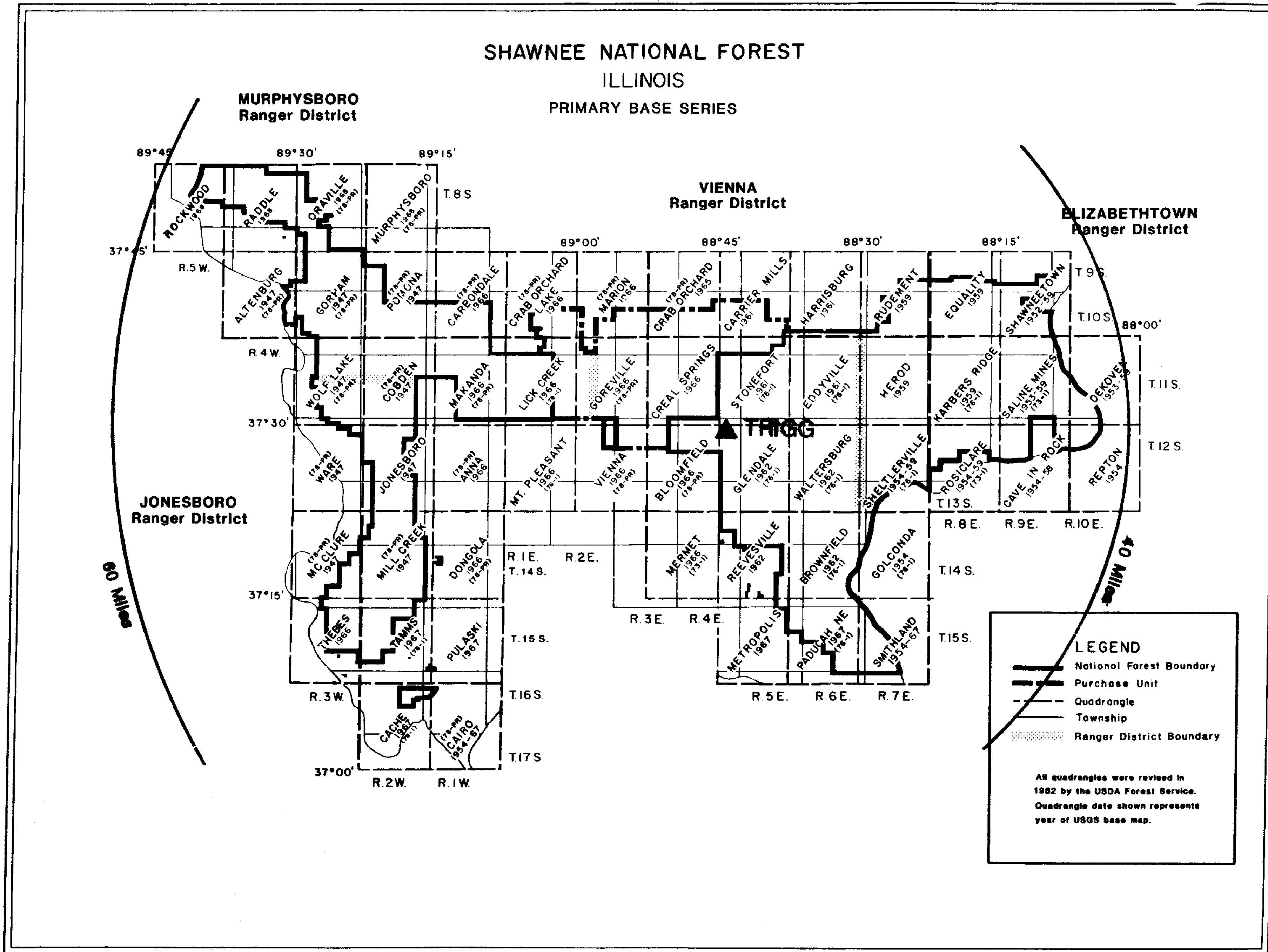

Figure 10.—Shawnee National Forest: one master station can control the entire Forest.

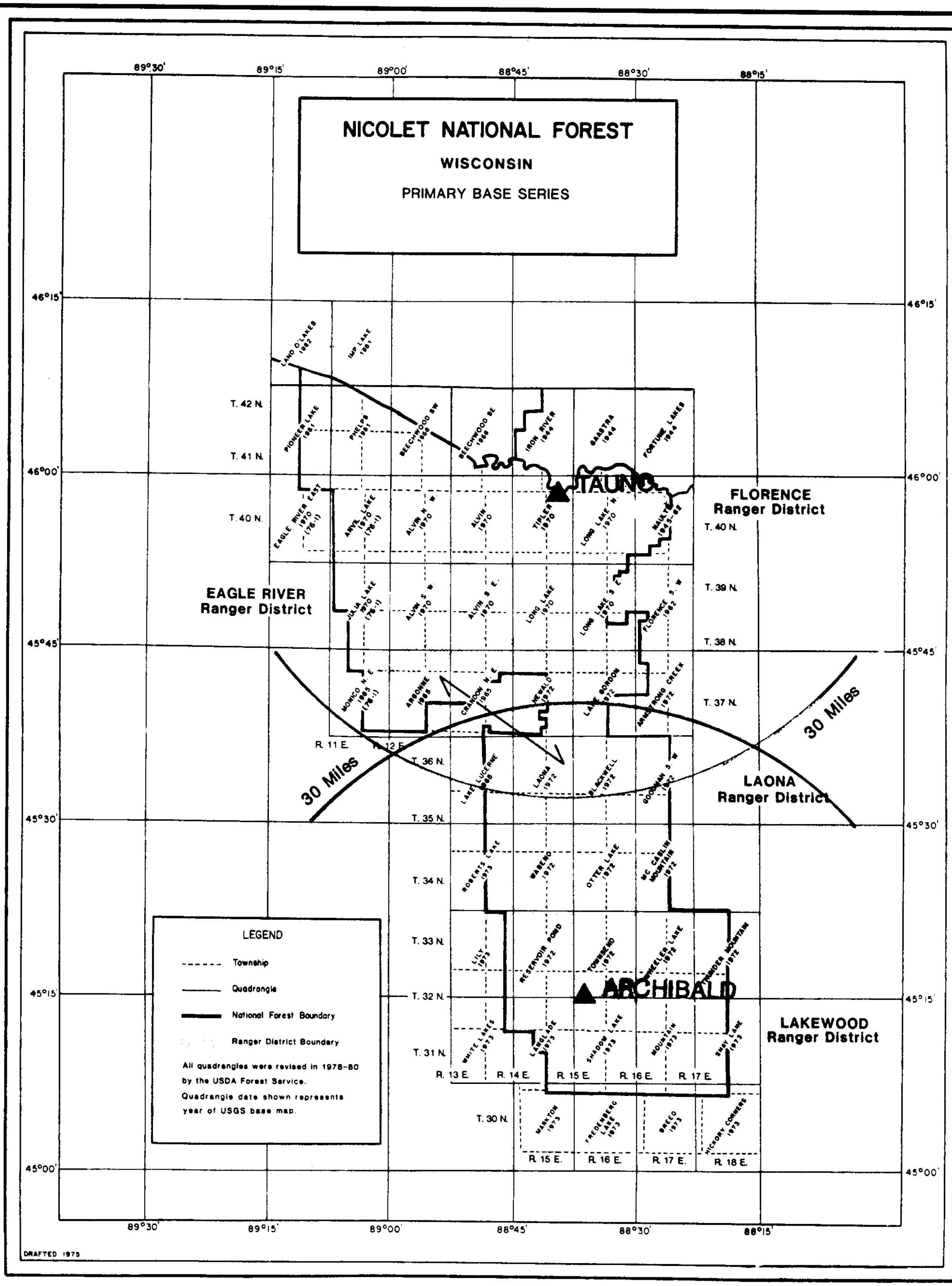

Figure 11.—Nicolet National Forest: with two NGS first-order stations.

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