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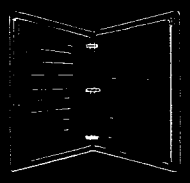
# ENGINEERING TECHNICAL INFORMATION SYSTEM

FIELD NOTES • TECHNICAL REPORTS
DATA RETRIEVAL • MANAGEMENT
PROFESSIONAL DEVELOPMENT

VOLUME 8 NUMBER 7

# Field Notes



Silicon Photovoltaic Solar Cells

Computer Programs for Hydraulic Analysis of Drainage Structures

Washington Office News

FOREST SERVICE

JULY 1976

U.S. DEPARTMENT OF AGRICULTURE

# ENGINEERING FIELD NOTES

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**FOREST SERVICE**
**U.S. DEPARTMENT OF AGRICULTURE**
**Washington, D.C. 20250**

# SILICON PHOTOVOLTAIC SOLAR CELLS

Jerry M. Hyde
Structures Engineer
Washington Office

Design and development of solar arrays which convert sunlight directly to electricity have been required in the space industry for many years. In the 21st century, advanced technology may allow solar cells to play a major role in the development of a satellite solar power station in space. The successful use of photovoltaic (P/V) arrays to supply electric energy to power SKYLAB and other spacecraft is the experience base to advance this technology for ground applications.

Here on earth, solar cells are generating electrical power in remote (and some not so remote) areas from the equator to the poles. Practical application of solar energy is needed in wilderness communications stations for radio and TV; ocean and lake buoys; navigational beacons; highway safety signals; marine battery charging; and remote installations of all types, including fire lookout towers, transmission relay stations, and climatological data recording and transmitting stations.

At the third Energy Technology Conference/Exposition held in Washington, D.C., on March 29-31, 1976, Mr. Gustave Johnson of the MITRE Corporation in McLean, Virginia, told the group about the largest terrestrial solar cell array in the world. These panels are mounted on top of a MITRE Corporation building, and they are being studied on an experimental basis.

According to the May 1975 document, "Survey of Solar Energy Products and Services" (available from the U.S. Government Printing Office [GPO], $4.60), the following seven companies are involved in photovoltaic conversion:

(1) COMSAT Laboratories
(2) ITEK Corporation
(3) Mobil Tyco Solar Energy Corporation
(4) Optical Coating Laboratory, Inc.
(5) Solar Energy Systems, Inc.
(6) Solar Power Corporation
(7) Solarex Corporation

Other companies are included in the October 1975 document, "Catalog on Solar Energy Heating and Cooling Products–ERDA-75" (available from GPO, $3.80).

The "Sensor Technology Solar Power Systems" brochure includes specifications for single-module outputs and typical outputs of multimodule systems.

Although there are several companies producing Solar Photovoltaic Conversion Systems (SPCS), there are two major problems that must be overcome before the use of SPCS can be widespread. According to the Energy Research and Development Administration (ERDA), these are:

(1) *High cost*—Terrestrial photovoltaic panels now sell from $20,000 to $25,000 per peak KW.

(2) *Low production*—The current terrestrial SPCS market in the United States for 1975 was estimated to be 100 peak KW.

The major goals are to establish a total plant capacity capable of producing at least 500 peak MW per year of solar array modules at a market price of less than $500 per peak KW by Fiscal Year 1985; and 50,000 peak MW per year of solar array modules at a market price of $100-$300 per peak KW by Fiscal Year 2000.

## *SOLAR CELLS—AN ALTERNATIVE ENERGY SOURCE*

The U.S. Forest Service uses reliable solar cells for powering unmanned radio relay devices in rugged mountainous terrain from Arizona to Alaska. Storage batteries are recharged by the solar cells to provide electrical power during periods of darkness and cloudy weather.

### Forest Service Solar-Powered Flush Toilet Systems

Another example of converting solar energy is the use of solar power panels to generate electrical power for use in operation of a flush toilet system in an eight-fixture toilet building. The first comfort station powered by solar energy will be initiated when the Custer National Forest in the Montana Rockies opens for the summer season this year (FIELD NOTES, Vol. 8, No. 3, March 1976).

Plans are being developed for a photovoltaic demonstration program for the Pilot Peak Lookout on the Plumas National Forest and the Antelope Lookout on the Lassen National Forest. Plans are to make this a cooperative project with the National Aeronautics and Space Administration, Lewis Research Center (NASA/LRC), Cleveland, Ohio.

The design steps involved with these photovoltaic power system are:

(1) *Power system electrical design*—Determination of size of the P/V array and the amount of battery storage capacity required.

(2) *Hardware designs*—Design of the P/V array frames and support structure. The array will be tilted toward the sun and face south.

(3) *Batteries*—The Forest Service will procure the number required and provide for the battery enclosure. NASA will design the battery charge regulator.

(4) *Instrumentation*—NASA will design manually read instrumentation for the P/V power system.

(5) *Cabling*—NASA will specify the intercomponent cabling by type, configuration, and connector.

Lookouts without access to commercial power sources will benefit from this type of power source as the need for yearly replacement of dry cell batteries for radio c perations will be eliminated.

It would be desirable to provide power for lighting, heat, and some small motor operation from an electric source rather than liquid petroleum gas because of the logistics problems of transporting gas to remote sites. Many existing propane generators at radio repeater sites could be replaced with solar cells in the future.

*SUMMARY*

Production of silicon solar panels appears to be expanding. The latest publications from Edmund Scientific Co., 4632 Edscorp Building, Barrington, NJ 08007, carry several models of panels such as 1½-, 12-, and 14-volt selections. The 12-volt high current model provides 25 watts of power output, and comes ready to use on a metal frame with tilt-adjusting brackets.

Ultimately, this form of solar energy (solar cells) may be used as a principal source of electric power for many facilities. We have both an abundant supply of silicon on earth and, for all practical purposes, a perpetual supply of the sun's radiant energy.

# COMPUTER PROGRAMS FOR HYDRAULIC ANALYSIS OF DRAINAGE STRUCTURES

Dick L. Jones
Civil Engineer
Regional Office
Region 8

In recent years, the Federal Highway Administration (FHWA) has been developing computer programs for the analysis of highway drainage structures. Three of these programs have been converted for use at the Fort Collins Computer Center by Michael Efird of the R-8 Computer Science Group.

The three electronic computer programs are documented in the following FHWA publications:

Electronic Computer Program (HY-6) *Hydraulic Analysis of Culverts*;
Electronic Computer Program (HY-4-69) *Hydraulic Analysis of Bridge Waterways*;
Hydraulic Design Series No. 1 (HDS-1) *Hydraulic Analysis of Bridge Waterways*;
Hydraulic Engineering Circular No. 13 (HEC-13) *Hydraulic Design of Improved Inlets for Culverts*;
Hydraulic Engineering Circular No. 14 (HEC-14) *Hydraulic Design of Energy Dissipators for Culverts and Channels*;
Report No. FHWA-RD-508 *Culvert Outlet Protection Design: Computer Program Documentation.*

## *HYDRAULICS OF BRIDGE WATERWAYS PROGRAM*

This program, described in publication HY-4-69, is a revised version of an earlier FHWA program. The newer version incorporates changes in the method of computing backwater and also provides a more general-purpose program.

The basic theory and method of computing backwater used in the program are explained in publication HDS-1, which was republished in 1973. Anyone who uses the bridge computer program should be familiar with the theory and assumptions explained in this publication. The program input format is contained in publication HY-4-69.

This program will compute and plot a stage-discharge curve for natural channels. It also calculates backwater depths and flow velocities for given bridge sizes and shapes at various discharges. Under the user's direction, the program will automatically increase or decrease the bridge length and then recalculate the backwater depths.

The advantage of this program is that it enables the designer to analyze several bridge sizes in a short time with little extra effort. The laborious task of performing these calculations by hand has discouraged designers from making accurate analyses and has led to the use of less reputable methods, such as the Talbot formula.

Caution should be maintained if the assumptions used in the program are violated. Also, recent research has shown that the method underestimates backwater depth for very wide wooded floodplains. But even at its worst, this type of analysis is much better than none at all.

Region 8 has used this bridge hydraulic program many times in the last 2 years and now considers it to be nearly indispensable.

### *HYDRAULIC ANALYSIS OF CULVERTS*

This program, described in publication HY-6, is a very recent FHWA computer program which analyzes both conventional and improved inlet-type culverts. The program will work for round or box culverts made of either concrete or corrugated metal. The program may be expanded in the future to include arch and oval culverts.

The data input format and computer documentation is contained in publication HY-6. This program follows the design principles and philosophy as presented in publication HEC-13.

The advantage of this program is that it will analyze a wide range of culvert sizes and inlet configurations that will meet a given set of design criteria. For example, it may be used to determine allowable headwater at a given discharge. Such information enables the designer to pick the most economical size for his project site.

### *CULVERT OUTLET PROTECTION DESIGN PROGRAM*

This program was developed by the Wyoming Highway Department and is being published and distributed by FHWA. The theory and design methods used in this program are detailed in publication HEC-14. The program input format is described in report FHWA-RD-75-508.

This program will analyze several types of energy dissipators for culverts with given size, shape, and outlet flow conditions. The dissipators analyzed include rock-riprapped blankets and basins, concrete stilling basins, and impact type of energy dissipators.

Program output gives several basins that will meet the criteria of a maximum downstream velocity. The basin dimensions will depend on the available size of riprap and the allowable width of the basin. These parameters are set by the user.

While these programs will not solve all of the drainage engineer's problems, they will provide analyses for a large number of alternative designs with little extra work. With a large number of alternatives, the engineer is much more likely to choose the most economical design for his project.

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*Editor's Note*

*Copies of the referenced publications have been mailed to all Regions with 7110 letters of July 3, 1975, and May 25, 1976.*

## WASHINGTON OFFICE NEWS

### OPERATIONS

Harold L. Strickland
Assistant Director

### *AUTOMATED CARTOGRAPHY SYSTEM*

The Geometronics Development Group is currently evaluating automated cartography systems to support the Geometronics Service Center's (GSC) full production projections. Automated cartographic systems exist at various stages of development throughout the cartographic industry. Some systems are operational on a production basis, primarily the two-axis and three-axis systems requiring manual input stations. Other configurations involving automatic line-following and raster scanning are more in the research and/or development stage.

Development of a system for our applications was begun with the objective of evaluating the use of automated drafting techniques as an alternative to the traditional scribing methods presently used in map production. The project is continuing under Terry Gossard with the primary emphasis on developing a system to collect and store map data in digital form and also have the capability to plot the data at the proper scale and with correct symbolization to produce the Primary and Secondary Base Series layers. Production of these map products is the charter of the Geometronics Service Center's Phase I operation.

This system, called CALPLOTPAC, is software oriented to UNIVAC 1108 FORTRAN programs, and hardware oriented to a Calma Digitizing System and Calcomp 1136 Drum Plotter. The software has been developed around the use of the USGS *Symbols for Standard Topographic Maps Published at the Scale 1:63,360 and Larger to be Scribed at 1:24,000–1:48,000.* The scribing specifications used for these symbols were also used as the plotting output specifications in this system. The hardware used is not designed as a total system, but only as a usable system from existing hardware capable of testing the software functions (see schematic attached).

Test data have been restricted thus far to 1:24,000 USGS color separation plates and revision data to update these separations, but the system can handle any type and scale of planimetric source data.

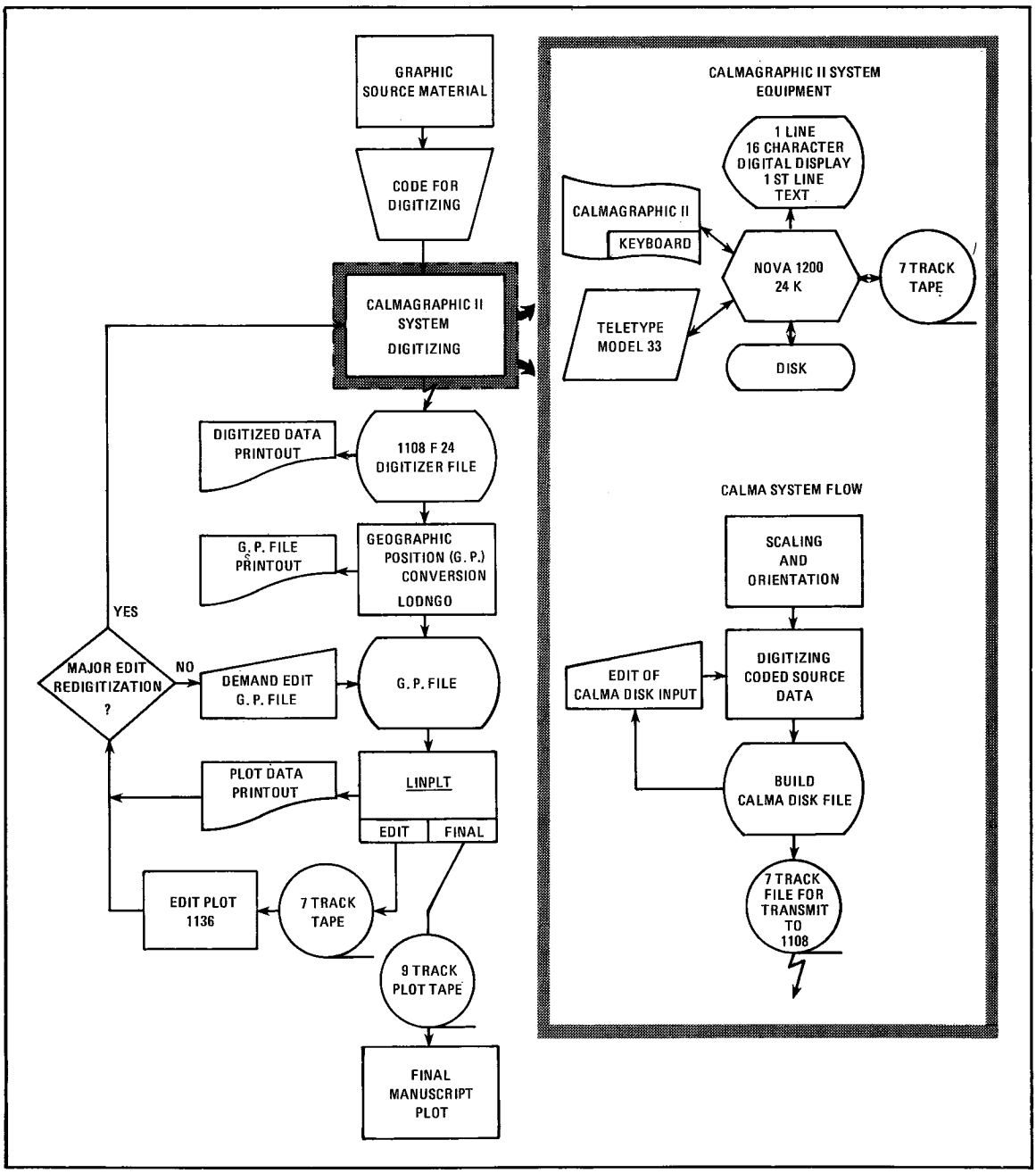
Four types of graphic input can be accommodated:

1. *Single-point:* standard symbol at a particular location, i.e., triangulation stations, bench marks, quarry sites, etc.

2. *Two-point:* for features whose size and/or orientation varies.

3. *Discrete line:* planimetric features which do not close on themselves, i.e., drains, highways, trails, etc.

4. *Closed figure:* polygon-type features, i.e., lakes, large buildings, etc.




*Schematic of Cal Plot Pac System Flow*

In addition to the four types of graphic input, the Calmagraphic II, with disk, can record data in either scaled-state plane coordinates or table coordinates (.001 of an inch) registered to geographic coordinates. In either case, the coordinates have to be transformed in decimal geographic positions to be used in the system. All software to use these two types of data is currently operational.

The hardware output has been limited thus far to a Calcomp 1136 Drum Plotter using ink or ballpoint pens. Preliminary programming has been completed to obtain plots on the following flatbed plotters: Calcomp 748 and 745, Kongsberg 1216, Gerber 1232. This programming was done in conjunction with our ongoing Flatbed Plotter Evaluation Test and will be documented later when all the test plots have been received and evaluated. Light beam plotting commands will also be added to the system in the future.

The system is very flexible in its output format capability. The output can be arranged in seven layers: black, brown, blue, red, green tint, blue tint, and annotation plates. These plates can be plotted at any scale and maintain registration. The system cannot change the size of the symbols, as their size is fixed to USGS scribing specifications. The "FS 1/2" = 1 mile symbols have been programmed but have not been combined as yet into a working option in the system.

The provision to generate symbols by scale is coming into focus as bases other than the 7½" quad format are used. The need to generate symbols at a scale for our Secondary Base Series is evident if we intend to use the system to revise this base effectively. Also, the USGS 1:100,000 series is being evaluated for possible support to or replacement of our ½" series. No work has been done with symbolization for the 1:100,000 series.

Eventually most, if not all, map revision will be done with an automated cartographic system. It is apparent that other mapping agencies (USGS, Defense Mapping Agency, etc.) are also evaluating current "state-of-the-art" equipment on which to build a system. Our efforts are being coordinated with these other activities. It is the intent of this project to develop an operational system for use in production at GSC and hopefully within the not too distant future.

## CONSULTATION & STANDARDS

C. R. Weller
Assistant Director

### *DAM SAFETY INSPECTIONS*

A special dam safety and condition inspection was recently performed by an A/E consultant on the Scholz Dam near Williams, Arizona. This inspection, financed as a national study, was a cooperative effort between this office and Region 3. The work was conducted to meet criteria developed by the Corps of Engineers as a model dam inspection process. Through performing this sample inspection, valuable experience was gained in preparing and administering a professional services contract for this specialized type of work. Although such inspections, that is, those following Corps of Engineers criteria, are not actually required by law at this time, this prototype study will enable the Forest Service to meet future legal requirements and to show the feasibility of contracting similar inspections on other dams.

The dam is located on the Kaibab National Forest and has a varied and complex history. Basically, it was constructed as a privately owned dam with some engineering assistance from the Soil Conservation Service. Originally the structure was to be less than 15 feet high. Currently, it is 24 feet high and stores 200 acre-feet of water. The dam is now owned by the Forest Service and is used for wildlife and grazing purposes.

The A/E consultant, Engineers Testing Laboratories, Inc., spent approximately 32 days performing field surveys, inspections, geologic surveys, record searches, and office engineering, and provided the Forest Service with a comprehensive report regarding the current condition of the dam. Since the study did not require detailed engineering calculations or analysis, specific design or restoration criteria were not developed. Following Corps of Engineers terminology, this more detailed work would be in a Phase II study.

Sufficient funds remain to award one more study on a different project. Current plans are to select a second dam in R-3. The scope of the contract will be slightly expanded to include a more detailed hydrologic study. Soil sampling and stability analysis work will continue to be considered more appropriate for a Phase II study if the conclusions from Phase I indicate such work is needed.

People interested in following up on these studies can contact either Larry Hendrickson, Engineering, WO, or Jim Wolfe, Engineering, R-3.

## TECHNOLOGICAL IMPROVEMENTS

Heyward T. Taylor
Assistant Director

### *INTEGRATED CIVIL ENGINEERING SYSTEMS' COORDINATED GEOMETRY PROGRAM*

Forest Service engineers have been using the computer to solve geometric problems in areas of surveying, mapping, design geometrics, etc., for many years. One of the tools used to obtain these solutions was the Coordinate Geometry Program (COGO) which is explained in the Engineering Computer Application Handbook (FSH 7109.16). Although a powerful and effective tool, COGO never attained the popularity it deserved, probably because of the time lapse between defining the problem and obtaining the solution. This time lapse was due to having to mail the problem data to the Regional Office, time required to keypunch the data and process it, and the subsequent time loss in returning the data to the designer.

However, now, with the use of computer terminals on most forests, the solutions to geometric problems can be obtained as rapidly as the problems can be defined. The version of COGO presented in the handbook was not written to be conversational or for interaction with the designer and should not be used in these ways. Instead, a version of COGO is available on the Fort Collins Computer that can be used by designers on their terminals. This is the Integrated Civil Engineering Systems (ICES) version of COGO, developed at the Massachusetts Institute of Technology (MIT).

Instructions on how to use ICES' COGO are in two publications, R67-46 and R68-6. These can be obtained by sending a purchase order to:

Massachusetts Institute of Technology
Room 1-125
39 Massachusetts Avenue
Cambridge, MA 02139

The purchase order should be payable to Massachusetts Institute of Technology, Account No. 21396, for $12.50, plus postage.

COGO is executed by entering the command '@ADD FC*ICESC2', then entering your problem data when requested.

In most Regions, individuals who usually process Road Design Systems (RDS) in the Engineering Staff Unit are willing and qualified to assist with any problems you might encounter. For further assistance call Myron Kaplan on FTS 8-323-5267.

## INVITATION TO READERS OF FIELD NOTES

Every reader is a potential author of an article for FIELD NOTES. If you have a news item or short article you would like to share with Service engineers, we invite you to submit it to FIELD NOTES for publication.

Material submitted to the Washington Office for publication should be reviewed by the respective Regional Office to see that the information is current, timely, technically accurate, informative, and of interest to engineers Service-wide (FSM 7113). The length of material submitted may vary from several short sentences to several typewritten pages; however, short articles or news items are preferred. All material submitted to the Washington Office should be typed double-spaced, and all illustrations should be original drawings or glossy black and white photos.

Each Region has an Information Coordinator to whom field personnel should submit both questions and material for publication. The Coordinators are:

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Coordinators should direct questions concerning format, editing, publishing dates, and other problems to:

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