U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
FEDERAL HIGHWAY ADMINISTRATION

Computer Program for Point Location And Calculation of ERror (PLACER)

Open-File Report 99-99

A Contribution to the
NATIONAL HIGHWAY RUNOFF DATA AND METHODOLOGY SYNTHESIS

U.S. Department of Transportation

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U.S. Department of the Interior
U.S. Geological Survey

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By GREGORY E. GRANATO

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Northborough, Massachusetts
1999

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PREFACE

Knowledge of the characteristics of highway runoff (concentrations and loads of constituents and the physical and chemical processes which produce this runoff) is important for decision makers, planners, and highway engineers to assess and mitigate possible adverse-impacts of highway runoff on the Nation’s receiving waters. In October, 1996, the Federal Highway Administration and the U.S. Geological Survey began the National Highway Runoff Data and Methodology Synthesis to provide a catalog of the pertinent information available; to define the necessary documentation to determine if data are valid (useful for intended purposes), current, and technically supportable; and to evaluate available sources in terms of current and foreseeable information needs. This paper is one contribution to the National Highway Runoff Data and Methodology Synthesis and is being made available as a U.S. Geological Survey Open-File Report pending its inclusion in a volume or series to be published by the Federal Highway Administration. More information about this project is available on the World Wide Web at http://ma.water.usgs.gov/fhwa/runwater.htm

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(in pocket)

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Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

NOTE: Volumes greater than 1000 l shall be shown in m^3.

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

Computer Program for Point Location And Calculation of ERror (PLACER)

By Gregory E. Granato

Abstract

A program designed for point location and calculation of error (PLACER) was developed as part of the Quality Assurance Program of the Federal Highway Administration/U.S. Geological Survey (USGS) National Data and Methodology Synthesis (NDAMS) review process. The program provides a standard method to derive study-site locations from site maps in highway-runoff, urban-runoff, and other research reports. This report provides a guide for using PLACER, documents methods used to estimate study-site locations, documents the NDAMS Study-Site Locator Form, and documents the FORTRAN code used to implement the method.

PLACER is a simple program that calculates the latitude and longitude coordinates of one or more study sites plotted on a published map and estimates the uncertainty of these calculated coordinates. PLACER calculates the latitude and longitude of each study site by interpolating between the coordinates of known features and the locations of study sites using any consistent, linear, user-defined coordinate system. This program will read data entered from the computer keyboard and(or) from a formatted text file, and will write the results to the computer screen and to a text file. PLACER is readily transferable to different computers and operating systems with few (if any) modifications because it is written in standard FORTRAN. PLACER can be used to calculate study site locations in latitude and longitude, using known map coordinates or features that are identifiable in geographic information data bases such as USGS Geographic Names Information System, which is available on the World Wide Web.

INTRODUCTION

Well-defined sampling-site locations are necessary to document water-quality data and resultant interpretations from research reports as valid, current, and technically defensible (Granato and others, 1998). Site-location information is critical to conduct an areal assessment of available data for use on a local, state, regional, or national level. Documented information about study-site-sampling locations is necessary to:

- permit independent evaluation of the suitability of study sites used in a water-quality investigation;
- establish the repeatability of a study by ensuring the ability to repeat sampling operations at the same location at a later time;
- establish comparability between study sites in terms of geographic, climactic, and land-use characteristics; and
- assess the geographic scale of a study with multiple data-collection sites through examination of the distribution of and distance between study sites.

To provide sufficient site information, each study should have a table describing each site that includes latitude, longitude, and the estimated uncertainty of these measurements (ITFM, 1995A, 1995b). Additionally, or in place of the table, each study should produce a site map with identifiable locations, a defined scale, and at least two points defined with latitude and longitude.

The latitude and longitude (LAT/LON) convention is a universally recognized coordinate system applicable to any point on the Earth. This Coordinate system is not based upon any particular choice of map projection (as are many State plane coordinate systems), or upon a secondary classification method such as road-mile markers, or road survey-station and offset. Consistent use of LAT/LON is important: (1) for a standardized national water-quality data base; (2) to facilitate map creation; (3) for geographic or spatial analysis; and (4) for integration with other geographic data sets, such as climate, census, or land-use information. The Intergovernmental Task

Force on Monitoring Water Quality (ITFM) defined sampling location as one of the minimum set of required metadata standards, and identified LAT/LON as the standard site location coordinate system (ITFM, 1995a, 1995b).

Review of over 200 published studies of highway and urban runoff indicate that this information is often not available, even when location tables and maps are included in report documentation. Therefore, a method was needed to facilitate and standardize the process used to determine study-site locations in LAT/LON coordinates. The program Point Location and Calculation of ERror (PLACER) reads input entered from the keyboard or from an input file, interpolates the coordinates of study sites in relation to known features, and documents results in an output file. The program is designed to interpolate the latitude and longitude of study sites plotted on published base maps when their coordinates are not provided.

PLACER was developed as part of the Quality Assurance Program of the Federal Highway Administration (FHWA)/U.S. Geological Survey (USGS) National Data and Methodology Synthesis (NDAMS) review process to provide a standard method to derive study site locations. Standard methods designed to minimize the possibilities for error are important for the management, assessment, and validation of project data (Jones, 1998). The PLACER software application provides the user with a standard method for consistently calculating a unique latitude and longitude for a point, such as a study-site location that is plotted on a map, as well as for determining the uncertainty in the calculated position. When used with a report's base map and the study-site locator form (appendix 1), PLACER provides a documentable process that reduces or eliminates the potential for human error in interpolating site coordinates from published site maps. PLACER creates an output file that documents input data and results of the calculations. The information documented in the output file can be checked manually or by rerunning the program using this record as an input file. Automation of the simple, but tedious and error-prone interpolation process facilitates quality assurance and quality control of the site-location values calculated for the NDAMS bibliographic data base.

This report provides a guide for the use of PLACER, documents the methods used to estimate study-site locations, documents the NDAMS Study Site Locator Form (appendix 1), and documents the FORTRAN code (appendix 2) used to implement the method. The report provides information about the computer program, installation of the program from a distribution media (such as floppy disk or CD-ROM), instructions for using PLACER, and case studies to illustrate use of the program.

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THE PLACER PROGRAM

PLACER is used to determine the LAT/LON of a point plotted on a map and to estimate the uncertainty of the LAT/LON coordinates calculated using input data. The program may be used to estimate study-site locations from LAT/LON tick marks on a base map, or from known locations featured on a published map. Known locations may be features that can be located on a published map, or feature locations that can be determined using a national atlas, or information services, such as the USGS Geographic Names Information System (GNIS) data base (USGS, 1998a, 1998b), the National Imagery and Mapping Agency (NIMA) GEOnet Names Server data base (NIMA, 1998), or the Natural Resources Canada (NRC) Canadian Geographic Names Server (Natural Resources Canada, 1998) available through the World Wide Web. PLACER interpolates between these known points—referred to as features—and the unknown location of data-collection points—referred to as sites, using any arbitrary (but consistent and linear) user-defined coordinate system (UDCS). PLACER also provides an estimate of the uncertainty in each calculated location as an indication of data quality.

The accuracy and precision needed to locate a given study site depends upon study objectives. If the objectives are to verify results or to detect changes or trends in measured water quality by repeating a sampling effort, then sites must be located precisely—within a few feet (tenths of a second). If the sampling site is well documented and(or) is located at a recognizable landmark—so that the precise sampling point could be easily recognized from a distance—then the location may be specified within hundreds of feet (a few seconds). The minimum symbol size for a site plotted on an 11-by-8.5-inch map of the conterminous United States has a radius of about 50 miles (about 40 minutes). Therefore, accuracies within 5 to 20 miles (about 4 to 18 minutes) may be acceptable for grouping sites by region for statistical interpretation, or for mapping on a national or regional scale.

To establish a relation between the LAT/LON coordinates of known locations—map features—and the UDCS, at least two known locations are required. The intersection of lines of latitude and longitude from these two locations, or potentially the location of a third map feature, is then used to establish the origin. The Y and X locations for the origin and each feature with respective latitude and longitude values are defined using any measurement scale (the UDCS). The standard LAT/LON coordinate expression of degrees, minutes, and seconds is then converted to a total number of seconds to facilitate calculations. The program then reads the location of each site in the UDCS.

PLACER will read data from the computer keyboard and(or) a formatted text file, and will write results to the computer screen and to an ASCII (American Standard Code for Information Interchange) text file. PLACER is currently configured to accept up to 21 features and 21 sites. The user can define the desired number of features and sites using the keyboard/screen or input-file interface. If the user needs more features or sites, the FORTRAN code (appendix 2) can be modified to accept more. During the review of more than 200 reports relevant to highway and urban runoff for the USGS-FHWA NDAMS study, however, there was rarely a need for more than about 10 features or sites.

Once the input of all necessary data is complete, PLACER calculates and records:

1. the ratio of the distances in terms of LAT/LON to UDCS map units (seconds per measured unit) for each map feature,
2. the average and the standard deviation for this population of coordinate ratios,
3. the LAT/LON coordinate for each site as the product of the Y and X coordinates of each site and the average ratios of the feature population's latitude and longitude coordinates, respectively, and
4. the standard deviation of the population of nonzero coordinate-ratios.

The standard deviations may be used to estimate the uncertainty or error of the interpolation process. Only features with nonzero coordinates are used in the calculations to avoid division-by-zero errors. These calculated standard deviations indicate potential problems in the input data and(or) indicate the uncertainty of the estimated site-location coordinates. The location of features that differ significantly from the average should be investigated for measurement error, a faulty LAT/LON coordinate, and(or) the use of a map with an axis orientation that differs significantly from a true North-South axis.

PLACER prints the input values and the calculated results to the screen and to a user-specified output file for documentation, review, and assessment. The ratio of LAT/LON to UDCS coordinate values of each feature should be compared to the average and the standard deviation of these ratios to assess each point. If an outlier in the ratios indicates that an input error occurred, the output file can be corrected using an ASCII-compatible text editor, and PLACER can be rerun using the corrected file as an input file.

INSTALLING PLACER

The PLACER code is readily transferable among different computers and operating systems with little if any modifications because it is written in standard FORTRAN. The original FORTRAN code (appendix 1) and several runtime versions (table 1) are provided on the disk for ease of installation. The FORTRAN code and executable versions are available on disk for DOS/Windows, Macintosh OS personal computer (PC) operating systems, and Data General Unix.

Table 1. Computer files containing raw and executable FORTRAN code for PLACER—the Point Location And Calculation of ERror program.

Filename	Platform	Compiler
PLACERv2.for	Not specific	Uncompliled FORTRAN code (Appendix 2)
PLACERv2.out	Data General Unix	Green Hills FORTRAN compiler (Green Hills Software Inc., 1990)
PLACERv2.exe	MS-DOS, or MS-Windows	Microsoft FORTRAN compiler version 5 (Microsoft Corporation, 1989)
PLACERv2.bin	Macintosh OS	Metrowerks Code Warrior MPW version 3.4.2 (Metrowerks Corporporation, 1997)

PLACER is a simple program without a graphic user interface, so that almost any available computer and operating system should be able to run this code. PLACER can be run from the installation disk, but it is preferable to run the program from a designated directory on a local hard disk or an equivalent device with read and write capabilities. The successful operation of PLACER requires the following:

- the executable version of the PLACER code must be compiled under the same operating system as the computer being used to run program (for example, the personal computer version can be run under DOS 2.0 or higher and Windows 3.0 or higher), and
- the program must be run on a disk/directory that has enough accessible memory to be able to hold the executable version and at least one small text file (about 60 kilobytes (KB) for DOS/Windows, about 170 KB for Macintosh PCs, and about 180 KB for Data General Unix).

Specific instructions for loading and implementing PLACER are machine dependent. Generally, the proper executable file should be loaded in a new directory. To use PLACER on a computer system that is not listed in table 1, it will be necessary to create a machine-specific executable code. To do this, users must have a FORTRAN compiler that is suitable for their computer and operating systems.

USING PLACER

The PLACER process includes the definition of known features, the location of sites of interest, and the calculation of results by establishing LAT/LON coordinates for each site. To implement the PLACER process the user:

1. establishes axes that are aligned as closely as possible with the lines of latitude and longitude,
2. measures the coordinates of each feature location (in LAT/LON and the UDCS) and records these values along with other documentation on the NDAMS study site locator form,
3. measures the coordinates of sites of interest (in the UDCS) and records these positions on the NDAMS study site locator form, and
4. inputs the location data for features and sites manually or by use of an appropriate input file, and the PLACER program,
5. interpolates the position of the sites of interest (in LAT/LON coordinates) from the information about the relative locations (in UDCS coordinates) of features (of known LAT/LON coordinates) and sites,
6. presents the user with input values and the results of calculations, by writing input and output to the screen, and
7. documents the information by writing input and output to a text file.

PLACER is started using the standard method to initiate a program in each operating system. For example, the executable file name is typed on the command line in DOS or Unix systems, and the program-file icon is activated by the mouse in Windows and Macintosh systems. If the file is activated from a CD-ROM or from another read-only memory location, the input and output file names must contain the full path name of a drive and directory where the user can save files. File names can be up to 60 characters long, including the drive and the directory specification, although the actual file name should not exceed the "8.3" configuration of standard DOS files if these files are to be fully compatible for all systems.

PLACER's user interface is structured to operate in a linear manner. When the program is started, an introductory screen comes up with brief instructions and three choices. The initial choices are data entry through (1) manual input or (2) an input file. This menu also allows the user to exit immediately in case of accidental activation of the PLACER program. The manual entry choice prompts a series of menus that lead the user through the process. The input file choice is programmed to skip manual entry and read all values from the input file specified by the user. Compared to commercial programs, the input structure is relatively primitive and somewhat unforgiving, because the potential uses of the program did not justify an extensive user interface development process. The program, however, was written with some internal data-checking logic and opportunities for the user to reenter information when mistakes are detected. The manual data-entry process is not trivial when there are more than a few features and sites. Therefore, unrecoverable mistakes in the input data set are most easily corrected by editing the output file using a nonformatting text editor. The user can then run this corrected version through PLACER as an input file to generate the final output.

Data entry by keyboard or input file is constrained by the input/output features of FORTRAN, and screen entry behaves slightly differently from data-file entry. Data-file entry requires that each line and each character of the input file follow fixed formats. Keyboard entry is also constrained by fixed formats. When UDCS values are entered, a decimal point in the appropriate space is mandatory. If the value "1" is entered, the program will read "0.01", but if a "1." is entered, "1.00" will be read. The minimum UDCS value is 0.01, and the maximum is 9,999,999 (entered without commas as "9999999."). at the screen prompt. Any internally consistent units for measuring length can be used because the LAT/LON coordinates of each site is calculated using the average ratios of latitude and longitude to the UDCS values.

The LAT/LON values entered into the program are dependent upon the location and the characteristics of the LAT/LON coordinate system. Latitude is measured in degrees (D), minutes (M), and seconds (S), increasing from zero degrees at the equator to 90 degrees at each pole. Therefore, latitude is entered in the format DDMMSS and the program is designed to register a positive measurement along the Y axes from south to north (bottom to top) as an increase in latitude. Longitude is also measured in degrees, minutes, and seconds, increasing from zero degrees at the prime meridian, which passes through Greenwich, England, westward and eastward, to 180 degrees located in the Pacific Ocean. Therefore, longitude is entered in the format DDDMMSS and the program is designed to register a positive measurement along the X axes from west to east (left to right) as a decrease in longitude. This system is appropriate for all of North America and Hawaii. PLACER can be applied to locations in any hemisphere as long as the orientation of UDCS is constantly and appropriately aligned. The latitude and longitude inputs are read by PLACER from left to right, so it is important to add any leading zeroes on manual input or the program will misinterpret the input when degrees and minutes are converted to seconds for the calculations.

Input values of minutes and seconds can be greater than or equal to 60 as long as the conversion to seconds will yield the proper input values for calculations in seconds. For example, a value of 99 minutes is equivalent to 1 degree and 39 minutes, both of which are calculated as 5940 seconds. Input coordinates for features are output in the same format as entered by the user. Output coordinates for sites, however, are in the format of degrees, minutes, and seconds. These format differences become apparent when a subset of feature locations are also input as sites (to check the accuracy and precision of calculations). For example, the LAT/LON coordinates for a feature (that is also used a check site) entered as 99 minutes would be written as "009900" with the feature-coordinate data, and "013900" (1 degree and 39 minutes) with the site-coordinate data. The input data is not reformatted by PLACER because reformatting may obscure data entry errors.

PLACER was designed with the assumption that the ratio of latitude and longitude to the Y and X UDCS measurements, respectively, would be constant on the small local site-maps used to locate study areas. Two conditions would violate this design assumption. The first condition would be the placement of the UDCS axes on a site map that are not oriented with the true LAT/LON axes. This condition, if it introduces substantial bias, will be reflected in the standard deviation of the ratio of the LAT/LON to UDCS measurements and in the calculated LAT/LON coordinates of features that are also input as sites to check the calculations. Tests indicate that as long as the user locates features beyond the farthest sites on each axis, these outlying features will affect the calculated average and standard deviation so that the reported LAT/LON and associated uncertainty will encompass the true location of the site. A map projection is the method used to portray all or part of the spherical earth on a flat surface. The second condition that violates the assumption of a linear relation between the LAT/LON and UDCS values occurs on maps covering large areas where distortions are caused by the projection of the base map. The effect of distortions in the relation between the LAT/LON and measured units depends on latitude (because the lines of longitude converge at the poles), the projection method used, and the areal extent of the map. Again, however, well-placed features will account for this error, which will be reflected in the calculated average and standard deviation in the relation between the LAT/LON and measurement units.

Manual-Input Method

Once PLACER has been activated and the manual-input feature has been chosen for data entry, the user will be prompted for detailed information. The program requires the output-file name, the map name, the number of features, the number of sites, the LAT/LON of the origin, the LAT/LON of map features, the Y/X coordinates of the map features, and (since the LAT/LON of sites is unknown) the Y/X coordinates of the sites. After the introductory information is entered and after each feature and site is entered, PLACER initiates an input-data check. If the user enters the value "0" or executes a carriage return on the input-data check line, then the program progresses to the next task. If the user enters the value "1", to indicate an error in the data as entered, then all the data in the previous section must be reentered. The user must complete the entire data entry process to create an output file. The program is relatively robust, but cannot accept nonalphanumeric input. Once data entry is complete, the program calculates the necessary information and writes the input data and the results of the calculations to the screen and to the output file.

Input-File Method

Once PLACER has been activated and the input-file feature chosen for data entry, the user will be prompted for the file name. An input file is created (as an output file of a previous program execution) when the manual-input method is used to enter data. These files can be modified for further use using a text editor. A user could also create an input file using a text editor, but the file would have to conform to the relatively strict FORTRAN input format structure as defined by the format statements in the program code (appendix 3). In the input-file mode, PLACER requires the user to enter both the input and output file names and reads all the remaining information from the input file. The program has an internal check and feedback loop to ensure that the user does not accidently destroy an input file so input and output file names cannot be the same. Once the file name information has been entered correctly, the program reads the input file and calculates the necessary information. The program then writes the input data and the results of the calculations to the screen and to the output file. When using the input-file method, the program reads only those values that would be entered when using the manual method. Therefore, only revisions to feature and site names, the LAT/LON and Y/X coordinates of features, and the Y/X coordinates of sites are read and used. Features and(or) sites may be added to or deleted from an input file (following the proper formats), if the appropriate number of features and sites is entered on the correct line at the top of the file.

Anatomy of an Input/Output File

The Input/Output (I/O) file structure is arranged sequentially to facilitate manual and automated management, assessment, and validation of site-location metadata by the operator and by PLACER. Figure 1 is an annotated example of an I/O file created by PLACER. The basic information is at the head of the file (fig. 1). The number of features and the number of study sites indicate to PLACER, or to a person reading the file, how many sites and locations are to be expected. Each line of feature data provides the input data as well as the LAT/LON coordinates in total seconds (fig. 1). Each line of site data provides both the input data (UCDS measurements) and the output data (LAT/LON coordinates in degrees, minutes, and seconds and in total seconds). The I/O file documents the ratio of latitude and longitude to the Y and X UDCS values, respectively. The I/O file also documents the differences in LAT/LON (in seconds) and in Y/X UDCS values from each respective user-defined axis.

```
INPUT FILENAME: IOFile.txt
 MAP NAME: USGS QUAD Boston South, MA          BASIC INFORMATION
 NUMBER OF MAP FEATURES:  8
 NUMBER OF STUDY SITES:  4
 OUTPUT   FEATURE                DDDMMSS  SSSSSSSS    X OR Y
  Lat & y: Map Origin at SW      0421500    152100      0.00
  Lon & x: Map Origin at SW      0710300    255780      0.00
  Lat & y: Known Coord2          0421500    152100      0.00
  Lon & x: Known Coord2          0710000    255600      4.80
  Lat & y: Known Coord3          0421800    152280      4.80
  Lon & x: Known Coord3          0710000    255600      4.80
  Lat & y: Known Coord4          0421800    152280      4.80        FEATURE
  Lon & x: Known Coord4          0710300    255780      0.00        DATA
  Lat & y: Thimble Island(GNIS)  0421827    152307      5.50
  Lon & x: Thimble Island(GNIS)  0710128    255688      2.45
  Lat & y: Savin Hill (GNIS)     0421838    152318      5.80
  Lon & x: Savin Hill (GNIS)     0710300    255780      0.00
  Lat & y: Forbes Hill (GNIS)    0421525    152125      0.65
  Lon & x: Forbes Hill (GNIS)    0710142    255702      2.10
  Lat & y: Halftide Rock (GNIS)  0421818    152298      5.30
  Lon & x: Halftide Rock (GNIS)  0710142    255702      2.20
  Lat & y: Norfolk Downs (GNIS)  0421620    152180      2.15
  Lon & x: Norfolk Downs (GNIS)  0710115    255675      2.80
 **********************************************************************
  OUTPUT   SITE                  DDDMMSS  SSSSSSSS    X OR Y
  Lat & y: Tenean Beach Drain    0421736    152256      4.15
  Lon & x: Tenean Beach Drain    0710241    255761      0.52
  Lat & y: Interchange 20 Drain  0421709    152229      3.45         SITE
  Lon & x: Interchange 20 Drain  0710235    255755      0.70         DATA
  Lat & y: Known Coord3          0421800    152280      4.80
  Lon & x: Known Coord3          0710002    255602      4.80
  Lat & y: Norfolk Downs (GNIS)  0421620    152180      2.15
  Lon & x: Norfolk Downs (GNIS)  0710117    255677      2.80
 **********************************************************************
  FEATURE VALUES           DLAT/DY     DLAT        DY
  Known Coord2                0.00        0      0.00        LATITUDE
  Known Coord3               37.50      180      4.80          CALCULATION
  Known Coord4               37.50      180      4.80            RESULTS
  Thimble Island (GNIS)      37.64      207      5.50
  Savin Hill (GNIS)          37.59      218      5.80
  Forbes Hill (GNIS)         38.46       25      0.65
  Halftide Rock (GNIS)       37.36      198      5.30
  Norfolk Downs (GNIS)       37.21       80      2.15
 **********************************************************************
  LAT AVG & STD DEV (SD):  AVERAGE        SD    2 X SD    3 X SD
                             37.61      0.40     0.81      1.21
 **********************************************************************
  FEATURE VALUES           DLON/DX     DLON        DX
  Known Coord2              -37.50     -180      4.80        LONGITUDE
  Known Coord3              -37.50     -180      4.80         CALCULATION
  Known Coord4                0.00        0      0.00           RESULTS
  Thimble Island (GNIS)     -37.55      -92      2.45
  Savin Hill (GNIS)           0.00        0      0.00
  Forbes Hill (GNIS)        -37.14      -78      2.10
  Halftide Rock (GNIS)      -35.45      -78      2.20
  Norfolk Downs (GNIS)      -37.50     -105      2.80
 **********************************************************************
  LON AVG & STD DEV (SD):  AVERAGE        SD    2 X SD    3 X SD
                            -37.11      0.82     1.65      2.47
 **********************************************************************
```

Figure 1. Example of the format of an input/output file from the PLACER program.

Points along the axis are set to zero by the program and are not used in calculating the average and standard deviation. Examination of the average and the standard deviation, as well as any individual outliers in the results of the calculations, will identify any individual sources of uncertainty. If the features were entered correctly by the person using PLACER, the standard deviation will indicate the uncertainty for locations that can be determined from a given base map.

CASE STUDIES

Two case studies are provided to illustrate the use of and operation of PLACER with different types of data from a base map. Two hypothetical sites along Interstate 93 in Boston, Massachusetts, were plotted and located using PLACER. The two sites, shown as filled circles on figure 2, are a hypothetical Tenean Beach Drain and a hypothetical Interchange 20 Drain. In the first case study, known coordinates of latitude and longitude from the base map are used, and in the second case study (used to illustrate an example in which the coordinates are not plotted on the map), the latitude and longitude of the feature locations are derived from the USGS GNIS data base (U.S. Geological Survey, 1998a, 1998b).

Case 1: Map Coordinates

If at least two points of known latitude and longitude are included on the site map available in a report of investigations, then the position of any point on the map can be determined by interpolation using PLACER. The LAT/LON coordinates and the Y and X UDCS locations of the intersections of each LAT/LON axis can be input to derive the location of each study site on the base map. All that is needed to interpolate the site locations using PLACER is the origin point, one intersection of known LAT/LON, and another point that is off the axis of the origin. However, use of more than two LAT/LON coordinates is preferable because additional features provide points for check measurements that indicate the degree to which the area inscribed by the features is out of square. The map area can be out of square because of photocopy distortions, map projection, or high latitude.

In this example, the latitude and longitude of the two hypothetical study sites along Interstate 93 in Boston, Massachusetts, are located using map features defined by known LAT/LON coordinates from a site map (fig. 2). The four known coordinates, shown as bold crosses on figure 2, are listed as the "Origin" and "Known Coord. #2" through "Known Coord. #4" on the I/O file shown in figure 3. The known coordinates for these features were recorded and entered via manual input. For these features, the average number of seconds per measurement unit were 37.90 and -37.50 for latitude and longitude, respectively. These numbers are then used to calculate the LAT/LON coordinates of each site.

If, (1) the base map has been made properly, (2) sites of interest are not in high latitudes, and (3) there have been no distortions or measurement errors, the standard deviation of this average should be zero because the exact locations of the features are known. A small error in the estimate for the Y coordinate was intentionally introduced for demonstration on one of the features (fig. 3). This error appears in the calculated standard deviations and in the calculated latitude of the site "Known Coord. #4" which was entered as a check measurement. The latitude and longitude of each site was recorded in the I/O file. The uncertainty in the site-location coordinates can be estimated by using the product of the largest value of the user-defined map units in the I/O file and twice the calculated standard deviation (theoretically, including about 95 percent of the population of feature location coordinates). For this example, the estimated uncertainty in the site coordinates of the data set is about plus or minus one second, if the sites are properly located and the symbol size is smaller than 1 second.

Case 2: Known Locations

To be complete, a project site map should include (1) a small outline map to place the study area within the boundaries of a recognizable geographic unit such as a State map, (2) a scale, (3) a North Arrow, and (4) a defined coordinate system (such as LAT/LON) clearly marked upon the margins (Hansen, 1991). Each of these features is apparent on figure 2, but we will, for the purpose of this case study, assume that these marks are not available.

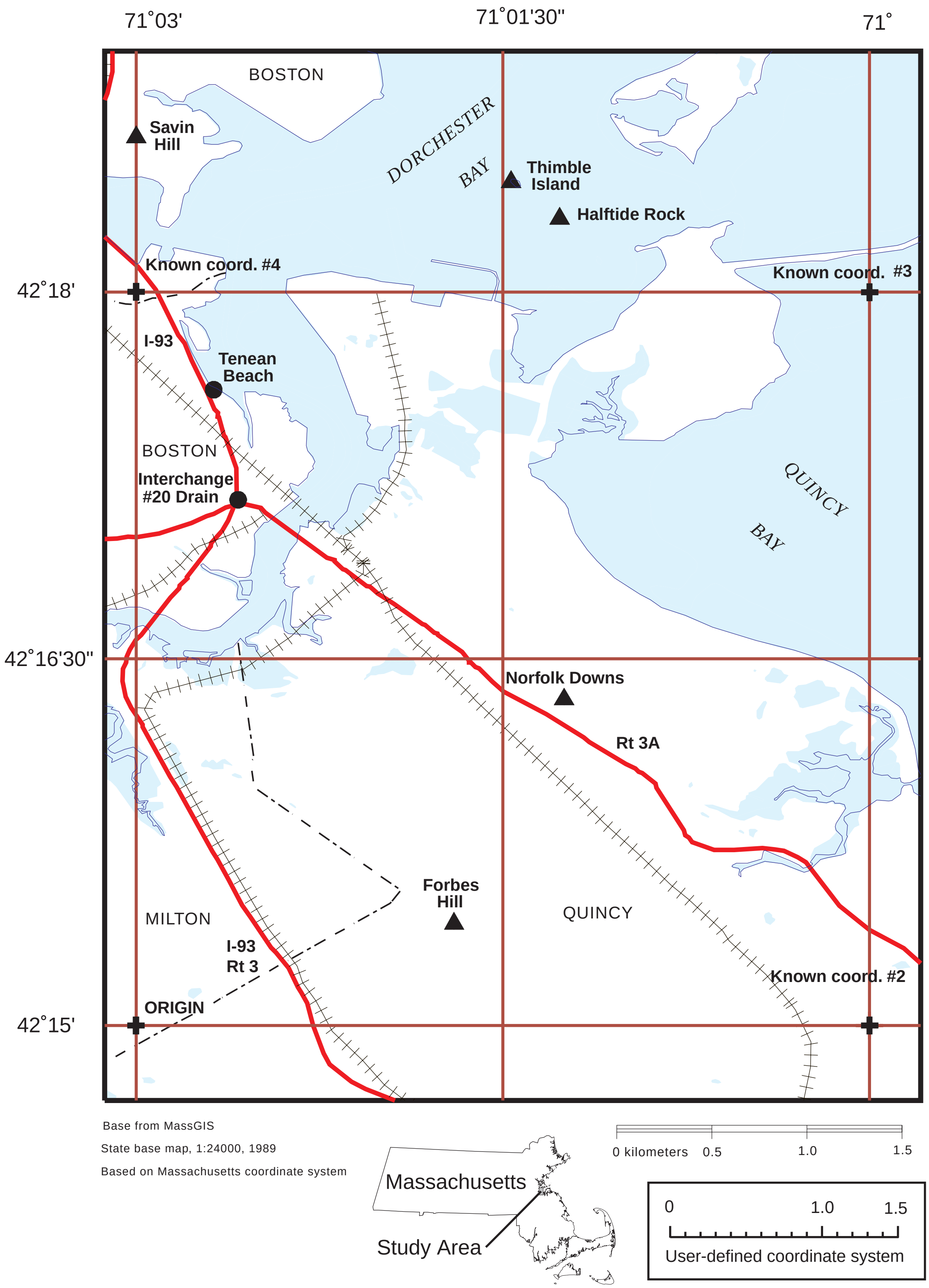

Figure 2. Base map of southwest Boston, Massachusetts, with a user-defined coordinate system (UDCS) scale for example calculations using PLACER program.

```
INPUT FILENAME:  Sample1.txt
 MAP NAME: USGS QUAD Boston South, MA
 NUMBER OF MAP FEATURES:  3
 NUMBER OF STUDY SITES:  4
  OUTPUT   FEATURE               DDDMMSS  SSSSSSSS    X OR Y
  Lat & y: Map Origin at SW      0421500    152100      0.00
  Lon & x: Map Origin at SW      0710300    255780      0.00
  Lat & y: Known Coord2          0421500    152100      0.00
  Lon & x: Known Coord2          0710000    255600      4.80
  Lat & y: Known Coord3          0421800    152280      4.80
  Lon & x: Known Coord3          0710000    255600      4.80
  Lat & y: Known Coord4          0421800    152280      4.70
  Lon & x: Known Coord4          0710300    255780      0.00

**********************************************************************
  OUTPUT   SITE                  DDDMMSS  SSSSSSSS    X OR Y
  Lat & y: Tenean Beach Drain    0421737    152257      4.15
  Lon & x: Tenean Beach Drain    0710241    255761      0.52
  Lat & y: Interchange 20 Drain  0421710    152230      3.45
  Lon & x: Interchange 20 Drain  0710234    255754      0.70
  Lat & y: Known Coord3          0421801    152281      4.80
  Lon & x: Known Coord3          0710000    255600      4.80
  Lat & y: Norfolk Downs (GNIS)  0421621    152181      2.15
  Lon & x: Norfolk Downs (GNIS)  0710115    255675      2.80

**********************************************************************
  FEATURE VALUES           DLAT/DY     DLAT         DY
  Known Coord2                0.00        0       0.00
  Known Coord3               37.50      180       4.80
  Known Coord4               38.30      180       4.70

**********************************************************************
  LAT AVG & STD DEV (SD):  AVERAGE         SD    2 X SD    3 X SD
                             37.90       0.56      1.13      1.69

**********************************************************************
  FEATURE VALUES           DLON/DX     DLON         DX
  Known Coord2              -37.50     -180       4.80
  Known Coord3              -37.50     -180       4.80
  Known Coord4                0.00        0       0.00

**********************************************************************
  LON AVG & STD DEV (SD):  AVERAGE         SD    2 X SD    3 X SD
                            -37.50       0.00      0.00      0.00

**********************************************************************
```

Figure 3. Calculation of site coordinates by the PLACER program using known latitude and longitude coordinates as features.

The NDAMS report review process revealed that most reports published outside of the USGS do not include site maps and many of the site maps that were available did not meet these basic mapping standards. Therefore, the latitudes and longitudes were more difficult to determine. When site maps had features that were identifiable using the USGS GNIS data base or other similar sources (USGS, 1998a, 1998b; NIMA, 1998; Natural Resources Canada, 1998), however, site locations could be estimated using these features.

The USGS GNIS data base contains LAT/LON information for almost 2 million known places, features (except roads and highways), and areas in the United States that are identifiable by a proper name (USGS, 1998a, 1998b). This location information was digitized during the period from 1978 to 1986 from 1:24,000-scale, 1:62,500-scale, and 1:250,000-scale maps, depending upon the availability of published maps for a given area (USGS, 1998a, 1998b). Point locations such as hilltops, geographic features, and schools can easily be identified. However, the digitized location of populated places (such as towns) was set at the local post office or town hall, which may not correspond precisely to the locations of a place name on a site map provided in a given report. Therefore, locations derived using coordinates from GNIS will generally have more uncertainty than locations derived from exact LAT/LON coordinates on the base map of a report. The method described in this example can also be used for a site anywhere in the world, if the features can be located using the international NIMA data base (NIMA,1998), which is similar to the GNIS data base.

In this example, the latitude and longitude of the two hypothetical study sites along Interstate 93 in Boston, Massachusetts, were located using five map features on a site map that were identifiable in the GNIS data base (fig. 2). These five known features, shown as filled triangles on figure 2, are listed as their place names on the I/O file shown in figure 4. The coordinates for these features were recorded and were entered via manual input. For this example, the origin from the known LAT/LON coordinates was used to facilitate comparisons between the examples using map coordinates and known locations (and for comparison to the calculations for the combined data set illustrated in figure 1). If the LAT/LON coordinates were not known, one feature, or the intersection of the LAT/LON axes of two features, could have been used as an origin. For the features from GNIS, the average number of seconds per UDCS measurement unit were 37.65 and -36.91 for latitude and longitude, respectively. These numbers were then used to calculate the LAT/LON coordinates of each site. The standard deviation of the feature location averages was about 0.5 and 1 second per UDCS map unit for latitude and longitude, respectively. Therefore, using twice the standard deviation, and the maximum distance from the origin, the uncertainty in LAT/LON coordinates of the site locations could be estimated to within plus or minus 11 seconds. If this uncertainty is acceptable, these results would be used. If not, the measurements of feature and site locations should be verified and the possibility of dropping and(or) adding features considered. For comparison, when the GNIS features and the map coordinate features were combined, the average number of seconds per measurement unit was 37.61 and -37.11 for latitude and longitude, respectively, and the estimated uncertainty in the LAT/LON coordinates of site locations was about plus or minus 9 seconds.

```
INPUT FILENAME:  Sample2.txt
MAP NAME: USGS QUAD Boston South, MA
NUMBER OF MAP FEATURES:  5
NUMBER OF STUDY SITES:  4
 OUTPUT   FEATURE               DDDMMSS  SSSSSSSS    X OR Y
 Lat & y: Map Origin at SW      0421500    152100      0.00
 Lon & x: Map Origin at SW      0710300    255780      0.00
 Lat & y: Thimble Island(GNIS)  0421827    152307      5.50
 Lon & x: Thimble Island(GNIS)  0710128    255688      2.45
 Lat & y: Savin Hill (GNIS)     0421838    152318      5.80
 Lon & x: Savin Hill (GNIS)     0710300    255780      0.00
 Lat & y: Forbes Hill (GNIS)    0421525    152125      0.65
 Lon & x: Forbes Hill (GNIS)    0710142    255702      2.10
 Lat & y: Halftide Rock (GNIS)  0421818    152298      5.30
 Lon & x: Halftide Rock (GNIS)  0710142    255702      2.20
 Lat & y: Norfolk Downs (GNIS)  0421620    152180      2.15
 Lon & x: Norfolk Downs (GNIS)  0710115    255675      2.80
**********************************************************************
 OUTPUT   SITE                  DDDMMSS  SSSSSSSS    X OR Y
 Lat & y: Tenean Beach Drain    0421736    152256      4.15
 Lon & x: Tenean Beach Drain    0710241    255761      0.52
 Lat & y: Interchange 20 Drain  0421709    152229      3.45
 Lon & x: Interchange 20 Drain  0710235    255755      0.70
 Lat & y: Known Coord3          0421800    152280      4.80
 Lon & x: Known Coord3          0710003    255603      4.80
 Lat & y: Norfolk Downs (GNIS)  0421620    152180      2.15
 Lon & x: Norfolk Downs (GNIS)  0710117    255677      2.80
**********************************************************************
 FEATURE VALUES          DLAT/DY     DLAT         DY
 Thimble Island (GNIS)     37.64      207       5.50
 Savin Hill (GNIS)         37.59      218       5.80
 Forbes Hill (GNIS)        38.46       25       0.65
 Halftide Rock (GNIS)      37.36      198       5.30
 Norfolk Downs (GNIS)      37.21       80       2.15
**********************************************************************
 LAT AVG & STD DEV (SD):  AVERAGE        SD    2 X SD    3 X SD
                            37.65      0.49      0.97      1.46
**********************************************************************
 FEATURE VALUES          DLON/DX     DLON         DX
 Thimble Island (GNIS)    -37.55      -92       2.45
 Savin Hill (GNIS)          0.00        0       0.00
 Forbes Hill (GNIS)       -37.14      -78       2.10
 Halftide Rock (GNIS)     -35.45      -78       2.20
 Norfolk Downs (GNIS)     -37.50     -105       2.80
**********************************************************************
 LON AVG & STD DEV (SD):  AVERAGE        SD    2 X SD    3 X SD
                           -36.91      0.99      1.98      2.97
**********************************************************************
```

Figure 4. Calculation of site coordinates by the PLACER program using the latitude and longitude coordinates of map features located using the U.S. Geological Survey Geographic Names Information System (GNIS).

SUMMARY

Well defined sampling-site locations are necessary to document data and to help establish that the data and the resultant interpretations are valid, current, and technically defensible. A program designed for point location and calculation of error (PLACER) was developed as part of the Quality Assurance Program of the Federal Highway Administration/U.S. Geological Survey National Data and Methodology Synthesis (NDAMS) review process, to provide a standard method to derive study-site locations from site maps in highway-runoff reports. Use of a base map from an environmental-monitoring report, the study-site locator form, and PLACER provides a documentable process that reduces or eliminates the potential for human error in interpolating site coordinates from published site maps. The purpose of this report is to (1) provide a guide for using PLACER, (2) to document the methods used to estimate study-site locations, (3) to document the NDAMS Study Site Locator Form (appendix 1), and (4) to document the FORTRAN code (appendix 2) used to implement the program method.

PLACER is a simple computer program that interpolates between known feature locations and unknown sites of interest on a published map using any consistent, linear, user-defined coordinate system (UDCS). PLACER is used to determine the LAT/LON of a point plotted on a map and to estimate the uncertainty of the LAT/LON coordinates calculated using input data. The program determines study-site locations in latitude and longitude using known map coordinates or features that are identifiable in available geographic information data bases.

PLACER is configured to accept keyboard and(or) formatted data-file entry and to output results to the computer screen and to an ASCII text file. PLACER was developed using standard FORTRAN and, thus, the code should be readily transferable to different computers and operating systems, with few (if any) modifications. The FORTRAN code, and executable versions of PLACER for DOS/Windows, the Macintosh operating system, and Data General Unix, are available on disk.

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APPENDIX 1: STUDY-SITE LOCATOR FORM

FHWA Project Study-Site Locator Form Version 2
Please attach: Copy of figure or table used to locate sites & program file printout
Person locating sites: ____

Report being reviewed: ____

Figure or table from which site locations were determined:

____

How determined: By text, by placer, by hand interpolation

For Placer:

Final output file name: ___________________________________

Origin:
Name of origin lat/y ____

latitude: _ _ _ _ _ _   y location: _ _ _ **0. 00**
d d m m s s

Name of origin lon/x ____

longitude: _ _ _ _ _ _ _   x location: _ _ _ **0. 00**
d d d m m s s

Number of map features (up to 21): ____

1. Feature name ____

latitude: _ _ _ _ _ _   y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _   x location: _ _ _ . _ _
d d d m m s s

2. Feature name ____

latitude: _ _ _ _ _ _   y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _   x location: _ _ _ . _ _
d d d m m s s

3. Feature name ____

latitude: _ _ _ _ _ _   y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _   x location: _ _ _ . _ _
d d d m m s s

4. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

5. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

6. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

7. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

8. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

9. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

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10. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

11. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

12. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

13. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

14. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

15. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

16. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

17. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

18. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

19. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

20. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

21. Feature name ____

latitude: _ _ _ _ _ _ y location: _ _ _ . _ _
d d m m s s

longitude: _ _ _ _ _ _ _ x location: _ _ _ . _ _
d d d m m s s

Number of map sites (up to 21): ____

1. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

2. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

3. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

4. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

5. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

6. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

7. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

8. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

9. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

10. Site name ______________________________________

y location: _ _ _ . _ _   x location: _ _ _ . _ _

11. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

12. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

13. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

14. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

15. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

16. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

17. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

18. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

19. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

20. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

21. Site name ____

y location: _ _ _ . _ _   x location: _ _ _ . _ _

comments: ____

____

____

____

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APPENDIX 2: FORTRAN CODE FOR PLACER

```
C     PLACER--Point Location And Calculation of ERror
C     VERSION 2.0  UPDATED USER INTERFACE
C     A program designed to assign a latitude and longitude (lat/lon) to
C     points plotted on a map from "known" reference points, the program
C     also estimates the uncertainty of the lat/lons generated by
C     calculating the standard deviation of the population of known
C     points.
C
C     Programmed by Gregory E. Granato, ggranato@usgs.gov, October, 1997
C     U.S. Geological Survey, Water Resources Division
C     Massachusetts Rhode Island District, Northborough, MA 01532
C
C     Establish Variables
      IMPLICIT NONE
      CHARACTER*60 ifnm,ofnm,FNMOLD
      CHARACTER*20 feature(21),site(21),orgname
      CHARACTER*60 mapnm,JUNK*80
C
      INTEGER latfd(21),latfm(21),latfs(21)
      INTEGER latsd(21),latsm(21),latss(21)
      INTEGER lonfd(21),lonfm(21),lonfs(21)
      INTEGER lonsd(21),lonsm(21),lonss(21)
      INTEGER LATF(21),LATS(21),LONF(21),LONS(21)
      INTEGER latdo(21),londo(21)
      INTEGER nf,ns,LONO,LATO,ok
      INTEGER lonod,lonom,lonos,latod,latom,latos,I
      INTEGER xnum,ynum,MANOR
C
      REAL xs(21),ys(21),xf(21),yf(21),rx(21),ry(21),ydo(21),xdo(21)
      REAL XO,YO,xsum,ysum,xavg,yavg,sx,sy,sysum,sxsum,tmpx,tmpy
      REAL sxii,syii,sxiii,syiii
C
C     SET ORIGINAL VALUES
C     ON READ AND WRITE FUNCTIONS: * --keyboard and screen
C     UNIT 10 -- INPUT FILE  UNIT 11 --OUTPUT FILE
C
      orgname='Map Origin at SW'
C     WELCOME SCREEN
 10   WRITE (*,9000)
      WRITE (*,9010)
      WRITE (*,9020)
      WRITE (*,9000)
      WRITE (*,9030)
      WRITE (*,9040)
      WRITE (*,9050)
      WRITE (*,9060)
      WRITE (*,9070)
      WRITE (*,9080)
      WRITE (*,9090)
      WRITE (*,9100)
```

```
      WRITE (*,9110)
      WRITE (*,9000)
      WRITE (*,9000)
      WRITE (*,9200)
      WRITE (*,9210)
      READ  (*,9211) MANOR
      WRITE (*,9000)
C     RESPOND TO MODE CHOICE
C     0= BYE  1 = MANUAL  2=INPUT FILE  ELSE=START AGAIN
       IF (MANOR.EQ.0) THEN
        WRITE (*,9220)
        WRITE (*,9000)
        GOTO 900
       ELSEIF (MANOR.EQ.1) THEN
        WRITE (*,9230)
        WRITE (*,9000)
        GOTO 100
       ELSEIF (MANOR.EQ.2) THEN
        WRITE (*,9240)
        WRITE (*,9241)
        WRITE (*,9000)
        GOTO 200
       ELSE
        GOTO 10
       END IF
C     ****************************************************
C     MANUAL ENTRY
C     ****************************************************
 100  WRITE (*,9302)
      READ  (*,9312) OFNM
      WRITE (*,9310)
      READ  (*,9312) MAPNM
 101  WRITE (*,9314)
      READ  (*,9318) NF
       IF ((NF.LT.1).OR.(NF.GT.21))  THEN
        WRITE (*,9315)
        GOTO 101
       END IF
 103   WRITE (*,9316)
      READ  (*,9318) NS
       IF ((NS.LT.1).OR.(NS.GT.21))  THEN
        WRITE (*,9315)
        GOTO 103
       END IF
C     CHECK MANUAL INPUT loop1 start
      WRITE (*,9000)
      WRITE (*,9900)
      WRITE (*,9340) OFNM
      WRITE (*,9342) MAPNM
      WRITE (*,9344) NF
```

```
      WRITE (*,9346) NS
      CALL getok(ok)
C       WRITE (*,9951)
C       READ  (*,9952) OK
      if (ok.ne.0) goto 100
      WRITE (*,9000)
C     CHECK MANUAL INPUT loop1 end
C     INPUT ORIGIN IN IN LATLONG & MAP UNITS = 0,0
C
 110  WRITE (*,9400)
      WRITE (*,9401)
      READ  (*,9411) LATOD,LATOM,LATOS
      WRITE (*,9402)
      READ  (*,9412) LONOD,LONOM,LONOS
C     CONVERT DEGREES, MINUTES & SECONDS TO TOTAL SECONDS
      CALL DMS2S(LATOD,LATOM,LATOS,LATO)
      CALL DMS2S(LONOD,LONOM,LONOS,LONO)
      XO=0.00
      YO=0.00
      WRITE (*,9722)
      write (*,9725) orgname,LATOD,LATOM,LATOS,lato,YO
      write (*,9726) orgname,LONOD,LONOM,LONOS,lono,XO
c     check loop 2. start
      CALL getok(ok)
c      write (*,9951)
c      read  (*,9952) ok
      if (ok.ne.0) goto 110
      WRITE (*,9000)
c     check loop 2. end
C
C     INPUT FEATURE LOCATIONS IN LATLONG & MAP UNITS
C
      DO 130, I=1,NF
 120  WRITE (*,9410) I
      WRITE (*,9405)
      READ  (*,9415) FEATURE(I)
      WRITE (*,9401)
      READ  (*,9411) LATFD(I),LATFM(I),LATFS(I)
      WRITE (*,9404)
      READ  (*,9414) YF(I)
      WRITE (*,9402)
      READ  (*,9412) LONFD(I),LONFM(I),LONFS(I)
      WRITE (*,9403)
      READ  (*,9413) XF(I)
C     CONVERT DEGREES, MINUTES & SECONDS TO TOTAL SECONDS
      CALL DMS2S(LATFD(I),LATFM(I),LATFS(I),LATF(I))
      CALL DMS2S(LONFD(I),LONFM(I),LONFS(I),LONF(I))
      WRITE (*,9722)
      write (*,9725) feature(I),LATFD(I),LATFM(I),LATFS(I),LATF(I),yf(I)
      write (*,9726) feature(I),LonFD(I),LonFM(I),LonFS(I),LonF(I),xf(I)
```

```
c     check loop 3. start
      CALL getok(ok)
c      write (*,9951)
c      read  (*,9952) ok
      if (ok.ne.0) goto 120
      WRITE (*,9000)
c     check loop 3. end
 130   CONTINUE
C     END FEATURE LOOP
C
C     INPUT SITE LOCATIONS IN LATLONG & MAP UNITS
C
      DO 150, I=1,NS
 140  WRITE (*,9409) I
      WRITE (*,9406)
      READ  (*,9416) SITE(I)
      WRITE (*,9404)
      READ  (*,9414) YS(I)
      WRITE (*,9403)
      READ  (*,9413) XS(I)
      WRITE (*,9500)
      WRITE (*,9510) SITE(I), YS(I)
      WRITE (*,9520) SITE(I), XS(I)
c     check loop 4. start
      CALL getok(ok)
c      write (*,9951)
c      read  (*,9952) ok
      if (ok.ne.0) goto 140
      WRITE (*,9000)
c     check loop 4. end
 150   CONTINUE
C     **************************************************
C     GOTO CALCULATION AND DATA RECORDING
      GOTO 300
C
C     **************************************************
C     INPUT FILE ENTRY
C     **************************************************
 200  WRITE (*,9300)
      READ  (*,9304) IFNM
      WRITE (*,9302)
      READ  (*,9304) OFNM
C     CHECK  FILE ENTRY/KEYBOARD INPUT loop1 start
       IF (IFNM.EQ.OFNM) THEN
        WRITE (*,9301)
        GOTO 200
       ENDIF
      WRITE (*,9900)
      WRITE (*,9340) IFNM
      WRITE (*,9341) OFNM
```

```
      CALL getok(ok)
c     WRITE (*,9951)
c     READ  (*,9952) OK
      WRITE (*,9000)
      if (ok.ne.0) goto 200
C     CHECK  FILE ENTRY/KEYBOARD INPUT loop1 end
      OPEN (UNIT=10,FILE=Ifnm)
      READ (10,8342) FNMOLD
      READ (10,8342) MAPNM
      READ (10,8344) NF
      READ (10,8346) NS
      WRITE (*,9000)
      WRITE (*,9700)
      WRITE (*,9900)
      WRITE (*,9340) OFNM
      WRITE (*,9342) MAPNM
      WRITE (*,9344) NF
      WRITE (*,9346) NS
      WRITE (*,9700)
C     READ FINAL FEATURE NAME, LAT/LON, & XY COORDINATES FROM FILE
      READ (10,8700) JUNK
      WRITE (*,8700) JUNK
      READ (10,8725) orgname,LATOD,LATOM,LATOS,YO
      READ (10,8725) orgname,LONOD,LONOM,LONOS,XO
      CALL DMS2S(LATOD,LATOM,LATOS,LATO)
      CALL DMS2S(LONOD,LONOM,LONOS,LONO)
      write (*,9725) orgname,LATOD,LATOM,LATOS,lato,YO
      write (*,9726) orgname,LONOD,LONOM,LONOS,lono,XO
      do 220, i=1,nF
      READ (10,8725) feature(I),LATFD(I),LATFM(I),LATFS(I),yf(I)
      READ (10,8725) feature(I),LonFD(I),LonFM(I),LonFS(I),xf(I)
      CALL DMS2S(LATFD(I),LATFM(I),LATFS(I),LATF(I))
      CALL DMS2S(LONFD(I),LONFM(I),LONFS(I),LONF(I))
      write (*,9725) feature(I),LATFD(I),LATFM(I),LATFS(I),LATF(I),yf(I)
      write (*,9726) feature(I),LonFD(I),LonFM(I),LonFS(I),LonF(I),xf(I)
 220  CONTINUE
C     Dont READ line of asterix
      READ (10,8700) JUNK
      WRITE (*,8700) JUNK
C     Dont READ header
      READ (10,8700) JUNK
      WRITE (*,8700) JUNK
c     read site info
      do 240, i=1,ns
      READ (10,8726) site(i),yS(I)
      READ (10,8726) site(i),xS(I)
      write (*,7725) site(i),yS(I)
      write (*,7726) site(i),xS(I)
 240  CONTINUE
C     Dont READ OLD CALCULATION RESULTS
```

```
C     **************************************************
C     GOTO CALCULATION AND DATA RECORDING
      GOTO 300
C
C     **************************************************
C     CALCULATION AND DATA RECORDING
C     **************************************************
C     INITIALIZE POPULATION/SUMMATION VARIABLES
 300  WRITE (*,9700)
      WRITE (*,9990)
      WRITE (*,9700)
      xsum=0.00
      ysum=0.00
      sxsum=0.00
      sysum=0.00
      xnum=0.00
      ynum=0.00
      tmpx=0.0
      tmpy=0.0
      sx=0.0
      sy=0.0
C     **************************************************
C     CALCULATE THE NUMBER OF LAT/LON SECONDS PER MAP UNIT DSEC/DMAP
C     FOR EACH OF THE FEATURES
      DO 320, I=1,NF
C     COMPUTE DISTANCE TO ORIGIN
      latdo(i)=latf(i)-lato
      londo(i)=lonf(i)-lono
      xdo(i)=xf(i)-xo
      ydo(i)=yf(i)-yo
C     USE NON-ORIGIN FEATURES TO CALCULATE STATISTICS
C     X & LON
      if (xdo(i).ne.0.00)  then
      rx(i)=(real(londo(i)))/xdo(i)
      xsum=rx(i)+xsum
      sxsum=(rx(i)*rx(i))+sxsum
      xnum=xnum+1
      else
      xsum=xsum
      sxsum=sxsum
      xnum=xnum
      endif
C     Y & LAT
      if (ydo(i).ne.0.00)  then
      ry(i)=(real(latdo(i)))/ydo(i)
      ysum=ry(i)+ysum
      sysum=(ry(i)*ry(i))+sysum
      ynum=ynum+1
      else
```

```
      ysum=ysum
      sysum=sysum
      ynum=ynum
      endif
 320  continue
C     CALCULATE MEAN DSEC/DMAP
      xavg=xsum/(real(xnum))
      yavg=ysum/(real(ynum))
C     CALCULATE STANDARD DEVIATION DSEC/DMAP
      tmpx=(sxsum-((xsum*xsum)/xnum))
      tmpy=(sysum-((ysum*ysum)/ynum))
      if ((xnum-1).ne.0.00) sx=(sqrt(tmpx/(real(xnum-1))))
      if ((ynum-1).ne.0.00) sy=(sqrt(tmpy/(real(ynum-1))))
      sxii=2.0*sx
      sxiii=3.0*sx
      syii=2.0*sy
      syiii=3.0*sy
C     ****************************************************
C     CALCULATE THE LAT/LONS FROM MEAN DSEC/DMAP AND SITE X & Y INFO
      do 340, i=1,ns
      lons(i)=lono+(int(xs(i)*xavg))
      lats(i)=lato+(int(ys(i)*yavg))
      call s2dms(lons(i),lonsd(i),lonsm(i),lonss(i))
      call s2dms(lats(i),latsd(i),latsm(i),latss(i))
 340  CONTINUE
C     ****************************************************
C     PRINT ALL TO SCREEN
C     ****************************************************

 600  CONTINUE
C
C     PRINT FINAL FEATURE INFORMATION TO THE SCREEN
      WRITE (*,9722)
      write (*,9725) orgname,LATOD,LATOM,LATOS,lato,YO
      write (*,9726) orgname,LONOD,LONOM,LONOS,lono,XO
      do 620, i=1,nF
      write (*,9725) feature(I),LATFD(I),LATFM(I),LATFS(I),LATF(I),yf(I)
      write (*,9726) feature(I),LonFD(I),LonFM(I),LonFS(I),LonF(I),xf(I)
 620  CONTINUE
C     PRINT FINAL CALCULATION INFORMATION TO THE SCREEN
      WRITE (*,9700)
      WRITE (*,9820)
      do 624, i=1,nF
      write(*,9860) feature(I),ry(i),latdo(i),ydo(i)
 624  CONTINUE
      WRITE (*,9700)
      WRITE (*,9822)
      WRITE (*,9862)  YAVG,SY,SYII,SYIII
      WRITE (*,9700)
      WRITE (*,9840)
```

```
      do 626, i=1,nF
      write(*,9860) feature(I),rx(i),londo(i),xdo(i)
 626  CONTINUE
      WRITE (*,9700)
      WRITE (*,9842)
      WRITE (*,9862)  XAVG,SX,SXII,SXIII
      WRITE (*,9700)
C
C     PRINT FINAL SITE INFORMATION TO THE SCREEN
      WRITE (*,9723)
      do 640, i=1,ns
      write (*,9725) site(i),LATSD(I),LATSM(I),LATSS(I),LATS(I),yS(I)
      write (*,9726) site(i),LonSD(I),LonSM(I),LonSS(I),LonS(I),xS(I)
 640  CONTINUE
C
C     ****************************************************
C     OPEN THE OUTPUT FILE AND BEGIN DATA RECORDING
C     ****************************************************
 700  OPEN (UNIT=11,FILE=ofnm)
      WRITE (11,9340) OFNM
      WRITE (11,9342) MAPNM
      WRITE (11,9344) NF
      WRITE (11,9346) NS
C
C     PRINT FINAL FEATURE INFORMATION TO THE FILE
      WRITE (11,9722)
      write (11,9725) orgname,LATOD,LATOM,LATOS,lato,YO
      write (11,9726) orgname,LONOD,LONOM,LONOS,lono,XO
      do 720, i=1,nF
      write(11,9725) feature(I),LATFD(I),LATFM(I),LATFS(I),LATF(I),yf(I)
      write(11,9726) feature(I),LonFD(I),LonFM(I),LonFS(I),LonF(I),xf(I)
 720  CONTINUE
      WRITE (11,9700)
C     PRINT FINAL SITE INFORMATION TO THE FILE
      WRITE (11,9723)
      do 740, i=1,ns
      write (11,9725) site(i),LATSD(I),LATSM(I),LATSS(I),LATS(I),yS(I)
      write (11,9726) site(i),LonSD(I),LonSM(I),LonSS(I),LonS(I),xS(I)
 740  CONTINUE
C     PRINT FINAL CALCULATION INFORMATION TO THE FILE
      WRITE (11,9700)
      WRITE (11,9820)
      do 744, i=1,nF
      write(11,9860) feature(I),ry(i),latdo(i),ydo(i)
 744  CONTINUE
      WRITE (11,9700)
      WRITE (11,9822)
      WRITE (11,9862)  YAVG,SY,SYII,SYIII
      WRITE (11,9700)
      WRITE (11,9840)
```

```
      do 746, i=1,nF
      write(11,9860) feature(I),rx(i),londo(i),xdo(i)
 746  CONTINUE
      WRITE (11,9700)
      WRITE (11,9842)
      WRITE (11,9862)  XAVG,SX,SXII,SXIII
      WRITE (11,9700)
C
C     **************************************************
C     END  DATA RECORDING
C     **************************************************
C     FORMAT STATEMENTS 7000'S FOR INPUT FILE screen write
 7725 FORMAT (1X,' Site  y: ',1a20,19x,1f10.2)
 7726 FORMAT (1X,' Site  x: ',1a20,19x,1f10.2)
C     FORMAT STATEMENTS 8000'S FOR INPUT FILE
 8341 FORMAT (18X,1A20)
 8342 FORMAT (11X,1A60)
 8344 FORMAT (25X,1i2)
 8346 FORMAT (24X,1i2)
 8700 FORMAT (1A80)
 8725 FORMAT (11X,1a20,2x,1i3.3,2i2.2,10X,1f10.2)
 8726 FORMAT (11X,1a20,19x,1f10.2)
C     FORMAT STATEMENTS 9000'S FOR SCREEN ENTRY
 9000 FORMAT (1X,'*****************************************************')
 9010 FORMAT (1X,'********************** PLACER **********************')
 9020 FORMAT (1X,'*****  Point Location And Calculation of ERror *****')
 9030 FORMAT (1X,'* ENTER FILE NAME, MAP NAME, THE NUMBER OF SITES,  *')
 9040 FORMAT (1X,'* AND THE NUMBER OF MAP FEATURES FROM GLIS OR A    *')
 9050 FORMAT (1X,'* MAP AS WELL AS LAT, LONG & LOCATION OF SITES     *')
 9060 FORMAT (1X,'* AND FEATURES THIS PROGRAM WILL PRODUCE LAT AND   *')
 9070 FORMAT (1X,'* LONG FOR SITES OF INTEREST. IT IS ADVISABLE TO   *')
 9080 FORMAT (1X,'* ENTER AT LEAST ONE FEATURE AS A SITE AS WELL AS  *')
 9090 FORMAT (1X,'* AN INPUT FEATURE TO CHECK YOUR IMPLEMENTATION.   *')
 9100 FORMAT (1X,'* PROGRAM ASSUMES +X IS -LONG AND +Y IS +LAT BUT   *')
 9110 FORMAT (1X,'* OTHER INTERNALLY CONSISTENT AXES SHOULD WORK.    *')
 9200 FORMAT (1X,'*          CHOOSE DATA ENTRY MODE                 *')
 9210 FORMAT (1X,'ENTER: MANUAL(1ST TIME)=1 INPUT FILE=2 EXIT=0 :',$)
 9211 FORMAT (1i1)
 9220 FORMAT (1X,' GOOD BYE!')
 9230 FORMAT (1X,'  KEYBOARD INPUT')
 9240 FORMAT (1X,'  INPUT FILE: READS ONLY THE DATA FROM A PLACER')
 9241 FORMAT (1X,'  OUTPUT FILE FORMAT (ORIGINAL OR EDITED)')
 9300 FORMAT (1X,'ENTER THE INPUT FILENAME (UP TO 60 CHARACTERS): ',$)
 9301 FORMAT (1X,'INPUT AND OUTPUT FILENAMES CANNOT MATCH')
 9302 FORMAT (1X,'ENTER THE OUTPUT FILENAME (UP TO 60 CHARACTERS): ',$)
 9304 FORMAT (1A20)
 9310 FORMAT (1X,'ENTER THE MAP NAME (UP TO 60 CHARACTERS): ',$)
 9312 FORMAT (1A60)
 9314 FORMAT (1X,'ENTER THE NUMBER OF MAP FEATURES (21 POSSIBLE): ',$)
 9315 FORMAT (1X,'**** ERROR DETECTED, PLEASE TRY AGAIN ****',)
```

```
 9316 FORMAT (1X,'ENTER THE NUMBER OF STUDY SITES (21 POSSIBLE): ',$)
 9318 FORMAT (1i2)
 9340 FORMAT (1X,'INPUT FILENAME:  ',1A60)
 9341 FORMAT (1X,'OUTPUT FILENAME: ',1A60)
 9342 FORMAT (1X,'MAP NAME: ',1A60)
 9344 FORMAT (1X,'NUMBER OF MAP FEATURES: ',1i2)
 9346 FORMAT (1X,'NUMBER OF STUDY SITES: ',1i2)
 9400 FORMAT (1X,'ENTER LAT/LON FOR THE ORIGIN (X&Y DEFAULT = 0.00): ')
 9410 FORMAT (1X,'ENTER LAT/LON AND LOCATION FOR FEATURE #',1I2)
 9409 FORMAT (1X,'ENTER LOCATION FOR SITE #',1I2)
 9401 FORMAT (1X,'INPUT LAT DDMMSS : ',$)
 9411 FORMAT (3I2)
 9402 FORMAT (1X,'INPUT LON DDDMMSS : ',$)
 9412 FORMAT (1I3,2I2)
 9403 FORMAT (1X,'INPUT X IN UNITS FROM ORIGIN (Use decmal: 1=0.01): ',$
     +)
 9413 FORMAT (1g10.2)
 9404 FORMAT (1X,'INPUT Y IN UNITS FROM ORIGIN (Use decmal: 1=0.01): ',$
     +)
 9414 FORMAT (1g10.2)
 9405 FORMAT (1X,'INPUT FEATURE NAME (UP TO 20 CHARACTERS): ',$)
 9415 FORMAT (1A20)
 9406 FORMAT (1X,'INPUT SITE NAME (UP TO 20 CHARACTERS): ',$)
 9416 FORMAT (1A20)
C     SCREEN/FILE OUTPUT
 9500 FORMAT (1X,' OUTPUT  ',1x,'SITE    ',15X,'   X OR Y')
 9510 FORMAT (1X,' SITE Y  ',1x,1A20,2X,1F10.2)
 9520 FORMAT (1X,' SITE X  ',1x,1A20,2X,1F10.2)
C
 9700 FORMAT (1X,'*******************************************************
     +****************')
 9705 FORMAT (' dlon/dx ',1a20,2x,1i8,3f10.3)
 9706 FORMAT (' dlat/dy ',1a20,2x,1i8,3f10.3)
 9720 FORMAT (' site lat: ',1a20,1f10.2,2x,1i8,2x,1i3.3,2i2.2)
 9721 FORMAT (' site lon: ',1a20,1f10.2,2x,1i8,2x,1i3.3,2i2.2)
C
C     SCREEN & FILE OUTPUT
C
 9722 FORMAT (1X,' OUTPUT  ',1x,'FEATURE',15X,'DDDMMSS',2X,'SSSSSSSS','
     +    X OR Y')
 9723 FORMAT (1X,' OUTPUT  ',1x,'SITE    ',15X,'DDDMMSS',2X,'SSSSSSSS','
     +    X OR Y')
 9725 FORMAT (1X,' Lat & y: ',1a20,2x,1i3.3,2i2.2,2X,1i8,1f10.2)
 9726 FORMAT (1X,' Lon & x: ',1a20,2x,1i3.3,2i2.2,2X,1i8,1f10.2)
 9820 FORMAT (2X,'FEATURE VALUES',8X,'   DLAT/DY',5X,'DLAT',9X,'DY')
 9822 FORMAT (2X,'LAT AVG & STD DEV (SD):',2x,'AVERAGE',8X,'SD',4X,'2 X
     +SD',4X,'3 X SD')
 9840 FORMAT (2X,'FEATURE VALUES',8X,'   DLON/DX',5X,'DLON',9X,'DX')
 9842 FORMAT (2X,'LON AVG & STD DEV (SD):',2x,'AVERAGE',8X,'SD',4X,'2 X
     +SD',4X,'3 X SD')
```

```
 9860 FORMAT (2X,1A20,2X,1F10.2,1X,1I8,1X,1F10.2)
 9862 FORMAT (2X,22X,4F10.2)
C
C    FEEDBACK LOOP
 9900 FORMAT (1X,'CHECK INPUT DATA')
 9951 FORMAT (1X,'* If values are ok hit 0 or enter, if not hit 1:',$)
 9952 FORMAT (1i1)
 9990 format (1x,'BEGIN CALCULATIONS')
C
C
C
C    CLOSE THE OPEN UNITS (FILES)
 898  CLOSE (10)
 899  CLOSE (11)
C    END PROGRAM
 900  STOP
      END
C
C
C    **********************************************
C
C    SUBROUTINES
C
C    **********************************************
C
      subroutine dms2s(ddd,mm,ss,sssss)
c     converts degrees min and sec to total sec
      integer ddd,mm,ss,sssss
      sssss=(ddd*60*60)+(mm*60)+ss
      return
      end
c
      subroutine s2dms(sssss,ddd,mm,ss)
c     converts total sec to degrees min and sec
      integer ddd,mm,ss,sssss
      ddd=int(sssss/(60*60))
      mm=int((sssss-(ddd*60*60))/60)
      ss=int((sssss-(ddd*60*60)-(mm*60)))
      return
      end
c
      subroutine getok(ok)
C      reads input & corrects to number value
      integer ok
      character*60  oktext
 10   WRITE (*,9951)
      read (*,9000) oktext
      if (oktext.eq.'0') then
       ok=0
       elseif (oktext.eq.' ') then
```

```
       ok=0
       elseif (oktext.eq.'1') then
       ok=1
       else
       goto 10
      endif
9000 format (1A1)
9951 FORMAT (1X,'* If values are ok hit 0 or enter, if not hit 1:',$)
      return
      end
```

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