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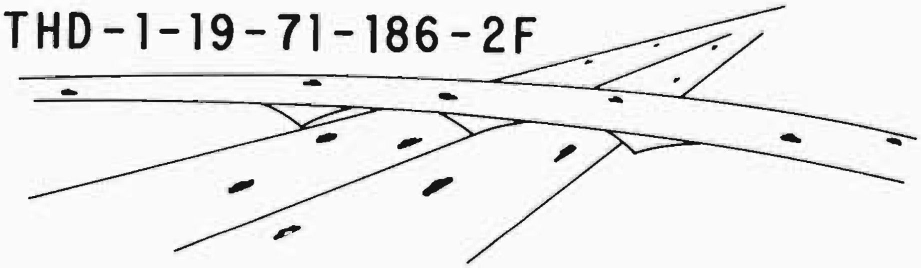
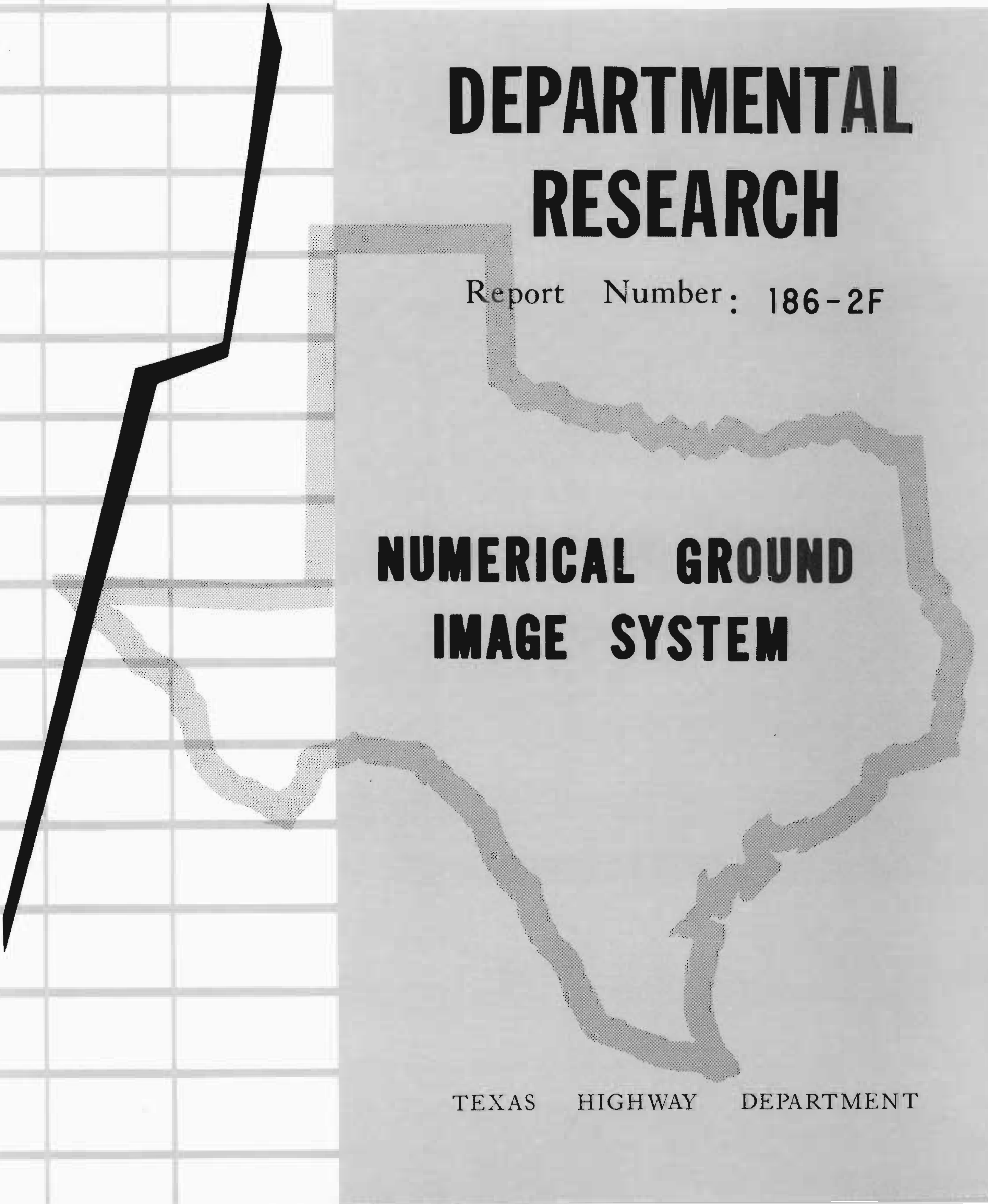


DEPARTMENTAL RESEARCH

Report Number: 186-2F



NUMERICAL GROUND IMAGE SYSTEM

TEXAS HIGHWAY DEPARTMENT

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16. Abstract

This report (1) explains the scan profile method for representing the terrain surface using a numerical surface and (2) provides user instructions for retrieval of cross-sections computed from this surface model along any specified alignment using the Roadway Design System (RDS). The appendix contains an example problem, a detailed explanation of the algorithms used, and the program documentation for the Numerical Ground Image (NGI) system.

17. Key Words

numerical ground image, digital terrain model, surface model, scan profile, roadway design, RDS, NGI, cross-sections

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Numerical Ground Image System

By

William L. Crawford

and

Roy R. Guess

Research Report 186-2F

Implementation of Numerical Ground Image System

Research Study 1-19-71-186

conducted by

Division of Automation
Texas Highway Department
In cooperation with the
U.S. Department of Transportation
Federal Highway Administration

October, 1974

SUMMARY

The interface of a Numerical Ground Image (NGI) System with the Roadway Design System (RDS) for purposes of automated terrain evaluation was the objective of this study. Either the NGI system produced by a previous Texas Highway Department sponsored Research Project or one of the available proprietary systems was to be implemented. The evaluation of the systems and the recommendation of the scan profile method, which was conceived by Mr. Larry G. Walker of the Department and developed by the project staff, was discussed in Departmental Research Report 186-1, "Implementation of Numerical Ground Image System".

The interface of an NGI system with RDS was accomplished by the project staff's developing a scan profile numerical terrain storage system and adding to RDS a cross-section request capability and cross-section retrieval system which provides computed cross-section information from the NGI terrain model. This manual explains the data acquisition techniques and gives instructions for building the terrain model. Instructions are also included for requesting cross-sections through the use of RDS input. An example problem is given in Appendix A to illustrate the use of the NGI/RDS acquisition of cross-sections. Detailed explanations of the algorithms used are in Appendix B and program documentation is in Appendix C. Appendix D contains a Glossary.

IMPLEMENTATION

The overall objective of the study was directed toward the implementation of a flexible numerical terrain storage-retrieval system and the interfacing of this facility with the Roadway Design System (RDS) to provide capability in RDS for acquisition of cross-sections along any alignments defined to RDS. These cross-sections could then be used for preliminary route location or design. This objective has been accomplished by the project staff's developing a scan profile NGI system for numerical terrain storage and writing routines in RDS to access the NGI file and develop terrain cross-sections. These capabilities are presently available to use in a design environment.

ACKNOWLEDGEMENTS

The Numerical Ground Image System was developed by the Division of Automation of the Texas Highway Department, Hubert A. Henry, Engineer-Director, in cooperation with the Federal Highway Administration.

Special recognition is given to Mr. Larry G. Walker for his contribution to this study in developing the scan profile technique of numerical storage and acquisition of terrain data. As reported in Departmental Research Report Number 186-1, "Implementation of Numerical Ground Image System", Mr. Walker's development of this simplified method of data storage and acquisition has provided for an efficient terrain acquisition system interfaced with the Roadway Design System (RDS). Recognition must also be given to Mrs. Karen Jordahl for her assistance to Mr. Walker in the early development of the scan profile technique. Mrs. Jordahl was also responsible for interfacing the Numerical Ground Image System with the Roadway Design System. Mr. Randy Guess designed and programmed the Numerical Ground Image System which was interfaced with the Roadway Design System under this study.

Special thanks are given to Mr. Will Beatty for his contribution in obtaining test data and evaluating the test results, and to Mr. Dan Wyly for his work in user testing of the system and preparation of the user instruction portion of this report.

Mrs. Margaret Walter is given grateful acknowledgement for her technical assistance in editing and final preparation of the technical reports of this study.

William L. Crawford
Study Supervisor

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NUMERICAL GROUND IMAGE SYSTEM

I. Introduction

Numerical ground image (NGI) systems are computer programs which approximate the terrain surface with a numerical surface. These systems offer advantages in storing and retrieving terrain data for many applications of route location and design. When conventional survey methods are used, new cross-sections must be taken each time there is a shift in the horizontal alignment. This is not necessary with an NGI system because the terrain surface is not referenced to any specific alignment. Therefore, NGI allows the designer to modify alignments, explore alternate routes or locations and design interchange areas. All of this offers the designer a tool that enables him to evaluate more alternatives and to be more thorough in the evaluation and planning of safe, fast, efficient transportation.

The overall objective of this study was the implementation of a flexible numerical ground image system which would augment and interface with the Roadway Design System (RDS). The latter system was developed in a previous research effort by the Texas Highway Department in cooperation with the Federal Highway Administration. The implementation was to be approached by first evaluating several available NGI systems and then implementing the most feasible one. The interim report (THD-1-19-71-186-1) for this research project gave the conclusions reached after studying two commercially available systems, one system developed under an earlier Texas Highway Department sponsored HPR project and a new simplified system which was conceived by Mr. Larry G. Walker of this Department and was developed by the study staff during the course of the study. It was concluded from the study that the simplified system which is referred to as the scan profile system would be the most feasible to implement since it is a combination data acquisition scheme and simplified approach to storage and retrieval of the terrain data required by RDS. It is particularly adaptable to conventional photogrammetric data acquisition methods which require some changes in the stereoplotter operator's procedures and degree of expertise.

The specific objectives of this research study were as follows:

1. Study the NGI System produced under Research Project No. 120.
2. Study the available commercial offerings.
3. Prepare an interim report recommending the implementation of either the previously developed NGI system or one of the commercially available systems.
4. Adapt and install the selected system.
5. Develop and demonstrate program modules which will create terrain cross-sections from the numerical ground model along alignments stored in the Roadway Design System.

The first three objectives were covered in the Interim Report (186-1) and the last two are covered in this report which also serves as a user manual for the scan profile NGI system and acquisition of cross-sections using RDS.

This report provides instructions on the acquisition of NGI scan profile data and explains the building of the NGI terrain model. Instructions are also provided for requesting roadway cross-sections through the use of RDS from the NGI terrain model. Portions of RDS must be used in connection with these cross-section requests and all of the capabilities of RDS may be used in any program execution. For these reasons it is necessary that the reader be familiar with RDS as described in FHWA Report No. 72D-104R-2, Roadway Design System, Volume II, User Manual (Revised March, 1974). Since most NGI data acquisition will be by photogrammetric methods, knowledge of photogrammetric techniques and terms is assumed.

An example problem is given in Appendix A to illustrate the use of the NGI/RDS acquisition of cross-sections. Detailed explanations of the algorithms used are in Appendix B and program documentation is in Appendix C. Appendix D contains a Glossary.

II. Scan Profile NGI System For Terrain Definition and Roadway Cross-Sections

Introduction

The scan profile NGI system produces a numerical representation of the terrain surface. The terrain data for this system is taken in the form of parallel scan profiles. These can be taken by either conventional or photogrammetric methods. The profiles may be irregularly spaced and points along the profiles may be irregularly spaced. The roughness of the terrain determines the density and distribution of data points. By the use of an algorithm the program connects points on adjacent profiles to produce a series of three or four-sided facets which cover the entire surface area between the profiles. (Four-sided facets may represent a curved surface while three-sided facets represent a flat surface.) The faceted surface model in effect makes up a quasiorthogonal grid which varies in size locally to fit the terrain data and it contains all the data points which were taken. For this reason varying degrees of accuracy are obtained by taking more or less data. The faceted model produces cross-sections for use in RDS or similar systems. It has been demonstrated to produce reasonable contours in a direct manner and the approach used is compatible to the data acquisition for orthophoto mapping.

Theory of the NGI System

The scan profiles are analogous to a set of cross-sections along a straight baseline as illustrated in Figure 1, but the data includes a very significant set of additional information which identifies significant slope discontinuity boundaries. A close observation of the complete set of profiles in Figure 1 reveals to the trained observer an obvious V-bottom ditch which enters on the left side and proceeds diagonally across the surface area shown. The mental

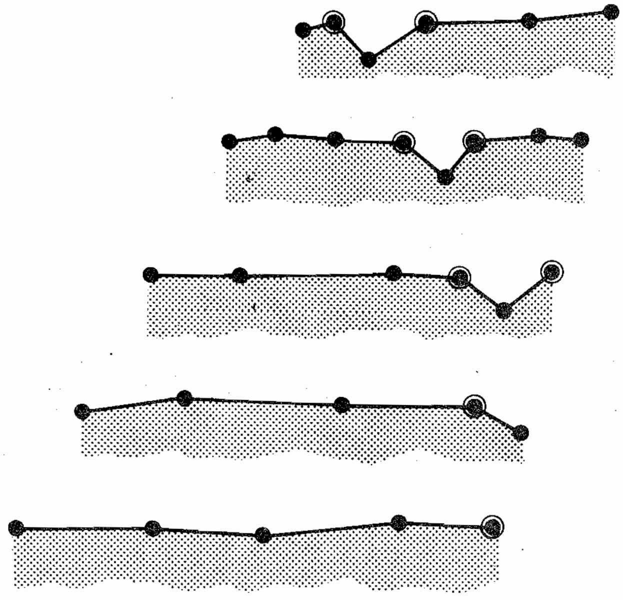


Figure 1. Scan Profiles with Discontinuity Points Noted

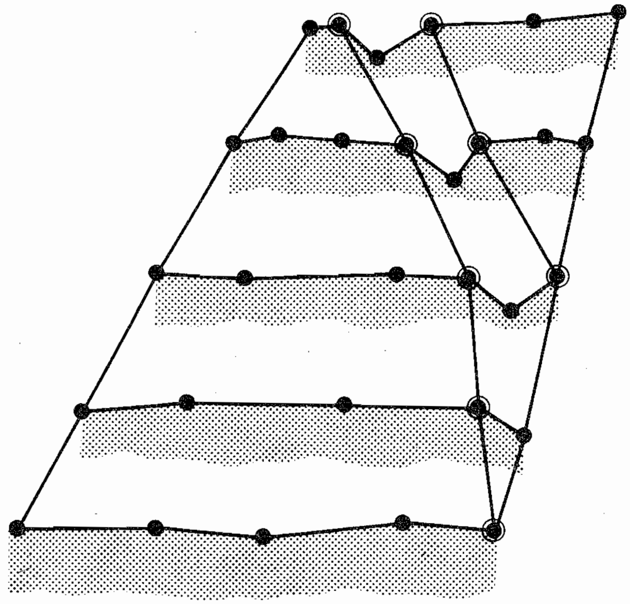


Figure 2. Scan Profiles with Discontinuity Points Connected

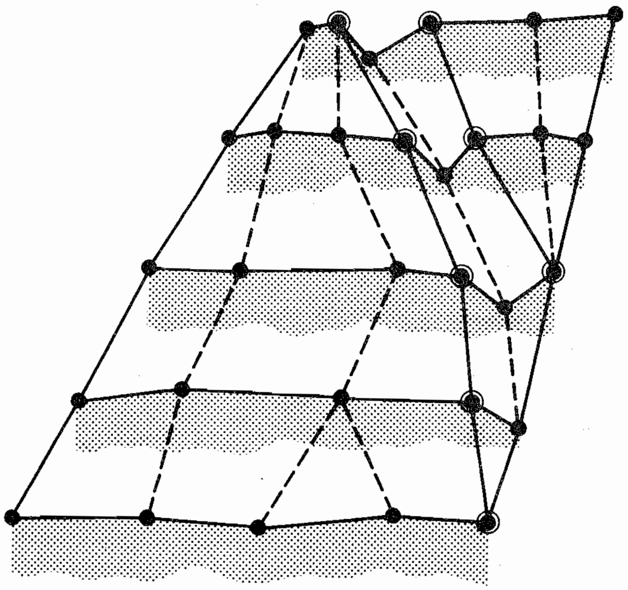


Figure 3. Scan Profiles with All Points Connected

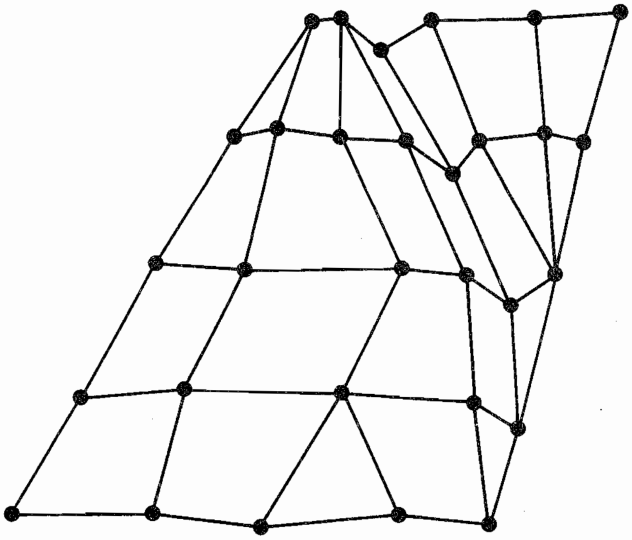
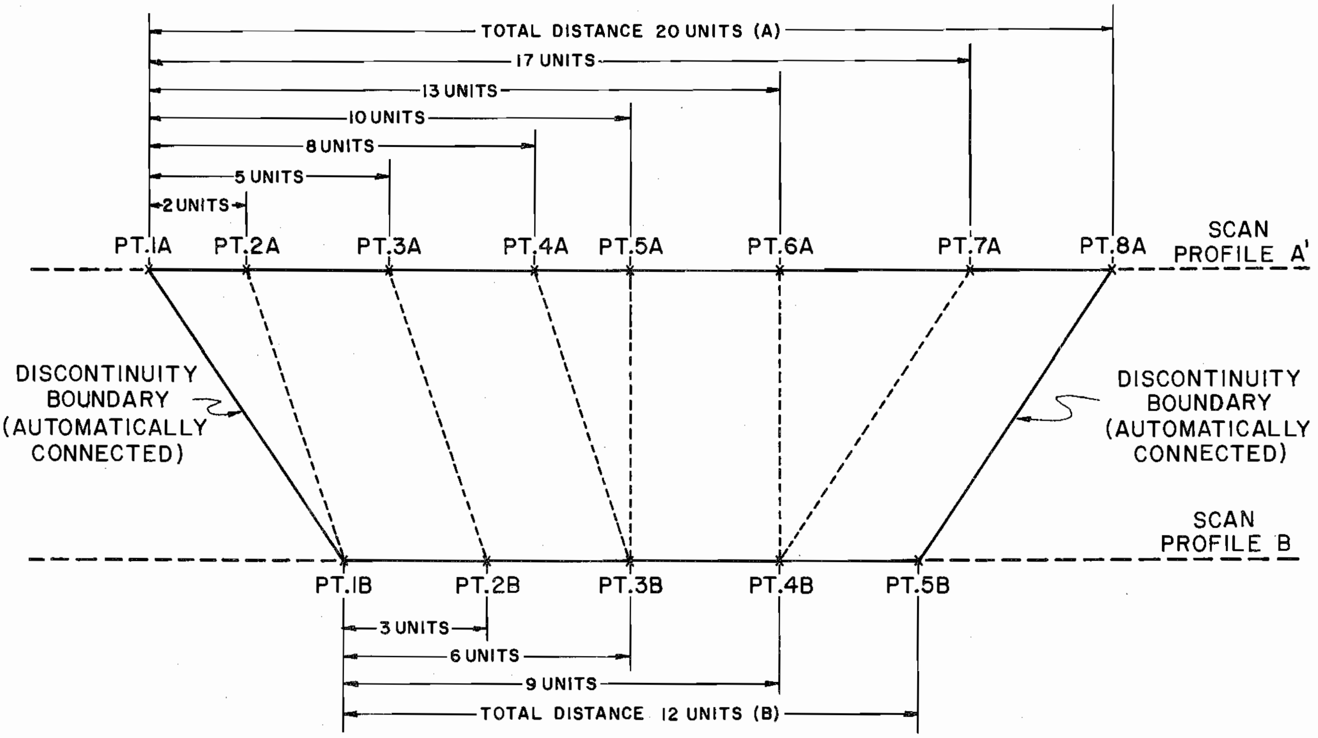


Figure 4. Faceted Surface Model

process used in arriving at this conclusion seems simple but actually it involved a complex intuitive thought process. To reach the same conclusion by computer logic from the raw data would be almost prohibitive. For this reason the scan profile approach depends upon the stereoplotter operator to identify significant slope discontinuity boundaries. (These are identified by special coding when the profiles are taken.)

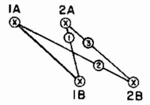
In taking the profile points, the operator selects the outside edges of the profiles which are automatic discontinuity boundaries and any points that represent significant changes in elevation. The operator then must identify the other significant boundaries (discontinuities) which, in the example in Figure 1, were the two edges of the V-bottom ditch. All discontinuities do not need to be identified (such as a V-bottom ditch if it ran perpendicular to the scan profiles), but the ones that are identified divide the surface into discrete areas as shown in Figure 2. Within each discrete area the system uses an algorithm to connect up the points to achieve a transition from profile to profile as illustrated in Figure 3. The scan profile algorithm connects points on adjacent profiles on the basis of their relative position between their common discontinuity boundary. It follows that the operator needs only to establish enough discontinuity boundaries so that the algorithm point connect process from profile to profile in any given area will adequately determine the model. When digitizing data from a photogrammetric stereo model, the desired discontinuity boundaries are sketched on the manuscript and then the discontinuity points are recorded as specially coded (multiple entry) data points on the scan profile. This assures that the faceted model as shown in Figure 4 will always reflect the slope discontinuities which have been identified.

The algorithm used to connect the points in each discrete area between two adjacent scan profiles starts with the leftmost discrete area and proceeds to the right. Figure 5 explains mathematically how the algorithm connects the points.



In the drawing above, points 1A and 1B are automatically connected (discontinuity boundary). The point connection process then considers the following cases for connecting the next points on each scan profile.

Case 1. Point 2A connects with point 1B,
Case 2. Point 2B connects with point 1A,
Case 3. Point 2A connects with point 2B.



The connection process the program uses is based on the average of the fractional distances of adjacent points. The fractional distances for each point are computed by the equation:

$$\text{Fraction Point} = \frac{\text{Distance from beginning boundary to given point}}{\text{Total distance between boundaries}}$$

Therefore, for the example shown above:

Fraction point 1A = 0/20 = 0
Fraction point 2A = 2/20 = .1
Fraction point 1B = 0/12 = 0
Fraction point 2B = 3/12 = .25

Now the algorithm uses these fractions to check:

+If the fraction for point 2A < average of fractions for points 1B and 2B, then it connects point 2A with point 1B and continues.

+If the fraction for point 2B < average of fractions for points 1A and 2A, then it connects point 2B with point 1A and continues.

+If neither of the two conditions above exists, it connects point 2A with 2B and continues.

When the proper connection has been established, the process is repeated using unconnected points to the right. In the previous example, point 3A and point 2B would be checked and since their fractions are equal, they are automatically connected. Similarly, point 5A would be connected to point 3B, etc.

Figure 5. Point Connect Process

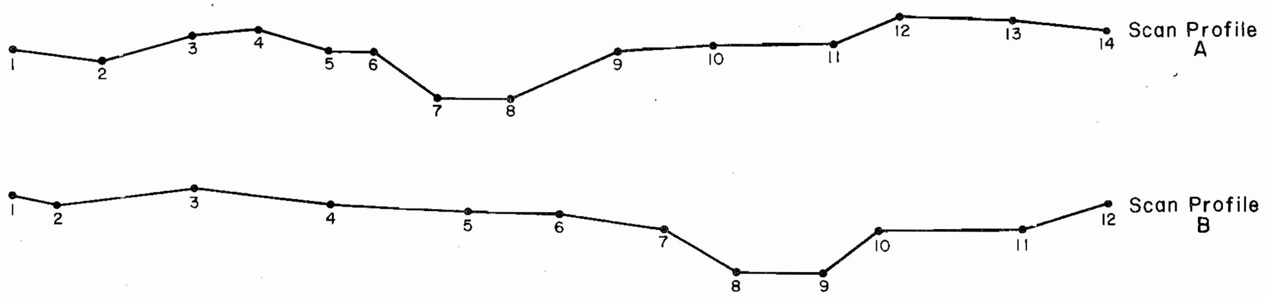
Discrete areas must be bounded by two discontinuity lines. Each line is defined by two discontinuity points - one on each scan profile. If there are no internal discontinuities, the left and right scan profile boundaries form the discrete area bounded by two discontinuity lines. If there are internal discontinuities, there must be the same number of internal discontinuity points coded on any pair of adjacent scan profiles. Therefore, in cases where two internal discontinuity lines begin or end at the same point on a scan profile, two identically specially coded readings one foot apart must be taken so that there will be the same number of internal discontinuity points between adjacent scan profiles. The algorithm connects discontinuity points from left to right. If there is an extra discontinuity point on one of the scan profiles, the rightmost extra internal discontinuity point will be ignored. On the scan profiles where internal discontinuities begin or end, additional special coding is needed to indicate that the discontinuity point(s) applies in only one direction (ahead or back).

The selection of internal discontinuities requires skill and practice. Figure 6 shows two examples of the point connect process on two adjacent scan profiles. The two examples use the same two scan profiles. One example indicates internal discontinuity boundaries and the other does not. The resulting roadway cross-sections show the importance of indicating discontinuities.

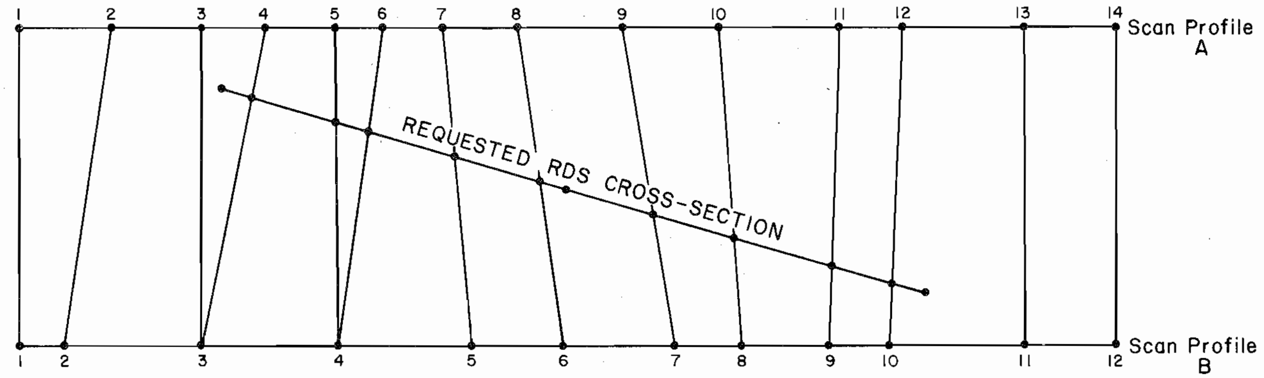
Scan Profile Requirements

The width of ground coverage available when photogrammetric processes are used to obtain the scan profiles is limited to the width of the flight strip. The program can utilize as many as 47 flight strips or tangents.

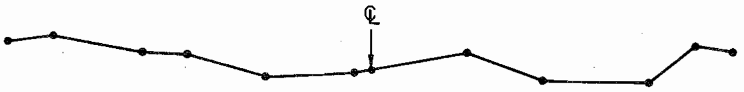
The profiles are taken in a coordinate system where the profile lines have a relatively constant flight strip width (Y value). The coordinate system may be along or parallel to a flight line or parallel to a given surface coordinate system. The arbitrarily chosen coordinate system must be referenced to the coordinate system being used by RDS.



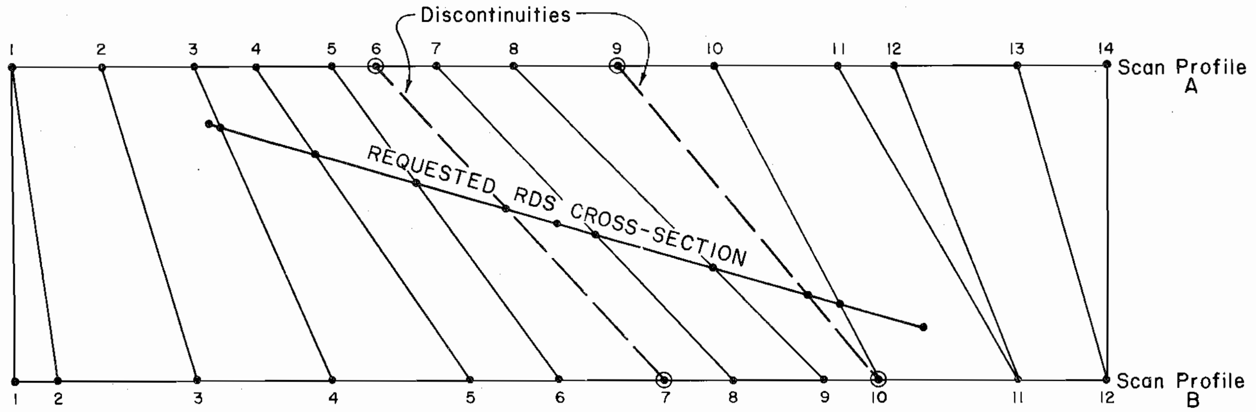
Cross-Section view of two adjacent Scan-Profiles, A and B. The numbered points indicate readings taken.



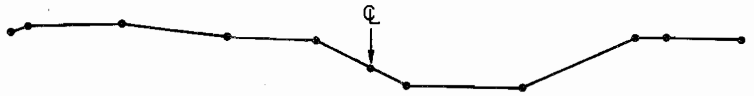
Points connected when Discontinuities were not noted.



RDS Cross-Section from Scan Profiles A and B where Discontinuities were not noted.



Points connected when Discontinuities were noted.



RDS Cross-Section from Scan Profiles A and B where Discontinuities were noted.

Figure 6. Cross-Section Built From Scan Profiles With and Without Discontinuities

The baseline used for the scan profiles must be a straight line; therefore, a logical series of lines to select for the baseline would be the flight tangents for the photogrammetric survey. The tangents selected should overlap in such a way that when an RDS baseline alignment is developed, each roadway cross-section can be completely generated with data from a single flight strip. Figure 7 shows flight strips that do not overlap sufficiently. The dashed boundaries on the flight strips would have given the necessary overlap to develop all RDS cross-sections. Since the location of the RDS baseline is not necessarily known when the NGI baseline is selected, adequate strip width and overlap are essential to guarantee a complete terrain file for any roadway alignment location.

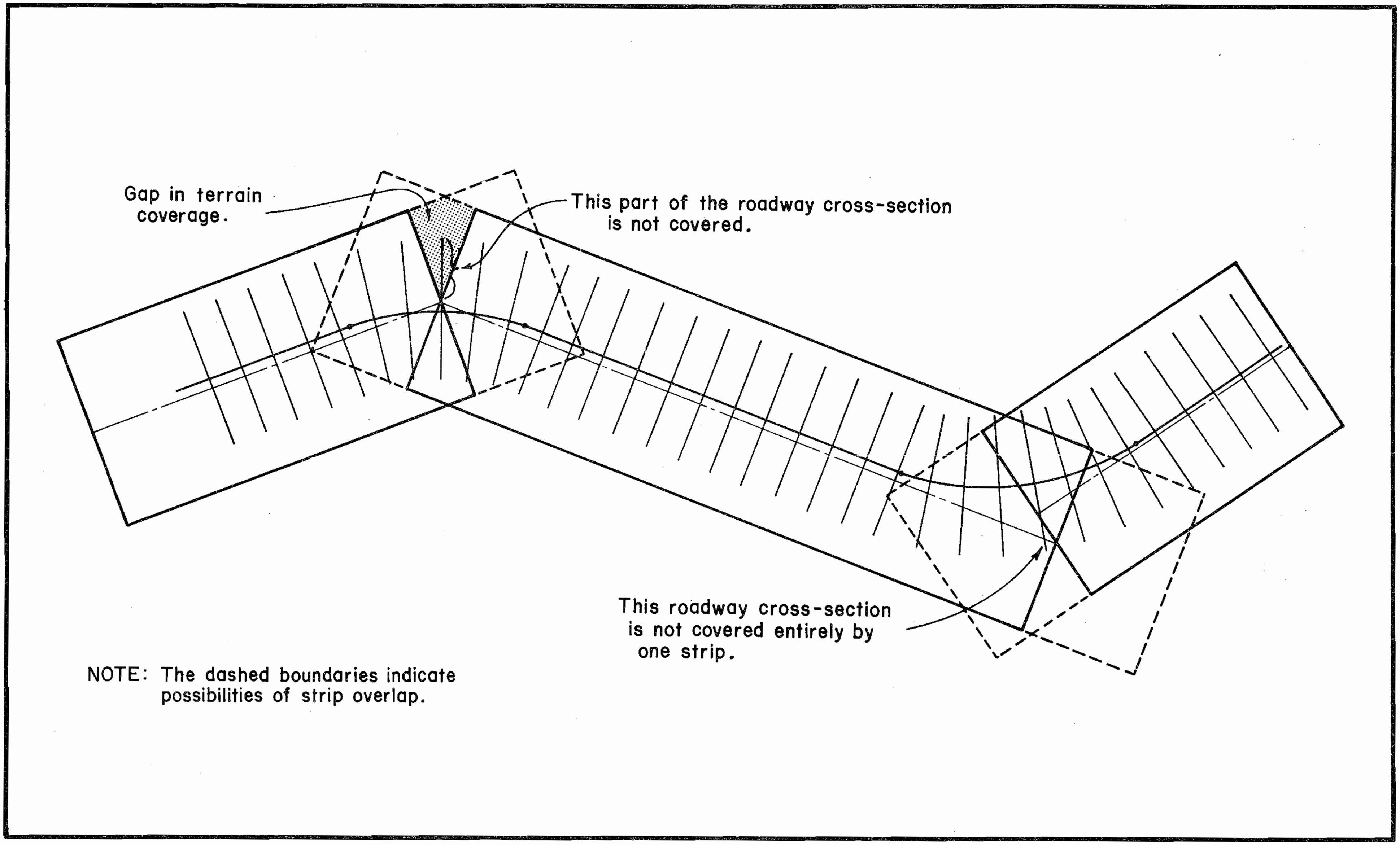
Program Procedure for Building Cross-Sections

The X,Y,Z coordinates and point connecting codes produced by NGI are stored on a tape or disk file. This file is referred to as the NGI data file and can be accessed to develop roadway cross-sections using the Roadway Design System.

The Roadway Design System stores PI coordinates for the baseline alignment (G). This alignment must be stored in the same surface coordinate system as the beginning and ending real coordinates of the NGI flight strips. Cross-sections are developed along alignment G. Alternate sets of cross-sections may be developed by defining a new alignment G on any number of separate runs.

In order for RDS to develop roadway cross-sections, the coordinates of the left limit, centerline point and the right limit for each cross-section station requested along alignment G must be computed by RDS. Each cross-section is then developed in the following manner:

1. The NGI data file is searched to find the flight strip which contains the surface coordinates of the three points defining the roadway cross-section station.



Gap in terrain coverage.

This part of the roadway cross-section is not covered.

This roadway cross-section is not covered entirely by one strip.

NOTE: The dashed boundaries indicate possibilities of strip overlap.

Figure 7. Flight Strip Overlap For Obtaining Roadway Design System Cross-Sections

2. The three points are converted to the flight strip coordinates.
3. The X-coordinates of the left and right limits are used to determine which scan profiles are needed to develop the roadway cross-section.
4. The roadway cross-section points are computed by interpolating elevations (Z-coordinates) for three given points, and then interpolating the X, Y, Z coordinates for each intersection point of the transverse line defining the roadway cross-section and the lines connecting the scan profile points.
5. The roadway cross-section points as indicated in Item 4 are converted to RDS terrain cross-section data points (station, offset, and elevation). They are stored on the RDS station file and made available for use in all RDS processes requiring cross-sections.

A technical description of this process is given in Appendix B. A schematic of the RDS/NGI interface is shown in Figure 8.

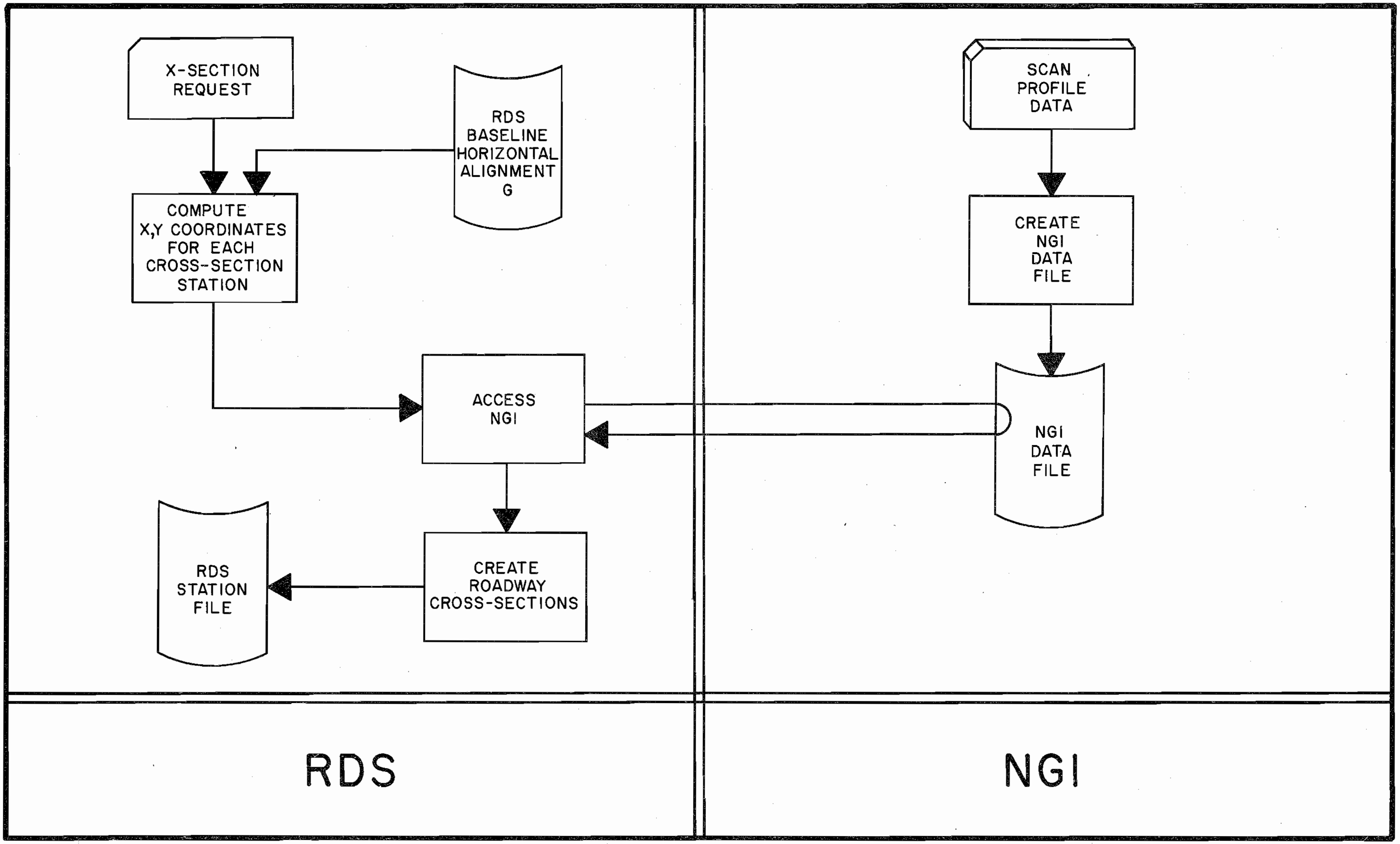


Figure 8. Schematic of RDS/NGI Interface

III. Building The NGI Data File

Introduction

Chapter II described the scan profile NGI system for terrain definition: how it works, the requirements for taking scan profiles, and the program procedure for building roadway cross-sections. This chapter will explain the procedures used to build the NGI data file. The reader should understand the theory given in Chapter II before attempting to use the system.

Taking the Scan Profile Data

The scan profiles taken by the stereoplotter operator are essentially the same as cross-sections taken along any baseline. The operator sketches in the discontinuities on the manuscript and then decides where along the flight strip baseline he should take scan profiles in order to adequately describe the ground surface. As in cross-section data acquisition, it is up to trained observers to know when to record profiles and where plus stations are needed. In most cases, discontinuity boundaries should determine the necessity for plus stations.

Points on scan profiles that indicate changes in elevation and right and left outside boundaries are identified by one shot (one set of Y, Z coordinate readings). Internal discontinuity points are indicated by double, triple, and quadruple entries (multiple shots) of identical data (the same Y, Z coordinates). The formula for indicating the type of internal discontinuity points is as follows:

1. Two identical readings (double shot on one scan profile with the same offset distance and elevation) mean that scan profile point is connected to a multiple shot <u>at both the scan profile ahead and back</u>.

2. Three identical readings (triple shot on one scan profile with the same offset distance and elevation) indicate the beginning of an internal discontinuity. This discontinuity point connects to a multiple shot <u>at the ahead scan profile only</u> and to a single shot at the back scan profile.
3. Four identical readings (quadruple shot on one scan profile with the same offset distance and elevation) indicate the end of an internal discontinuity. This discontinuity point connects to a multiple shot <u>at the back scan profile only</u> and to a single shot at the ahead scan profile.

If two discontinuity lines begin or end at the same point on a single scan profile, then two sets of identical multiple shots must be taken one foot apart. This scheme identifies two distinct discontinuity boundaries which are required to define the terrain accurately. Figure 9 shows an example of two discontinuity boundaries which merge at the same point. Any significant elevation changes between internal discontinuity boundaries are indicated by a single Y, Z coordinate reading or shot.

It should be noted that the right and left outside points on the profiles must not be multiple entires since these are automatic discontinuity boundaries. If a ridge line enters or leaves the scan profile coverage area at the far limit of a scan profile, then the limit should be moved out one foot so that the multiple shot will be inside the scan profile limits. Figure 10 shows an example of multiple shot use. It shows that there cannot always be constant left and right limits for acquisition of data. It will be necessary to widen particular scan profiles in order to include an accurate discontinuity boundary in the case of a skewed ridge line. In Figure 10 this was done as indicated at 1 and 2, and an extra reading was then taken to determine the outside boundary.

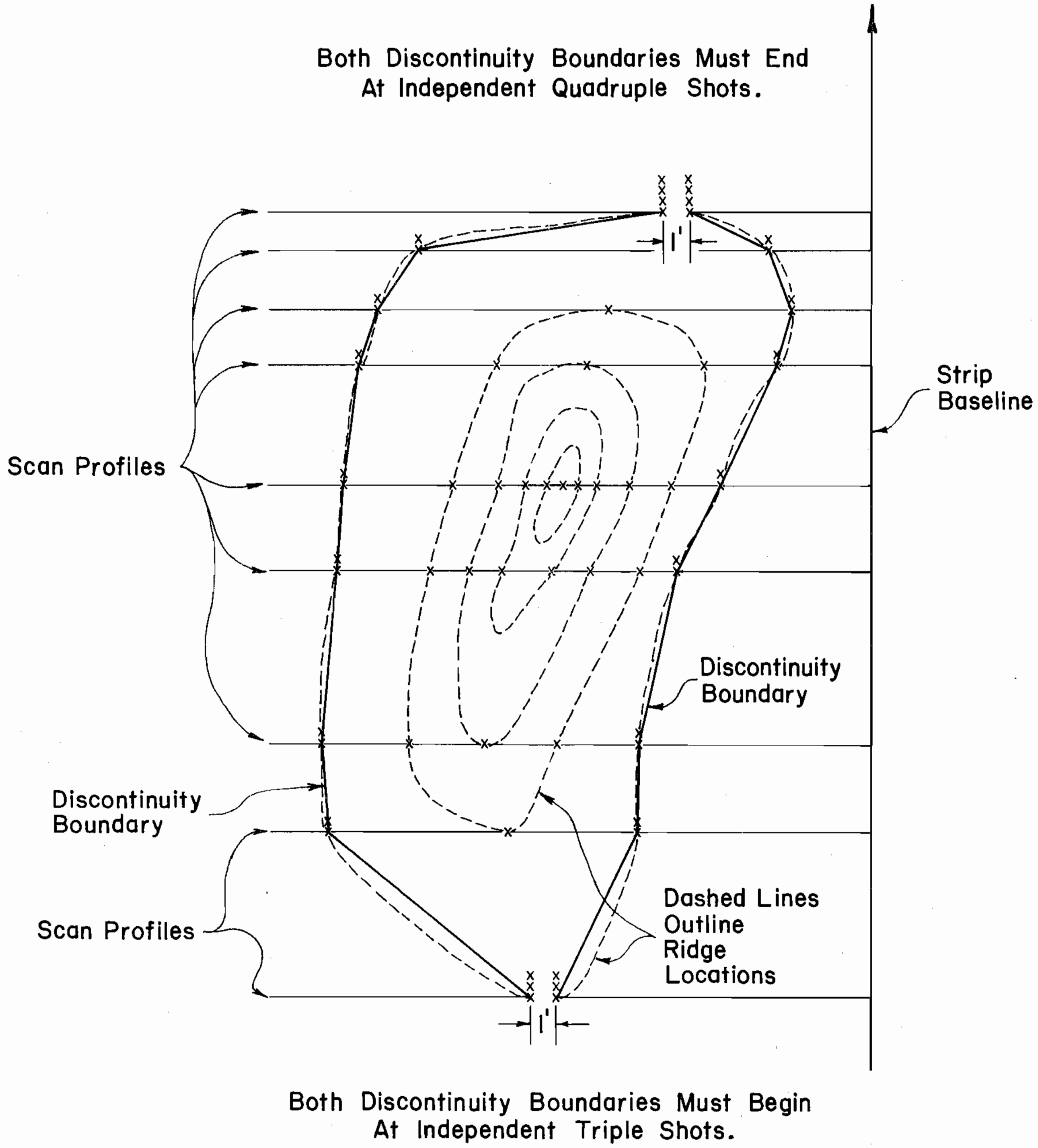


Figure 9. Two Discontinuity Boundaries Merging at One Point

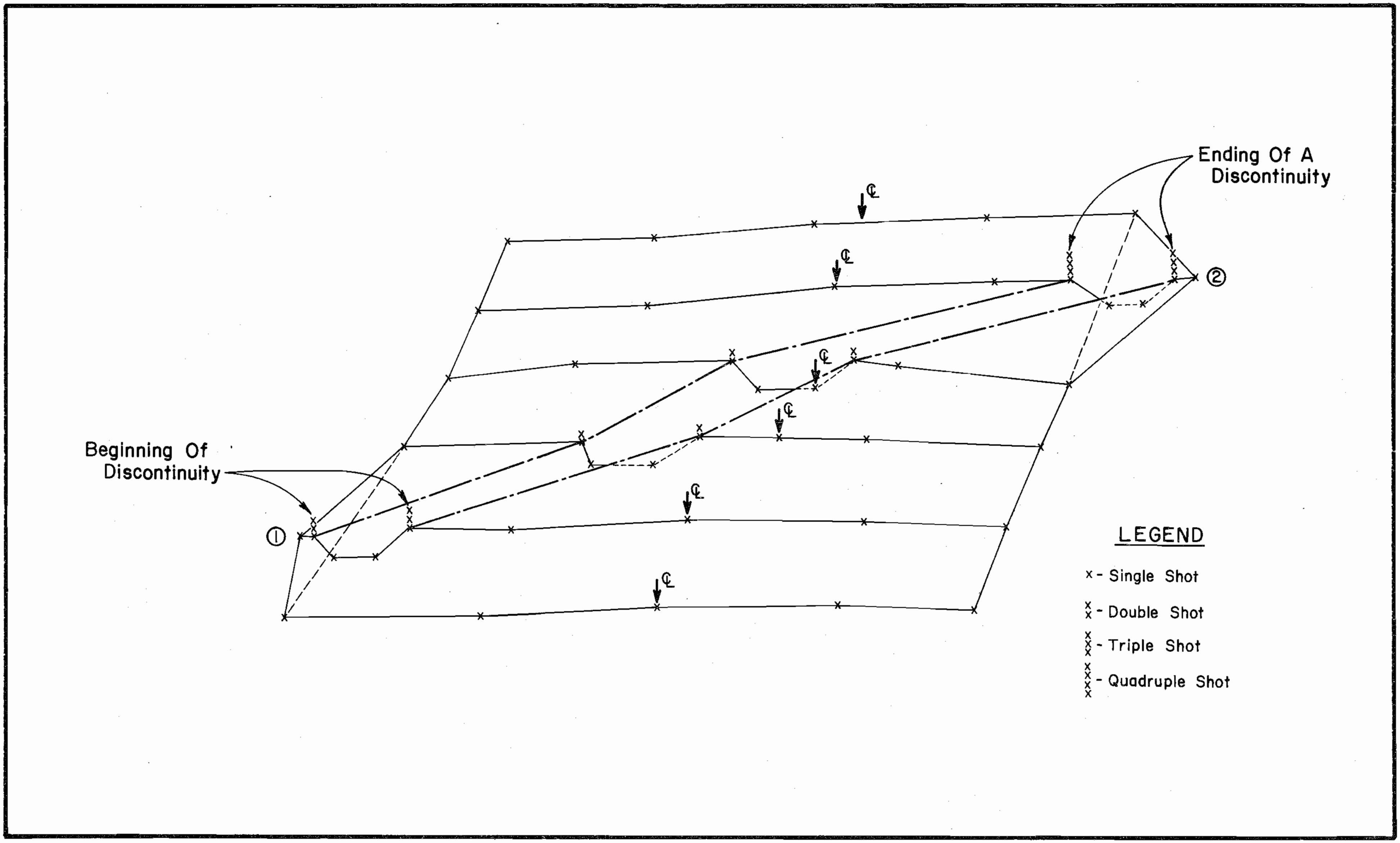


Figure 10. Extending the Scan Profile Limits for Discontinuities

The scan profile readings are taken in even feet and the elevation is read to the nearest tenth of a foot. The maximum distance left and right from the scan profile reference line is determined by the width of the flight strip but it cannot exceed 9999 feet to the left and 9999 feet to the right.

The punched card format is the Texas Highway Department RDS terrain format (card type THD) as discussed in the "Roadway Design System User Manual". These cards can be run as RDS cross-sections, and profile plots may be obtained; however, the designer will probably need planimetric and/or topographic maps before he can select his roadway cross-section baseline(s).

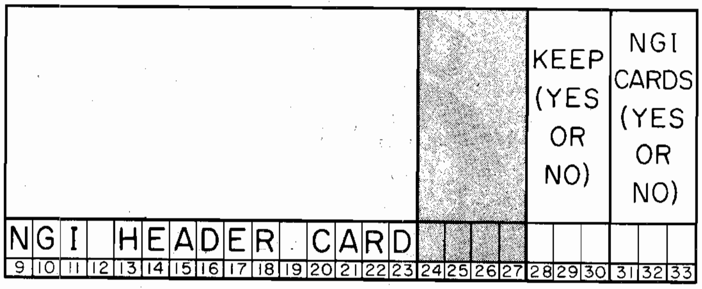
Creating the NGI Data File

After the stereoplotter operator has recorded all the scan profile points, they are processed with the NGI program which develops the terrain model. The input for this program includes the following:

1. One NGI Header card
2. One NGI Strip Header card for each flight strip
3. Scan profile data cards.

Data for Items 1 and 2 above are entered on Form 1381 which is shown in Figure 11. Data entry for each of the above items will be discussed separately.

NGI Header Card. The NGI Header card must be the initial card in the data deck assembly and there can only be one per run. The function of this card is to indicate whether or not the NGI data file is to be stored on a project tape.



KEEP (YES OR NO)

NGI CARDS (YES OR NO)

NGI HEADER CARD

9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

CONTROL & SECTION

							R
1	2	3	4	5	6	7	8

DISTRICT________ RES. NO.________
I.P.E.________ PROJ.________
CO.________ HWY.________

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
NGI HEADER INPUT FORM

SHEET________ OF________
DATE________
PREPARED BY________

																			KEEP (YES OR NO)			NGI CARDS (YES OR NO)		
N	G	I		H	E	A	D	E	R		C	A	R	D										
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33

THE NGI HEADER CARD MUST BE THE FIRST CARD IN THE DECK STRUCTURE. THERE SHOULD ONLY BE ONE NGI HEADER CARD IN THE DECK AND IT MUST BE DIRECTLY FOLLOWED BY AN NGI STRIP HEADER CARD.

NGI STRIP HEADER INPUT FORM

					BEGINNING X - COORDINATE															BEGINNING Y - COORDINATE															ENDING X - COORDINATE															ENDING Y - COORDINATE														
N	G	I																																																														
9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73

ONE NGI STRIP HEADER CARD MUST PRECEDE THE SCAN PROFILE DATA FOR EACH STRIP.

Figure 11. NGI Header Card Input Form and NGI Strip Header Input Form

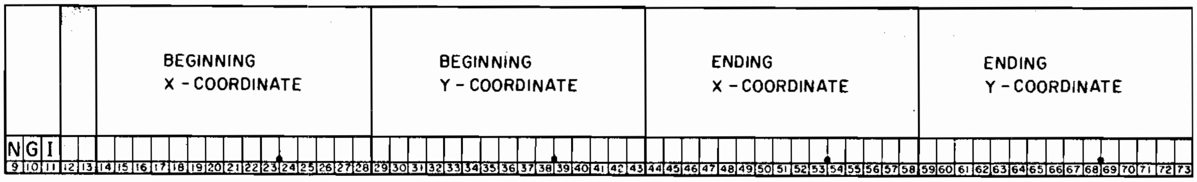
Form 1381

If "YES" is entered in the "KEEP" columns (28 through 30), the NGI data file will be stored on a specified project tape. If "NO" is entered, the file is not written on tape. "NO" would only be entered if an RDS job step accessed the NGI data file directly after the NGI job step in the data deck structure.

If "YES" is entered in columns 28 through 30, the input data will also be written on tape on a separate data set from the NGI data file. This input data is in an edited format (page 21) with a positive or negative distance, elevation, and type for each scan profile point. The types indicate whether the points are normal scan profile points (1) or discontinuity points (2, 3, or 4). The outside points are always entered as type 2. This edited input data may be punched out and used on subsequent runs by entering a "YES" in columns 31 through 33. Corrections to the input are made using this card format by deleting existing points or by changing the type of point.

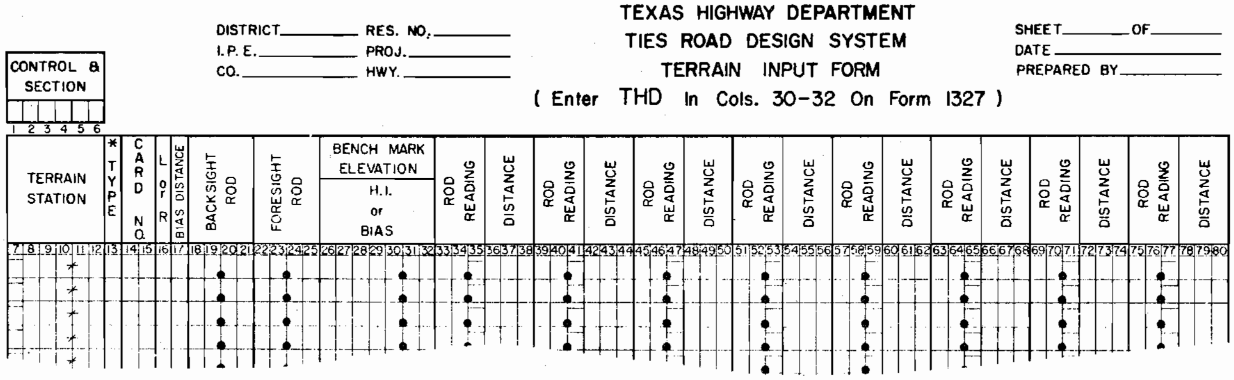
<u>NGI Strip Header Card</u>. The NGI Header card must be followed by an NGI Strip Header card for the first flight strip. (Each subsequent flight strip must have an NGI Strip Header card also.) The program can process a maximum of 47 flight strips. The NGI Strip Header card supplies the beginning and ending surface coordinates for the flight strip baseline of the scan profile data that follows. These surface coordinates must be in the same coordinate system that the RDS baseline alignment will be in.

NGI STRIP HEADER INPUT FORM



ONE NGI STRIP HEADER CARD MUST PRECEDE THE SCAN PROFILE DATA FOR EACH STRIP.

Scan Profile Data. The NGI scan profile data cards for a specific flight strip are placed in the deck structure directly following their NGI Strip Header card. These data cards must be entered in scan profile baseline station order. As in all cross-section data, NGI scan profiles are recorded as elevations and distances to the left and/or right of the baseline along perpendiculars to a given station. Data should reflect breaks in the terrain and should not necessarily represent a grid system. Data is entered in the Texas Highway Department's RDS terrain format or in the alternate card format (NGI cards) as shown below.

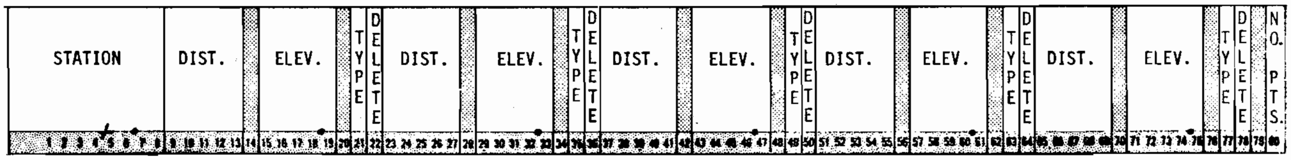


TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
TERRAIN INPUT FORM
(Enter THD In Cols. 30-32 On Form 1327)

DISTRICT________ RES. NO.________
I. P. E.________ PROJ.________
CO.________ HWY.________

SHEET________OF________
DATE________
PREPARED BY________

The card format shown above is discussed in Chapter 6 of the "RDS User Manual".



The NGI card format shown above allows a maximum of five elevations and distances to be entered per card. Data must be entered in successive columns in left to right order of the distances. There are columns for type of point and point deletion for each scan profile. Each point must have a type entered. The point will be ignored if an "X" is entered in its Delete column. Column 80 indicates the number of sets of points entered on each card.

NGI Data Deck Assembly. The data deck assembly for building an NGI data file is shown in Figure 12.

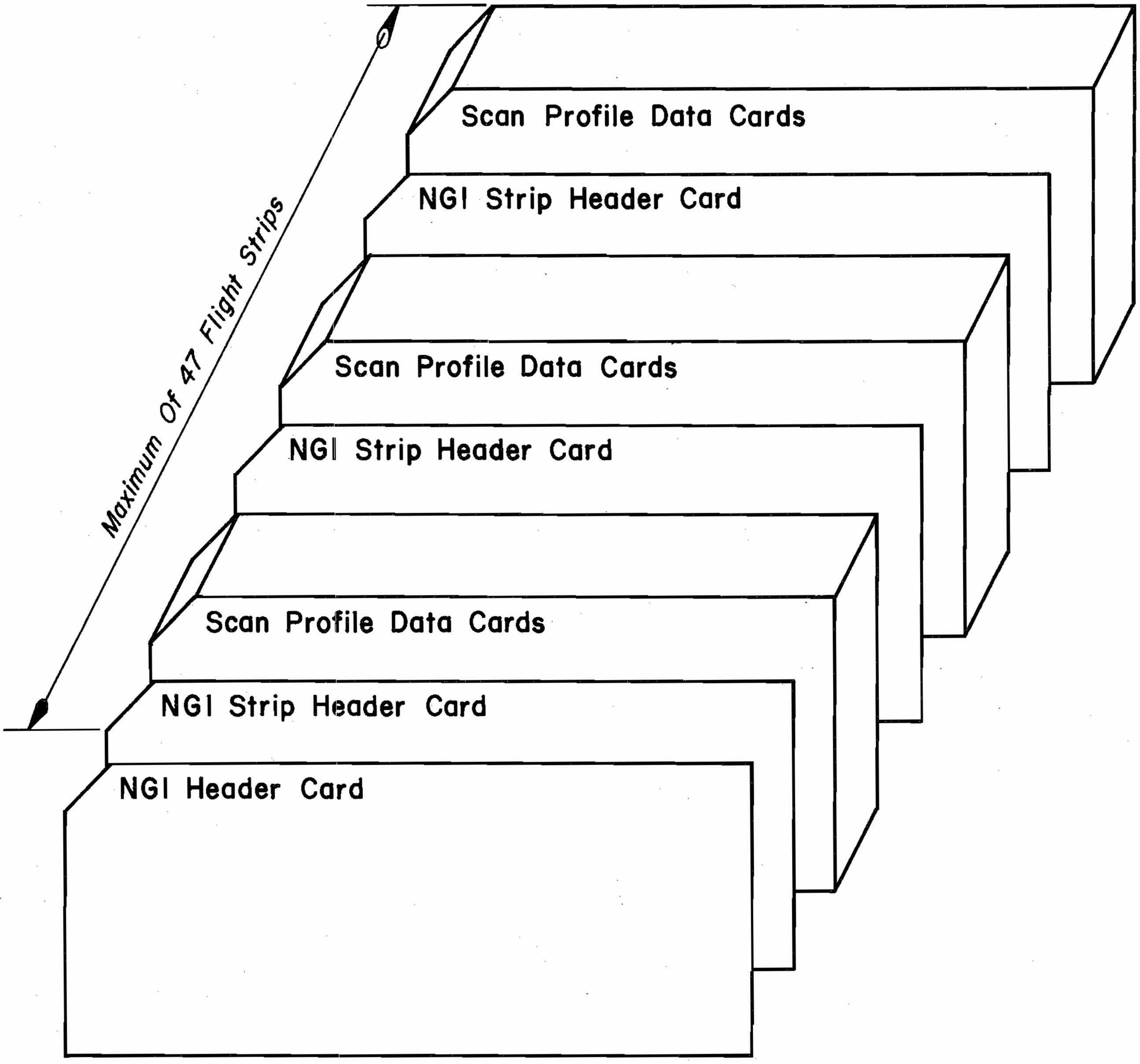


Figure 12. NGI Data Deck Assembly

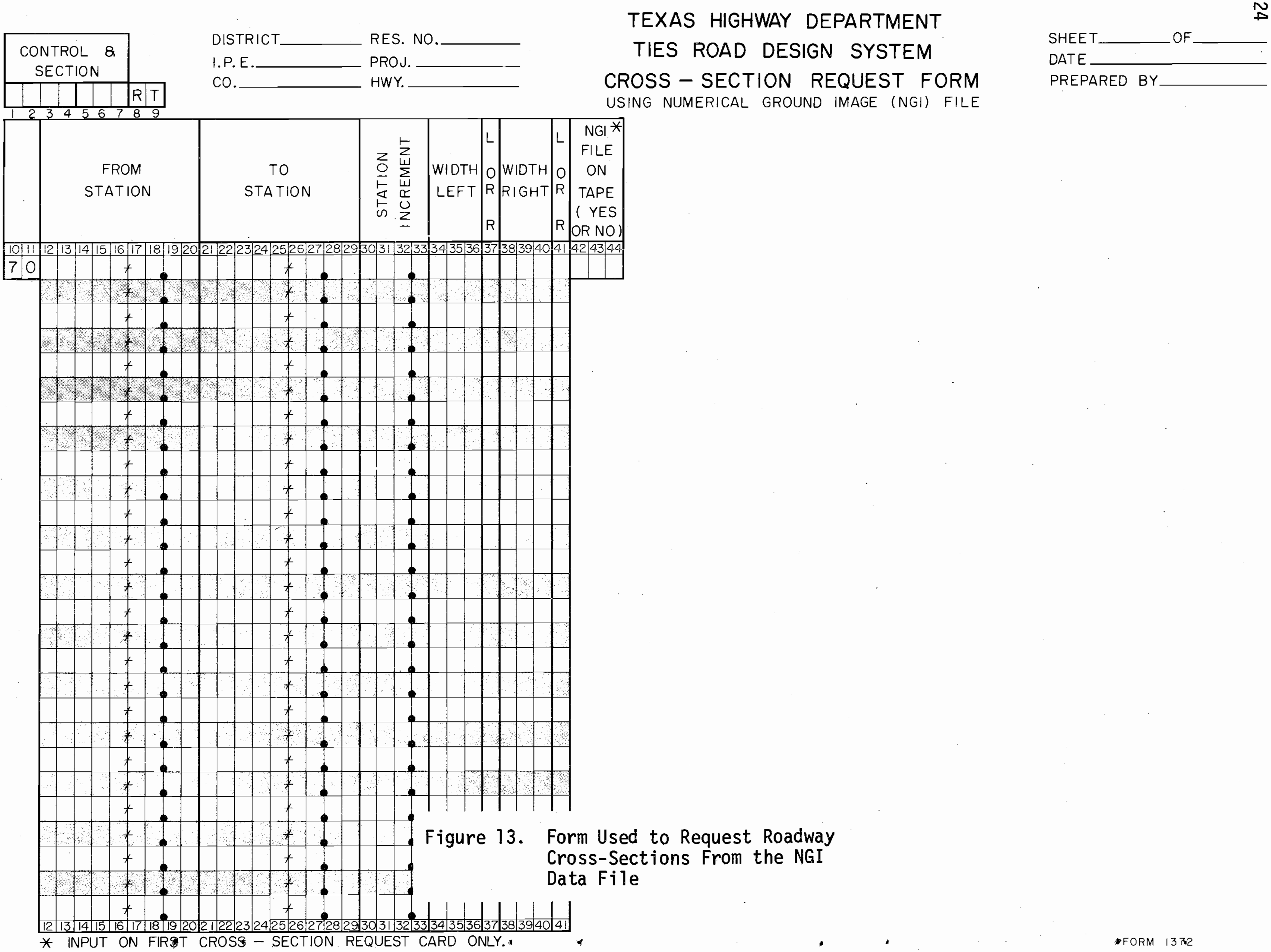
IV. Requesting Roadway Cross-Sections

The NGI data file which has been built can be used to generate cross-sections along any specified RDS baseline alignment (alignment G) which has been previously stored or defined. The cross-section station limits, station increments, and left and right offset limits must be specified. This request is made on the RDS Cross-Section Request Form (Form 1372) which is shown in Figure 13. An example input is shown below:

	FROM STATION	TO STATION	STATION INCREMENT	WIDTH LEFT	L OR R	WIDTH RIGHT	L OR R	NGI* FILE ON TAPE (YES OR NO)
10 11	12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29	30 31 32 33	34 35 36	37	38 39 40	41	42 43 44
7 0	100+00.	150+00.	50.	200	L	200	R	YES
	150+30.	150+30.	.	200	L	200	R	
	150+50.	201+00.	50.	150	L	175	R	
	201+13.	201+13.	.	150	L	175	R	
	+ .	+ .	.					
	+ .	+ .	.					
	+ .	+ .	.					
	+ .	+ .	.					
	+ .	+ .	.					
	+ .	+ .	.					

The first line of the form has a field (columns 42 through 44) to indicate whether the NGI data file is on tape or not. If this column is marked "NO", the RDS job must be preceded by an NGI run which creates the NGI data file. This field should only be used on the <u>first card</u>.

The above input requests roadway cross-sections to be built from station 100+00 to 150+30 at increments of 50 feet and with left and right limits of 200 feet from the RDS baseline G alignment. From 150+50 to 201+13, the left limit is 150 feet and the right limit is 175 feet. Two single plus stations (150+30



CONTROL & SECTION

							R	T
1	2	3	4	5	6	7	8	9

DISTRICT________ RES. NO.________

I.P.E.________ PROJ.________

CO.________ HWY.________

TEXAS HIGHWAY DEPARTMENT

TIES ROAD DESIGN SYSTEM

CROSS – SECTION REQUEST FORM

USING NUMERICAL GROUND IMAGE (NGI) FILE

SHEET________ OF________

DATE________

PREPARED BY________

	FROM STATION	TO STATION	STATION INCREMENT	WIDTH LEFT	L OR R	WIDTH RIGHT	L OR R	NGI FILE ON TAPE (YES OR NO) *
10 11	12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29	30 31 32 33	34 35 36	37	38 39 40	41	42 43 44
7 0								

Figure 13. Form Used to Request Roadway Cross-Sections From the NGI Data File

* INPUT ON FIRST CROSS – SECTION REQUEST CARD ONLY.

FORM 1372

and 201+13 are requested by giving the same station number for the From Station and To Station leaving the Station Increment blank, and entering the Left and Right Widths.

If more than one line of input is entered on this form, the cards must be in ascending station order. Different sets of cross-sections may need to be built along other baselines as in the case of an interchange. This will require as many cross-section request runs as the number of baselines since cross-sections can only be requested along RDS baseline alignment G. Each run would access the NGI data file with a different alignment G and different Cross-Section Request data. The different sets of cross-sections can then be either stored on tape or punched on cards to be used in the various RDS processes.

RDS Data Deck Assembly

A data deck assembly for requesting cross-sections is shown in Figure 14.

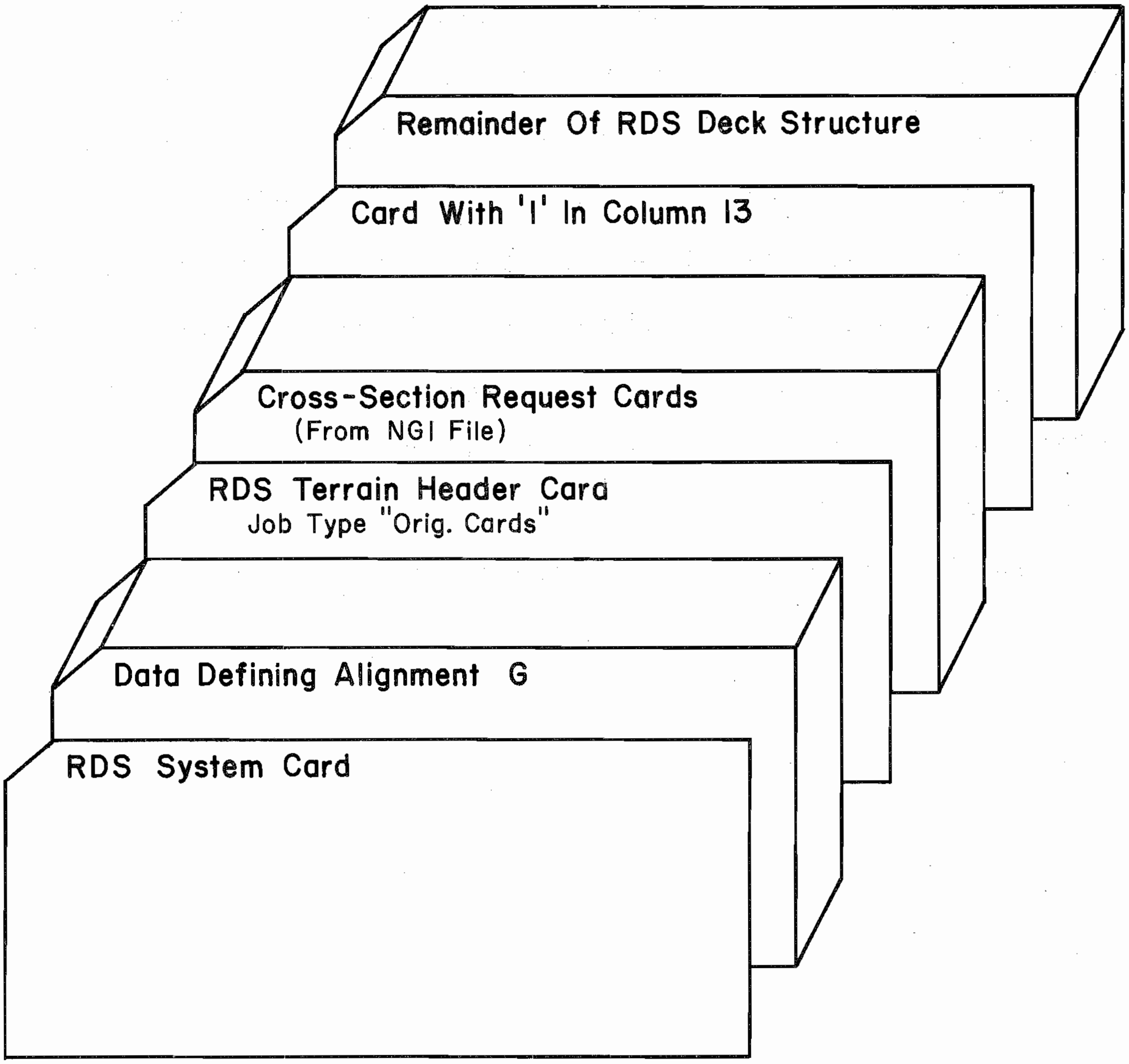


Figure 14. Data Deck Assembly for Building Cross-Sections Using the NGI Data File

V. Conclusions and Recommendations

The NGI/RDS interface has been shown to be a flexible tool for use in roadway design. It provides the design engineer with a means of studying designs of alternate locations without requiring cross-sectioning of each proposed alignment or re-cross-sectioning of alignments that are revised.

Projects proposed to be developed utilizing the RDS/NGI procedure need to be evaluated to determine if there is a need for the more extensive scan profiles required to define a terrain surface of sufficient size to be used for alternate alignments. Projects where deviation from the original alignment is considered remote would not normally benefit from the acquisition of NGI scan profiles and building of the NGI data file.

Proposed enhancements to the NGI/RDS process which were not developed under the current project but are recommended to be implemented on an orderly basis are as follows:

1. The system should be expanded to handle multiple adjacent flight strips so that terrain files of block areas may be defined. This ability eliminates the need of overlaping NGI scan profiles at the junction of adjacent strips of a series of strips as shown in Figure 7.
2. Photogrammetric digitizing equipment should be modified to provide an alternate means for indicating discontinuity points instead of the multiple shot indicators presently used.
3. A means of contour plotting selected areas of the NGI data file should be developed.
4. The RDS routine that builds the roadway cross-sections should be modified to provide transitioning of the cross-section limits.

5. The ability to take partial scan profiles to define areas of isolated discontinuities such as hills and holes should be provided.

The above listed recommendations could not be developed in the limited scope of implementing a numerical ground image system and are not listed in any order of priority. The need for any of the recommendations should be studied and justified on the basis of cost benefit before programming is accomplished.

Appendix A. Example Problem

EXAMPLE PROBLEM

An example of the use of NGI and RDS in preliminary route location is shown on the following pages. The data for this example is from a photogrammetric project at a 1"=400' map scale where control was already established. The terrain is very rough, and the routes selected do not depict actual roadway designs but were used only to demonstrate the NGI/RDS capabilities.

Photogrammetric cross-sections were taken to provide a comparison with RDS cross-sections that were developed from the NGI terrain model. The number of scan profile points and discontinuities taken for this problem are probably more than would be needed for preliminary route studies; however, this accuracy was needed to develop NGI/RDS cross-sections that could be compared with the photogrammetric cross-sections to test the accuracy of the NGI model.

In order to show the accuracy of the NGI terrain model, the NGI/RDS and photogrammetric cross-sections have been superimposed on the same plot. Some of the cross-sections are shown on pages A-19 and A-20. It should be noted that the plots compare very closely in most cases. The differences may be attributed to the procedure used in taking the scan profile points and photogrammetric cross-sections. NGI scan profiles are taken in the same manner as photogrammetric cross-sections. The procedure used at the Texas Highway Department for taking photogrammetric cross-sections is to draw the position of the cross-section on the manuscript. This provides for the positioning of the X, Y, Z digitizer. At a scale of 1"=400' the position of these lines cannot be drawn to exactly duplicate the mathematical position represented. However, NGI develops the terrain model using the given scan profile coordinates, and RDS mathematically computes cross-sections at precise, horizontal coordinate positions. The RDS cross-sections were compared with a set of photogrammetric cross-sections that are likely to have the same type of position error as the NGI scan profiles. Therefore, the two sets of sections are probably not in the same position; and with steep, sloping terrain, this could cause significant error.

For further comparison, an earthwork design was run against both the NGI/RDS and photogrammetric cross-sections. Examples of design volumes from these two runs are shown on pages A-22 and A-23. This example shows a 2 percent difference in volume which indicates that the NGI/RDS cross-sections for this example would be adequate for preliminary design.

Cross-sections were also developed along an alternate alignment to show the system's capability in route location.

Partial input and output is included on the following pages for each step of the NGI and RDS runs.

Plot of Scan Profiles and NGI Baseline

CONTROL & SECTION (1–6)	7	8
999970		R

DISTRICT________ RES. NO. ________
I.P.E. ________ PROJ. ________
CO. ________ HWY. ________

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
NGI HEADER INPUT FORM

SHEET ______ OF ______
DATE ____________
PREPARED BY ________

		KEEP (YES OR NO)	NGI CARDS (YES OR NO)
NGI HEADER CARD		YES	
9–23	24–27	28–30	31–33

THE NGI HEADER CARD MUST BE THE FIRST CARD IN THE DECK STRUCTURE. THERE SHOULD ONLY BE ONE NGI HEADER CARD IN THE DECK AND IT MUST BE DIRECTLY FOLLOWED BY AN NGI STRIP HEADER CARD.

NGI STRIP HEADER INPUT FORM

		BEGINNING X - COORDINATE	BEGINNING Y - COORDINATE	ENDING X - COORDINATE	ENDING Y - COORDINATE
NGI		336835.5001	797535.1660	331478.4526	788423.2539
9–11	12–13	14–28	29–43	44–58	59–73

ONE NGI STRIP HEADER CARD MUST PRECEDE THE SCAN PROFILE DATA FOR EACH STRIP.

NGI Input

Form 1381

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
TERRAIN INPUT FORM
(Enter THD in Cols. 30-32 On Form 1327)

DISTRICT________ RES. NO.________
I.P.E.________ PROJ.________
CO.________ HWY.________

SHEET______ OF______
DATE________
PREPARED BY________

CONTROL & SECTION
999970
1 2 3 4 5 6

TERRAIN STATION	* TYPE	CARD NO.	L or R	BIAS DISTANCE	BACKSIGHT ROD	FORESIGHT ROD	BENCH MARK ELEVATION H.I. or BIAS	ROD READING	DISTANCE	ROD READING	DISTANCE	ROD READING	DISTANCE	ROD READING	DISTANCE	ROD READING	DISTANCE	ROD READING	DISTANCE	ROD READING	DISTANCE	ROD READING	DISTANCE
7 8 9 10 11 12	13	14 15	16	17	18 19 20 21	22 23 24 25	26 27 28 29 30 31 32	33 34 35	36 37 38	39 40 41	42 43 44	45 46 47	48 49 50	51 52 53	54 55 56	57 58 59	60 61 62	63 64 65	66 67 68	69 70 71	72 73 74	75 76 77	78 79 80
139302	2	1	L	5			4600	428	930	525	870	733	780	937	685								
139302	2	2	L	5			4700	183	563	594	386	900	270										
139302	2	3	L	5			4800	27	204	49	90	909	16										
139302	2	4	L	4			4700	669	922	440	834	211	672	991	485	809	321	728	196	728	196	728	196
139302	2	5	L	4			4600	698	23														
139302	2	6	L	3			4600	742	963	826	802	873	603	914	462								
139302	2	7	L	3			4700	65	357	124	309	124	309	124	309	218	240	434	129	740	34		
139302	2	8	L	2			4800	40	970	196	922	449	798	714	682								
245002	2	8	R	0			4400	137	474	181	772												
245002	2	9	R	1			4400	183	106	165	304	176	457	176	480	191	514	173	542	174	565	226	843
245002	2	10	R	2			4400	207	704														
245002	2	11	R	3			4400	219	500	179	875	155	951										
245002	2	12	R	4			4400	166	57	088	300	39	422	976	760	917	922						
245002	2	13	R	5			4300	888	029	875	260	900	410	967	557	990	647	964	717	890	825	795	971

Note: This input represents the initial photogrammetric scan profile data. NGI cards were punched from tape and used on subsequent runs.

NGI Input

```
                              NUMERICAL GROUND IMAGE SYSTEM

                                 SCAN PROFILE DATA LIST

STATION      POINT    ELEV    DIST    POINT    ELEV    DIST    POINT    ELEV    DIST    POINT    ELEV    DIST    POINT    ELEV    DIST
NUMBER       NUMBER    IN      IN     NUMBER    IN      IN     NUMBER    IN      IN     NUMBER    IN      IN     NUMBER    IN      IN
             (TYPE)   FEET    FEET    (TYPE)   FEET    FEET    (TYPE)   FEET    FEET    (TYPE)   FEET    FEET    (TYPE)   FEET    FEET

139+30.00      1(2)  4642.8 -5930       2(1)  4652.5 -5870       3(1)  4673.3 -5780       4(1)  4693.1 -5685       5(1)  4718.3 -5563
               6(1)  4759.4 -5386       7(1)  4790.0 -5270       8(1)  4802.7 -5204       9(1)  4804.9 -5090      10(1)  4790.9 -5016
              11(1)  4766.9 -4922      12(1)  4744.0 -4834      13(1)  4721.1 -4672      14(1)  4699.1 -4485      15(1)  4680.9 -4321
              16(3)  4672.8 -4196      17(1)  4669.8 -4023      18(1)  4674.2 -3963      19(1)  4682.6 -3802      20(1)  4687.3 -3603
              21(1)  4691.4 -3462      22(1)  4706.5 -3357      23(3)  4712.4 -3309      24(1)  4721.8 -3240      25(1)  4743.4 -3129
              26(1)  4774.0 -3034      27(1)  4804.0 -2970      28(1)  4819.6 -2922      29(1)  4844.9 -2798      30(1)  4871.4 -2682
              31(1)  4901.1 -2544      32(1)  4917.9 -2463      33(1)  4926.3 -2392      34(1)  4927.6 -2330      35(1)  4921.9 -2240
              36(1)  4906.9 -2075      37(1)  4892.9 -1960      38(1)  4876.1 -1891      39(1)  4855.1 -1812      40(1)  4825.2 -1724
              41(1)  4807.6 -1652      42(3)  4791.1 -1594      43(1)  4752.2 -1534      44(1)  4709.6 -1414      45(1)  4683.7 -1356
              46(1)  4658.8 -1286      47(3)  4649.7 -1214      48(1)  4633.1 -1176      49(1)  4636.5 -1152      50(1)  4662.3 -1091
              51(3)  4674.3 -1052      52(1)  4708.5  -948      53(1)  4723.4  -884      54(1)  4730.5  -847      55(1)  4726.2  -770
              56(1)  4740.2  -729      57(3)  4765.2  -672      58(1)  4787.5  -630      59(1)  4809.3  -574      60(1)  4821.4  -530
              61(1)  4833.3  -474      62(1)  4840.8  -383      63(1)  4842.0  -332      64(1)  4839.1  -252      65(1)  4830.6  -178
              66(1)  4825.3  -116      67(1)  4809.3   -43      68(1)  4809.7     0      69(1)  4815.5    85      70(1)  4826.3   180
              71(1)  4807.1   255      72(2)  4774.1   314      73(1)  4740.3   374      74(1)  4707.2   458      75(1)  4669.7   590
              76(2)  4646.8   712      77(1)  4630.9   860      78(1)  4619.3   980      79(1)  4605.9  1144      80(2)  4589.6  1441
              81(1)  4583.2  1536      82(1)  4578.0  1648      83(2)  4582.6  1683      84(1)  4584.7  1765      85(1)  4591.2  1856
              86(1)  4594.8  1920      87(1)  4589.8  1982      88(2)  4577.7  2082      89(1)  4570.8  2172      90(1)  4569.7  2307
              91(1)  4564.9  2354      92(1)  4557.7  2426      93(2)  4565.8  2532      94(1)  4568.2  2650      95(2)  4563.4  2732
              96(1)  4553.5  2807      97(1)  4553.6  2867      98(2)  4561.5  2949      99(1)  4570.2  3053     100(1)  4573.6  3158
             101(1)  4571.8  3231     102(1)  4563.3  3362     103(1)  4550.3  3469     104(2)  4544.8  3494     105(1)  4534.0  3569
             106(1)  4537.2  3658     107(2)  4551.9  3768     108(2)  4563.4  3874     109(1)  4568.5  3972     110(1)  4569.7  4052
             111(1)  4568.8  4072     112(1)  4572.0  4103     113(1)  4569.7  4130     114(1)  4573.1  4152     115(1)  4574.6  4308
             116(1)  4573.0  4633     117(1)  4570.6  5014     118(1)  4562.5  5279     119(1)  4553.7  5435     120(2)  4544.9  5550
             121(1)  4530.8  5702     122(2)  4514.4  5825     123(1)  4511.2  6032     124(2)  4511.0  6138
```

BK is the number of discontinuity points for the back direction (2's + 4's). FWD is the number of discontinuity points for the forward direction (2's + 3's). The FWD must always be equal to the BK for the next station.

```
DISCONTINUITIES-  15(2)    6(3)    0(4)   15 BK   21 FWD

POINT CONNECTIONS      1 TO   1     1 TO   2     2 TO   3     3 TO   4     4 TO   5     4 TO   6     5 TO   7     6 TO   8
                       7 TO   9     8 TO   9     8 TO  10     9 TO  11    10 TO  12    11 TO  13    12 TO  14    13 TO  15
                      14 TO  16    15 TO  17    16 TO  18    17 TO  19    18 TO  20    19 TO  21    19 TO  22    20 TO  23
                      20 TO  24    21 TO  25    22 TO  26    23 TO  27    24 TO  28    25 TO  29    26 TO  30    27 TO  30
                      28 TO  31    29 TO  31    30 TO  32    31 TO  33    32 TO  34    33 TO  35    34 TO  36    35 TO  37
                      36 TO  38    37 TO  39    38 TO  40    39 TO  40    39 TO  41    40 TO  42    41 TO  42    42 TO  43
                      43 TO  44    43 TO  45    43 TO  46    44 TO  47    45 TO  47    46 TO  48    46 TO  49    47 TO  50
                      48 TO  51    49 TO  51    50 TO  52    51 TO  53    52 TO  54    53 TO  55    54 TO  56    55 TO  57
                      56 TO  57    57 TO  58    58 TO  59    59 TO  60    60 TO  60    61 TO  61    62 TO  62    63 TO  62
                      64 TO  63    65 TO  63    66 TO  64    67 TO  65    68 TO  65    69 TO  66    70 TO  67    71 TO  68
                      71 TO  69    72 TO  70    73 TO  71    74 TO  72    75 TO  73    76 TO  74    77 TO  75    78 TO  75
                      79 TO  76    80 TO  77    80 TO  78    81 TO  79    82 TO  80    83 TO  81    84 TO  82    84 TO  83
                      85 TO  84    86 TO  85    87 TO  86    88 TO  87    89 TO  88    90 TO  89    91 TO  89    92 TO  90
                      93 TO  91    94 TO  92    94 TO  93    95 TO  94    96 TO  95    97 TO  96    98 TO  97    99 TO  98
                     100 TO  99   101 TO 100   102 TO 101   103 TO 102   104 TO 102   105 TO 103   106 TO 104   107 TO 105
                     108 TO 106   108 TO 107   109 TO 108   110 TO 109   110 TO 110   111 TO 111   112 TO 112   113 TO 113
                     114 TO 113   115 TO 114   116 TO 115   117 TO 116   118 TO 117   119 TO 117   120 TO 118   121 TO 119
```

Point 14 of this scan profile (139+30) connects to point 16 of the next scan profile (140+00).

Sample NGI Output

```
                                                                                                                    2
                                          NUMERICAL GROUND IMAGE SYSTEM

                                             SCAN PROFILE DATA LIST

   STATION      POINT    ELEV   DIST    POINT    ELEV   DIST    POINT    ELEV   DIST    POINT    ELEV   DIST    POINT    ELEV   DIST
   NUMBER       NUMBER    IN     IN     NUMBER    IN     IN     NUMBER    IN     IN     NUMBER    IN     IN     NUMBER    IN     IN
                (TYPE)   FEET   FEET    (TYPE)   FEET   FEET    (TYPE)   FEET   FEET    (TYPE)   FEET   FEET    (TYPE)   FEET   FEET

POINT CONNECTIONS    122 TO 120    123 TO 121    124 TO 122

   140+ 0.00      1(2)  4630.2 -5954      2(3)  4630.9 -5934      3(1)  4634.3 -5902      4(1)  4641.9 -5850      5(1)  4655.1 -5761
                  6(1)  4669.8 -5680      7(1)  4693.2 -5543      8(1)  4717.4 -5425      9(1)  4749.9 -5291     10(1)  4772.4 -5204
                 11(1)  4777.9 -5132     12(1)  4769.9 -5052     13(1)  4749.5 -4961     14(1)  4729.2 -4868     15(1)  4707.2 -4709
                 16(1)  4689.3 -4542     17(1)  4674.9 -4376     18(2)  4667.2 -4267     19(1)  4665.4 -4123     20(1)  4676.1 -4022
                 21(1)  4690.8 -3870     22(1)  4697.5 -3735     23(1)  4697.5 -3614     24(1)  4694.5 -3516     25(1)  4695.3 -3438
                 26(1)  4709.5 -3324     27(2)  4718.2 -3254     28(1)  4732.7 -3172     29(1)  4762.0 -3058     30(1)  4798.6 -2965
                 31(1)  4839.6 -2840     32(1)  4866.0 -2721     33(1)  4900.5 -2586     34(1)  4926.0 -2475     35(1)  4933.5 -2422
                 36(1)  4936.7 -2352     37(1)  4930.2 -2274     38(1)  4920.5 -2189     39(1)  4902.7 -2007     40(1)  4886.9 -1900
                 41(1)  4868.1 -1834     42(1)  4825.3 -1751     43(2)  4792.7 -1670     44(1)  4773.2 -1621     45(1)  4752.1 -1574
                 46(1)  4730.4 -1522     47(1)  4691.8 -1379     48(1)  4669.4 -1306     49(1)  4653.8 -1253     50(2)  4646.1 -1172
                 51(1)  4631.8 -1125     52(1)  4655.1 -1067     53(2)  4672.0  -995     54(1)  4687.9  -926     55(1)  4696.2  -867
                 56(1)  4697.8  -811     57(1)  4725.9  -734     58(2)  4766.5  -639     59(1)  4794.6  -582     60(1)  4804.0  -550
                 61(1)  4806.5  -448     62(1)  4808.3  -327     63(1)  4808.7  -197     64(1)  4801.4   -84     65(1)  4797.5     0
                 66(1)  4802.4    68     67(1)  4816.9   171     68(1)  4816.8   209     69(1)  4805.5   266     70(2)  4786.7   298
                 71(1)  4757.4   332     72(1)  4721.5   411     73(1)  4676.7   564     74(2)  4649.6   700     75(1)  4626.8   902
                 76(1)  4611.8  1068     77(1)  4591.8  1410     78(2)  4590.1  1455     79(1)  4582.5  1541     80(1)  4575.6  1640
                 81(2)  4582.3  1687     82(1)  4580.7  1745     83(1)  4588.5  1848     84(1)  4592.0  1940     85(1)  4588.8  2016
                 86(1)  4578.7  2128     87(2)  4569.6  2246     88(1)  4561.6  2345     89(1)  4555.3  2431     90(1)  4558.4  2558
                 91(2)  4562.5  2594     92(1)  4566.3  2682     93(1)  4564.4  2749     94(2)  4557.7  2794     95(1)  4549.4  2856
                 96(1)  4555.2  2918     97(2)  4561.4  2972     98(1)  4570.0  3083     99(1)  4571.1  3167    100(1)  4568.2  3277
                101(1)  4558.7  3409    102(2)  4542.9  3538    103(1)  4533.0  3571    104(1)  4534.7  3658    105(2)  4545.3  3731
                106(1)  4557.8  3818    107(2)  4562.0  3870    108(1)  4567.6  3968    109(1)  4568.8  4041    110(1)  4567.5  4054
                111(1)  4571.2  4088    112(1)  4568.2  4116    113(1)  4571.2  4140    114(1)  4572.0  4452    115(1)  4570.0  4840
                116(1)  4565.6  5179    117(1)  4556.3  5425    118(2)  4543.4  5607    119(1)  4526.6  5738    120(2)  4513.7  5825
                121(1)  4511.3  5934    122(2)  4510.2  6133

DISCONTINUITIES-  21(2)    1(3)    0(4)   21 BK   22 FWD

POINT CONNECTIONS      1 TO   1      2 TO   2      3 TO   2      4 TO   3      5 TO   3      6 TO   4      7 TO   5      8 TO   5
                       9 TO   6     10 TO   6     11 TO   6     12 TO   7     13 TO   8     14 TO   8     15 TO   9     16 TO  10
                      17 TO  11     18 TO  12     19 TO  13     20 TO  14     21 TO  15     21 TO  16     22 TO  17     23 TO  18
                      24 TO  19     25 TO  20     25 TO  21     26 TO  22     27 TO  23     28 TO  24     29 TO  25     30 TO  25
                      31 TO  26     32 TO  27     33 TO  28     34 TO  29     35 TO  30     36 TO  31     37 TO  32     38 TO  32
                      38 TO  33     39 TO  34     40 TO  35     41 TO  36     42 TO  37     43 TO  38     44 TO  39     45 TO  39
                      46 TO  40     47 TO  41     48 TO  42     49 TO  42     49 TO  43     50 TO  44     50 TO  45     51 TO  46
                      51 TO  47     52 TO  48     53 TO  49     54 TO  50     54 TO  51     55 TO  51     56 TO  52     57 TO  53
                      58 TO  54     58 TO  55     59 TO  55     60 TO  56     61 TO  57     62 TO  58     63 TO  59     64 TO  60
                      65 TO  61     66 TO  61     66 TO  62     67 TO  62     68 TO  63     69 TO  63     70 TO  64     71 TO  65
                      72 TO  66     72 TO  67     73 TO  68     74 TO  69     74 TO  70     75 TO  71     75 TO  72     76 TO  73
                      77 TO  74     78 TO  74     79 TO  75     79 TO  76     80 TO  77     81 TO  78     82 TO  79     83 TO  80
                      83 TO  81     84 TO  82     85 TO  82     86 TO  83     87 TO  84     87 TO  85     88 TO  86     89 TO  87
                      90 TO  88     91 TO  88     92 TO  89     93 TO  89     94 TO  90     95 TO  91     96 TO  92     97 TO  93
                      98 TO  94     99 TO  95    100 TO  96    101 TO  97    102 TO  98    102 TO  99    103 TO 100    104 TO 101
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Sample NGI Output

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                              NUMERICAL GROUND IMAGE SYSTEM

                                 SCAN PROFILE DATA LIST

     STATION      POINT    ELEV    DIST    POINT    ELEV    DIST    POINT    ELEV    DIST    POINT    ELEV    DIST    POINT    ELEV    DIST
     NUMBER       NUMBER    IN      IN     NUMBER    IN      IN     NUMBER    IN      IN     NUMBER    IN      IN     NUMBER    IN      IN
                  (TYPE)   FEET    FEET    (TYPE)   FEET    FEET    (TYPE)   FEET    FEET    (TYPE)   FEET    FEET    (TYPE)   FEET    FEET

POINT CONNECTIONS    104 TO 102     105 TO 103     106 TO 104     107 TO 105     108 TO 106     109 TO 107     110 TO 108     111 TO 109
                     112 TO 110     113 TO 110     113 TO 111     114 TO 111     115 TO 112     116 TO 113     117 TO 114     117 TO 115
                     118 TO 116     119 TO 117     119 TO 118     120 TO 119     121 TO 119     122 TO 120

     141+10.00      1(2)  4620.8 -5937      2(2)  4629.4 -5823      3(1)  4638.1 -5716      4(1)  4654.6 -5580      5(1)  4677.4 -5423
                    6(1)  4703.3 -5220      7(1)  4705.6 -5061      8(1)  4698.4 -4974      9(1)  4687.7 -4798     10(1)  4679.1 -4690
                   11(1)  4669.5 -4526     12(2)  4661.8 -4416     13(1)  4665.1 -4212     14(1)  4676.6 -4103     15(1)  4697.4 -3986
                   16(3)  4717.9 -3886     17(1)  4725.3 -3726     18(3)  4722.1 -3662     19(1)  4705.7 -3472     20(1)  4701.5 -3402
                   21(1)  4707.8 -3342     22(1)  4718.6 -3240     23(2)  4730.6 -3158     24(1)  4755.1 -3054     25(1)  4788.9 -2934
                   26(1)  4835.9 -2792     27(1)  4873.7 -2664     28(1)  4905.2 -2534     29(1)  4925.9 -2456     30(1)  4931.4 -2384
                   31(1)  4929.5 -2308     32(1)  4922.8 -2208     33(1)  4914.4 -2109     34(1)  4905.4 -1970     35(1)  4888.7 -1902
                   36(1)  4872.0 -1850     37(1)  4844.2 -1790     38(2)  4793.9 -1695     39(1)  4774.5 -1649     40(1)  4723.5 -1537
                   41(1)  4688.1 -1426     42(1)  4663.0 -1308     43(1)  4648.8 -1226     44(2)  4636.0 -1184     45(1)  4636.1 -1161
                   46(1)  4625.3 -1124     47(1)  4640.2 -1084     48(1)  4651.0  -996     49(2)  4663.9  -901     50(1)  4668.2  -851
                   51(1)  4677.1  -818     52(1)  4691.1  -762     53(1)  4716.4  -677     54(4)  4766.4  -594     55(1)  4771.9  -576
                   56(1)  4766.0  -498     57(1)  4759.1  -422     58(1)  4761.2  -334     59(1)  4769.1  -202     60(1)  4772.9  -107
                   61(1)  4774.1     0     62(1)  4779.1    51     63(1)  4791.4   155     64(4)  4787.0   208     65(1)  4775.0   268
                   66(1)  4745.8   330     67(1)  4708.3   449     68(1)  4667.5   603     69(1)  4646.6   709     70(2)  4642.4   738
                   71(1)  4628.4   871     72(1)  4618.8   979     73(1)  4605.3  1163     74(2)  4586.3  1495     75(1)  4581.5  1578
                   76(1)  4575.5  1617     77(1)  4575.1  1660     78(2)  4578.5  1710     79(1)  4579.5  1808     80(1)  4586.3  1882
                   81(1)  4588.7  1994     82(1)  4585.6  2095     83(1)  4574.0  2360     84(1)  4563.8  2475     85(2)  4557.5  2541
                   86(1)  4548.1  2590     87(1)  4550.5  2650     88(2)  4558.4  2699     89(1)  4561.3  2778     90(2)  4554.2  2816
                   91(1)  4541.2  2872     92(1)  4547.6  2917     93(2)  4557.6  2995     94(1)  4566.5  3082     95(1)  4570.7  3159
                   96(1)  4565.3  3320     97(1)  4557.5  3420     98(1)  4545.5  3519     99(2)  4540.6  3558    100(1)  4530.1  3632
                  101(1)  4530.2  3662    102(1)  4542.1  3723    103(2)  4551.3  3779    104(1)  4559.5  3844    105(2)  4562.0  3884
                  106(1)  4567.6  4024    107(1)  4566.0  4040    108(1)  4568.7  4076    109(1)  4564.9  4100    110(1)  4569.6  4124
                  111(1)  4569.9  4291    112(1)  4568.9  4691    113(1)  4564.3  5152    114(1)  4555.9  5401    115(1)  4547.9  5572
                  116(2)  4540.2  5677    117(1)  4525.1  5762    118(1)  4514.3  5824    119(2)  4511.5  5873    120(2)  4508.6  6133

DISCONTINUITIES-  20(2)    2(3)    2(4)   22 BK   22 FWD

POINT CONNECTIONS      1 TO   1      2 TO   2      2 TO   3      3 TO   4      4 TO   4      5 TO   5      6 TO   6      7 TO   7
                       8 TO   7      9 TO   8     10 TO   8     11 TO   9     12 TO   9     12 TO  10     13 TO  11     14 TO  12
                      15 TO  13     16 TO  14     16 TO  15     16 TO  16     17 TO  17     17 TO  18     17 TO  19     18 TO  20
                      18 TO  21     19 TO  22     20 TO  22     21 TO  23     22 TO  23     23 TO  24     24 TO  25     25 TO  26
                      26 TO  27     27 TO  27     28 TO  28     29 TO  29     30 TO  30     31 TO  30     32 TO  31     33 TO  32
                      34 TO  33     35 TO  34     36 TO  35     37 TO  35     38 TO  36     38 TO  37     39 TO  38     40 TO  39
                      41 TO  40     42 TO  41     43 TO  42     44 TO  42     45 TO  43     46 TO  44     47 TO  45     48 TO  46
                      48 TO  47     48 TO  48     49 TO  49     50 TO  49     51 TO  49     52 TO  50     53 TO  50     54 TO  51
                      55 TO  51     56 TO  52     57 TO  52     58 TO  52     59 TO  53     60 TO  54     60 TO  55     61 TO  56
                      62 TO  56     63 TO  57     63 TO  58     64 TO  59     65 TO  59     66 TO  60     67 TO  61     68 TO  62
                      69 TO  63     70 TO  63     71 TO  64     72 TO  65     73 TO  65     73 TO  66     74 TO  67     74 TO  68
                      75 TO  69     76 TO  70     77 TO  71     78 TO  72     79 TO  73     80 TO  74     81 TO  75     82 TO  76
                      82 TO  77     83 TO  78     83 TO  79     84 TO  80     85 TO  81     86 TO  82     87 TO  83     88 TO  84
                      89 TO  85     90 TO  85     91 TO  86     92 TO  87     93 TO  88     94 TO  89     95 TO  90     95 TO  91
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Sample NGI Output

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                                                                                                                           4
                                        NUMERICAL GROUND IMAGE SYSTEM

                                           SCAN PROFILE DATA LIST

  STATION              POINT   ELEV   DIST      POINT   ELEV   DIST      POINT   ELEV   DIST      POINT   ELEV   DIST      POINT   ELEV   DIST
  NUMBER              NUMBER    IN     IN      NUMBER    IN     IN      NUMBER    IN     IN      NUMBER    IN     IN      NUMBER    IN     IN
                      (TYPE)   FEET   FEET     (TYPE)   FEET   FEET     (TYPE)   FEET   FEET     (TYPE)   FEET   FEET     (TYPE)   FEET   FEET

POINT CONNECTIONS         96 TO  92          97 TO  93          98 TO  93          99 TO  94         100 TO  95         101 TO  95         101 TO  96         102 TO  97
                         103 TO  98         104 TO  99         105 TO  99         106 TO 100         107 TO 100         107 TO 101         108 TO 102         109 TO 103
                         110 TO 104         111 TO 105         112 TO 106         112 TO 107         113 TO 108         114 TO 109         115 TO 110         116 TO 111
                         117 TO 112         118 TO 112         119 TO 113         120 TO 114         120 TO 115

  142+30.00             1(2) 4620.6  -5937      2(1) 4627.3  -5698      3(2) 4631.6  -5591      4(1) 4640.0  -5486      5(1) 4653.4  -5351
                        6(1) 4662.1  -5217      7(1) 4664.0  -5038      8(1) 4661.5  -4810      9(2) 4658.4  -4627     10(1) 4656.7  -4529
                       11(1) 4660.4  -4359     12(1) 4665.5  -4193     13(1) 4683.8  -4082     14(2) 4708.8  -4004     15(1) 4749.2  -3936
                       16(1) 4762.2  -3822     17(1) 4767.7  -3732     18(1) 4763.3  -3668     19(1) 4741.5  -3576     20(1) 4723.7  -3498
                       21(2) 4712.9  -3422     22(1) 4713.0  -3306     23(1) 4719.9  -3222     24(2) 4732.2  -3128     25(1) 4757.3  -3017
                       26(1) 4796.3  -2867     27(1) 4845.8  -2702     28(1) 4886.3  -2528     29(1) 4905.9  -2407     30(1) 4914.0  -2328
                       31(1) 4911.7  -2203     32(1) 4911.1  -2018     33(1) 4905.8  -1919     34(1) 4892.3  -1856     35(1) 4872.5  -1807
                       36(1) 4821.0  -1714     37(2) 4797.8  -1672     38(1) 4776.3  -1626     39(1) 4716.0  -1484     40(1) 4679.0  -1370
                       41(1) 4649.6  -1244     42(2) 4635.9  -1157     43(1) 4623.0  -1116     44(1) 4629.4  -1083     45(1) 4631.3  -1031
                       46(1) 4640.8   -973     47(1) 4652.1   -884     48(1) 4650.2   -861     49(2) 4655.1   -800     50(1) 4685.3   -630
                       51(1) 4706.2   -522     52(1) 4720.9   -332     53(1) 4735.7   -166     54(1) 4741.0    -35     55(1) 4746.2      0
                       56(1) 4766.3     98     57(1) 4772.4    155     58(1) 4767.7    201     59(1) 4750.7    281     60(1) 4729.4    366
                       61(1) 4682.1    540     62(1) 4653.5    657     63(2) 4635.0    757     64(1) 4622.2    874     65(1) 4608.6   1080
                       66(1) 4593.7   1317     67(1) 4583.3   1478     68(2) 4580.7   1540     69(1) 4577.5   1619     70(1) 4575.9   1672
                       71(1) 4570.6   1705     72(2) 4574.8   1762     73(1) 4576.0   1831     74(1) 4581.0   1904     75(1) 4584.0   2025
                       76(1) 4578.6   2132     77(1) 4571.4   2228     78(1) 4571.7   2366     79(1) 4568.9   2456     80(1) 4557.0   2581
                       81(2) 4551.3   2621     82(1) 4542.6   2658     83(1) 4542.6   2706     84(4) 4553.2   2774     85(4) 4552.4   2806
                       86(1) 4537.3   2863     87(1) 4538.9   2925     88(2) 4545.9   2968     89(1) 4556.7   3046     90(1) 4566.7   3134
                       91(1) 4568.1   3208     92(1) 4563.2   3323     93(1) 4552.0   3447     94(2) 4541.2   3522     95(1) 4527.8   3623
                       96(1) 4527.9   3640     97(1) 4537.8   3676     98(2) 4544.9   3716     99(2) 4559.1   3852    100(1) 4563.8   4008
                      101(1) 4561.5   4029    102(1) 4564.1   4059    103(1) 4562.2   4086    104(1) 4566.0   4108    105(1) 4569.6   4291
                      106(1) 4569.2   4562    107(1) 4568.2   4902    108(1) 4561.2   5192    109(1) 4553.6   5425    110(1) 4541.7   5696
                      111(2) 4534.9   5756    112(1) 4525.7   5816    113(2) 4510.2   5875    114(1) 4508.1   6012    115(2) 4506.3   6138

DISCONTINUITIES-    20(2)    0(3)    2(4)   22 BK   20 FWD

POINT CONNECTIONS          1 TO   1           1 TO   2           1 TO   3           1 TO   4           1 TO   5           2 TO   6           2 TO   7           3 TO   8
                           4 TO   8           5 TO   8           6 TO   8           7 TO   9           8 TO   9           9 TO   9          10 TO  10          11 TO  11
                          12 TO  12          12 TO  13          12 TO  14          13 TO  15          14 TO  16          15 TO  16          16 TO  17          17 TO  17
                          18 TO  17          19 TO  17          20 TO  18          21 TO  18          22 TO  19          22 TO  20          22 TO  21          23 TO  22
                          24 TO  23          24 TO  24          24 TO  25          25 TO  25          26 TO  26          27 TO  27          28 TO  28          29 TO  29
                          30 TO  30          31 TO  31          32 TO  32          33 TO  33          34 TO  34          35 TO  34          36 TO  35          37 TO  36
                          38 TO  37          39 TO  38          40 TO  39          41 TO  40          42 TO  41          43 TO  42          44 TO  43          44 TO  44
                          45 TO  44          46 TO  45          47 TO  46          48 TO  46          49 TO  47          49 TO  48          50 TO  49          51 TO  50
                          52 TO  51          52 TO  52          53 TO  53          53 TO  54          53 TO  55          54 TO  56          55 TO  56          56 TO  57
                          57 TO  58          57 TO  59          58 TO  59          59 TO  60          60 TO  61          61 TO  62          62 TO  63          63 TO  64
                          64 TO  65          65 TO  66          66 TO  67          67 TO  67          68 TO  68          69 TO  69          70 TO  70          71 TO  71
                          72 TO  72          73 TO  73          74 TO  73          75 TO  74          76 TO  75          77 TO  76          77 TO  77          78 TO  78
                          79 TO  78          79 TO  79          80 TO  80          81 TO  80          82 TO  80          83 TO  81          84 TO  82          85 TO  82
                          86 TO  83          87 TO  84          88 TO  84          89 TO  85          90 TO  85          91 TO  86          92 TO  87          93 TO  88
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Sample NGI Output

CONTROL & SECTION
9999 70A
1 2 3 4 5 6 7

DISTRICT________ RES. NO.________
I.P.E.________ PROJ.________
CO.________ HWY.________

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
SYSTEM CARD

SHEET 1 OF________
DATE________
PREPARED BY________

	PROCESSES TO BE EXECUTED														JOB TYPE (OLD OR NEW)	KEEP (YES OR NO)	INIT. GEOM. FILES (YES OR NO)	INIT. DESIGN DATA FILES (YES OR NO)	INIT. BRG. FILES (YES OR NO)			COUNTY AND HIGHWAY	DATE
	CONTROL	COMMAND	TERRAIN	DESIGN DATA	ERWK DESIGN	VOLUMES	HAUL PLOT	XSEC PLOT	PROFILE PLOT	PERSP PLOT	BRIDGE												
SYSTEM			X	X				X							NEW	YES	YES	YES	YES			PRESIDO COUNTY	
8–13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28–30	31–33	34–36	37–39	40–42	43–45	46–48	49–64	65–80

CONTROL & SECTION
9999 70A RD
1 2 3 4 5 6 7 8 9

DISTRICT________ RES. NO.________
I.P.E.________ PROJ.________
CO.________ HWY.________

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
HORIZONTAL ALIGNMENT INPUT FORM

SHEET 2 OF________
DATE________
PREPARED BY________

	ROADWAY	P.I. NO.	STATION	BEG. STA. I.D.	DEGREE OF CURVE			RADIUS OR FORWARD TANGENT	SPIRAL		P.I. COORDINATES		GEOM. POINT STOR. NUMBER	RND BRG OR HOLD
					DEG	MIN	SEC		IN	OUT	X	Y		
10–11	12	13–14	15–23	24–26	27–28	29–30	31–34	35–44	45–48	49–52	53–63	64–74	75–78	79–80
05	G	5	100+00.	POT			.	.			342302.4077	799859.6159	1	
		10	+ .		2		.	.			338755.9132	798009.6492	2	
		15	+ .		3		.	.			337329.9556	796079.1973	3	
		20	+ .		3		.	.			337615.0000	793928.0000	4	
		25	+ .		2		.	.			335961.5626	791795.2737	5	
	↓	30	+ .		2		.	.			335268.4409	789936.6894	6	
	G	35	+ .				.	.			334724.2061	786986.4676	7	

CONTROL & SECTION
9999 70A R
1 2 3 4 5 6 7 8

DISTRICT________ RES. NO.________
I.P.E.________ PROJ.________
CO.________ HWY.________

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
TERRAIN HEADER INPUT FORM

SHEET 3 OF________
DATE________
PREPARED BY________

	JOB TYPE								PRINT TYPE						CROSS-SECTION CARD TYPE (THD OR TEX)		LIST OF CROSS-SECTION DATA INPUT CARDS? (YES OR NO)	COMMENTS
	ORIG. CARDS	ORIG. CD. / TAPE	FINAL CD. / TAPE	ORIG. EXTEN.	FINAL EXTEN.	TAPE TO DISK	DELETIONS	MODIF., HUBS, PRINT	ORIGINAL	DESIGN	FINAL	HORIZONTAL POSITION	ROW/MAX SL. INTC.	HUBS				
TERRAIN	X																	BUILD NGI CROSS-SECTIONS
9–15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30–32	33–35	36–44	45–80

Pages 1-3 of RDS Input

CONTROL & SECTION

1	2	3	4	5	6	7	8	9
9	9	9	9	7	0	A	R	T

DISTRICT ________ RES. NO. ________
I.P.E. ________ PROJ. ________
CO. ________ HWY. ________

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
CROSS – SECTION REQUEST FORM
USING NUMERICAL GROUND IMAGE (NGI) FILE

SHEET 4 OF ________
DATE ________
PREPARED BY ________

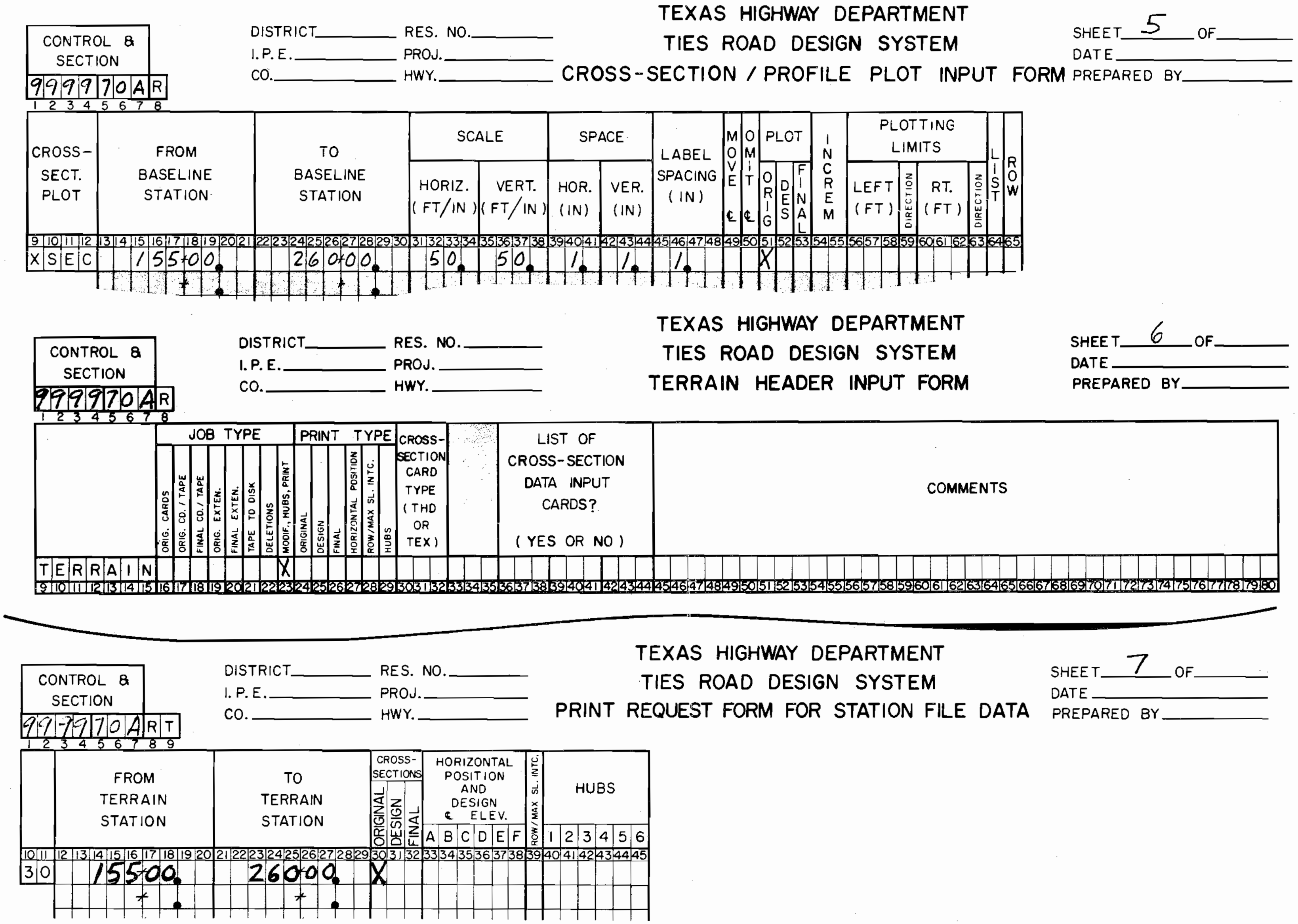
	FROM STATION	TO STATION	STATION INCREMENT	WIDTH LEFT	L OR R	WIDTH RIGHT	L OR R	NGI* FILE ON TAPE (YES OR NO)
10 11	12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29	30 31 32 33	34 35 36	37	38 39 40	41	42 43 44
70	155+00.	156+45.	145.	500	L	500	R	YES
	157+00.	158+25.	125.					
	160+00.	161+25.	125.					
	162+60.	165+00.	240.					
	166+50.	167+50.	100.					
	168+90.	170+00.	110.					
	171+75.	173+15.	140.					
	175+00.	176+40.	140.					
	177+50.	180+00.	250.					
	182+50.	184+00.	150.					
	185+00.	186+65.	165.					
	188+20.	190+00.	180.					
	191+80.	192+50.	70.					
	193+40.	195+00.	160.					
	195+80.	196+75.	95.					
	198+25.	200+00.	175.					
	201+40.	203+65.	225.					
	205+00.	206+35.	135.					
	208+05.	209+60.	155.					
	210+00.	212+30.	230.					
	215+00.	225+00.	500.					
	226+25.	227+85.	160.					
	230+00.	230+70.	70.					
	232+45.	235+00.	255.					
	235+80.	237+10.	130.					
	240+00.	242+70.	270.					
	245+00.	246+70.	170.					
	250+00.	252+50.	250.	↓	↓	↓	↓	
	255+00.	260+00.	500.	500	L	500	R	
	12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29	30 31 32 33	34 35 36	37	38 39 40	41	

* INPUT ON FIRST CROSS – SECTION REQUEST CARD ONLY.

Note: Non-uniform station increments were used to duplicate photogrammetric cross-sections.

FORM 1372

Page 4 of RDS Input



CONTROL & SECTION

1	2	3	4	5	6	7	8
9	9	9	9	7	0	A	R

DISTRICT______ RES. NO.______
I.P.E.______ PROJ.______
CO.______ HWY.______

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
CROSS-SECTION / PROFILE PLOT INPUT FORM

SHEET 5 OF______
DATE______
PREPARED BY______

CROSS-SECT. PLOT (9-12)	FROM BASELINE STATION (13-21)	TO BASELINE STATION (22-30)	SCALE HORIZ. (FT/IN) (31-34)	SCALE VERT. (FT/IN) (35-38)	SPACE HOR. (IN) (39-41)	SPACE VER. (IN) (42-44)	LABEL SPACING (IN) (45-48)	MOVE ℄ (49)	OMIT ℄ (50)	PLOT ORIG (51)	PLOT DES (52)	PLOT FINAL (53)	INCREM (54-55)	PLOTTING LIMITS LEFT (FT) (56-58)	DIRECTION (59)	RT. (FT) (60-62)	DIRECTION (63)	LIST (64)	ROW (65)
XSEC	155+00.	260+00.	50.	50.	1.	1.	1.			X									

CONTROL & SECTION

1	2	3	4	5	6	7	8
9	9	9	9	7	0	A	R

DISTRICT______ RES. NO.______
I.P.E.______ PROJ.______
CO.______ HWY.______

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
TERRAIN HEADER INPUT FORM

SHEET 6 OF______
DATE______
PREPARED BY______

(9-15)	JOB TYPE: ORIG. CARDS (16)	ORIG. CD./TAPE (17)	FINAL CD./TAPE (18)	ORIG. EXTEN. (19)	FINAL EXTEN. (20)	TAPE TO DISK (21)	DELETIONS (22)	MODIF., HUBS, PRINT (23)	PRINT TYPE: ORIGINAL (24)	DESIGN (25)	FINAL (26)	HORIZONTAL POSITION (27)	ROW/MAX SL. INTC. (28)	HUBS (29)	CROSS-SECTION CARD TYPE (THD OR TEX) (30-32)	(33-35)	LIST OF CROSS-SECTION DATA INPUT CARDS? (YES OR NO) (36-44)	COMMENTS (45-80)
TERRAIN								X										

CONTROL & SECTION

1	2	3	4	5	6	7	8	9
9	9	9	9	7	0	A	R	T

DISTRICT______ RES. NO.______
I.P.E.______ PROJ.______
CO.______ HWY.______

TEXAS HIGHWAY DEPARTMENT
TIES ROAD DESIGN SYSTEM
PRINT REQUEST FORM FOR STATION FILE DATA

SHEET 7 OF______
DATE______
PREPARED BY______

(10-11)	FROM TERRAIN STATION (12-20)	TO TERRAIN STATION (21-29)	CROSS-SECTIONS ORIGINAL (30)	DESIGN (31)	FINAL (32)	HORIZONTAL POSITION AND DESIGN ℄ ELEV. A (33)	B (34)	C (35)	D (36)	E (37)	F (38)	ROW/MAX SL. INTC. (39)	HUBS 1 (40)	2 (41)	3 (42)	4 (43)	5 (44)	6 (45)
30	15500.	26000.	X															

Pages 5-7 of RDS Input

```
                                                                                                         5
     TEXAS HIGHWAY DEPARTMENT        T I E S  ROADWAY DESIGN SUBSYSTEM     *** DESIGN DATA ***
     HORIZONTAL ALIGNMENT PROCESS                                                       NOV 13, 1974
     CONTROL 9999 SECTION 70A                                              COUNTY & HIGHWAY - PRESIDIO COUNTY
                                         HORIZONTAL ALIGNMENT LIST
                                              FOR ROADWAY G
  COMPUTATIONS BASED ON ARC DEFINITION

 P.I.                                                                                  X             Y

  5    100+00.0000                                                                342302.4077   799859.6159

                                     S 62 27  7.17 W       4000.0000 FEET

       133+38.6114 PC      661.3886 T                                             339342.3160   798315.5360

 10    140+00.0000 PI    2  0  0.0 D   26  0  0.0 LT  1300.0000 L   2864.7890 R   338755.9132   798009.6492

       146+38.6114 PT      661.3886 T                                             338362.9498   797477.6580

                                     S 36 27  7.17 W       2400.0000 FEET

       156+05.5895 PC      771.6333 T                                             337788.4207   796699.8643

 15    163+77.2227 PI    3  0  0.0 D   44  0  0.0 LT  1466.6667 L   1909.8593 R   337329.9556   796079.1973

       170+72.2561 PT      771.6333 T                                             337431.3149   795314.2501

                                     S  7 32 52.83 E       2170.0000 FEET

       176+73.0166 PC      797.6062 T                                             337510.2289   794718.6951

 20    184+70.6229 PI    3  0  0.0 D   45 20  0.0 RT  1511.1111 L   1909.8593 R   337615.0000   793928.0000

       191+84.1277 PT      797.6062 T                                             337126.3029   793297.6422

                                     S 37 47  7.17 W       2698.5879 FEET

       206+48.4407 PC      436.6688 T                                             336229.1116   792140.3782

 25    210+85.1094 PI    2  0  0.0 D   17 20  0.0 LT   866.6667 L   2864.7890 R   335961.5626   791795.2737

       215+15.1073 PT      436.6688 T                                             335808.9807   791386.1302
```

Horizontal Alignment List

```
TEXAS HIGHWAY DEPARTMENT        T I E S  ROADWAY DESIGN SUBSYSTEM     *** DESIGN DATA ***
HORIZONTAL ALIGNMENT PROCESS                                                NOV 13, 1974
CONTROL 9999 SECTION 70A                                      COUNTY & HIGHWAY - PRESIDIO COUNTY
                                             HORIZONTAL ALIGNMENT LIST
                                                 FOR ROADWAY G
  COMPUTATIONS BASED ON ARC DEFINITION

 P.I.                                                                                    X              Y


                                      S 20 27  7.17 W       1983.6212 FEET

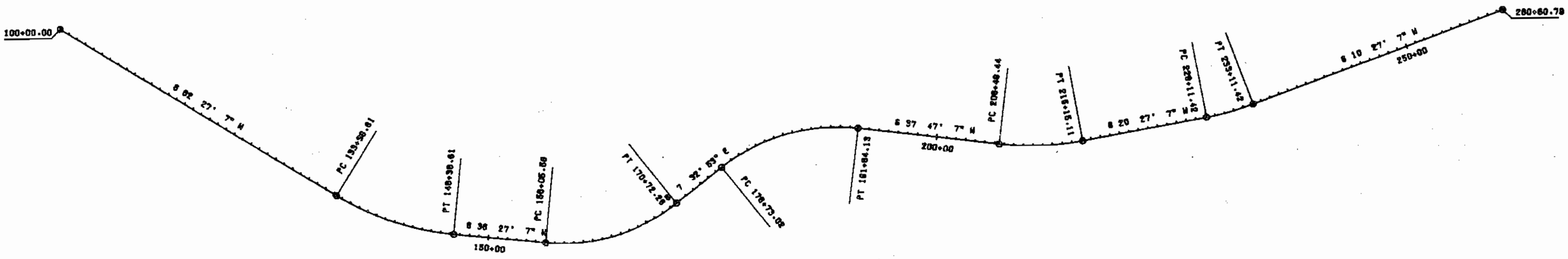

      228+11.4232 PC       250.6366 T                                           335356.0189    790171.5272

 30   230+62.0598 PI     2  0   0.0 D    10  0   0.0 LT     500.0000 L    2864.7890 R    335268.4409    789936.6894

      233+11.4232 PT       250.6366 T                                           335222.9725    789690.2116

                                      S 10 27  7.17 W       3000.0000 FEET


 35   260+60.7867                                                               334724.2061    786986.4676
```



Horizontal Alignment List and Plot

```
                                                                                                  8
TEXAS HIGHWAY DEPARTMENT       T I E S  ROADWAY DESIGN SUBSYSTEM     *** EARTHWORK ***
TERRAIN EDIT & STORE PROCESS                                                      NOV 13, 1974
CONTROL 9999 SECTION 70A                                          COUNTY & HIGHWAY - PRESIDIO COUNTY

              FROM                  TO               STATION     CROSS-SECTION LIMITS
        BASELINE STATION   BASELINE STATION     INCREMENT       LEFT        RIGHT
                                                    (FT)          (FT)        (FT)

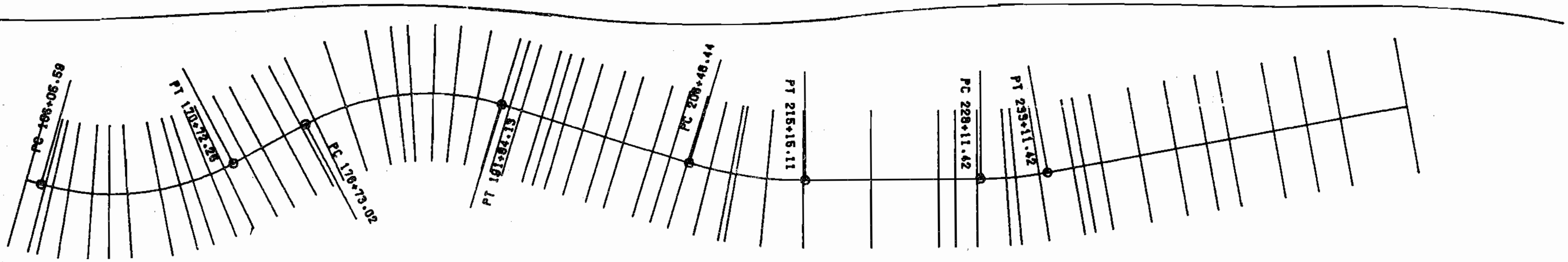
           155+ 0.00          156+45.00            145.0         500L        500R
           157+ 0.00          158+25.00            125.0         500L        500R
           160+ 0.00          161+25.00            125.0         500L        500R
           162+60.00          165+ 0.00            240.0         500L        500R
           166+50.00          167+50.00            100.0         500L        500R
           168+90.00          170+ 0.00            110.0         500L        500R
           171+75.00          173+15.00            140.0         500L        500R
           175+ 0.00          176+40.00            140.0         500L        500R
           177+50.00          180+ 0.00            250.0         500L        500R
           182+50.00          184+ 0.00            150.0         500L        500R
           185+ 0.00          186+65.00            165.0         500L        500R
           188+20.00          190+ 0.00            180.0         500L        500R
           191+80.00          192+50.00             70.0         500L        500R
           193+40.00          195+ 0.00            160.0         500L        500R
           195+80.00          196+75.00             95.0         500L        500R
           198+25.00          200+ 0.00            175.0         500L        500R
           201+40.00          203+65.00            225.0         500L        500R
           205+ 0.00          206+35.00            135.0         500L        500R
           208+ 5.00          209+60.00            155.0         500L        500R
           210+ 0.00          212+30.00            230.0         500L        500R
           215+ 0.00          225+ 0.00            500.0         500L        500R
           226+25.00          227+85.00            160.0         500L        500R
           230+ 0.00          230+70.00             70.0         500L        500R
           232+45.00          235+ 0.00            255.0         500L        500R
           235+80.00          237+10.00            130.0         500L        500R
           240+ 0.00          242+70.00            270.0         500L        500R
           245+ 0.00          246+70.00            170.0         500L        500R
           250+ 0.00          252+50.00            250.0         500L        500R
           255+ 0.00          260+ 0.00            500.0         500L        500R
```

Output of Cross-Section Request

```
TEXAS HIGHWAY DEPARTMENT       T I E S  ROADWAY DESIGN SUBSYSTEM     *** EARTHWORK ***
TERRAIN EDIT & STORE PROCESS                                               NOV 13, 1974
CONTROL 9999 SECTION 70A                                       COUNTY & HIGHWAY - PRESIDIO COUNTY

STATION         LEFT POINT COORDINATES      CENTERLINE POINT COORDINATES       RIGHT POINT COORDINATES
NUMBER            X              Y               X              Y                  X              Y

155+ 0.00     338253.3341   796487.7212     337851.1566   796784.7957       337448.9791   797081.8702
156+45.00     338173.5554   796379.2121     337765.3337   796667.9249       337357.1120   796956.6377
157+ 0.00     338150.5918   796345.7307     337734.2262   796622.5695       337317.8606   796899.4082
158+25.00     338102.0513   796267.2739     337668.4711   796516.2883       337234.8909   796765.3027
160+ 0.00     338042.9322   796152.4608     337588.3856   796360.7573       337133.8391   796569.0538
161+25.00     338007.2627   796067.3765     337540.0661   796245.4982       337072.8695   796423.6200
162+60.00     337975.0798   795973.0809     337496.4697   796117.7612       337017.8596   796262.4414
165+ 0.00     337934.5907   795800.7211     337441.6213   795884.2747       336948.6520   795967.8284
166+50.00     337920.3909   795690.9339     337422.3857   795735.5521       336924.3804   795780.1703
167+50.00     337915.7309   795617.2696     337416.0731   795635.7630       336916.4152   795654.2564
168+90.00     337915.6955   795513.9446     337416.0250   795495.7943       336916.3545   795477.6441
170+ 0.00     337920.9778   795432.9258     337423.1807   795386.0426       336925.3836   795339.1594
171+75.00     337940.4786   795278.0749     337444.8110   795212.3965       336949.1435   795146.7180
173+15.00     337958.8686   795139.2880     337463.2010   795073.6096       336967.5334   795007.9311
175+ 0.00     337983.1696   794955.8910     337487.5020   794890.2126       336991.8344   794824.5341
176+40.00     338001.5595   794817.1041     337505.8920   794751.4256       337010.2244   794685.7472
177+50.00     338016.7122   794687.8466     337518.8006   794642.1957       337020.8890   794596.5447
180+ 0.00     338024.9006   794372.7283     337525.2901   794392.4584       337025.6795   794412.1885
182+50.00     337991.8878   794059.2371     337499.1268   794144.0106       337006.3657   794228.7842
184+ 0.00     337952.5094   793874.1586     337467.9186   793997.3325       336983.3279   794120.5063
185+ 0.00     337918.2386   793752.7368     337440.7584   793901.1034       336963.2781   794049.4700
186+65.00     337847.9534   793556.8313     337385.0560   793745.8445       336922.1587   793934.8578
188+20.00     337766.7571   793378.9625     337320.7064   793604.8802       336874.6557   793830.7978
190+ 0.00     337654.7454   793181.4772     337231.9350   793448.3693       336809.1246   793715.2614
191+80.00     337524.6457   792995.4096     337128.8285   793300.9072       336733.0113   793606.4047
192+50.00     337481.0987   792939.2303     337085.9427   793245.5826       336690.7867   793551.9349
193+40.00     337425.9553   792868.1022     337030.7993   793174.4545       336635.6433   793480.8069
195+ 0.00     337327.9225   792741.6523     336932.7665   793048.0046       336537.6106   793354.3569
195+80.00     337278.9061   792678.4273     336883.7502   792984.7797       336488.5942   793291.1320
196+75.00     337220.6992   792603.3477     336825.5432   792909.7000       336430.3872   793216.0523
198+25.00     337128.7935   792484.8009     336733.6375   792791.1532       336338.4815   793097.5056
200+ 0.00     337021.5702   792346.4963     336626.4142   792652.8486       336231.2582   792959.2010
201+40.00     336935.7915   792235.8526     336540.6356   792542.2050       336145.4796   792848.5573
203+65.00     336797.9330   792058.0324     336402.7770   792364.3848       336007.6210   792670.7371
```



Output of Cross-Section Coordinates and Plot Representing the Cross-Section Lines

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                                                                                                      12
TEXAS HIGHWAY DEPARTMENT        T I E S  ROADWAY DESIGN SUBSYSTEM    *** EARTHWORK ***
TERRAIN EDIT & STORE PROCESS                                                       NOV 13, 1974
CONTROL 9999 SECTION 70A                                             COUNTY & HIGHWAY - PRESIDIO COUNTY
                                 ORIGINAL CROSS-SECTION LIST

STATION          ELEV     DIST      ELEV     DIST      ELEV     DIST      ELEV     DIST      ELEV     DIST
NUMBER           (FT)     (FT)      (FT)     (FT)      (FT)     (FT)      (FT)     (FT)      (FT)     (FT)

155+00.00     4825.37  500.00L   4802.64  458.17L   4793.88  441.16L   4774.42  393.59L   4773.06  390.46L
              4724.67  280.15L   4689.15  157.59L   4665.47   51.66L   4659.25   29.93L   4654.11    0.0
              4651.06   17.74R   4641.15   78.40R   4641.30   89.62R   4628.94  132.01R   4635.35  149.01R
              4653.62  215.58R   4669.66  289.64R   4683.31  349.22R   4685.46  356.22R   4692.68  400.08R
              4696.90  453.87R   4714.50  500.00R

156+45.00     4834.32  500.00L   4822.48  478.01L   4797.87  432.98L   4775.42  384.47L   4731.99  281.55L
              4716.19  245.12L   4679.93  135.12L   4652.10   14.90L   4649.74    0.0     4639.05   67.48R
              4635.92   77.59R   4626.62  113.07R   4628.17  146.34R   4634.25  193.17R   4644.67  260.30R
              4651.64  311.70R   4650.54  324.03R   4659.26  394.69R   4661.51  417.62R   4666.11  433.62R
              4680.52  500.00R

157+00.00     4831.70  500.00L   4826.24  489.55L   4798.11  437.77L   4771.01  378.51L   4718.36  255.54L
              4677.68  130.46L   4648.85    8.33L   4647.55    0.0     4634.92   80.58R   4622.63  122.16R
              4628.12  154.99R   4629.80  162.62R   4631.38  206.44R   4640.12  272.98R   4650.92  362.91R
              4649.27  383.38R   4654.73  443.14R   4655.12  446.33R   4665.30  500.00R

158+25.00     4826.66  500.00L   4798.72  447.77L   4762.56  366.87L   4724.11  279.87L   4720.03  269.16L
              4671.81  118.62L   4644.79    9.88L   4643.30    0.0     4630.33   85.79R   4620.36  129.18R
              4620.79  163.92R   4631.08  210.77R   4633.49  344.05R   4636.46  479.36R   4638.81  500.00R

160+00.00     4804.96  500.00L   4800.02  490.03L   4768.46  413.80L   4732.13  321.26L   4692.83  215.01L
              4653.93   70.66L   4642.22   16.50L   4639.85    0.0     4628.01   82.26R   4625.72  168.50R
              4616.17  201.99R   4613.77  258.98R   4624.39  288.05R   4621.00  385.47R   4620.19  406.23R
              4623.58  500.00R

161+25.00     4788.55  500.00L   4775.69  466.07L   4774.50  462.26L   4733.69  344.23L   4695.00  231.09L
              4654.46   87.03L   4635.12    0.0     4629.64   24.66R   4619.17  123.03R   4618.68  182.15R
              4618.63  190.34R   4611.15  213.40R   4610.50  264.28R   4617.07  294.04R   4618.88  299.84R
              4618.29  335.01R   4614.68  406.52R   4614.24  486.46R   4615.63  500.00R

162+60.00     4780.33  500.00L   4765.22  452.09L   4758.59  432.30L   4731.77  353.02L   4694.80  253.50L
              4658.79  129.15L   4636.67   29.23L   4631.35    6.39L   4630.28    0.0     4614.63   92.94R
              4605.47  134.95R   4606.53  189.89R   4608.37  236.50R   4613.96  264.13R   4613.24  310.20R
              4611.69  390.48R   4609.46  406.87R   4605.20  442.40R   4609.24  500.00R

165+00.00     4788.95  500.00L   4786.51  481.25L   4779.49  454.79L   4769.20  438.56L   4754.66  419.79L
              4724.42  362.19L   4680.44  269.84L   4677.34  263.18L   4638.51  130.89L   4638.19  129.25L
```
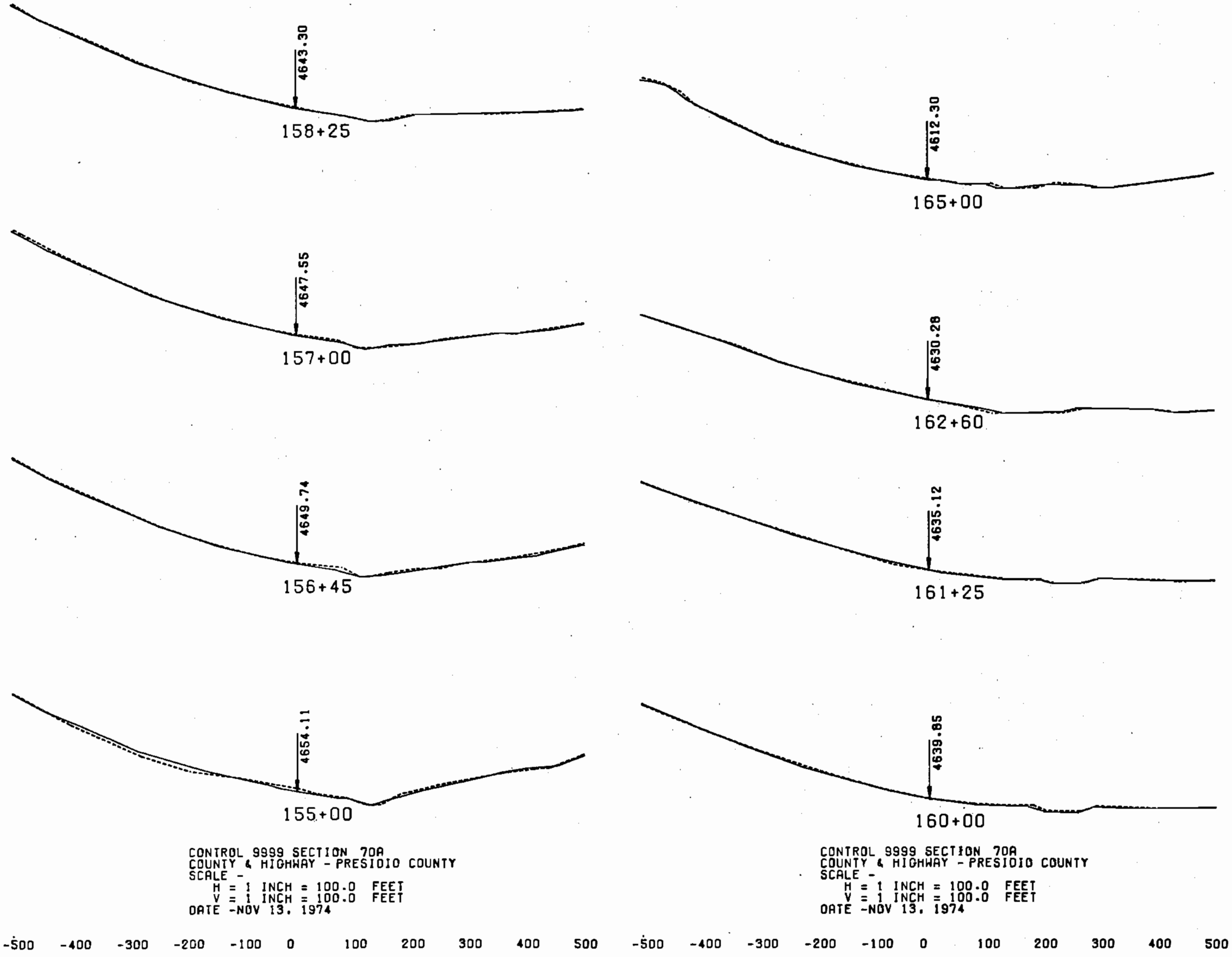
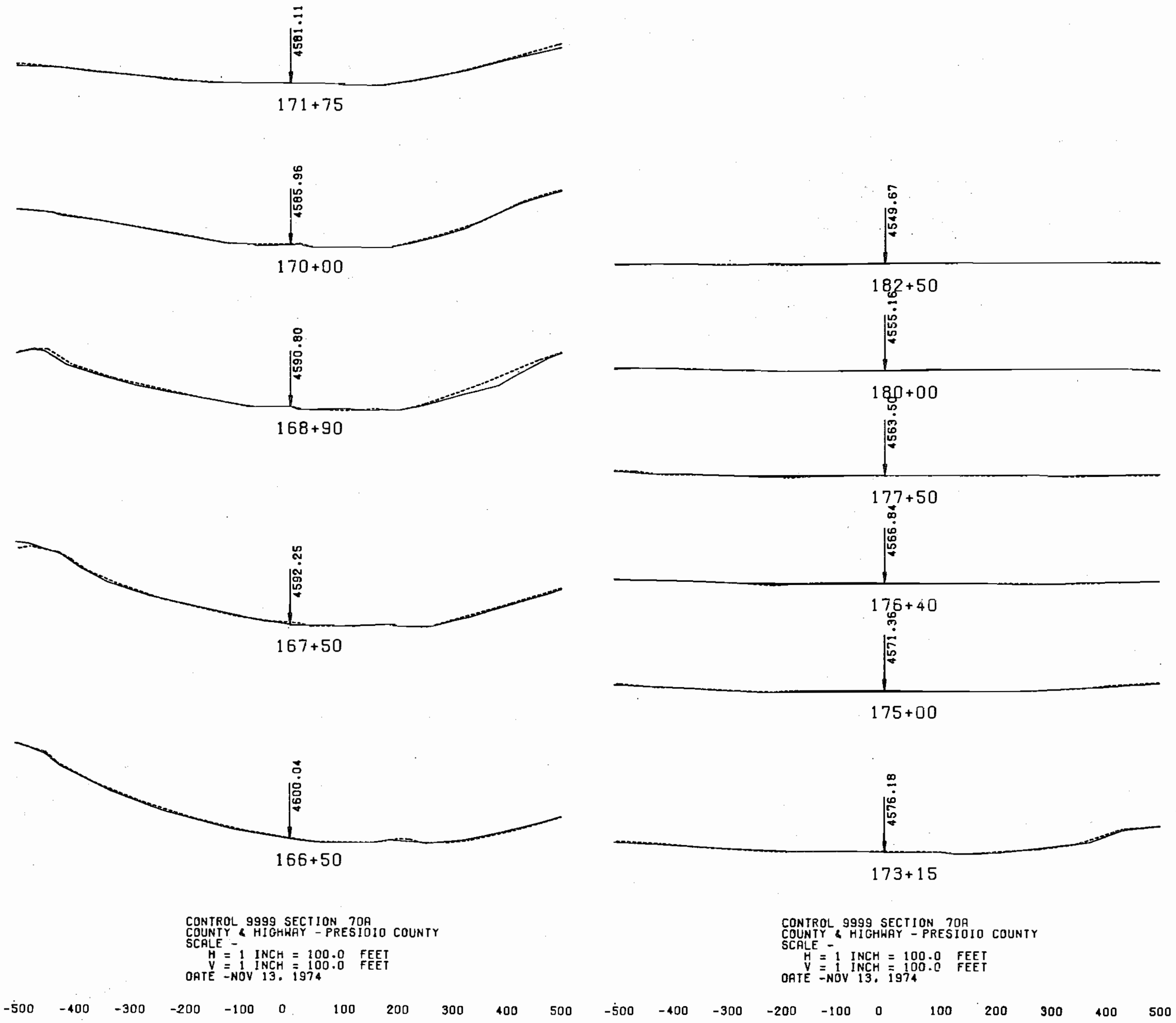

Example Output of Cross-Sections Developed From NGI File

```
                                                                                                           13
TEXAS HIGHWAY DEPARTMENT       T I E S  ROADWAY DESIGN SUBSYSTEM    *** EARTHWORK ***
TERRAIN EDIT & STORE PROCESS                                                          NOV 13, 1974
CONTROL 9999 SECTION 70A                                       COUNTY & HIGHWAY - PRESIDIO COUNTY
                                ORIGINAL CROSS-SECTION LIST

STATION          ELEV     DIST        ELEV     DIST        ELEV     DIST        ELEV     DIST        ELEV     DIST
NUMBER           (FT)     (FT)        (FT)     (FT)        (FT)     (FT)        (FT)     (FT)        (FT)     (FT)

165+00.00      4612.86    6.27L     4612.30    0.0       4609.75   28.84R     4603.97   60.83R     4603.71   81.64R
               4604.55   98.81R     4596.35  121.02R     4596.05  146.45R     4599.75  188.56R     4601.95  214.49R
               4601.72  270.07R     4596.31  306.59R     4595.46  311.79R     4595.31  312.96R     4606.39  404.68R
               4616.73  484.10R     4620.23  500.00R

166+50.00      4773.88  500.00L     4773.34  492.84L     4755.04  446.65L     4740.99  429.86L     4733.24  420.47L
               4731.54  417.26L     4687.15  328.77L     4658.68  254.57L     4649.19  227.90L     4618.86  110.57L
               4615.60   94.60L     4611.03   67.59L     4600.04    0.0       4597.00   18.70R     4592.47   55.49R
               4591.02  131.07R     4590.99  147.95R     4590.72  148.82R     4597.03  186.20R     4595.69  199.46R
               4592.25  245.56R     4590.28  252.77R     4596.77  321.74R     4606.48  369.45R     4615.27  409.42R
               4628.19  460.45R     4639.28  500.00R

167+50.00      4741.82  500.00L     4739.36  478.09L     4720.54  421.08L     4720.07  420.52L     4718.44  417.51L
               4694.36  382.48L     4668.91  334.00L     4644.63  258.91L     4642.08  248.94L     4602.99   69.84L
               4599.04   47.49L     4596.30   21.25L     4592.25    0.0       4590.80    7.62R     4590.91   79.90R
               4588.23   88.24R     4590.39  132.15R     4589.75  138.20R     4592.48  188.76R     4587.51  206.44R
               4588.08  262.00R     4589.46  267.30R     4599.82  305.70R     4604.86  329.95R     4622.82  387.98R
               4646.95  473.59R     4648.33  478.01R     4656.05  500.00R

168+90.00      4687.30  500.00L     4694.26  472.56L     4691.84  450.89L     4687.78  444.11L     4666.10  409.80L
               4648.77  354.59L     4629.55  286.05L     4617.42  223.82L     4593.00   84.86L     4592.03   76.02L
               4590.14   66.49L     4590.80    0.0       4590.80    0.30R     4587.07   11.47R     4585.05   15.89R
               4585.11   65.96R     4587.33  101.38R     4582.71  146.75R     4585.19  173.09R     4583.44  197.43R
               4583.24  200.80R     4592.18  245.65R     4611.96  316.13R     4629.39  384.11R     4644.80  410.19R
               4679.34  475.44R     4688.56  500.00R

170+00.00      4649.14  500.00L     4643.59  435.67L     4642.95  432.87L     4640.25  428.77L     4637.68  418.19L
               4628.01  344.29L     4604.06  210.78L     4593.39  144.88L     4589.33  123.19L     4587.39   70.25L
               4584.10   63.34L     4585.96    0.0       4586.50   18.25R     4584.58   25.94R     4581.60   43.23R
               4580.14  119.94R     4581.73  160.86R     4580.53  180.52R     4588.61  224.57R     4601.16  276.29R
               4616.23  326.28R     4620.51  333.41R     4637.09  369.62R     4662.19  428.12R     4670.12  452.99R
               4683.34  500.00R

171+75.00      4610.65  500.00L     4609.88  479.01L     4607.71  423.36L     4600.43  363.10L     4595.06  299.74L
               4589.74  249.62L     4586.87  234.71L     4584.35  200.67L     4581.45  149.78L     4581.43   22.92L
               4581.11    0.0       4579.96   81.70R     4578.77   91.70R     4577.35  102.02R     4576.82  166.06R
               4582.02  205.40R     4583.94  221.26R     4594.89  278.70R     4601.45  314.09R     4604.66  327.22R
               4621.94  395.10R     4645.75  500.00R
```

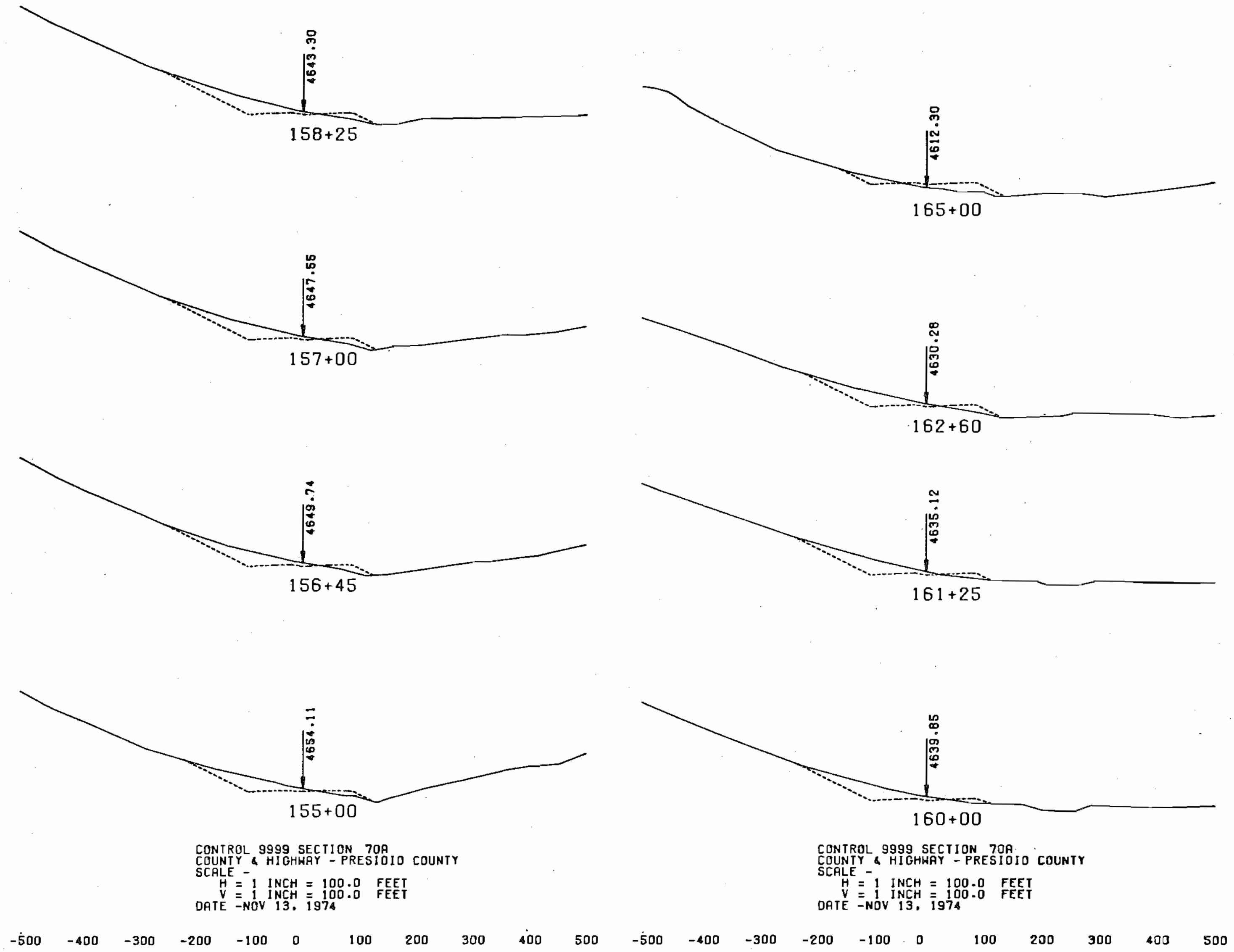
Example Output of Cross-Sections Developed From NGI File



Comparison of NGI/RDS (solid) and Photogrammetric (dashed) Cross-Sections



Comparison of NGI/RDS (solid) and Photogrammetric (dashed) Cross-Sections



Cross-Section Plot of Typical Earthwork Design Using NGI/RDS Cross-Sections

```
TEXAS HIGHWAY DEPARTMENT        T I E S  ROADWAY DESIGN SUBSYSTEM     *** EARTHWORK ***
EARTHWORK QUANTITIES CALCULATION PROCESS                                       NOV 13, 1974
CONTROL 9999 SECTION 7CA                                          COUNTY & HIGHWAY - PRESIDIO COUNTY
                    EARTHWORK QUANTITIES LIST FOR ROADWAYS A B C D E F

                                   ADJUSTED
BASELINE        STATION   STATION   STATION      ACCUM       ACCUM         MASS                   ADDED QUANTITIES
STATION          CUT       FILL      FILL         CUT         FILL       ORDINATE   COMPACTION    CUT          FILL
NUMBER         (CU-YD)   (CU-YD)   (CU-YD)     (CU-YD)      (CU-YD)      (CU-YD)      FACTOR    (CU-YD)      (CU-YD)

155+00.00            0         0         0           0            0            0    1.00000          0            0

156+45.00        17221      2852      2852       17221         2852        14369    1.00000          0            0

157+00.00         7045      1306      1306       24266         4158        20108    1.00000          0            0

158+25.00        16659      2878      2878       40925         7036        33889    1.00000          0            0

160+00.00        23103      2937      2937       64028         9973        54055    1.00000          0            0

161+25.00        16106      1742      1742       80134        11715        68419    1.00000          0            0

162+60.00        16354      2781      2781       96488        14496        81992    1.00000          0            0

165+00.00        16871     10413     10413      113359        24909        88450    1.00000          0            0

166+50.00         2255     13196     13196      115614        38105        77509    1.00000          0            0

167+50.00           93     12150     12150      115707        50255        65452    1.00000          0            0

168+90.00            0     18787     18787      115707        69042        46665    1.00000          0            0

170+00.00            0     15424     15424      115707        84466        31241    1.00000          0            0

171+75.00            0     21914     21914      115707       106380         9327    1.00000          0            0

173+15.00            0     14551     14551      115707       120931        -5224    1.00000          0            0

175+00.00            0     16739     16739      115707       137670       -21963    1.00000          0            0

176+40.00            0     10862     10862      115707       148532       -32825    1.00000          0            0

177+50.00            0      7565      7565      115707       156097       -40390    1.00000          0            0

180+00.00            0     14447     14447      115707       170544       -54837    1.00000          0            0

182+50.00           49      8452      8452      115756       178996       -63240    1.00000          0            0

184+00.00          215      1914      1914      115971       180910       -64939    1.00000          0            0
```

Earthwork Quantities From Design On NGI/RDS Cross-Sections

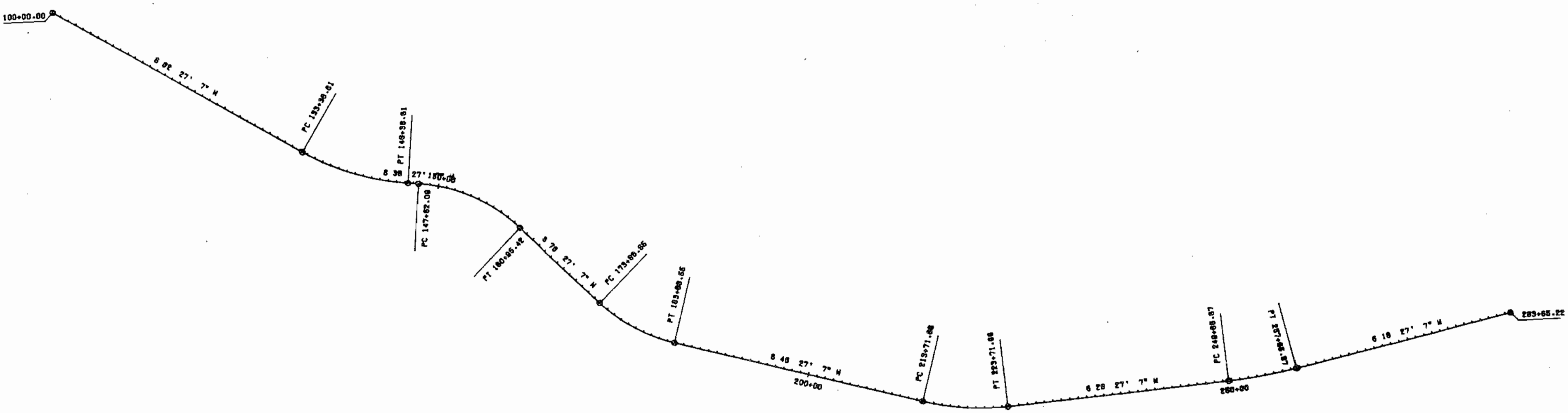
```
                                                                                                              19
TEXAS HIGHWAY DEPARTMENT       T I E S  ROADWAY DESIGN SUBSYSTEM    *** EARTHWORK ***
EARTHWORK QUANTITIES CALCULATION PROCESS                                           DEC 02, 1974
CONTROL 9999 SECTION 704                                        COUNTY & HIGHWAY - PRESIDIO COUNTY
                EARTHWORK QUANTITIES LIST FOR ROADWAYS A B C D E F

                                      ADJUSTED
BASELINE      STATION   STATION   STATION     ACCUM        ACCUM        MASS                   ADDED QUANTITIES
STATION         CUT      FILL      FILL        CUT          FILL      ORDINATE   COMPACTION    CUT        FILL
NUMBER        (CU-YD)  (CU-YD)   (CU-YD)     (CU-YD)      (CU-YD)     (CU-YD)      FACTOR    (CU-YD)    (CU-YD)

155+00.00          0         0         0          0            0           0     1.00000         0          0

156+45.00      17598      1942      1942      17598         1942       15656     1.00000         0          0

157+00.00       7217       917       917      24815         2859       21956     1.00000         0          0

158+25.00      16819      2772      2772      41634         5631       36003     1.00000         0          0

160+00.00      22577      3179      3179      64211         8810       55401     1.00000         0          0

161+25.00      14937      1644      1644      79148        10454       68694     1.00000         0          0

162+60.00      15717      3374      3374      94865        13828       81037     1.00000         0          0

165+00.00      17430     11048     11048     112295        24876       87419     1.00000         0          0

166+50.00       2527     12335     12335     114822        37211       77611     1.00000         0          0

167+50.00        199     11892     11892     115021        49103       65918     1.00000         0          0

168+90.00          0     19081     19081     115021        68184       46837     1.00000         0          0

170+00.00          0     15227     15227     115021        83411       31610     1.00000         0          0

171+75.00          0     21306     21306     115021       104717       10304     1.00000         0          0

173+15.00          0     14402     14402     115021       119119       -4098     1.00000         0          0

175+00.00          0     16978     16978     115021       136097      -21076     1.00000         0          0

176+40.00          0     11274     11274     115021       147371      -32350     1.00000         0          0

177+50.00          0      7887      7887     115021       155258      -40237     1.00000         0          0

180+00.00          0     15035     15035     115021       170293      -55272     1.00000         0          0

182+50.00         12      8566      8566     115033       178859      -63826     1.00000         0          0

184+00.00        126      2418      2418     115159       181277      -66118     1.00000         0          0
```

Earthwork Quantities From Design on Photogrammetric Cross-Sections

```
                                                                                                                          6
  TEXAS HIGHWAY DEPARTMENT        T I E S  ROADWAY DESIGN SUBSYSTEM     *** DESIGN DATA ***
  HORIZONTAL ALIGNMENT PROCESS                                                     DEC 05, 1974
  CONTROL 9999 SECTION 708                                              COUNTY & HIGHWAY - PRESIDIO COUNTY
                                              HORIZONTAL ALIGNMENT LIST
                                                   FOR ROADWAY G
COMPUTATIONS BASED ON ARC DEFINITION

P.I.                                                                                        X             Y

 5     100+00.0000                                                                     342302.4077   799859.6159


                                          S 62 27  7.17 W       4000.0000 FEET


       133+38.6114 PC      661.3886 T                                                  339342.3160   798315.5360

10     140+00.0000 PI    2  0  0.0 D   26  0  0.0 LT   1300.0000 L   2864.7890 R   338755.9132   798009.6492

       146+38.6114 PT      661.3886 T                                                  338362.9498   797477.6580


                                          S 36 27  7.17 W       1480.0000 FEET


       147+62.0908 PC      695.1319 T                                                  338289.5846   797378.3367

15     154+57.2227 PI    3  0  0.0 D   40  0  0.0 RT   1333.3333 L   1909.8593 R   337876.5727   796819.2038

       160+95.4241 PT      695.1319 T                                                  337200.7835   796656.3622


                                          S 76 27  7.17 W       2500.0000 FEET


       173+88.5469 PC      511.7453 T                                                  335943.6432   796353.4352

20     179+00.2921 PI    3  0  0.0 D   30  0  0.0 LT   1000.0000 L   1909.8593 R   335446.1377   796233.5538

       183+88.5469 PT      511.7453 T                                                  335075.2261   795880.9807


                                          S 46 27  7.17 W       4000.0000 FEET


       213+71.6620 PC      505.1396 T                                                  332913.0722   793825.7273

25     218+76.8016 PI    2  0  0.0 D   20  0  0.0 LT   1000.0000 L   2864.7890 R   332546.9484   793477.7053

       223+71.6620 PT      505.1396 T                                                  332321.9351   793025.4498
```

Horizontal Alignment List For an Alternate Route

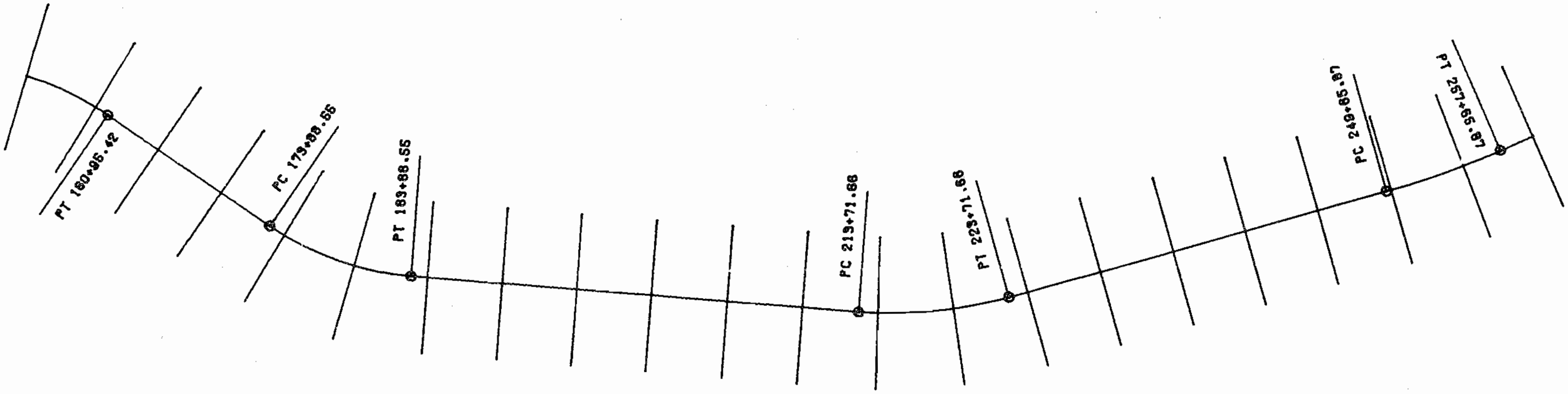
```
                                                                                                                        7
    TEXAS HIGHWAY DEPARTMENT         T I E S  ROADWAY DESIGN SUBSYSTEM     *** DESIGN DATA ***
    HORIZONTAL ALIGNMENT PROCESS                                                         DEC 05, 1974
    CONTROL 9999 SECTION 70B                                               COUNTY & HIGHWAY - PRESIDIO COUNTY
                                                   HORIZONTAL ALIGNMENT LIST
                                                       FOR ROADWAY G
  COMPUTATIONS BASED ON ARC DEFINITION

 P.I.                                                                                       X            Y


                                            S 26 27  7.17 W        3500.0000 FEET


      249+65.8713 PC      400.6511 T                                                    331166.3503   790702.8337

 30   253+66.5224 PI    1  0  0.0 D    8  0  0.0 LT    800.0000 L   5729.5780 R         330987.8811   790344.1276

      257+65.8713 PT      400.6511 T                                                    330861.0710   789964.0742


                                            S 18 27  7.17 W        3000.0000 FEET


 35   283+65.2202                                                                       330038.3513   787498.3600
```



Horizontal Alignment List and Plot for Alternate Route

```
      FROM                     TO                 STATION      CROSS-SECTION LIMITS
BASELINE STATION      BASELINE STATION           INCREMENT       LEFT       RIGHT
                                                    (FT)          (FT)       (FT)

   155+ 0.00             260+ 0.00                500.0          500L       500R
```

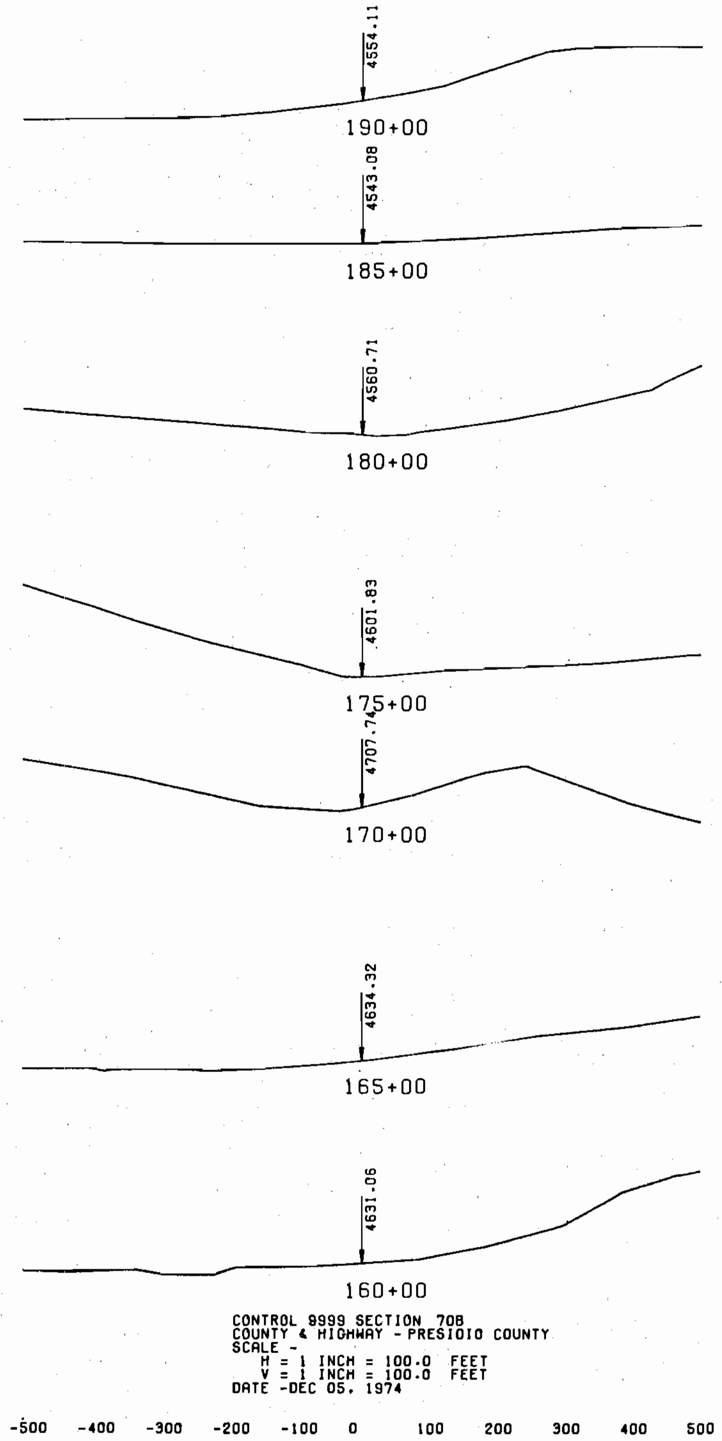
```
STATION          LEFT POINT COORDINATES          CENTERLINE POINT COORDINATES          RIGHT POINT COORDINATES
NUMBER             X                Y                X               Y                   X               Y

155+ 0.00     338009.3249    796456.3756       337748.7402    796883.1022         337488.1554    797309.8288
160+ 0.00     337434.2159    796201.3935       337292.9554    796681.0240         337151.6948    797160.6546
165+ 0.00     336924.5953    796075.4993       336807.4653    796561.5863         336690.3353    797047.6732
170+ 0.00     336438.5084    795958.3692       336321.3783    796444.4562         336204.2483    796930.5432
175+ 0.00     335981.3954    795845.7523       335836.1144    796324.1804         335690.8335    796802.6085
180+ 0.00     335646.1986    795693.7595       335382.0417    796118.2841         335117.8847    796542.8087
185+ 0.00     335338.9263    795441.7950       334994.4452    795804.1937         334649.9642    796166.5924
190+ 0.00     334976.5276    795097.3140       334632.0465    795459.7126         334287.5655    795822.1113
195+ 0.00     334614.1289    794752.8329       334269.6479    795115.2316         333925.1668    795477.6302
200+ 0.00     334251.7303    794408.3518       333907.2492    794770.7505         333562.7681    795133.1492
205+ 0.00     333889.3316    794063.8708       333544.8505    794426.2694         333200.3695    794788.6681
210+ 0.00     333526.9329    793719.3897       333182.4519    794081.7884         332837.9708    794444.1871
215+ 0.00     333182.4294    793388.6456       332822.0645    793735.2537         332461.6996    794081.8617
220+ 0.00     332923.6595    793067.7794       332508.5815    793346.5450         332093.5035    793625.3106
225+ 0.00     332712.4211    792687.8239       332264.7672    792910.5478         331817.1132    793133.2717
230+ 0.00     332489.6973    792240.1699       332042.0433    792462.8938         331594.3893    792685.6177
235+ 0.00     332266.9734    791792.5160       331819.3194    792015.2399         331371.6654    792237.9638
240+ 0.00     332044.2495    791344.8620       331596.5955    791567.5859         331148.9415    791790.3098
245+ 0.00     331821.5256    790897.2081       331373.8716    791119.9320         330926.2176    791342.6559
250+ 0.00     331600.2115    790452.1794       331151.2388    790672.2329         330702.2661    790892.2864
255+ 0.00     331417.4854    790034.1488       330951.0422    790214.2343         330484.5991    790394.3199
260+ 0.00     331261.2616    789583.7273       330786.9670    789741.9823         330312.6724    789900.2373
```



Output and Plot Representing the Alternate Route With Cross-Sections Requested Every 500 feet

```
TEXAS HIGHWAY DEPARTMENT          T I E S  ROADWAY DESIGN SUBSYSTEM     *** EARTHWORK ***
TERRAIN EDIT & STORE PROCESS                                                       DEC 05, 1974
CONTROL 9999 SECTION 70B                                            COUNTY & HIGHWAY - PRESIDIO COUNTY
                                  ORIGINAL CROSS-SECTION LIST

STATION         ELEV      DIST       ELEV      DIST       ELEV      DIST       ELEV      DIST       ELEV      DIST
NUMBER          (FT)      (FT)       (FT)      (FT)       (FT)      (FT)       (FT)      (FT)       (FT)      (FT)

160+00.00     4620.65   500.00L    4617.82   432.77L    4618.62   410.28L    4621.68   334.17L    4614.51   292.23L
              4614.37   242.09L    4613.85   219.40L    4624.93   185.47L    4625.83    95.84L    4628.55    35.56L
              4631.06     0.0      4637.04    84.76R    4638.79    94.29R    4649.39   147.14R    4655.33   179.98R
              4683.66   282.86R    4689.36   299.04R    4732.39   375.39R    4737.60   382.93R    4763.39   464.38R
              4764.45   474.55R    4769.89   500.00R

165+00.00     4620.52   500.00L    4621.45   405.25L    4616.77   380.49L    4618.67   374.61L    4619.84   350.58L
              4620.46   300.99L    4618.60   246.10L    4617.17   231.48L    4620.72   148.07L    4630.03    36.86L
              4634.32     0.0      4636.47    18.48R    4647.48    95.21R    4652.39   137.28R    4671.27   255.08R
              4685.38   394.09R    4700.80   500.00R

170+00.00     4778.62   500.00L    4758.12   374.21L    4753.21   346.47L    4709.80   151.78L    4702.21    33.62L
              4704.25    14.54L    4707.74     0.0      4726.37    77.59R    4727.04    79.58R    4752.30   157.76R
              4758.85   181.86R    4768.75   240.60R    4768.55   245.05R    4765.62   251.36R    4736.05   334.77R
              4730.74   348.80R    4715.03   393.36R    4700.40   445.99R    4686.79   500.00R

175+00.00     4736.18   500.00L    4712.24   425.24L    4704.21   397.82L    4683.80   336.91L    4671.21   294.51L
              4650.32   221.96L    4618.77    90.27L    4601.92    28.87L    4601.47    22.30L    4601.83     0.0
              4602.23    24.08R    4610.63   118.71R    4621.36   341.08R    4622.15   354.84R    4633.89   480.28R
              4634.32   500.00R

180+00.00     4598.28   500.00L    4589.86   402.73L    4577.92   241.15L    4574.97   213.02L    4570.00   142.03L
              4563.54    69.66L    4562.94    25.66L    4560.71     0.0      4558.72    22.84R    4560.49    64.87R
              4565.56    88.90R    4571.40   135.87R    4582.52   215.88R    4596.37   288.63R    4598.40   297.45R
              4628.00   427.27R    4639.73   448.25R    4663.69   500.00R

185+00.00     4545.13   500.00L    4541.17   189.91L    4541.84    71.59L    4542.03    22.12L    4543.08     0.0
              4551.62   179.95R    4553.07   200.51R    4564.41   359.29R    4570.03   500.00R

190+00.00     4525.09   500.00L    4526.79   385.76L    4527.26   323.25L    4527.64   282.22L    4531.15   203.49L
              4536.49   133.01L    4540.02   107.84L    4540.31   105.58L    4549.26    28.46L    4554.11     0.0
              4565.34    65.99R    4576.34   120.68R    4597.84   182.66R    4626.06   270.36R    4627.12   275.36R
              4631.79   315.33R    4635.45   420.84R    4634.00   500.00R
```

Example Cross-Section Output for Alternate Route



Example Cross-Section Plots for Alternate Route

Appendix B. Description of the Algorithm For Building Roadway Cross-Sections From the NGI File

DESCRIPTION OF THE ALGORITHM FOR BUILDING ROADWAY CROSS-SECTIONS FROM THE NGI FILE

After the Numerical Ground Image file has been built, it can be used to build roadway cross-sections along any selected baseline alignment. In order for this to be accomplished without any errors, the alignment must be defined such that all of the cross-sections to be taken lie within the range of the data stored on the NGI data file.

Assuming that a roadway alignment has been properly defined, a request for roadway cross-sections must contain the station limits on the specified alignment, the increment to be used between cross-sections, and the left and right offset distance for the cross-sections. Using this information, the surface coordinates for the left, centerline and right points may be computed for all requested cross-sections.

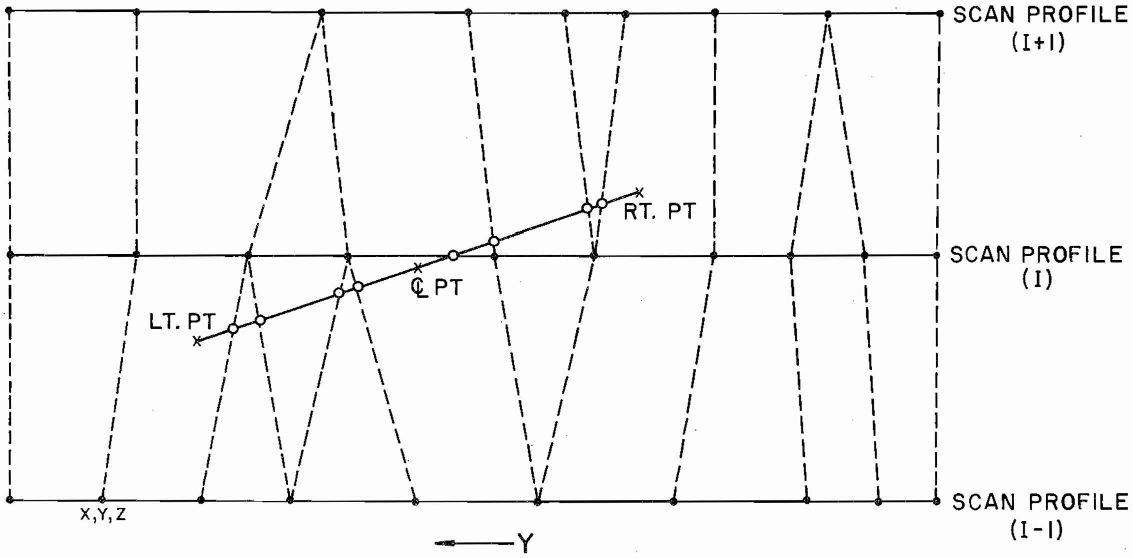
The algorithm for building roadway cross-sections from the NGI data file is based upon (1) receiving the three surface coordinates for the left, centerline, and right points on the roadway cross-section to be computed and (2) intersecting the bounded line (or line segment) defined by these three points with the proper connected point data of the NGI file.

The NGI data file would normally be so massive that it would be quite impractical to have all the data in core at the same time; therefore, an algorithm is used. The algorithm first brings into core only the flight strip index array. This array is in the first record of the file and contains the surface coordinate limits for each strip along with the number of scan profiles in each strip. This array is brought into core only once and remains resident throughout the whole process.

The algorithm uses the left point of the roadway cross-section to be computed to find which strip in the file contains the data that is relevant for computing that roadway cross-section. The method used for finding the proper strip is (1) to compute the interior angles between the given left point, the beginning point of the strip and the ending point of the strip and (2) to check if the angles at the beginning and ending points are less than or equal to a right angle. This is done for every strip until the proper one is found.

When the proper strip has been located, then the NGI scan profile index array for that strip is brought into core from the NGI data file. The NGI scan profile index array contains the scan profile station number, the number of points, and an index to retrieve the point data for every scan profile within the strip. Now the algorithm must translate and rotate the three given roadway cross-section points (left, centerline, and right) in such a way as to convert them to the coordinate system of the strip itself. When this is accomplished, then the X-coordinate of the left point of the three given points may be used to determine between which two scan profiles the computed roadway cross-section begins. A search through the scan profile station array is used to find the two proper profiles and then the retrieval indices are used to bring into core the actual point data for the two scan profiles. The basis for the whole algorithm centers around maintaining only two relevant scan profiles in core at the same time. This is done by computing all possible roadway cross-section points between the resident scan profiles and then retrieving the next scan profile and wiping out the unnecessary one of the previous two.

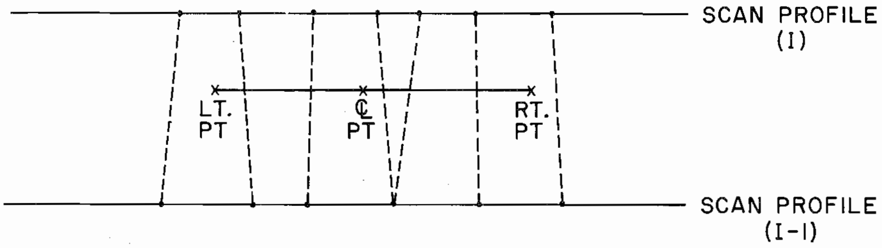
In the following sketch,



the left point lies between scan profile I and I-1. Data for these profiles is retrieved and the intersection points are calculated up to section I, then I-1 data is released and I+1 data is captured. Now the rest of the intersection points are calculated between I and I+1.

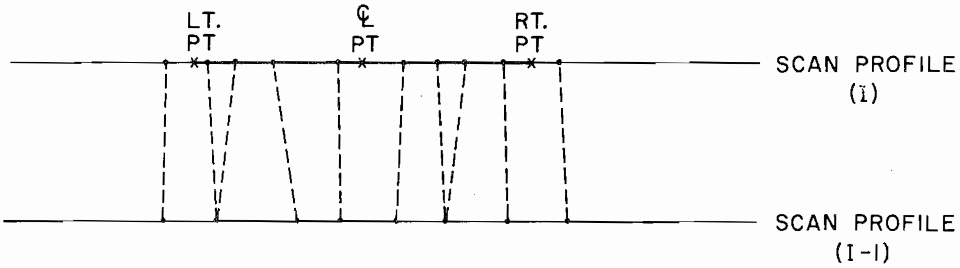
The algorithm for calculating the intersection points, i.e. the points that make up the computed roadway cross-section, must be able to handle several distinct cases:

Case 1: The three given points form a line segment that is parallel to and between two scan profiles.



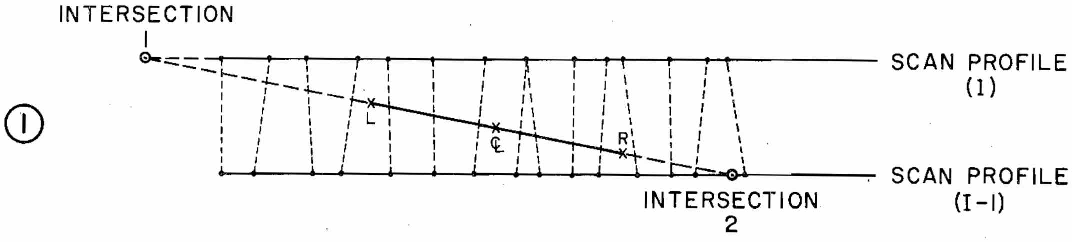
This is a special case because the line does not intersect either of the two profiles. Since the X-coordinate in this case remains constant, it is possible to use the equation for each connection line and solve for Y's until a Y coordinate is found that is bounded by the left and right given points.

Case 2: The three given points form a line segment that is coincident with a scan profile.

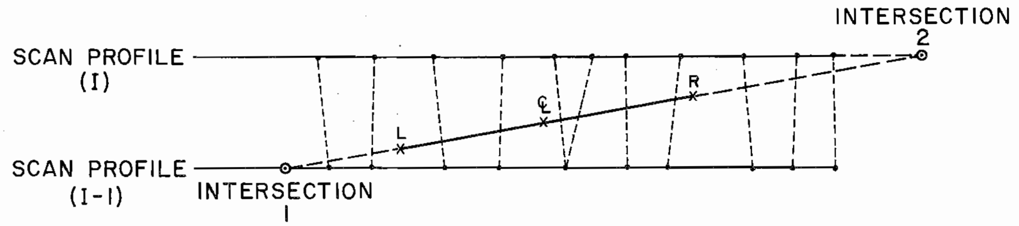


This is a simple case where the only points used will be the three given points (for which a Z coordinate must be interpolated) and all scan profile points bounded by the left and right given points.

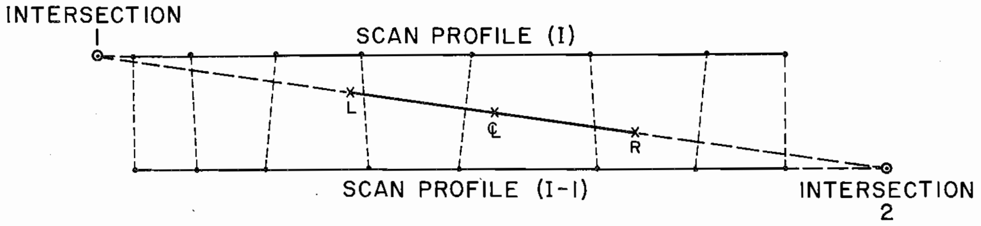
Case 3: The three given points form a line segment that is neither parallel to nor coincident with the scan profiles. This is the general case and there are many small variations that must be handled. The method used is to find the intersection points between the entire line defined by the three given points and the two entire lines defined by the scan profile points for the forward and the back scan profiles.



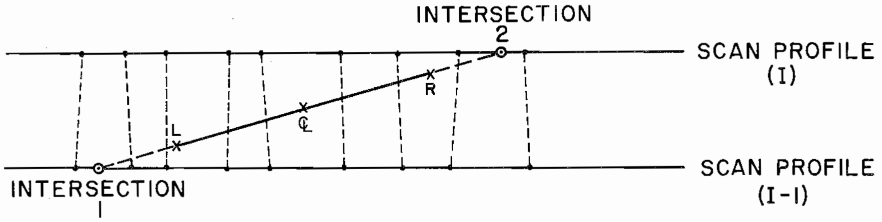
②



③



④



The examples show only some of the variations that are possible. When the intersections 1 and 2 are found, it is possible by intersecting the connection lines for each set of NGI points with the given line to find all the intersections that fall within the left and right given cross-section points. The Z-coordinate (elevation) for all the points found can be interpolated from the NGI point data.

Appendix C. NGI Computer Program Documentation

COMPUTER ARRANGEMENT AND STORAGE
OF THE NUMERICAL GROUND IMAGE DATA FILE

The NGI data file is composed of X, Y, Z point values, point connectors, and sufficient indices to enable retrieval of information for various applications. The first record of the file always contains the flight strip coordinate limits for each strip, the number of scan profiles for each strip, and the total number of strips in the file. At present, there can be a total of 47 strips with a maximum of 200 scan profiles for each strip. The coordinate limits are state plane coordinates for the beginning and ending points on the centerline of the flight strip. These limits are used later for finding which strip contains a given point. The next 47 records of the file are used to store the scan profile index arrays for each strip. These records are always reserved for the index arrays regardless of how many strips are in a given job. The index arrays contain the station for each scan profile, the number of points stored for that scan profile, the position (1-400) in the 400 word record where the point data for the scan profile begins, and the record number on which the data begins. The station occupies one word (4 bytes); and the number of points, the word position in the record, and the record number itself are all packed into a single word (4 bytes). Thus, two words are sufficient for storing the indices for one scan profile and 200 indices may be stored in the 400 word record.

The point data begins on record 49 and is stored dynamically, i.e. there is no wasted space on any data record since the point data for several scan profiles may be packed into the same disk record. This conserves needed space when a large volume of data is necessary for a given job, and yet the individual data points for any given scan profile may be easily retrieved with the indices provided. All point data for a given scan profile has an X value which is the station for the scan profile so that only one stored station value is sufficient to describe the X coordinate for up to 200 stored points on a scan profile. However, the distances from the flight strip centerline (Y-coordinate) and the elevations (Z-coordinate) for each point on the scan profile must be stored. The maximum distance allowed is 9999 feet left and right of the centerline and all distances are taken in even feet. The elevations are taken in tenths of a foot and have a maximum value of 9999.9 feet. Efficient storage of these values necessitates packing the distance and elevation into a single word of storage (4 bytes). All of the points on a scan profile must somehow be related to the points on the previous scan profile and the next scan profile. This is accomplished by storing point connectors that contain the point number from one scan profile and the point number on the previous scan profile that should be tied together. The two point numbers that make up the connector are packed into a single word (4 bytes). The point data for the first scan profile of a strip will have no connectors since there is no previous scan profile to connect the points to; however, every point on the remaining scan profile will have at least one connector tying it to a point on the previous scan profile. If a single point connects with more than one back point, then a connector is stored for each connection. In the data records, the number of connectors for a scan profile immediately follows the stored distance/elevation values. If the number of connectors is other than zero, then following it will be the number of connectors specified. Data for the next scan profile begins immediately following the last scan profile connectors; and, when the data reaches the end of the record, that record is written back out to disk and the remainder of the data is stored on the first part of the next record. This dynamic storage of point data is maintained until all point data has been stored for every scan profile for all strips. An arbitrary upper limit of 2350 four hundred word records has been set to handle massive amounts of point data, but this limit can be easily revised up or down to better handle jobs in the future.

Rec. 1 Flight Strip Index Record (Maximum 47 Strips)

	1						376			400
Rec. 1	$BegX_1$	$BegY_1$	$EndX_1$	$EndY_1$	...	$EndY_N$	No. of $Prof._1$	...	No. of $Prof._N$	No. of Strips
	R*8	R*8	R*8	R*8		R*8	I*2		I*2	I*2
	1st Strip					Nth Strip	1st		Nth	

$1 \leq N \leq 47$

BegX, BegY - R*8 State plane coordinates for the beginning point on the centerline of the strip.
EndX, EndY - R*8 State plane coordinates for the ending point on the centerline of the strip.
No. of Prof. - I*2 Number of scan profiles stored for any given strip.
No. of Strips - I*2 Number of strips stored for any given job.

(See Figure C-1.)

Rec. 2-48 Scan Profile Index Records (Maximum 200 Scan Profiles)

									400
Rec. 2	$XSTA_1$	No. of Pts_1	$Index_1$	$Data_1$ Record	...	$XSTA_{M_1}$	No. of Pts_{M_1}	$Index_{M_1}$	$Data_{M_1}$ Record
	I*4	I*4 ✱							

Index Record For Strip 1

$1 < M_1 \leq 200$

⋮

$1 < M_N \leq 200$

										400
Rec. N+1	$XSTA_1$	No. of Pts_1	$Index_1$	$Data_1$ Record	...	$XSTA_{M_N}$	No. of Pts_{M_N}	$Index_{M_N}$	$Data_{M_N}$ Record	▨

Index Record For Strip N

XSTA - Station number for the scan profile.
✱ No. of Pts. - Number of points (elevations and distances) stored for any given scan profile.
✱ Index - Location in the record where the stored point data begins.
✱ Data Record - Disk record upon which the stored point data begins.

✱ Packed Index (4 Bytes)

X X X	X X X	X X X X
No. of Pts.	Index	Data Record
1-200	1-400	1-2398

(See Figure C-1.)

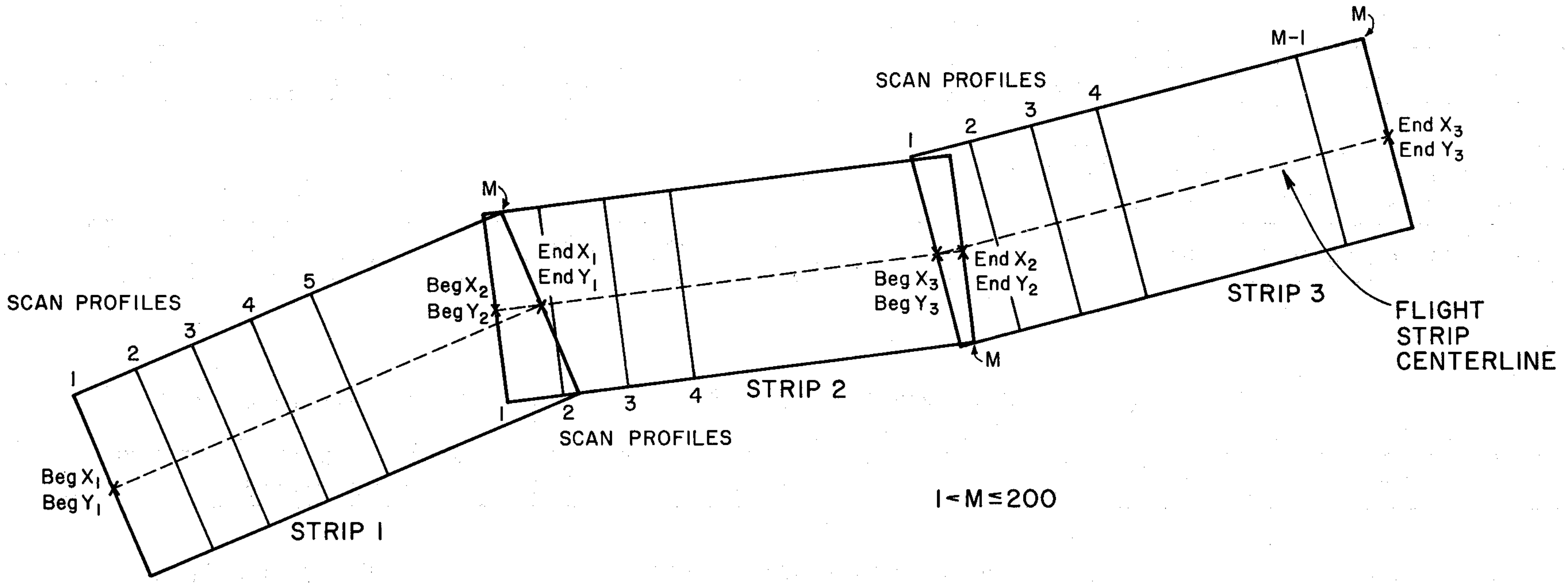
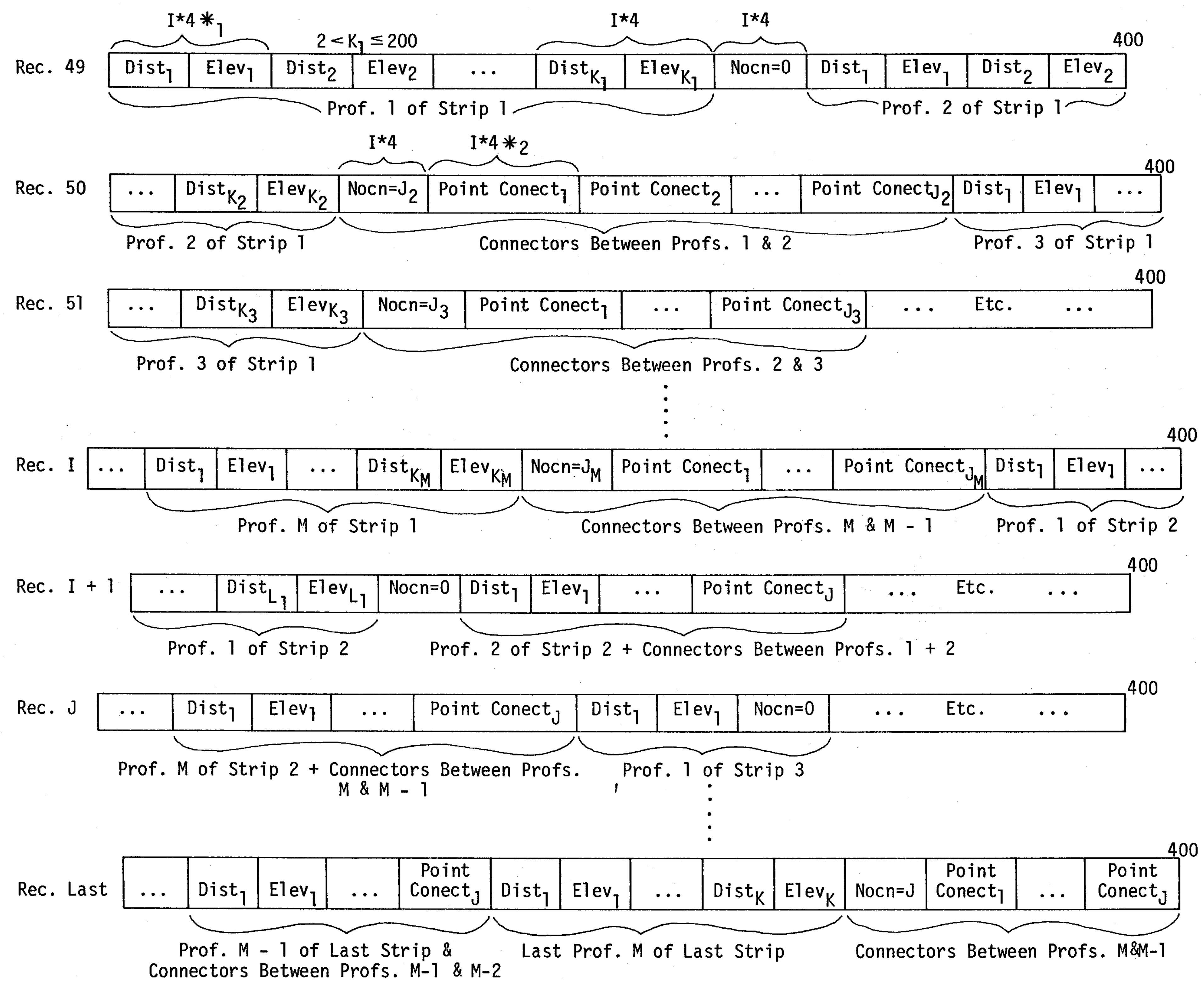


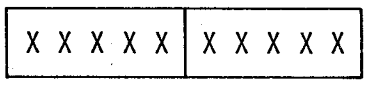
Figure C-1. Multiple Strips with Scan Profiles

Rec. 49-2398 Scan Profile Data Records (Dynamic)



$*_1$ { Dist - Distance from the strip centerline of the given point biased by 10,000 feet.
{ Elev - Elevation for the given point.
Nocn - Number of point connectors between two given scan profiles.
$*_2$ Point Conect - Connector between a point on one scan profile and a point on an adjacent scan profile.

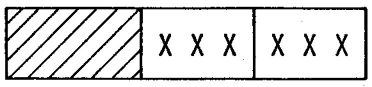
$*_1$ Packed Data (4 Bytes)



Dist. in Feet
(Present Max.
9999 Ft L or R)
1-19999

Elev. in Tenths
of Feet (<10,000)
.1-9999.9

$*_2$ Packed Index (4 Bytes)



Index to Point
on Ahead Prof.
1-200

Index to Point
on Back Prof.
1-200

PROGRAM DESCRIPTIONS

WRITTEN IN FORTRAN IV FOR IBM 370 MOD 155

NGI Driver

This routine is the driver for the numerical ground image file builder process. Its only concern is reading the header card and transferring control to subroutine NGI to do the actual file building. When the NGI file has been built, this routine will store the file on tape if so requested on the header card.

Subroutine NGI

Subroutine NGI is the routine that actually processes the data and stores it as the NGI disk file. NGI utilizes a read routine called CARD to read in all the given points for a given NGI scan profile; then it takes this data (in the form of a station for the scan profile and numerous elevations and distances across the scan profile) and packs it into a smaller area, and then it computes the points that are to be connected to the points on the last scan profile stored. In this way the completed NGI file is a series of interconnected elevations and distances (from the centerline) that describe the ground in question. NGI handles storage of all the necessary indices and limits required later for efficient data retrieval.

Subroutine PREP

Subroutine PREP is a routine within the RDS system that processes a cross-section request card and prepares the station file for the cross-section building routine. PREP reads an RT 70 card for the beginning and ending stations that cross-sections are to be computed for, the station increment between cross-sections, the cross-section width left and right, and a tape flag. If the tape flag is set, PREP reads the NGI file from tape and stores it on the disk. PREP opens the station file and stores on it all the stations (along with their left and right widths) for which a cross-section is to be computed. When all RT 70 cards have been processed, PREP passes the open station file to subroutine PLIST.

Subroutine PLIST

Subroutine PLIST is a routine within RDS that stores on the station file three state plane coordinates for the leftmost point, the centerline point, and the rightmost point of the cross-section to be computed. PLIST first retrieves the previously stored alignment along which the cross-sections will be computed, then using subroutine CALXY calculates the left, centerline, and right point for a station (with widths) from the station file and restores these coordinates in place of the left and right cross-section widths. PLIST then calls subroutine XBILD (the cross-section builder routine) which computes the entire cross-section using the three given coordinates and the NGI disk file. XBILD replaces the three given coordinates with the computed cross-section and PLIST stores the cross-section on the station file and calculates three more coordinates for the next station. PLIST continues until all stations have been processed.

Subroutine XBILD

Subroutine XBILD is a routine within RDS that takes the three given state plane coordinates and computes the entire cross-section through these points using the previously stored NGI file. XBILD first retrieves the coordinate limit arrays from the file and stores them in core. This is done only once for a given job. A search is then made to find which strip contains the given left point. When the proper strip is located, its scan profile index array is retrieved and stored in core. Another search is made to determine which scan profile(s) the left point of the cross-section falls on or between. When the proper NGI scan profiles are found, they are stored in core along with the point connectors. Now cross-section points can be computed at every intersection of the given line with various connected NGI scan profile points. If the whole cross-section cannot be computed between two adjacent NGI scan profiles, then more NGI scan profiles will be retrieved until the cross-section is complete. XBILD returns with the computed cross-section stored in the station file array.

DEFINITION OF VARIABLES

NGI Driver

ENDFL - End of file check variable, initialized to 1.
IQUIT - Flag denoting termination of processing, initialized to 0.
IYES - Constant 'Yes'.
JARG - Associated variable used in I/O for NGI disk file.
LAST - Number of last record on NGI file.
RECRD (400) - Array that NGI record is read into or written from.
SYSIN - Card reader unit designation = 5.
SYSOT - Printer unit designation = 6.
SYSTP - Tape unit designation = 16.

Subroutine NGI

CONECT (200) - Array containing point connector indices.
DATA (400) - Array containing input distances and elevations.
DBREC (188) - R*8 array used to store strip coordinate limits.
DIST (2) - Array with distances between fences for any scan profile.
ENDFL - Same as NGI driver.
FENCE (4) - Array indicating points on scan profiles which are boundary fences.
FRAC (4) - Array with ratios of distances between points.
I - Index used different ways.
IARG - Associated variable used for I/O with NGI disk file.
ICNT - Counter for multiple input points.
IDIS (2) - Array with a boundary fence distance.
IFL - Flag used to enter different areas of program.
IFRST - Flag denoting first time through logic.
INDX - Do-loop begin limit used to store NGI data.
IQUIT - Same as NGI driver.
IREC - Number of record of NGI file at any given time.
ISTRP - Logic flag indicating type of NGI card read.
ITYPE - Type designator for multiple shots on cross-section.
I2REC (48) - I*2 array used to store number of scan profiles per strip.
J - Index used various ways.
JCARD - Common variable indicating status of input cards.
JFL - Flag denoting forward or back scan profile for connecting points.
JNDX - Index for storing station and indices.
K - Do-loop index.
MAX - Constant set to maximum record size for NGI record.
N - Do-loop limit set to number of points.
N1 - Do-loop begin limit.
N2 - Do-loop limit.
N3 - Do-loop begin limit.
NOCN - Number of connectors associated with a given scan profile.
NOPT - Number of points (Dist, Elev) on a given scan profile.
NOSEC - Number of scan profiles in a given strip.
NOSTR - Number of strips in a given job.
NX - Do-loop limit.
PNTR (4) - Array used to store pointers in the connector building process.

Subroutine NGI (Cont'd)

REC (400, 2) - Array used to hold NGI data until ready to be written on disk.
SDATA (200, 2) - Array used to hold intermediate NGI data in packed form.
TNOPT - Number of points (Dist, Elev) on the adjacent scan profile.
XSTA - Station number (x-coor) associated with a given scan profile.
XYBE (4) - Beginning and end state plane coordinates for a given strip.

Subroutine PREP

ENDFL - Same as NGI driver.
EQTAB (7, 20, 2) - Table containing alignment equation stations (if any).
ESTA - Equation station from table.
I - Do-loop index.
I2 - Do-loop limit set to number of equations on table.
IBEG - Beginning station from request card.
IC13 - Variable containing contents of col. 13 of card.
ICHWY (4) - County and highway name for heading print-out.
IDATE (4) - Data array for heading print-out.
IEND - Ending station from request card.
IMAGE (20) - Card image array used for input.
INDEX - Associated variable used for I/O on disk file 8.
IPAGE - Page number for heading print-out.
IQUIT - Same as NGI driver.
IRSET - System flag for reset condition.
IRTYP - System flag for type of run.
ISTA1 - Integer part of station number for print-out.
ISTA2 - Integer part of station number for print-out.
ITAPE - Flag indicating if NGI file stored on tape.
ITYPE - Variable indicating card type (request card).
IWDL - Offset width left.
IWDR - Offset width right.
IYES - Constant 'Yes'.
JCSTA - Station stored on STFIL array.
JEQ - Equation flag.
JKEY - Logic flag.
JOBNO (2) - Job number array for heading print-out.
JTAPE - System indicator of tape condition.
KEYC - System indicator of next routine to be executed.
KEYT - System indicator if tape other than NGI was read.
L - Constant 'L'.
LCNT - Line counter for print-out.
LORL - Left offset indicator.
LORR - Right offset indicator.
NGIDX - Associated variable for NGI disk file.
NGITP - Tape unit number for NGI file 16.
NINE - Record initialization constant = 999999999.
NOEQ (26) - Array of number of equations.
ONE - Constant '1'.

Subroutine PREP (Cont'd)

OSTA - Old ending station number for last request.
OWIDL - Old offset width left for last request.
OWIDR - Old offset width right for last request.
RECRD (400) - Array that NGI record is read into or written from.
RT70 - Constant 'RT70' signifies cross-section request card.
STA1 - Real part of station number for print-out.
STA2 - Real part of station number for print-out.
STAF - Station file name = 'STAF'.
STFIL (852) - Station file record array.
SYSER - Error print-out unit number = 4.
SYSIN - Card reader unit number = 5.
SYSOT - Format print-out unit number = 6.
WIDEL - Offset width left.
WIDER - Offset width right.
XNCR - Station increment.
XPUT - ISAM record creation key.
XSTA - Input station number to subroutine STATN.
XXTA (2) - Output array from subroutine STATN.
YNCR - Station increment.

Subroutine PLIST

BAZ - AZIMUTH or bearing for subroutine BRDIS.
BDIST - Distance variable for subroutine BRDIS.
BX1 - First point's X value for subroutine BRDIS.
BX2 - First point's Y value for subroutine BRDIS.
BY1 - Second point's X value for subroutine BRDIS.
BY2 - Second point's Y value for subroutine BRDIS.
ENDFL - See NGI driver.
HASTA (50) - Array of horizontal alignment data stations.
I - Do-loop index.
ICHWY (4) - See subroutine PREP.
IDATE (4) - See subroutine PREP.
IEF - End of file flag.
IPAGE - See subroutine PREP.
IQFLG - Logic flag for closing station file.
IQUIT - See NGI driver.
ISTA1 - Integer part of station number.
ISTRP - Strip flag (parameter for subroutine XBILD) initialized=0.
JOBNO (2) - See subroutine PREP.
KPAG - Indicator of existence of horizontal alignment data.
LCNT - See subroutine PREP.
N - Do-loop limit.
NINE - See subroutine PREP.
NTIME - ISAM set counter.
NOEL - Number of elements of data for horizontal alignment G.
PI2 - Constant = $\pi/2$ radians.
STAF - See subroutine PREP.
STA1 - See subroutine PREP.
STFIL (852) - See subroutine PREP.
SYSER - See subroutine PREP.
SYSOT - See subroutine PREP.
WIDEL - See subroutine PREP.

Subroutine PLIST (Cont'd)

WIDER - See subroutine PREP.
XCLOS - ISAM close key.
XESTL - ISAM reset key.
XGET - ISAM retrieval key.
XOPEN - ISAM open key.
XPUTX - ISAM record replacement key.
XSETL - ISAM set key.
XSTA - Cross-section station number.
XTFIL (6) - X, Y coordinates (state plane) for the left, centerline, and right of given cross-section.
ZERO - ISAM initial record key.

Subroutine XBILD

ANG - Interior angle between beginning and end point and left point.
ANGL (D, D_1, D_2) - Statement function for computing enclosed angle (given three sides of triangle D, D_1, D_2).
CONECT (250, 2, 2) - Array of point connectors between forward and back cross-sections.
COSA - Cosine of rotation angle for converting state plane to strip coordinates.
DELTX - Difference of X's for axis translation.
DELTY - Difference of Y's for axis translation.
DIFF - Difference of left cross-section point with any NGI scan profile station.
DIST - Distance from beginning to end of strip.
DIST1 - Distance from beginning to left cross-section point.
DIST2 - Distance from end to left cross-section point.
EPS - Epsilon factor = 5×10^{-3}
FRAC - Fractional distance intersection is between two NGI points.
I - Index for NGI scan profile for strip.
I1 - Index counter for computed cross-section.
IB - Index used to pick out relevant data from disk record.
IBAC - Index for the back connector point.
IBC - Index for the back connector point.
IBEG - Index to beginning strip for search.
IBIAS - Constant = 1000 used to bias Y values (keeps them positive).
ICLFL - Flag set to which point of computed cross-section is the ℄ point.
IDFLG - Flag denoting if intersection point is on NGI scan profile.
IDIST - Integer used to store distance for maintaining precision.
IELV - Integer used to store elevation for maintaining precision.
IFD - Index for the forward connector point.
IFIND - Logic flag to skip test after first time.
IFLG - Logic flag to skip code after first time.
IFWD - Index for the forward connector point.
IKEY - Logic flag used in computed go to.

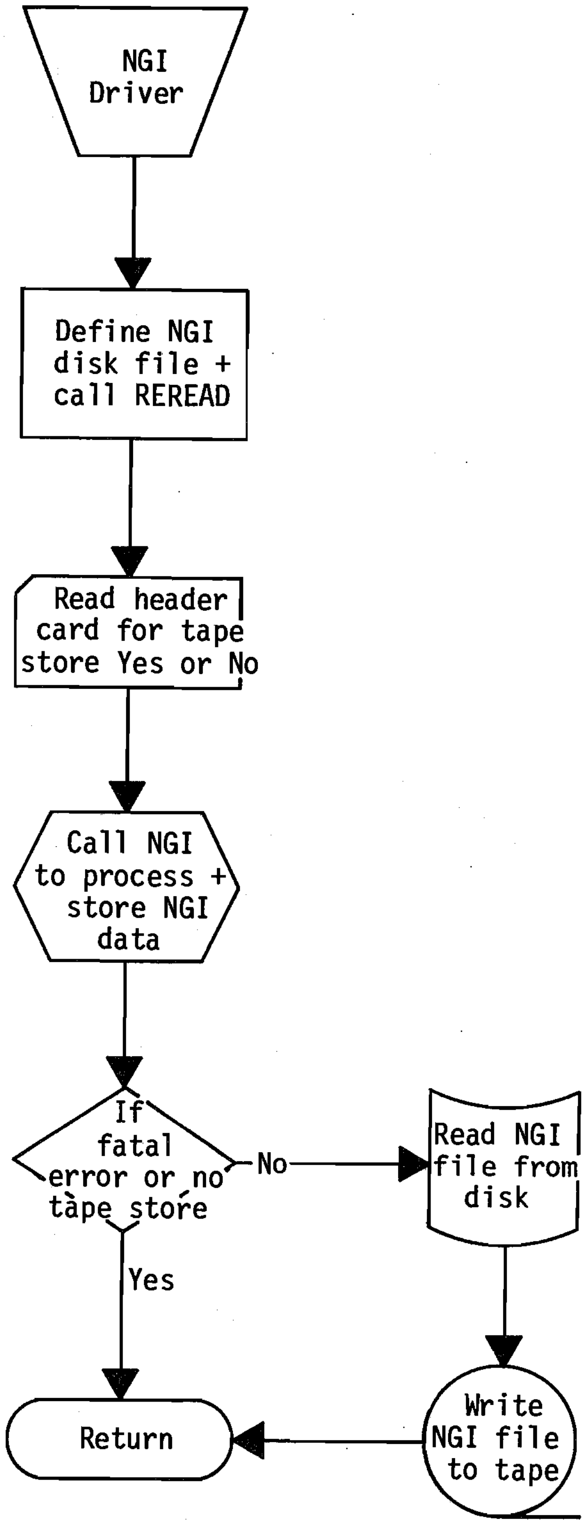
Subroutine XBILD (Cont'd)

ILAST - Limit for points in search procedures.
INDX (200) - Array of indices that point to data in the disk file.
IONFL - Flag telling if left point of cross-section is on NGI scan profile.
IQFLG - Quit flag to get out of loop.
IREC - Index as to which disk record is in core.
ISGN - Increment = ± 1 depending on which way alignment runs.
ISTRP - Strip flag set = strip number being used at present.
IXFLG - Counter for given (X,Y) coordinates (left, ℄ , right).
J - Index as to which NGI scan profile is in core.
JARG - Associated variable for NGI disk file.
JREC - Index as to which record from NGI file is in core.
K - Index = 1 or 2 where 1 means the back scan profile and 2 means the forward.
K1 - Index = 1 or 2 where 1 means the back scan profile and 2 means the forward.
L - Index to points for (X,Y,Z) computations.
L1 - Index used for shifting storage areas.
L2 - Index used for shifting storage areas.
LAST - Limit for points in search procedures.
LINE - Logic flag used in computed go to.
LX - Index for (X,Y,Z) computations.
M - Index to points for (X,Y,Z) computations.
M1 - Index to points for (X,Y,Z) computations.
M2 - Index to points for (X,Y,Z) computations.
MAX - Maximum number of words in NGI record = 400.
MM - Do-loop limit = total number of points for computed cross-section.
MX - Index for (X,Y,Z) computations.
N - Variable containing number of scan profiles for any given strip.
NCR - Index increment = ± 1 depending on which direction on scan profile.
NGIFL - NGI flag indicates if left point of cross-section is on ahead scan profile, on back scan profile, or between scan profiles.
NINES - See subroutine PREP.
NOCN (2) - Number of point connectors for ahead scan profile and back scan profile.
NOPT (2) - Number of points for ahead scan profile and back scan profile.
NOSEC (47) - Array of number of scan profiles in each strip.
NOSTP - Number of strips stored on NGI file.
PI - Constant π = 3.1415926535728.
SINA - Sine of rotation angle for converting state plane to strip coordinates.
SQDIS - Square root of distance^2 between point (X,Y) and points (X1,Y1).
STFIL (852) - See subroutine PREP.
STORE (400) - Array used to retrieve a data record from the NGI file.
STRX (3) - X-coordinate strip for a given strip for the left, ℄ , right points of a given cross-section.
STRY (3) - Y-coordinate strip for a given strip for the left, ℄ , right points of a given cross-section.

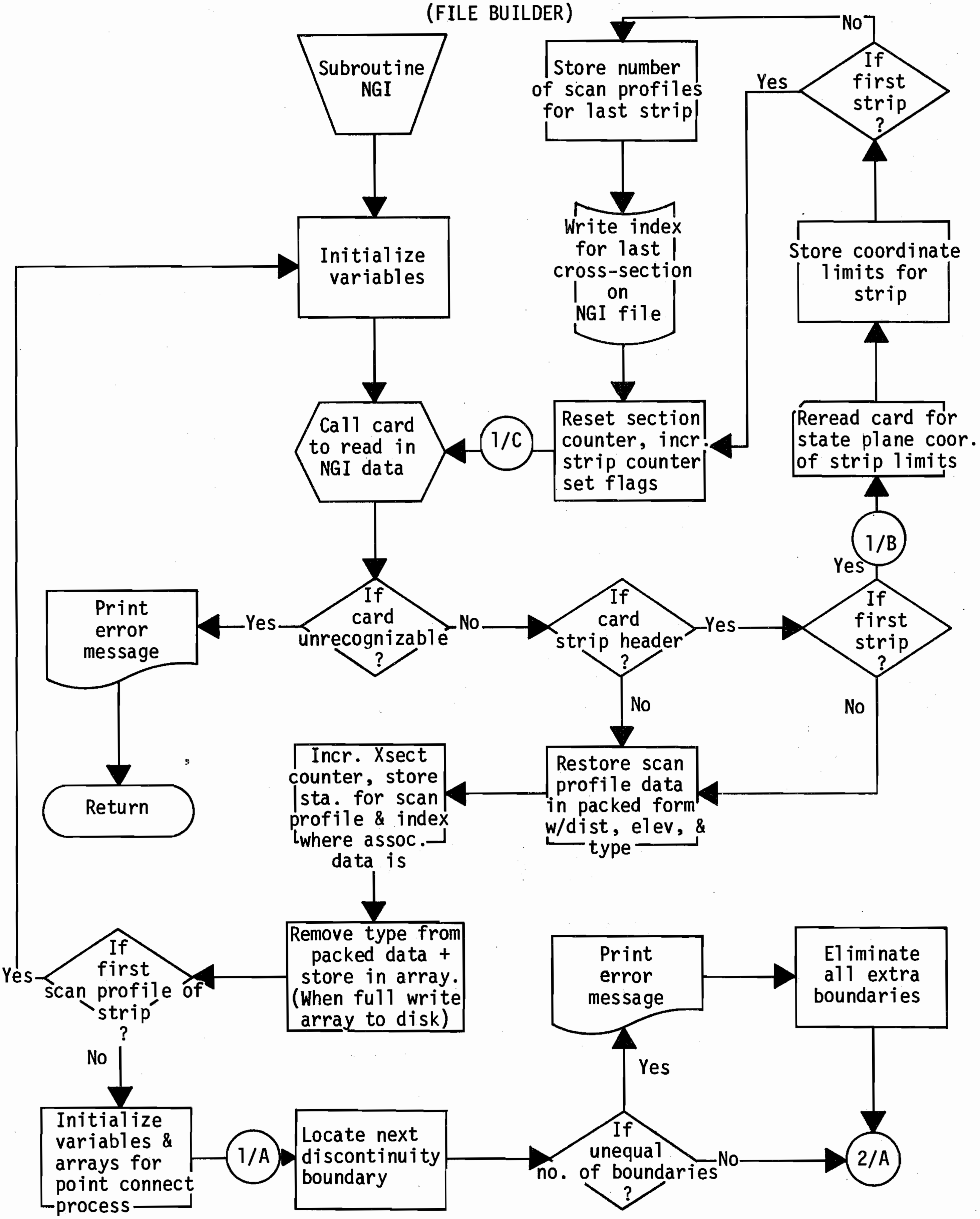
Subroutine XBILD (Cont'd)

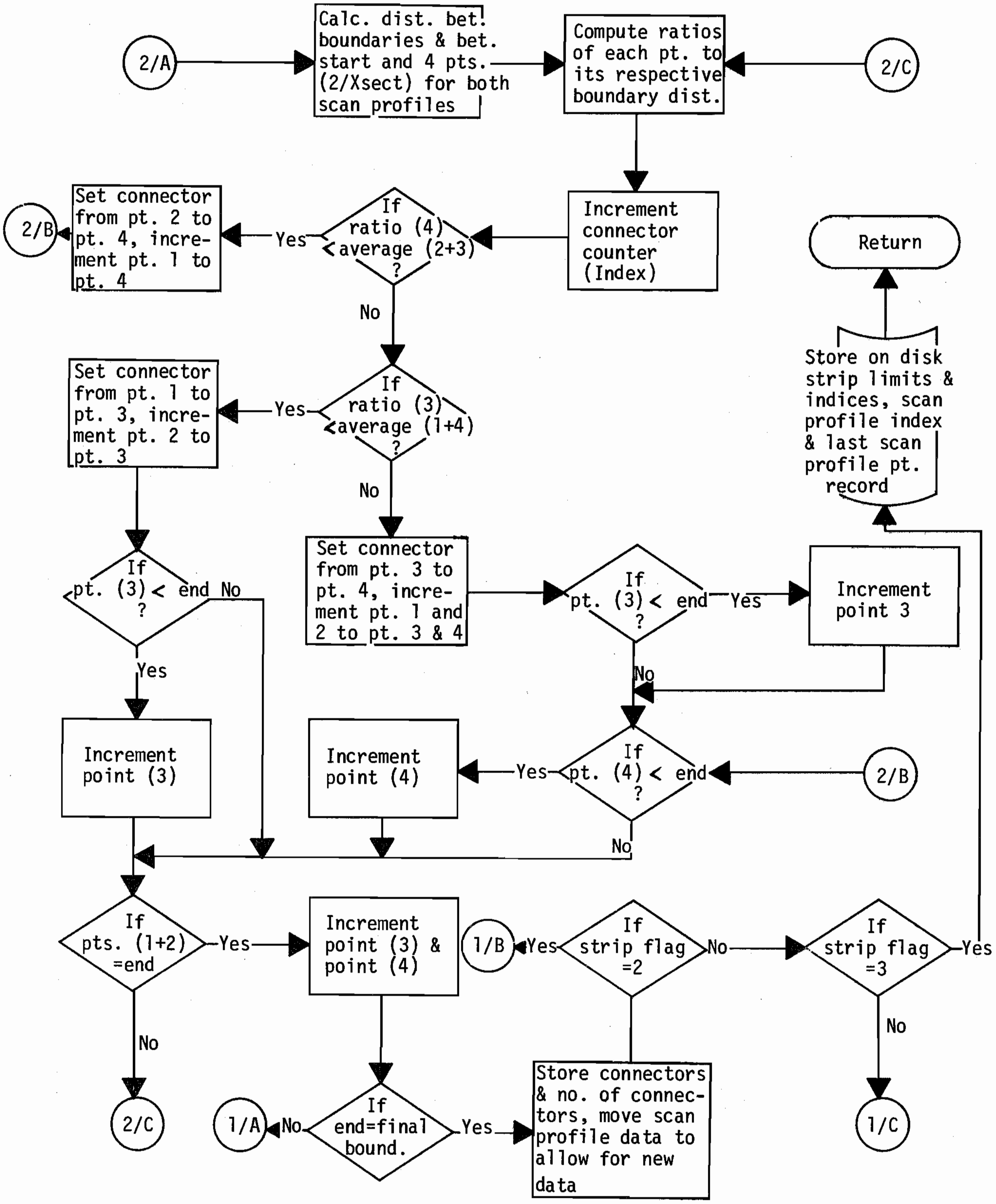
SYSER - See subroutine PREP.
XB (47) - Array of state plane X-coordinate for the beginning point of each strip.
XDIS (X, X1, Y, Y1) - Statement function for computing distance^2 between point (X,Y) and point (X1,Y1).
XE (47) - Array of state plane X-coordinate for the end point of each strip.
XI - Intermediate calculation X-coordinate for cross-section.
XJ - Intermediate calculation X-coordinate for cross-section.
XSECX (200) - X-coordinate array for all points of computed cross-section.
XSECY (200) - Y-coordinate array for all points of computed cross-section.
XSECZ (200) - Z-coordinate array for all points of computed cross-section.
XSTA (200) - Array of stations (X-coordinate) for any strip.
XTFIL (2, 3) - See subroutine PLIST.
YB (47) - Array of state plane Y-coordinate for the beginning point of each strip.
YD1 - Temporary variable with a distance (Y-coordinate).
YD2 - Temporary variable with a distance (Y-coordinate).
YDELT - Difference of forward and back Y's.
YDIST (200, 2) - Array of distances (from ℄) (Y-coordinate) for NGI scan profiles in core.
YE (47) - Array of state plane Y-coordinate for the ending point of each strip.
YI - Intermediate calculation Y-coordinate for cross-section.
YJ - Intermediate calculation Y-coordinate for cross-section.
YMAX - Maximum Y for given left cross-section point.
YMIN - Minimum Y for given left cross-section point.
YY (2) - Intersection points of given cross-section with forward and back NGI scan profile.
ZELV (200, 2) - Array of point elevations (Z-coordinate) for NGI scan profiles in core.
ZI - Intermediate calculation Z-coordinate for cross-sections.
ZJ - Intermediate calculation Z-coordinate for cross-sections.

NGI DRIVER

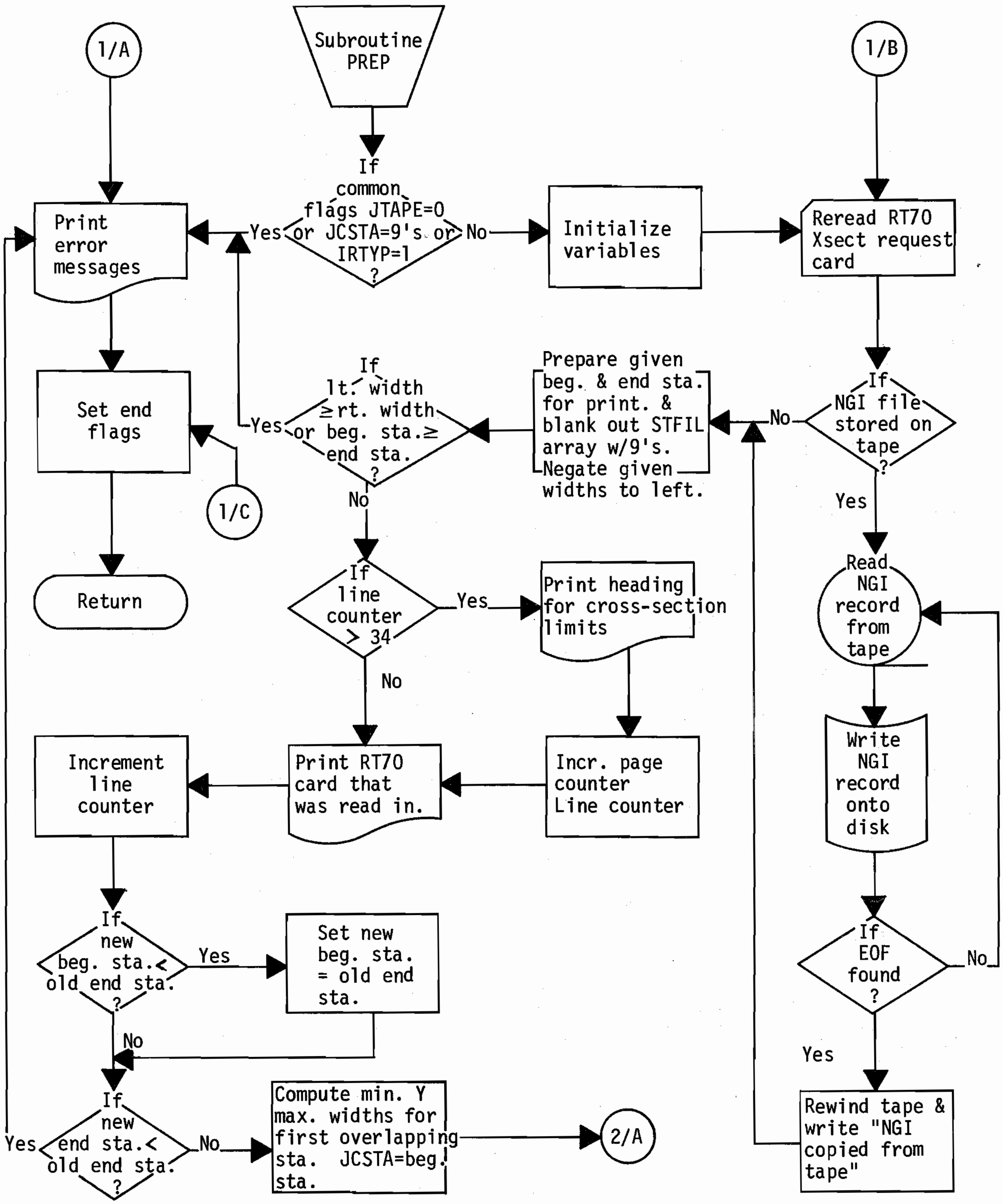

NGI Driver
Define NGI disk file + call REREAD
Read header card for tape store Yes or No
Call NGI to process + store NGI data
If fatal error or no tape store
No
Yes
Read NGI file from disk
Write NGI file to tape
Return

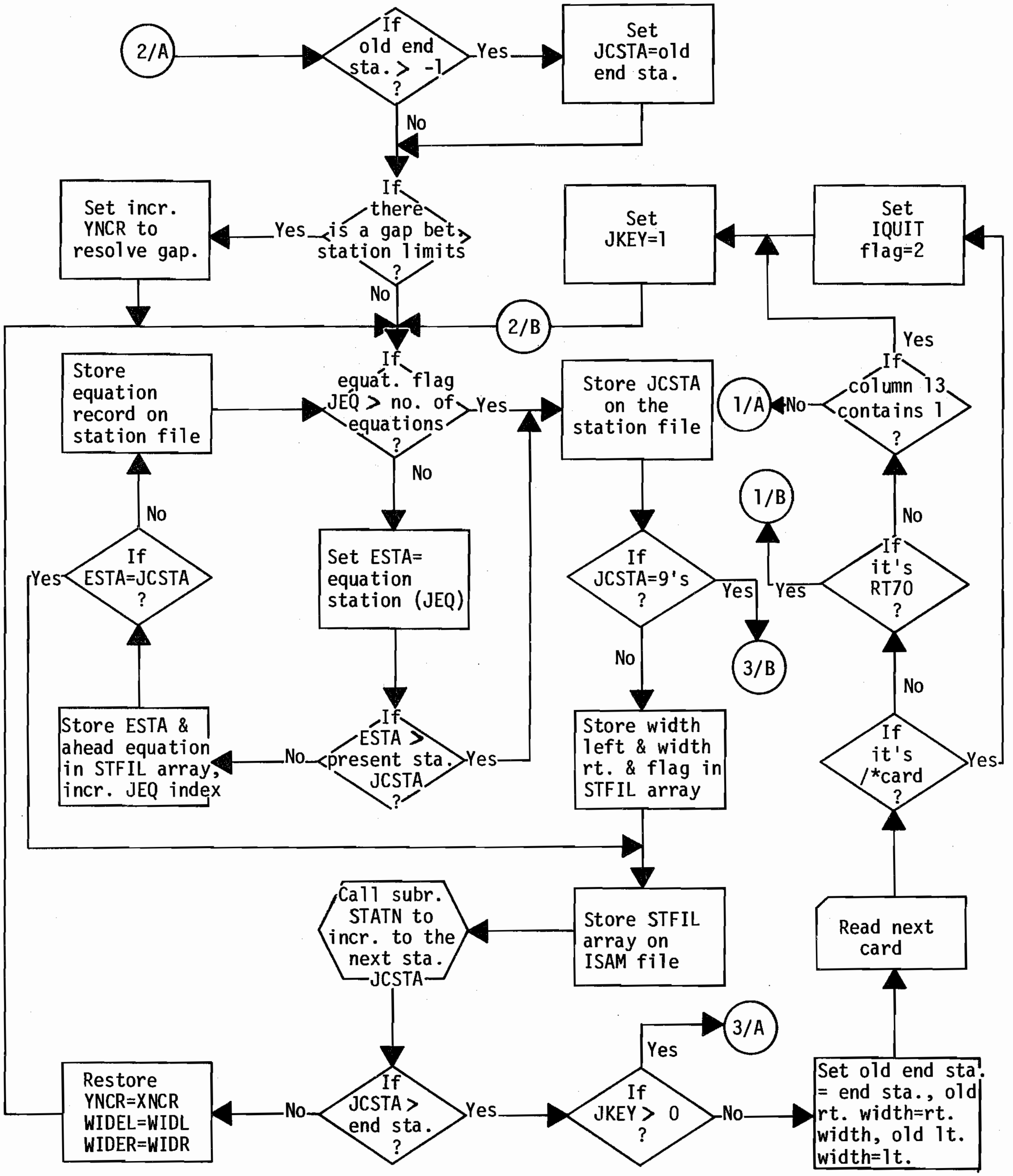
NUMERICAL GROUND IMAGE FLOWCHART
(FILE BUILDER)

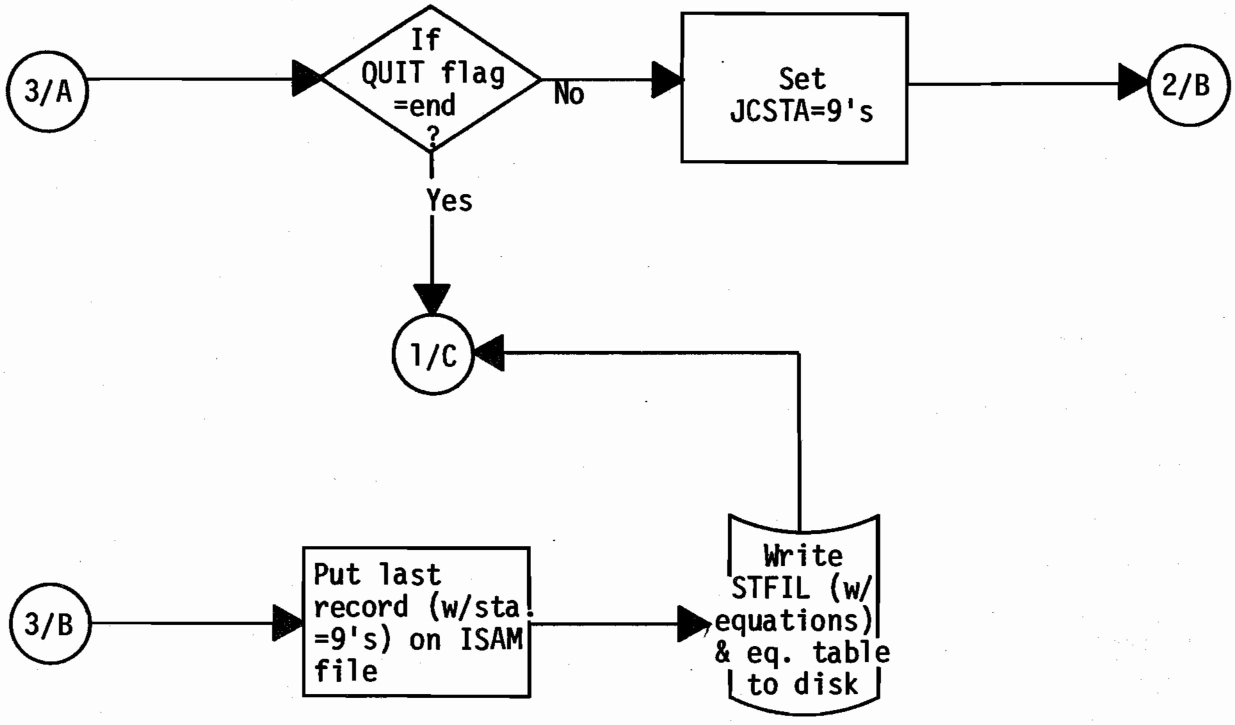



2/A
Calc. dist. bet. boundaries & bet. start and 4 pts. (2/Xsect) for both scan profiles
Compute ratios of each pt. to its respective boundary dist.
2/C
Increment connector counter (Index)
If ratio (4) < average (2+3) ?
Yes
Set connector from pt. 2 to pt. 4, increment pt. 1 to pt. 4
2/B
No
If ratio (3) < average (1+4) ?
Yes
Set connector from pt. 1 to pt. 3, increment pt. 2 to pt. 3
No
Set connector from pt. 3 to pt. 4, increment pt. 1 and 2 to pt. 3 & 4
Return
Store on disk strip limits & indices, scan profile index & last scan profile pt. record
If pt. (3) < end ?
No
Yes
Increment point (3)
If pt. (3) < end ?
Yes
Increment point 3
No
If pt. (4) < end ?
Yes
Increment point (4)
2/B
No
If pts. (1+2) =end
Yes
Increment point (3) & point (4)
No
2/C
If end=final bound.
No
1/A
Yes
Store connectors & no. of connectors, move scan profile data to allow for new data
If strip flag =2
Yes
1/B
No
If strip flag =3
Yes
No
1/C

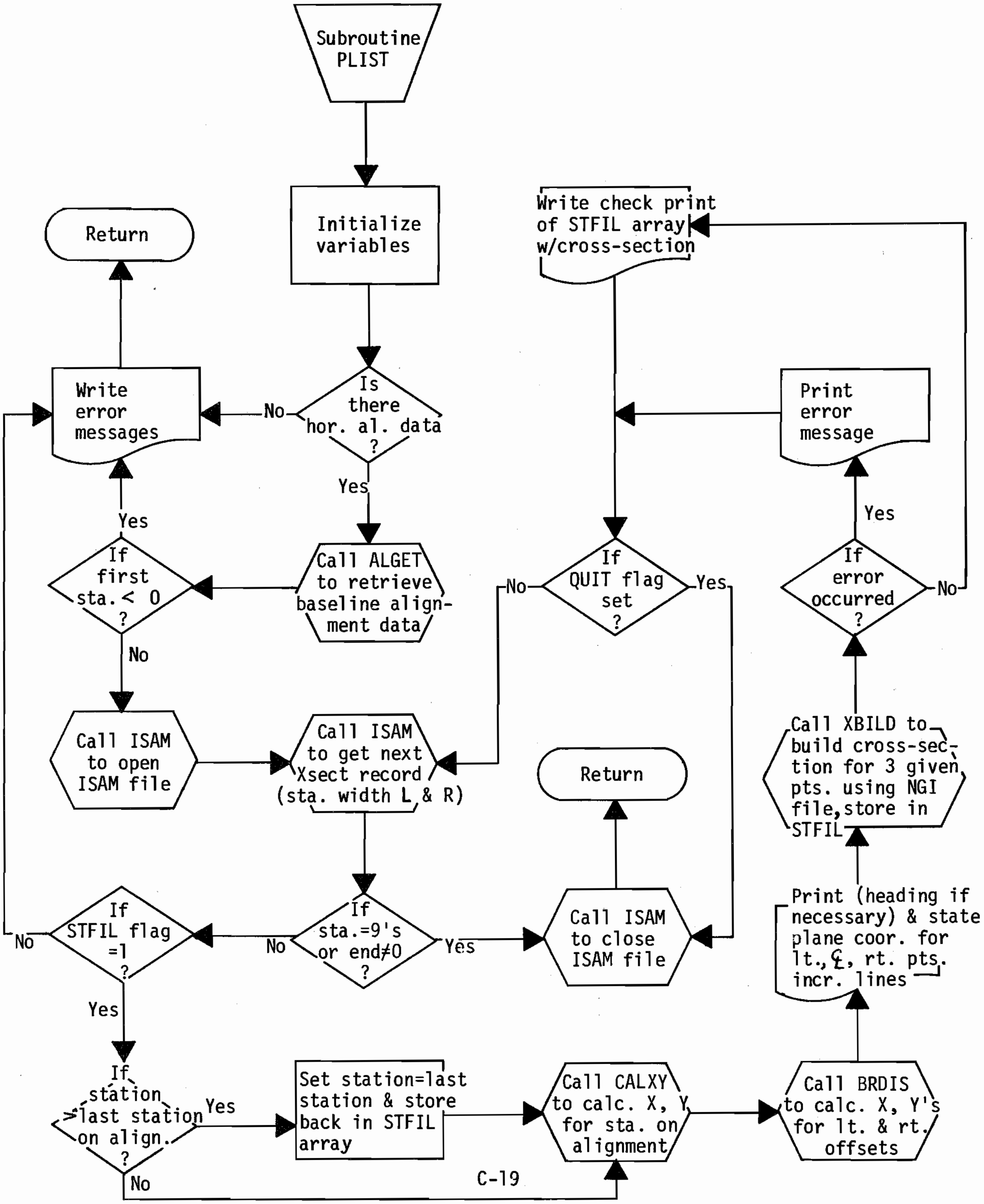
SUBROUTINE PREP



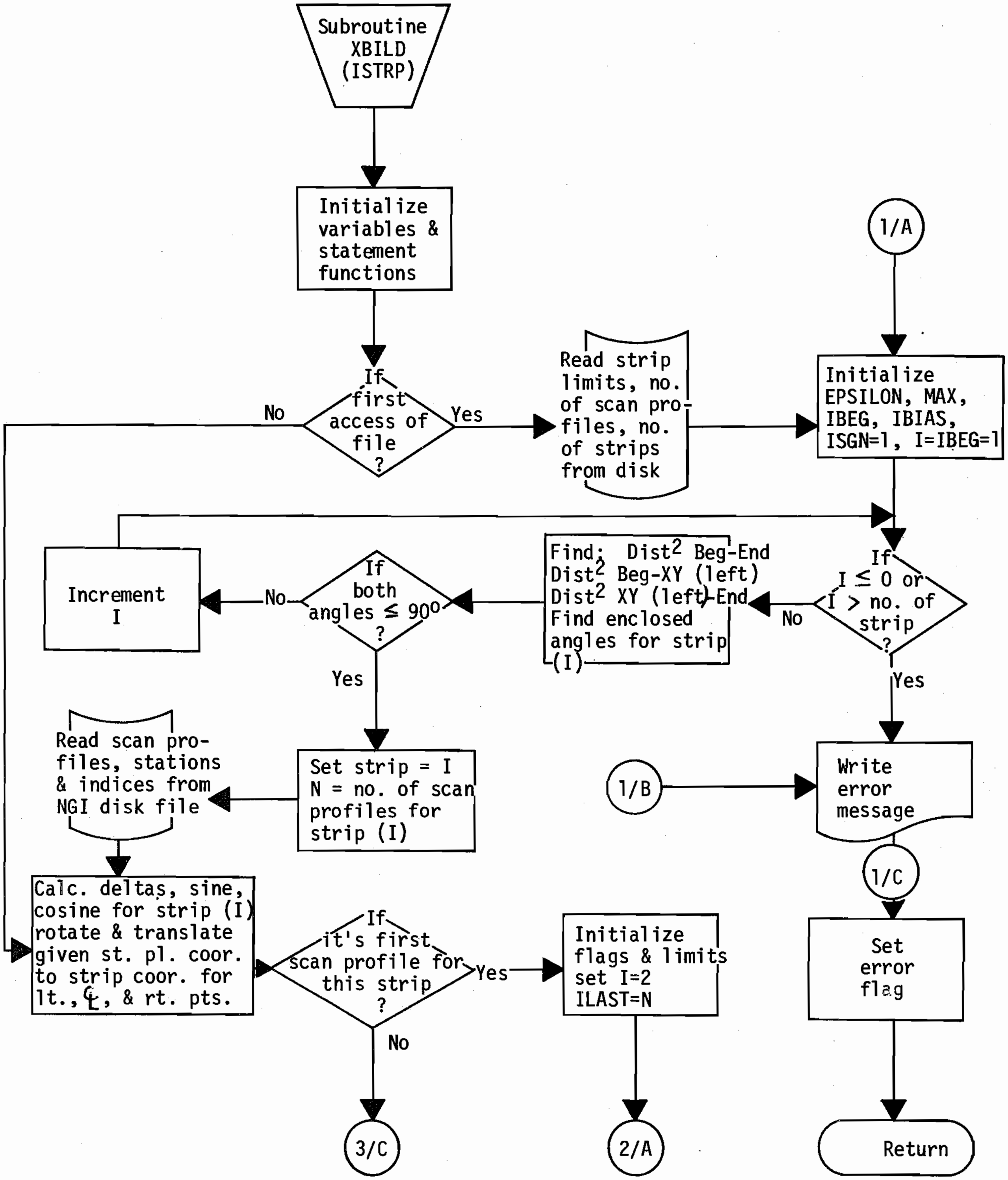

2/A
If old end sta. > -1 ?
Yes
Set JCSTA=old end sta.
No
If there is a gap bet. station limits ?
Yes
Set incr. YNCR to resolve gap.
No
2/B
Set JKEY=1
Set IQUIT flag=2
Yes
If column 13 contains 1 ?
No
1/A
Store equation record on station file
If equat. flag JEQ > no. of equations ?
Yes
Store JCSTA on the station file
No
1/B
No
If it's RT70 ?
Yes
Yes
If ESTA=JCSTA ?
No
Set ESTA= equation station (JEQ)
If JCSTA=9's ?
Yes
3/B
No
No
Store ESTA & ahead equation in STFIL array, incr. JEQ index
No
If ESTA > present sta. JCSTA ?
Yes
Store width left & width rt. & flag in STFIL array
If it's /*card ?
Yes
Call subr. STATN to incr. to the next sta. JCSTA
Store STFIL array on ISAM file
Read next card
3/A
Yes
Restore YNCR=XNCR WIDEL=WIDL WIDER=WIDR
No
If JCSTA > end sta. ?
Yes
If JKEY > 0 ?
No
Set old end sta. = end sta., old rt. width=rt. width, old lt. width=lt.

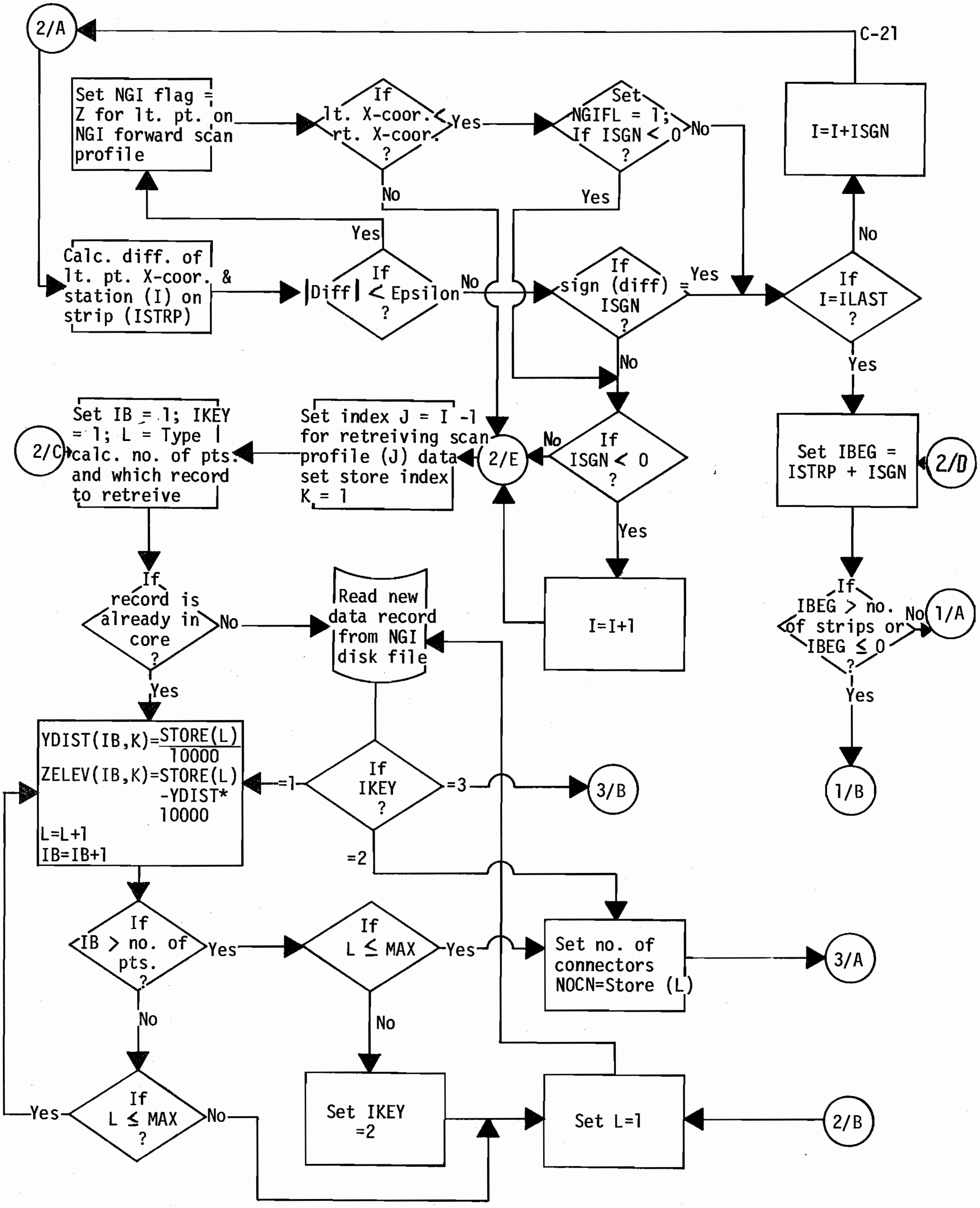

3/A
If QUIT flag =end ?
No
Set JCSTA=9's
2/B
Yes
1/C
3/B
Put last record (w/sta =9's) on ISAM file
Write STFIL (w/ equations) & eq. table to disk

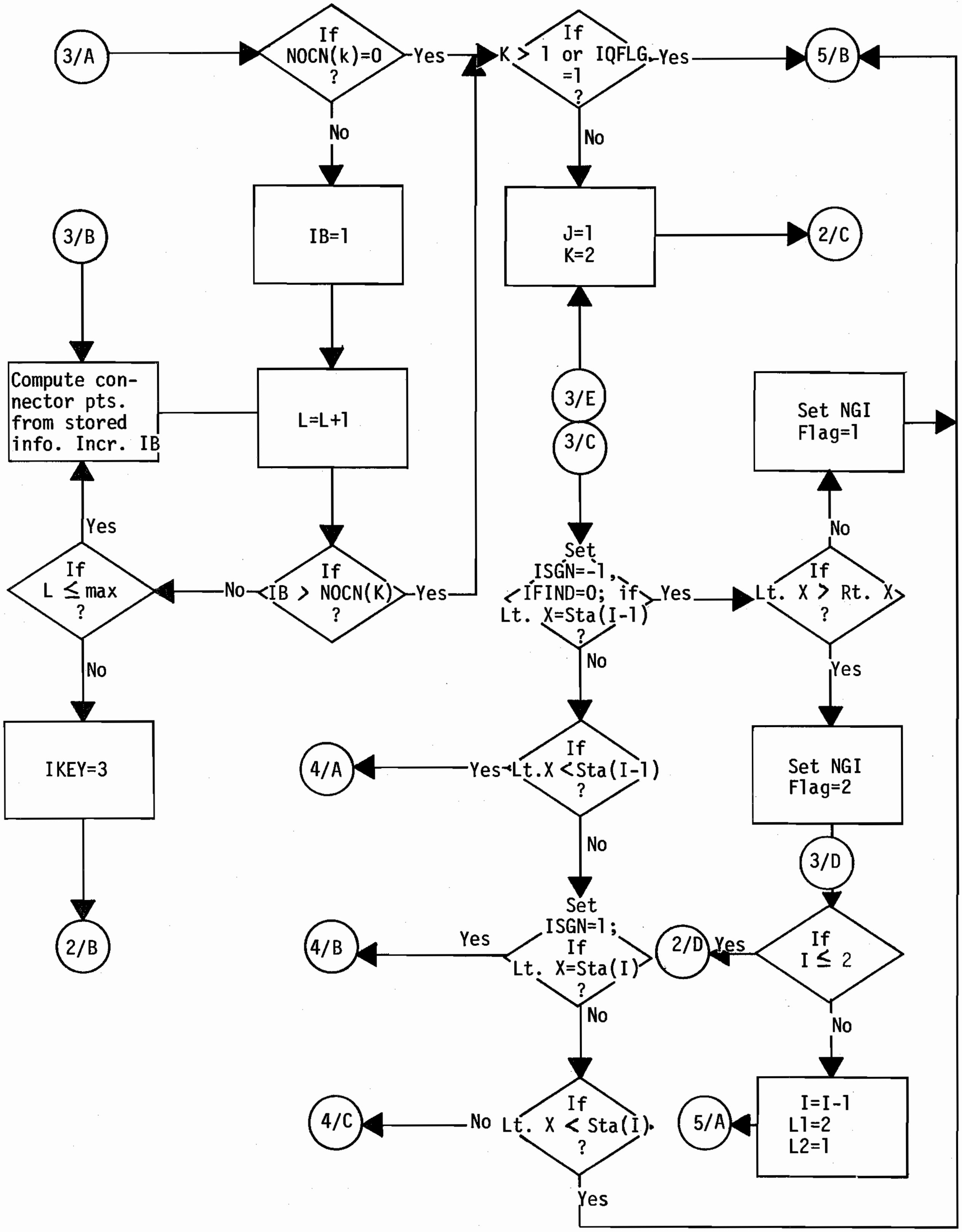
SUBROUTINE PLIST

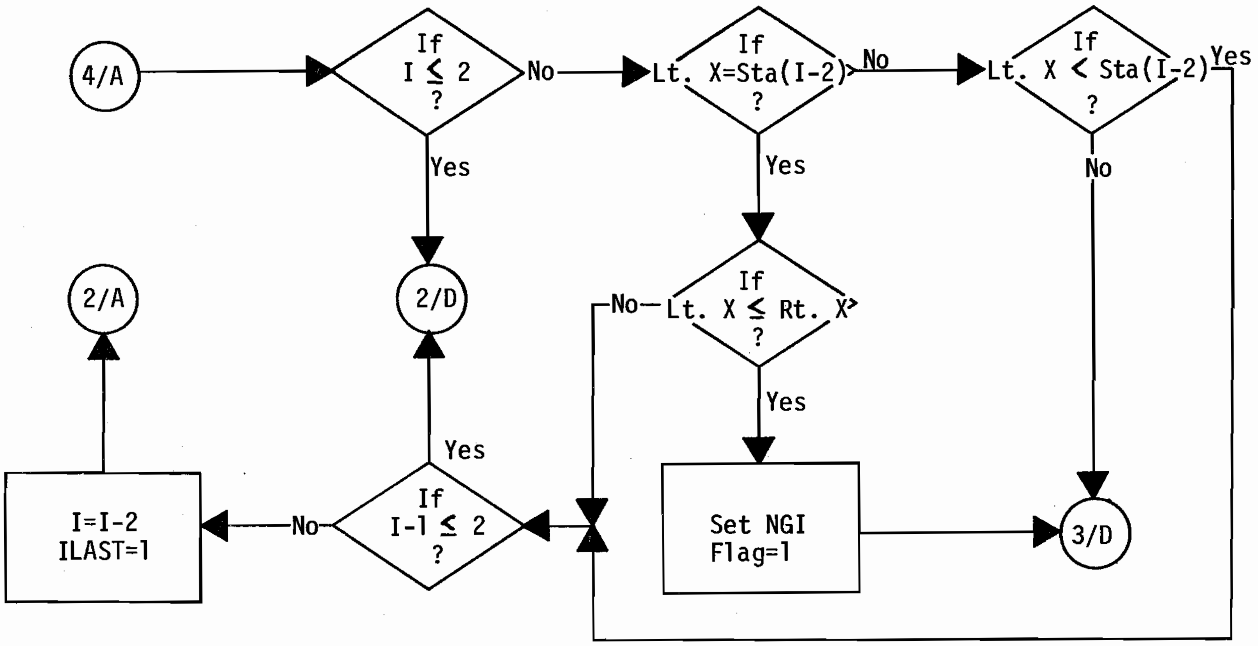


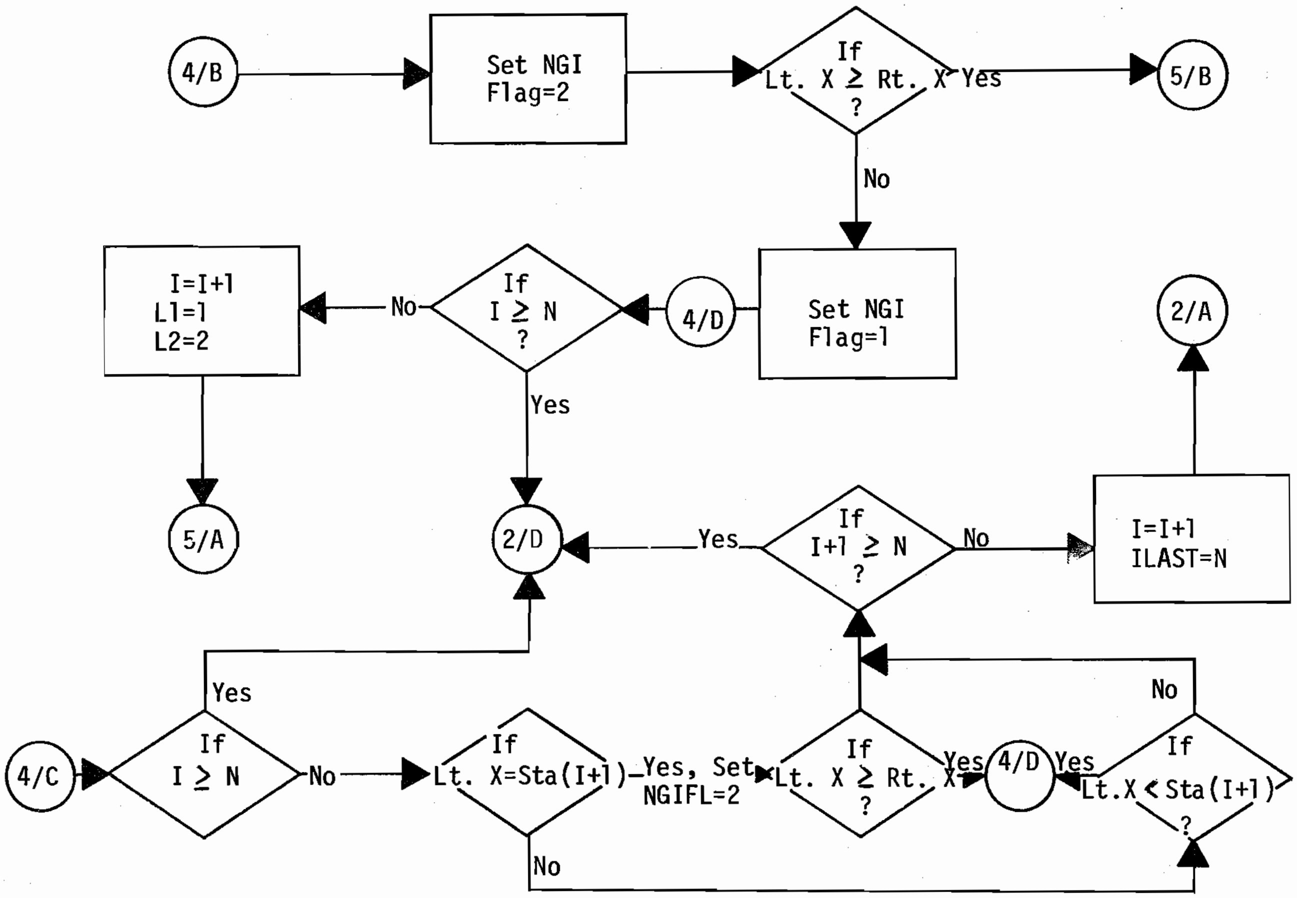
CROSS SECTION BUILDER FLOWCHART
(USING NGI DATA FILE)

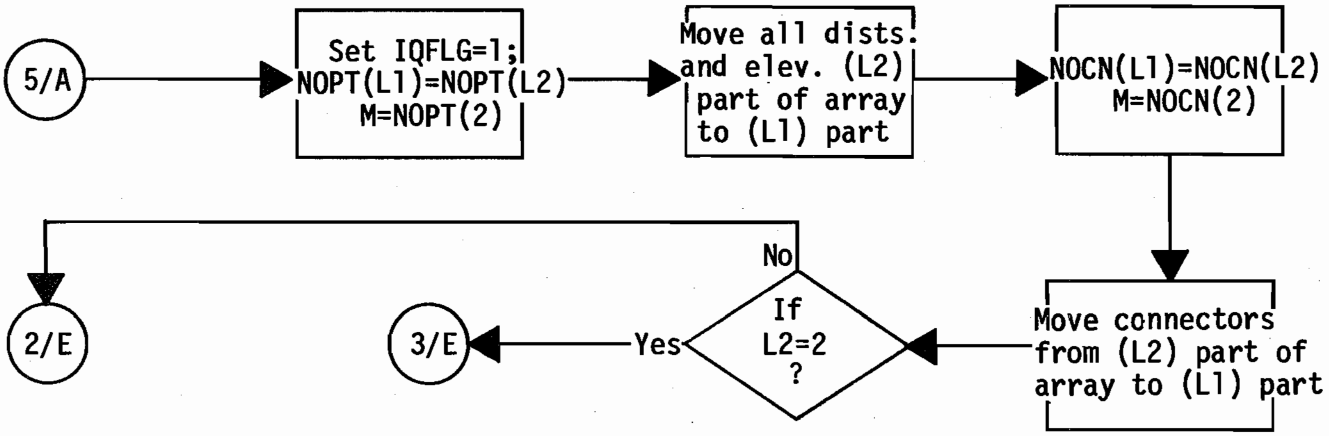


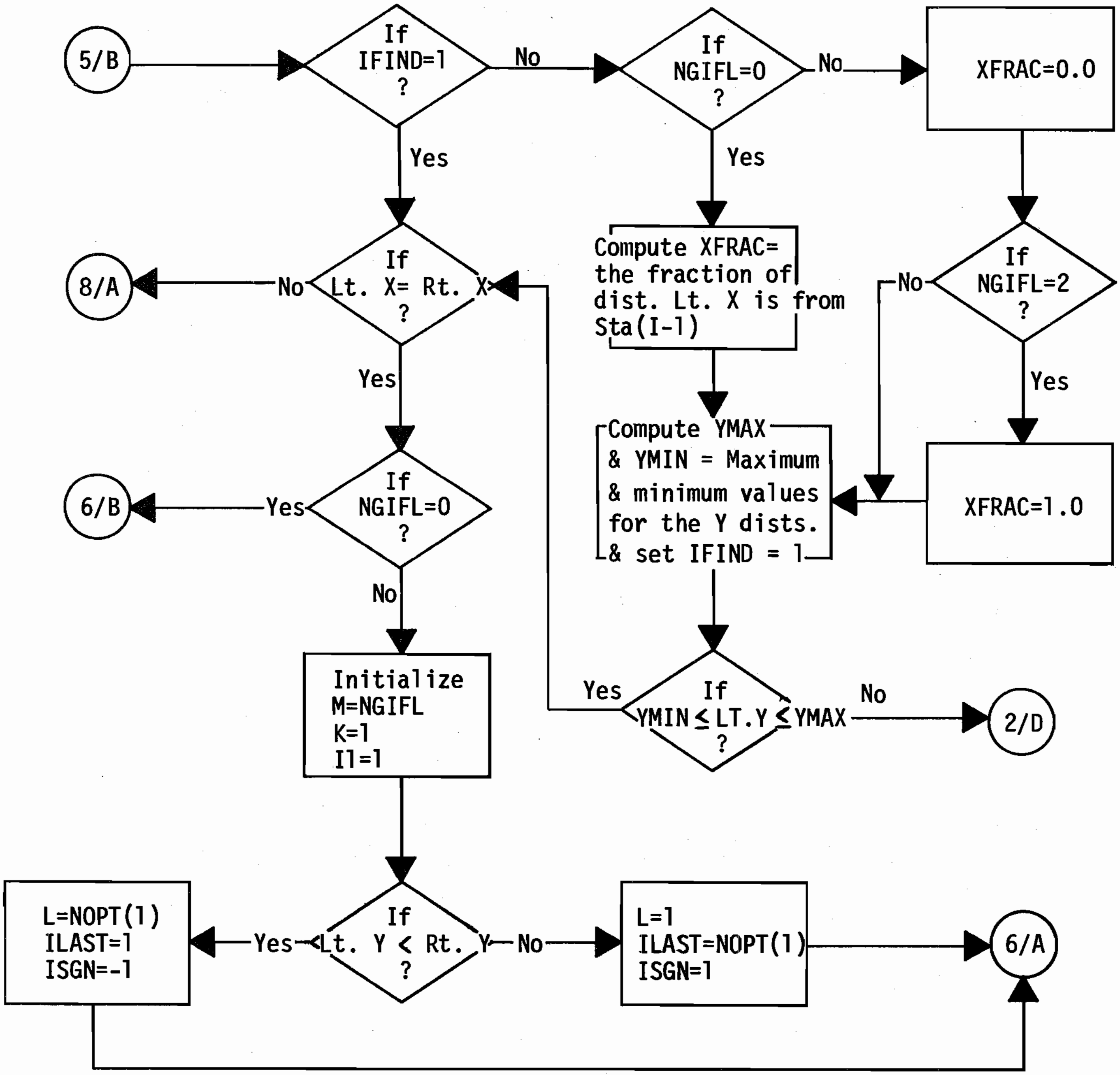

2/A
Set NGI flag = Z for lt. pt. on NGI forward scan profile
If lt. X-coor. < rt. X-coor. ?
Yes
No
Set NGIFL = 1; If ISGN < 0 ?
No
Yes
I=I+ISGN
No
Calc. diff. of lt. pt. X-coor. & station (I) on strip (ISTRP)
If |Diff| < Epsilon ?
Yes
No
If sign (diff) = ISGN ?
Yes
No
If I=ILAST ?
Yes
Set IBEG = ISTRP + ISGN
2/D
Set IB = 1; IKEY = 1; L = Type calc. no. of pts. and which record to retreive
2/C
Set index J = I -1 for retreiving scan profile (J) data set store index K = 1
2/E
If ISGN < 0 ?
No
Yes
I=I+1
If IBEG > no. of strips or IBEG ≤ 0 ?
No
1/A
Yes
1/B
If record is already in core ?
No
Yes
Read new data record from NGI disk file
YDIST(IB,K)=STORE(L)/10000
ZELEV(IB,K)=STORE(L)-YDIST*10000
L=L+1
IB=IB+1
If IKEY ?
=1
=3
=2
3/B
If IB > no. of pts. ?
Yes
No
If L ≤ MAX ?
Yes
No
Set no. of connectors NOCN=Store (L)
3/A
If L ≤ MAX ?
Yes
No
Set IKEY =2
Set L=1
2/B

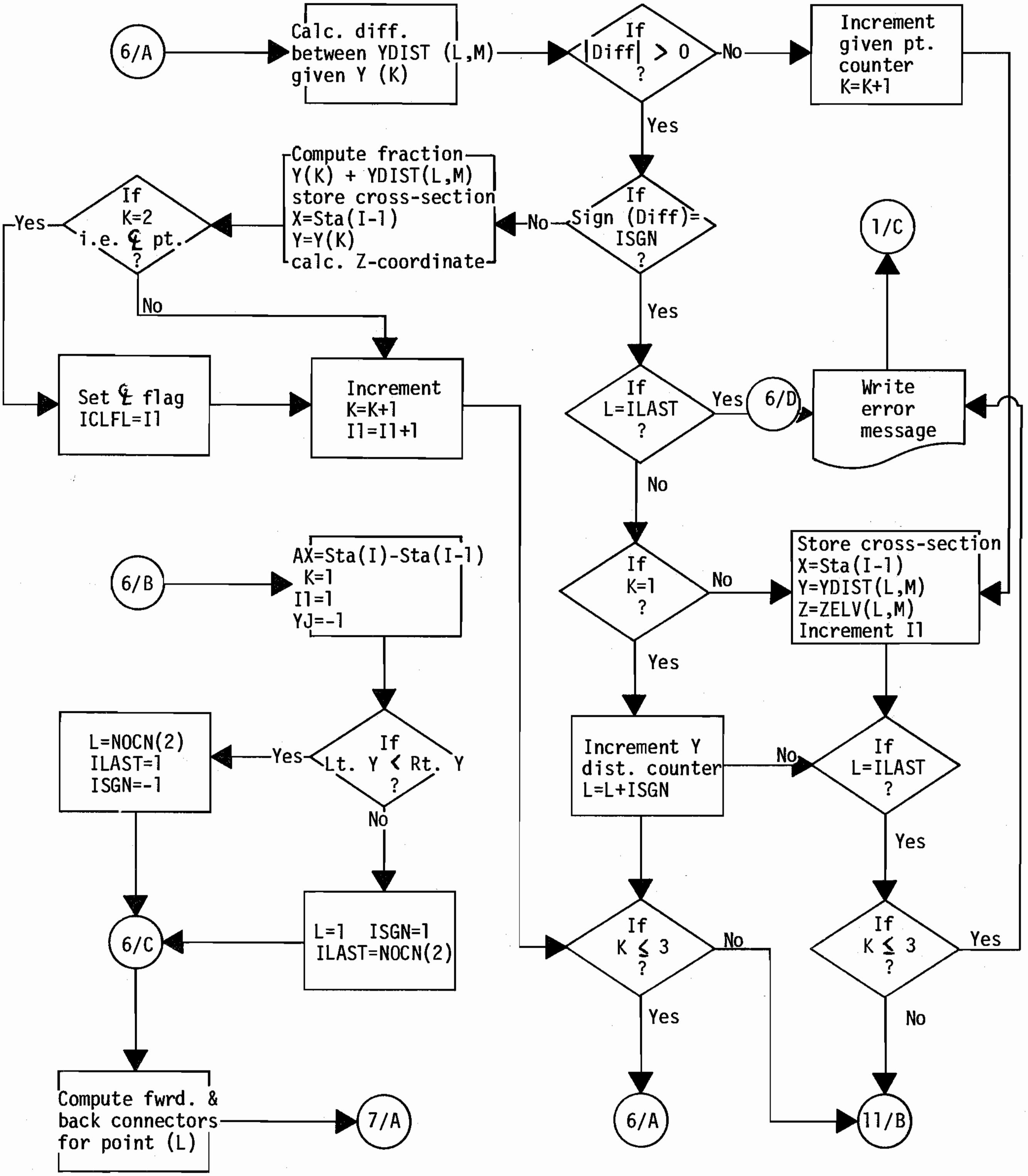

3/A
If NOCN(k)=0 ?
Yes
No
IB=1
If K > 1 or IQFLG =1 ?
Yes
5/B
No
J=1
K=2
2/C
3/B
Compute connector pts. from stored info. Incr. IB
L=L+1
3/E
3/C
Set NGI Flag=1
Yes
If L ≤ max ?
No
If IB > NOCN(K) ?
Yes
Set ISGN=-1, IFIND=0; if Lt. X=Sta(I-1) ?
Yes
If Lt. X > Rt. X ?
No
No
Yes
IKEY=3
4/A
Yes
If Lt.X <Sta(I-1) ?
Set NGI Flag=2
No
3/D
2/B
4/B
Yes
Set ISGN=1; If Lt. X=Sta(I) ?
2/D
Yes
If I ≤ 2
No
No
4/C
No
If Lt. X < Sta(I) ?
5/A
I=I-1
L1=2
L2=1
Yes

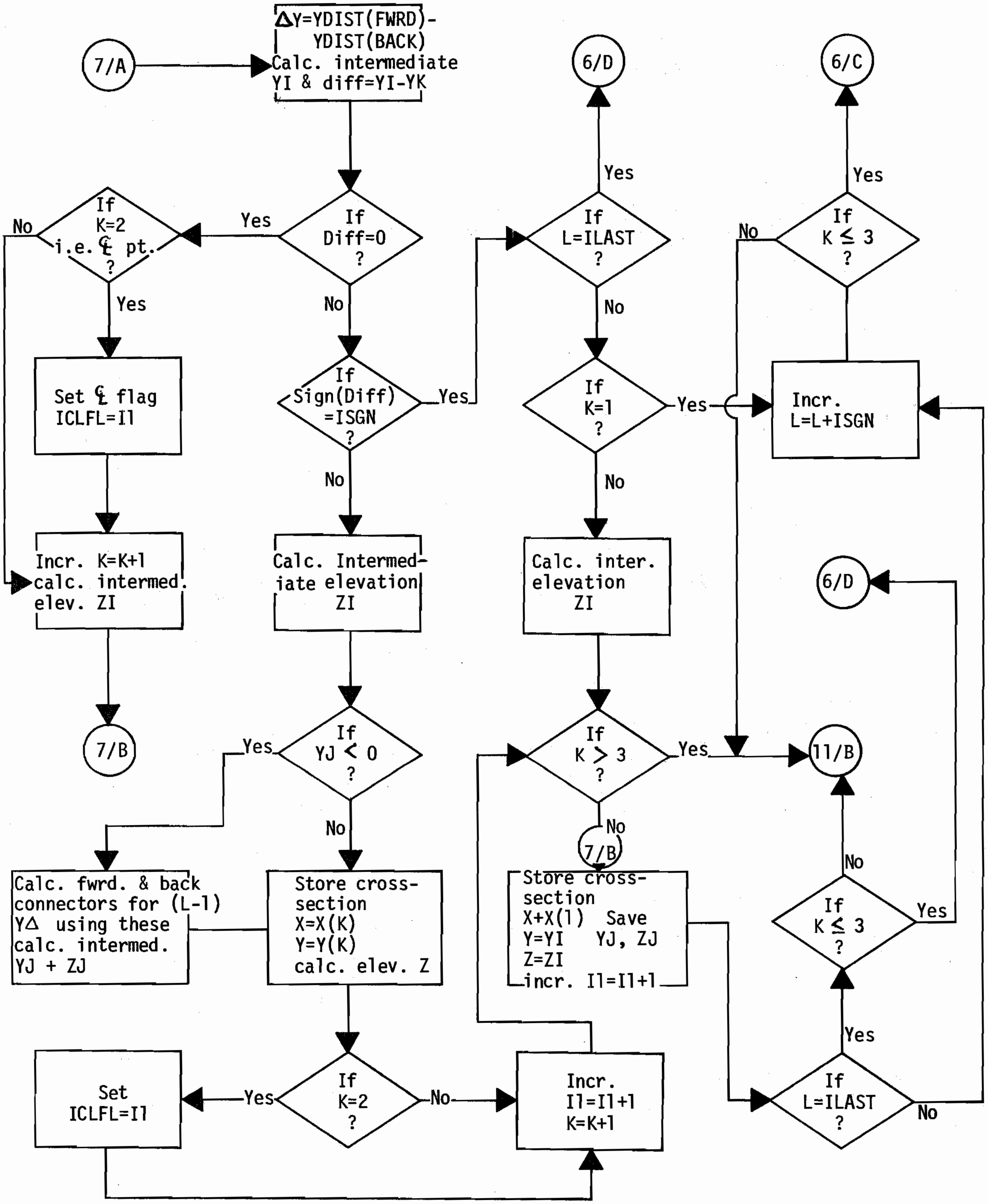

4/A
If
I ≤ 2
?
No
Yes
2/D
If
Lt. X=Sta(I-2)
?
No
Yes
If
Lt. X < Sta(I-2)
?
Yes
No
If
Lt. X ≤ Rt. X
?
No
Yes
Set NGI
Flag=1
3/D
2/A
I=I-2
ILAST=1
No
If
I-1 ≤ 2
?
Yes

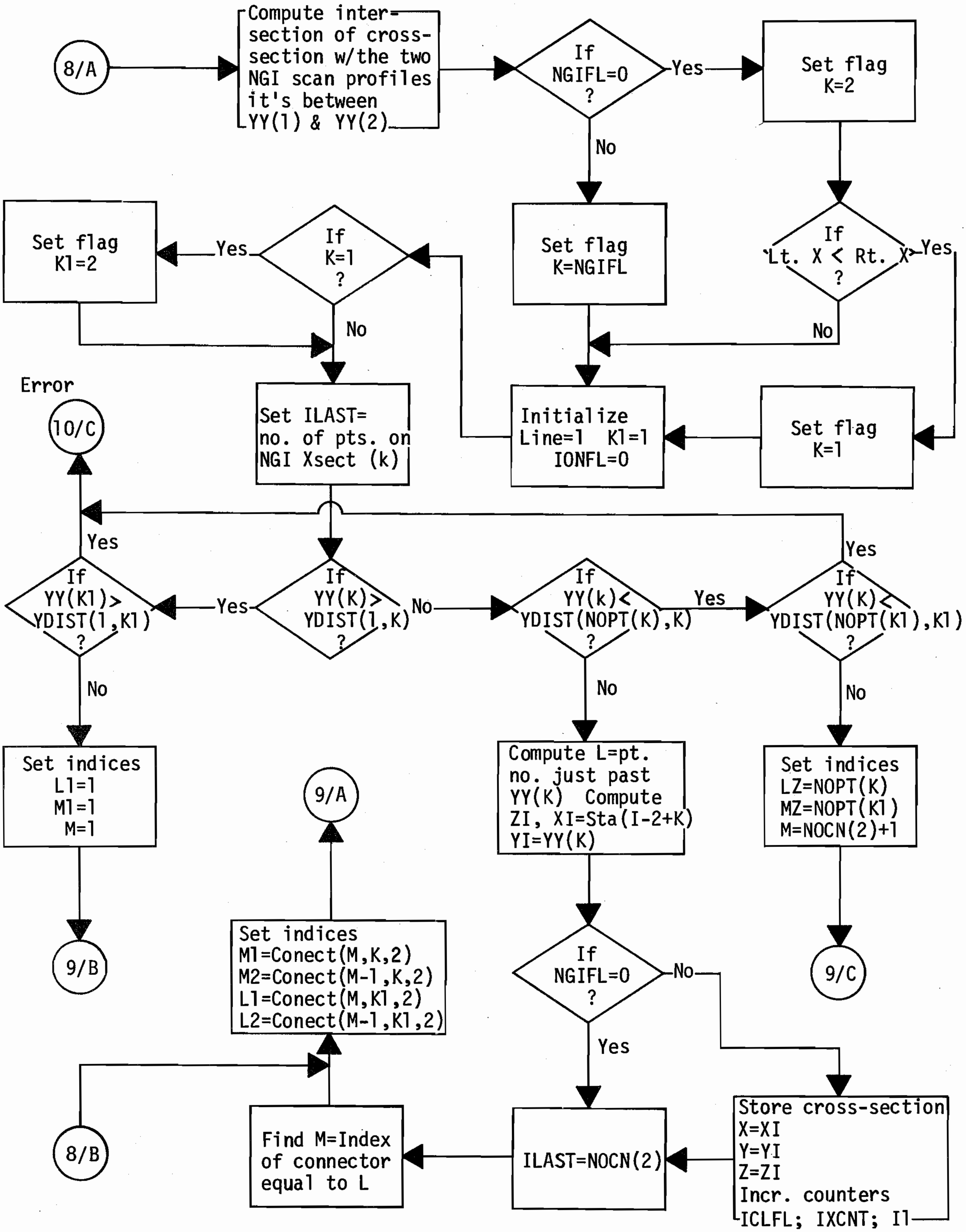

4/B
Set NGI
Flag=2
If
Lt. X ≥ Rt. X
?
Yes
5/B
No
Set NGI
Flag=1
4/D
If
I ≥ N
?
No
I=I+1
L1=1
L2=2
5/A
Yes
2/D
2/A
If
I+1 ≥ N
?
Yes
No
I=I+1
ILAST=N
4/C
If
I ≥ N
?
Yes
No
If
Lt. X=Sta(I+1)
?
Yes, Set
NGIFL=2
No
If
Lt. X ≥ Rt. X
?
Yes
4/D
Yes
If
Lt.X < Sta(I+1)
?
No

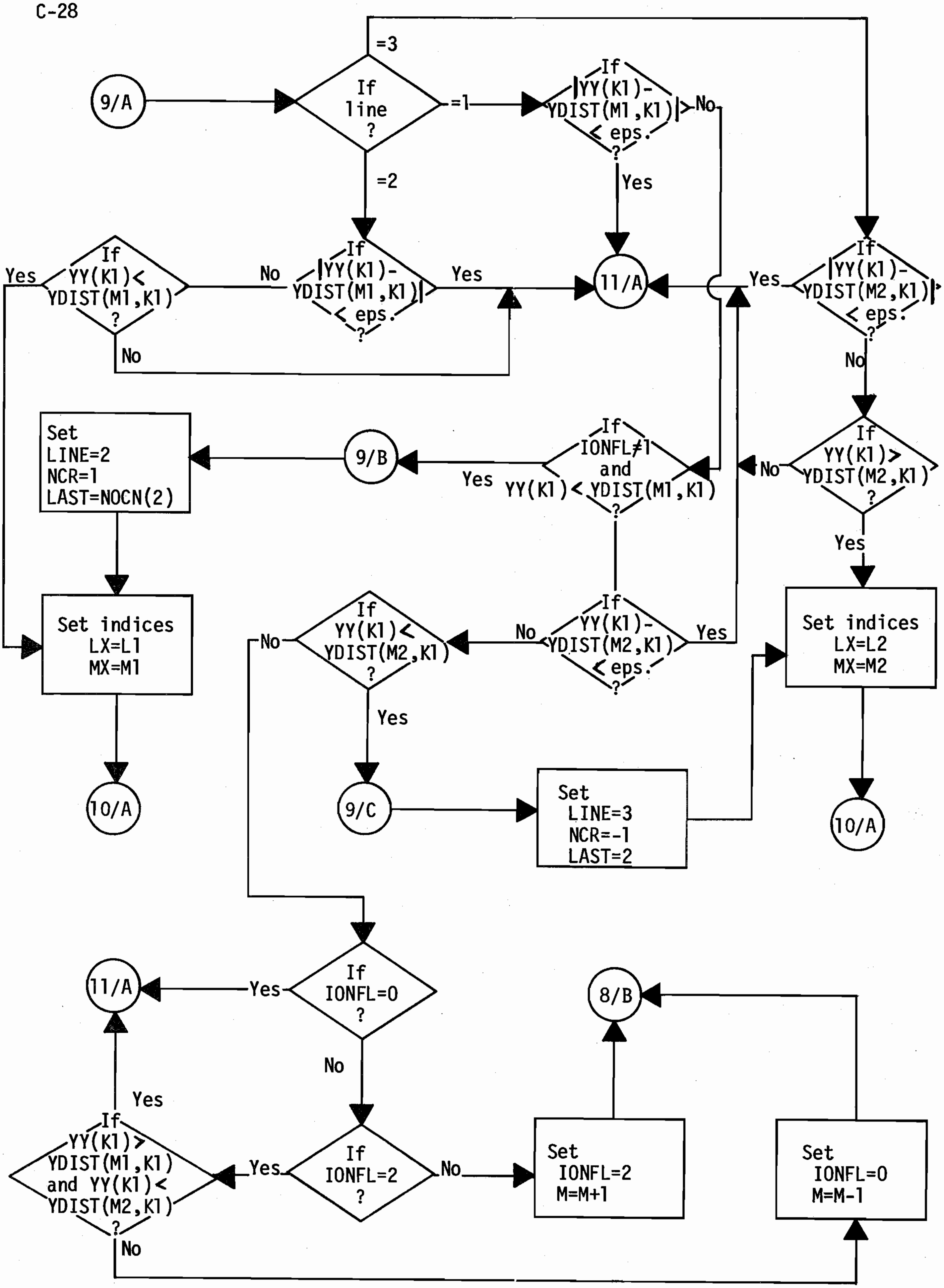

5/A
Set IQFLG=1;
NOPT(L1)=NOPT(L2)
M=NOPT(2)
Move all dists. and elev. (L2) part of array to (L1) part
NOCN(L1)=NOCN(L2)
M=NOCN(2)
Move connectors from (L2) part of array to (L1) part
If L2=2 ?
Yes
3/E
No
2/E

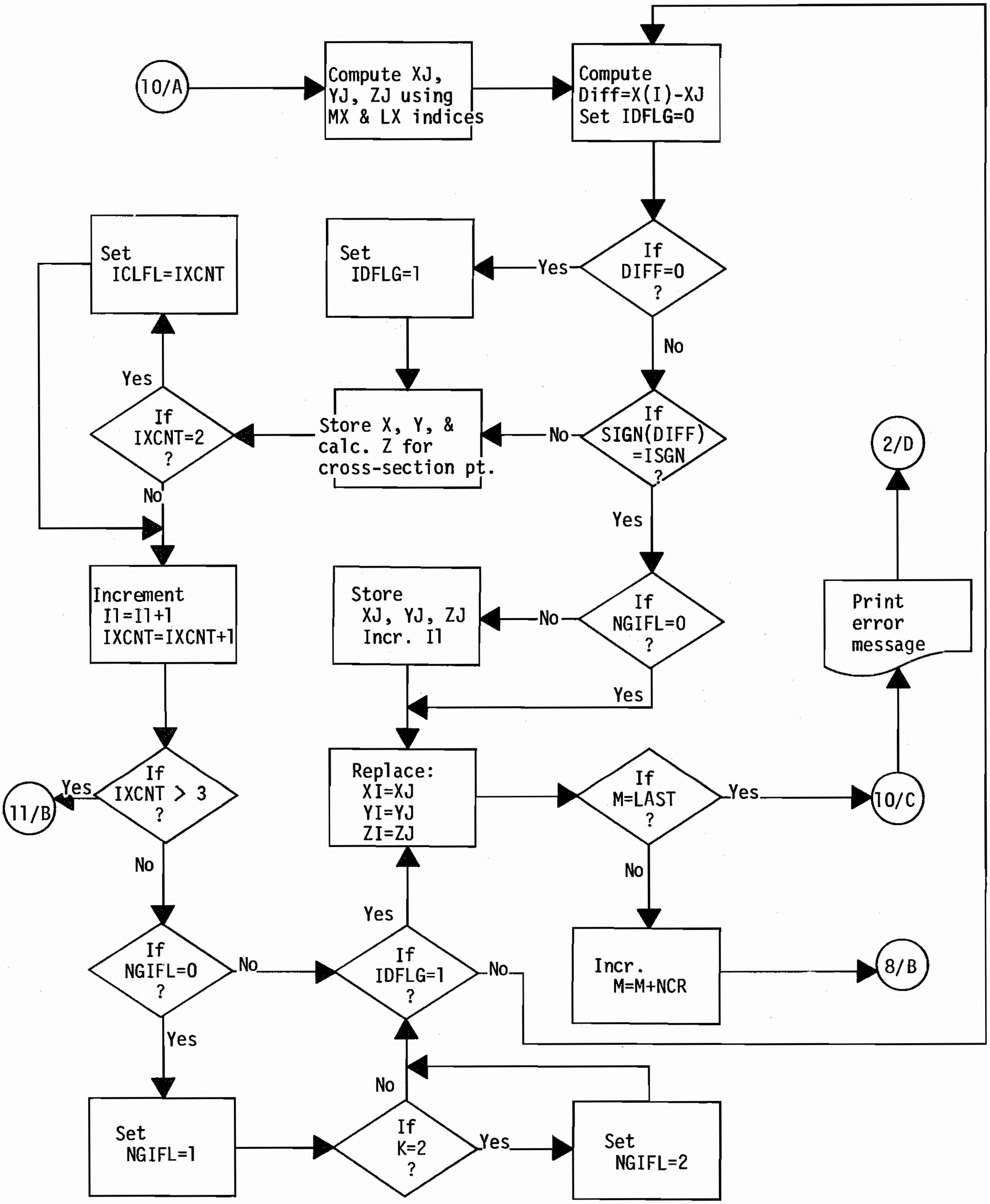

5/B
If IFIND=1 ?
No
If NGIFL=0 ?
No
XFRAC=0.0
If NGIFL=2 ?
Yes
XFRAC=1.0
No
Yes
Compute XFRAC= the fraction of dist. Lt. X is from Sta(I-1)
Compute YMAX & YMIN = Maximum & minimum values for the Y dists. & set IFIND = 1
If YMIN ≤ LT.Y ≤ YMAX ?
No
2/D
Yes
Yes
If Lt. X= Rt. X ?
No
8/A
Yes
If NGIFL=0 ?
Yes
6/B
No
Initialize
M=NGIFL
K=1
I1=1
If Lt. Y < Rt. Y ?
Yes
L=NOPT(1)
ILAST=1
ISGN=-1
No
L=1
ILAST=NOPT(1)
ISGN=1
6/A

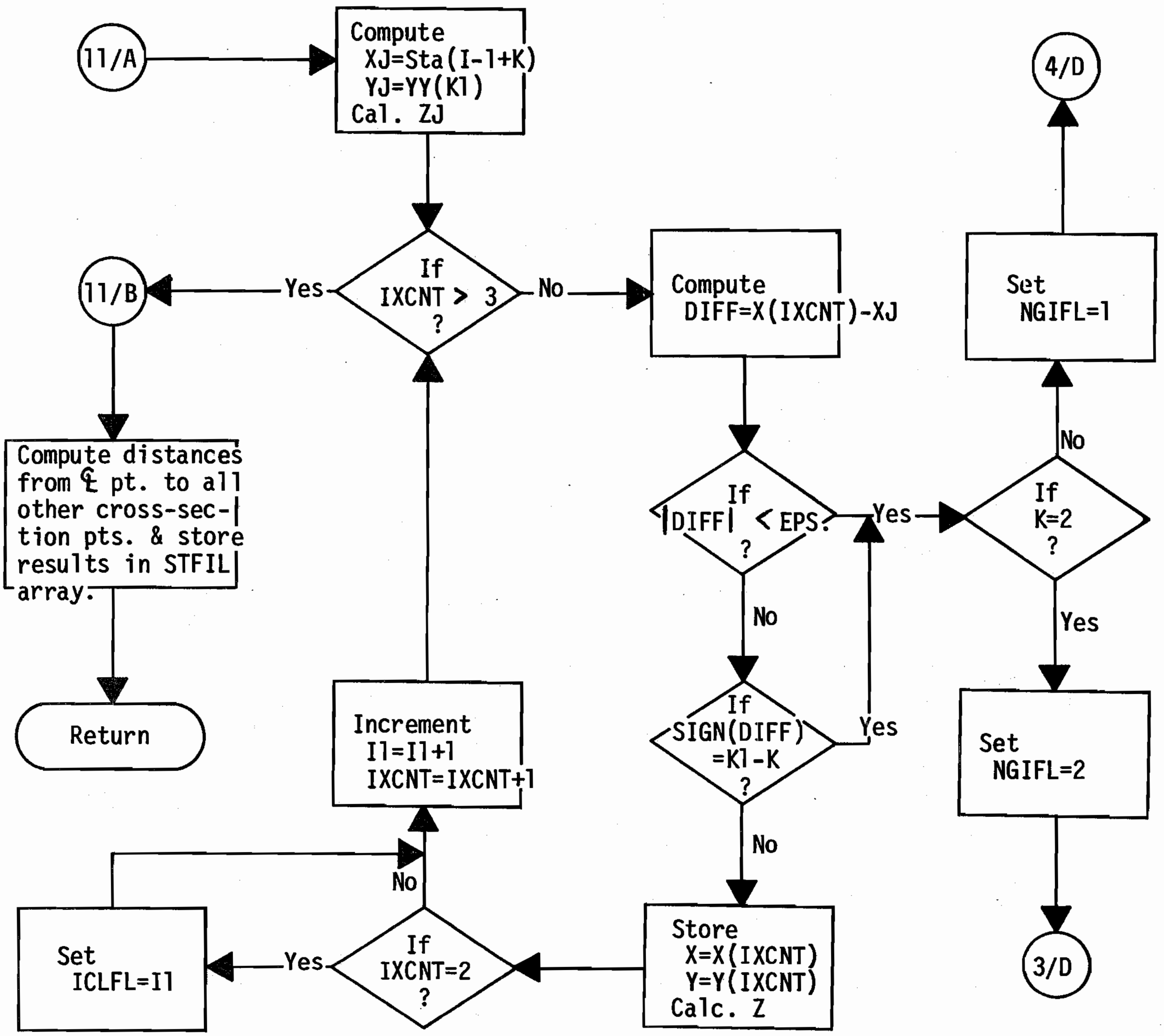

6/A
Calc. diff. between YDIST (L,M) given Y (K)
If |Diff| > 0 ?
No
Increment given pt. counter K=K+1
Yes
Compute fraction Y(K) + YDIST(L,M) store cross-section X=Sta(I-1) Y=Y(K) calc. Z-coordinate
If Sign (Diff)= ISGN ?
No
If K=2 i.e. ℄ pt. ?
Yes
No
1/C
Set ℄ flag ICLFL=I1
Increment K=K+1 I1=I1+1
If L=ILAST ?
Yes
6/D
Write error message
No
6/B
AX=Sta(I)-Sta(I-1) K=1 I1=1 YJ=-1
If K=1 ?
No
Store cross-section X=Sta(I-1) Y=YDIST(L,M) Z=ZELV(L,M) Increment I1
Yes
L=NOCN(2) ILAST=1 ISGN=-1
If Lt. Y < Rt. Y ?
Increment Y dist. counter L=L+ISGN
If L=ILAST ?
L=1 ISGN=1 ILAST=NOCN(2)
6/C
If K ≤ 3 ?
If K ≤ 3 ?
Compute fwrd. & back connectors for point (L)
7/A
6/A
11/B


7/A
ΔY=YDIST(FWRD)-
YDIST(BACK)
Calc. intermediate
YI & diff=YI-YK
If
Diff=0
?
Yes
No
If
K=2
i.e. ℄ pt.
?
No
Yes
Set ℄ flag
ICLFL=I1
Incr. K=K+1
calc. intermed.
elev. ZI
7/B
If
Sign(Diff)
=ISGN
?
Yes
No
Calc. Intermed-
iate elevation
ZI
If
YJ < 0
?
Yes
No
Calc. fwrd. & back
connectors for (L-1)
YΔ using these
calc. intermed.
YJ + ZJ
Store cross-
section
X=X(K)
Y=Y(K)
calc. elev. Z
If
K=2
?
Yes
No
Set
ICLFL=I1
Incr.
I1=I1+1
K=K+1
6/D
Yes
If
L=ILAST
?
No
If
K=1
?
Yes
No
Calc. inter.
elevation
ZI
If
K > 3
?
Yes
No
7/B
Store cross-
section
X+X(1)
Y=YI
Z=ZI
incr. I1=I1+1
Save
YJ, ZJ
6/C
Yes
If
K ≤ 3
?
No
Incr.
L=L+ISGN
6/D
11/B
No
If
K ≤ 3
?
Yes
Yes
If
L=ILAST
?
No


8/A
Compute intersection of cross-section w/the two NGI scan profiles it's between YY(1) & YY(2)
If NGIFL=0 ?
Yes
No
Set flag K=2
If Lt. X < Rt. X ?
Yes
No
Set flag K=NGIFL
Set flag K=1
Initialize Line=1 K1=1 IONFL=0
If K=1 ?
Yes
No
Set flag K1=2
Set ILAST= no. of pts. on NGI Xsect (k)
Error
10/C
Yes
If YY(K1)> YDIST(1,K1) ?
Yes
If YY(K)> YDIST(1,K) ?
No
If YY(k)< YDIST(NOPT(K),K) ?
Yes
Yes
If YY(K)< YDIST(NOPT(K1),K1) ?
No
No
No
Set indices L1=1 M1=1 M=1
9/A
Compute L=pt. no. just past YY(K) Compute ZI, XI=Sta(I-2+K) YI=YY(K)
Set indices LZ=NOPT(K) MZ=NOPT(K1) M=NOCN(2)+1
9/B
Set indices M1=Conect(M,K,2) M2=Conect(M-1,K,2) L1=Conect(M,K1,2) L2=Conect(M-1,K1,2)
If NGIFL=0 ?
No
Yes
9/C
8/B
Find M=Index of connector equal to L
ILAST=NOCN(2)
Store cross-section X=XI Y=YI Z=ZI Incr. counters ICLFL; IXCNT; I1


9/A
If line ?
=3
=1
=2
If |YY(K1)-YDIST(M1,K1)| < eps. ?
No
Yes
11/A
If |YY(K1)-YDIST(M1,K1)| < eps. ?
Yes
No
If YY(K1) < YDIST(M1,K1) ?
Yes
No
If |YY(K1)-YDIST(M2,K1)| < eps. ?
Yes
No
If YY(K1) > YDIST(M2,K1) ?
No
Yes
If IONFL≠1 and YY(K1) < YDIST(M1,K1) ?
Yes
9/B
Set LINE=2 NCR=1 LAST=NOCN(2)
Set indices LX=L1 MX=M1
10/A
If |YY(K1)-YDIST(M2,K1)| < eps. ?
Yes
No
If YY(K1) < YDIST(M2,K1) ?
No
Yes
9/C
Set LINE=3 NCR=-1 LAST=2
Set indices LX=L2 MX=M2
10/A
If IONFL=0 ?
Yes
No
11/A
If IONFL=2 ?
Yes
No
If YY(K1) > YDIST(M1,K1) and YY(K1) < YDIST(M2,K1) ?
Yes
No
Set IONFL=2 M=M+1
8/B
Set IONFL=0 M=M-1


10/A
Compute XJ, YJ, ZJ using MX & LX indices
Compute Diff=X(I)-XJ Set IDFLG=0
If DIFF=0 ?
Yes
Set IDFLG=1
No
If SIGN(DIFF) =ISGN ?
No
Store X, Y, & calc. Z for cross-section pt.
If IXCNT=2 ?
Yes
Set ICLFL=IXCNT
No
Yes
If NGIFL=0 ?
No
Store XJ, YJ, ZJ Incr. I1
Yes
Increment I1=I1+1 IXCNT=IXCNT+1
If IXCNT > 3 ?
Yes
11/B
No
If NGIFL=0 ?
No
Yes
Set NGIFL=1
Replace: XI=XJ YI=YJ ZI=ZJ
If IDFLG=1 ?
Yes
No
If K=2 ?
No
Yes
Set NGIFL=2
If M=LAST ?
Yes
10/C
No
Incr. M=M+NCR
8/B
Print error message
2/D


11/A
Compute
XJ=Sta(I-1+K)
YJ=YY(K1)
Cal. ZJ
4/D
11/B
Yes
If
IXCNT > 3
?
No
Compute
DIFF=X(IXCNT)-XJ
Set
NGIFL=1
Compute distances from ℄ pt. to all other cross-section pts. & store results in STFIL array.
If
\|DIFF\| < EPS
?
Yes
No
If
K=2
?
No
Yes
Return
Increment
I1=I1+1
IXCNT=IXCNT+1
If
SIGN(DIFF)
=K1-K
?
Yes
Set
NGIFL=2
No
No
Set
ICLFL=I1
Yes
If
IXCNT=2
?
Store
X=X(IXCNT)
Y=Y(IXCNT)
Calc. Z
3/D

PROGRAM LISTINGS

Some of the objectives of this research project were to implement an NGI system, and develop and demonstrate program modules which would create terrain cross-sections from the numerical ground model along alignments stored in the Roadway Design System (RDS). These objectives were accomplished; however, due to the limited time and funds several previously written routines were used for expediency. These routines performed the functions required along with functions extraneous to NGI. It was the intention of the project staff that these routines would be replaced after more experience in the use of the system was gained.

In order to run NGI, the user must have version 5.0 of RDS (which was transmitted to FHWA on May 23, 1974) or a later version. Two RDS routines (CARD and BLOCK DATA) were utilized in the NGI system with very slight modifications. The listings for these two routines are given on the following pages along with the two new NGI routines (MAIN and NGI).

Three new routines (PREP, PLIST and XBILD) were written for RDS to access the NGI file and build cross-sections. These routines were included in version 5.0 of RDS; however, they have been revised and listings of the latest version are included. In addition the following routines must be copied exactly from version 5.0 of RDS and used with the previously mentioned routines: STANO, STATN and PRNTR. Since some of the RDS routines used in NGI call other RDS routines, it is necessary to use the following dummy RDS routines: DELETE, EXTND, HUB, ISAM, PREP, PNCH, DCODE, and LETR. The documentation for the routines PREP, PLIST and XBILD included in this report updates that contained in version 5.0 of RDS. A link edit (module map) is given on the next two pages. This shows all the routines necessary for the NGI system.

Pages C-72 and C-73 are the JCL for job stepping NGI and RDS. Page C-74 is the JCL for processing NGI and building an intermediate tape file. Page C-75 is the JCL for accessing the intermediate tape file and executing RDS. These JCL were used in testing NGI.

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F44-LEVEL LINKAGE EDITOR OPTIONS SPECIFIED LIST,LET,MAP
         DEFAULT OPTION(S) USED -  SIZE=(65536,26624)


                                                      MODULE MAP


 CONTROL SECTION                        ENTRY

   NAME     ORIGIN  LENGTH                NAME    LOCATION      NAME     LOCATION      NAME     LOCATION      NAME     LOCATION

 MAIN           00      2D2
 CDATA         2D8      6C0
 CMAIN         998       28
 CPRNT         9C0       68
 SYSTM         A28       20
 EQBLK         A48      92C
 TITLE        1378       2C
 NGI          13A8     3FD8
 CARD         5380     2CC8
 PRNTR        8048     5342
 STAND        D390      618
 STATN        D9A8      470
 DELET        DE18       F6
 EXTND        DF10       F6
 HUB          E008       F6
 ISAM         E100       F6
 PREP         E1F8       F6
 PLIST        E2F0       F6
 DCODE        E3E8       F6
 LETR         E4E0       F6
 PNCH         E5D8       F6
 IHCEDIOS*    E6D0      E6E
                                        DIOCS#       E6D0
 IHCECOMH*    F540      F61
                                        IBCOM#       F540   FDIOCS#       F5FC   INTSWTCH     10486
 IHCCOMH2*   104A8      65D
                                        SEQDASD     10820
 REREAD# *   10B08       DA
                                        REREAD      10B08
 IHCFCVTH*   10BE8     119D
                                        ADCON#      10BE8   FCVAOUTP     10C92   FCVLOUTP     10D22   FCVZOUTP     10E72
                                        FCVIOUTP    11220   FCVEOUTP     11722   FCVCOUTP     1193C   INT6SWCH     11C23
 IHCEFNTH*   11D88      542
                                        ARITH#      11D88   ADJSWTCH     12124
 IHCEFIOS*   122D0      F28
                                        FIOCS#      122D0   FIOCSBEP     122D6
 IHCFIOS2*   131F8      52E
 IHCERRM *   13728      5D4
                                        ERRMON      13728   IHCERRE      13740
 IHCUATBL*   13D00      638
 IHCUOPT *   14338      350
 IHCETRCH*   14688      28E
                                        IHCTRCH     14688   ERRTRA       14690
 CERWK       14918       14
```

```
    NAME     ORIGIN  LENGTH                NAME    LOCATION      NAME    LOCATION      NAME    LOCATION      NAME    LOCATION

  CDELE       14930       4C
  PARM        14980       5C
  CSORT       149E0      644
  CSTAT       15028        8
  CIXSE       15030        C
  QSAM        15040      D78

 ENTRY ADDRESS         00
 TOTAL LENGTH      15DB8

****MAIN       DOES NOT EXIST BUT HAS BEEN ADDED TO DATA SET
```

```
C**** NGI DRIVER ****
      COMMON /SYSTM/ SYSIN,SYSOT,SYSER,SYSTP,NINES,IQUIT,ENDFL,JARG
      COMMON /TITLE/ IPAGE,IDATE(4),ICHWY(4),JOBNO(2)
      COMMON /CMAIN/ IDUMM(9),LIST
      COMMON /CDATA/ ISTA,IDUM,DATA(400),NOPT,IDUM1,IDUM2(8),IDUM3(20)
      INTEGER IYES/'YES'/,DATA,SYSIN,SYSOT,SYSER,SYSTP,ENDFL
      DEFINE FILE 15(2398,400,U,JARG)
      CALL REREAD
      READ (SYSIN,5) ITAPE,ICRD,ICRDP,IPRNT
    5 FORMAT(27X,2A3,43X,A3,A1)
      IF(ICRDP.EQ.IYES) LIST=1
      CALL NGI(IPRNT,ICRD,ITAPE)
      IF(ITAPE.NE.IYES) GO TO 20
      END FILE SYSTP
      LAST=JARG-1
      JARG=1
      DO 10 I=1,LAST
      READ (15'JARG) DATA
   10 WRITE (SYSTP) DATA
      END FILE SYSTP
      REWIND SYSTP
      WRITE (6,15)
   15 FORMAT(//' THE NGI FILE HAS BEEN PUT ON THE TAPE'//)
   20 CONTINUE
      STOP
      END
```

```
LEVEL 21.8 ( JUN 74 )                          OS/360  FORTRAN H                                    DATE  74.353/08.51.25

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                             SOURCE,EBCDIC,LIST,DECK,LOAD,MAP,NOEDIT,NOID,XREF
  ISN 0002             BLOCK DATA
  ISN 0003             COMMON /CDATA/ JCSTA,OF,DATA(400),SNUMC,KEY,INDEX(8),OVER(20)
  ISN 0004             COMMON /CMAIN/ IRTYP,JRTYP,IRSET,JCARD,ITSTA,ODUMP,FDUMP,FINAL,
                      *               INTPL,LIST
  ISN 0005             COMMON /CPRNT/ DT,EL1,NUMC,HIBI,FS,BS,BM,NUM,LOR,ICARD,TYPE,NEQ
  ISN 0006             COMMON /SYSTM/ SYSIN,SYSOT,SYSER,SYSTP,NINES,IQUIT,ENDFL,IARG
  ISN 0007             COMMON /EQBLK/ NOEQ(26),EQTAB(7,20,2),NSET
  ISN 0008             COMMON /TITLE/ IPAGE,IDATE(4),ICHWY(4),JOBNO(2)
  ISN 0009             REAL*8 EQTAB
  ISN 0010             INTEGER  NEQ/1/,IRSET/1/,ODUMP/0/,FDUMP/0/,JCARD/1/,
                      *          JCSTA/999999999/,FINAL/0/,INTPL/0/,KEY/1/,INDEX/3,797,
                      *          'STAF',3400,2,403,'FINF',1754/,OVER/'1','2','3','4','5',
                      *          '6','7','8','9','0','J','K','L','M','N','O','P','Q','R',
                      *          -801095616/,ICARD/1/,IRTYP/1/,LIST/0/,NOEQ/7*0/,
                      *          NSET/1/,SYSIN/5/,SYSOT/6/,SYSER/6/,SYSTP/2/,
                      *          NINES/999999999/,IQUIT/0/,ENDFL/1/,IARG/0/,IPAGE/1/,
                      *          IDATE/4*' '/,ICHWY/4*' '/,JOBNO/2*' '/,DT(8),EL1(8)
  ISN 0011             END
```

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                             SOURCE,EBCDIC,LIST,DECK,LOAD,MAP,NOEDIT,NOID,XREF
  ISN 0002           SUBROUTINE NGI(IP,IC,IT)
  ISN 0003           COMMON /CDATA/ XSTA,IDUM,DATA(400),NOPT,IDUM1,IDUM2(8),IDUM3(20)
  ISN 0004           COMMON /CMAIN/ IRTYP,JRTYP,IRSET,JCARD,ITSTA,ODUMP,ISTRP,FINAL,
                    *               INTPL,LIST
  ISN 0005           COMMON /SYSTM/ SYSIN,SYSOT,SYSER,SYSTP,NINES,IQUIT,ENDFL,IARG
  ISN 0006           COMMON /PARM/ IMAGE(23)
  ISN 0007           DIMENSION FRAC(4),DIST(2),ELEV(5)
  ISN 0008           INTEGER SYSIN,SYSOT,SYSER,SYSTP,ENDFL
  ISN 0009           INTEGER REC(400,2),SDATA(200,2),FENCE(4),PNTR(4),IDIS(2),TNOPT,
                    *DATA,XSTA,CONECT(200),FINAL,IPTNO(5),ITYP(5),IDIST(5),IBACK(8),
                    *IAHED(8),OSTA,ICHEK(5),STA,STOLD,IELV(5)
  ISN 0010           REAL*8 DBREC(188),XYBE(4)
  ISN 0011           INTEGER*2 NOSTR,I2REC(48),SDIND(200,2)
  ISN 0012           EQUIVALENCE (I2REC(48),NOSTR)
  ISN 0013           DATA MY/'Y'/,IX/'X'/,IYES/'YES'/,NGI/'NGI'/
  ISN 0014           NOSTR=0
  ISN 0015           IREC=49
  ISN 0016           INDX=1
  ISN 0017           NOPT=0
  ISN 0018           MAX=400
  ISN 0019           IPG=0
  ISN 0020           LCNT=56
  ISN 0021         5 IFRST=0
  ISN 0022           OSTA=XSTA
  ISN 0023           TNOPT=NOPT
  ISN 0024        10 IF(IC.NE.IYES) GO TO 14
  ISN 0026           ISTRP=1
  ISN 0027           IF(JCARD.EQ.2) GO TO 12
  ISN 0029        11 READ (5,1,END=22) IMAGE
  ISN 0030         1 FORMAT(3A4,A1,2A4,2A1,2A4,A3,2A4,A2,9A4)
  ISN 0031           IF(IMAGE(3).EQ.NGI) GO TO 23
  ISN 0033        12 N2=2-IFRST
  ISN 0034           READ (99,2) STA,(IDIST(I),IPTNO(I),ITYP(I),ICHEK(I),I=1,5),N
  ISN 0035         2 FORMAT(I8,5(2(I5,1X),I1,A1),1X,I1)
  ISN 0036           IF(JCARD.EQ.1) GO TO 19
  ISN 0038           IF(STA.NE.STOLD) GO TO 24
  ISN 0040        19 IF(N.EQ.0) N=5
  ISN 0042           DO 21 I=1,N
  ISN 0043           IF(ICHEK(I).EQ.IX) GO TO 21
  ISN 0045           J=J+1
  ISN 0046           SDATA(J,N2)=(10000-IDIST(I))*100000+IPTNO(I)
  ISN 0047           SDIND(J,N2)=ITYP(I)
  ISN 0048           IF(IP.EQ.MY) WRITE (6,18) I,J,N2,SDATA(J,N2),SDIND(J,N2)
  ISN 0050        18 FORMAT(' ',I3,I3,I3,I12,I2)
  ISN 0051        21 CONTINUE
  ISN 0052           STOLD=STA
  ISN 0053           JCARD=2
  ISN 0054           GO TO 11
  ISN 0055        22 ISTRP=3
  ISN 0056           GO TO 24
  ISN 0057        23 ISTRP=2
  ISN 0058           IF(JCARD.EQ.1) GO TO 17
  ISN 0060        24 XSTA=STOLD
  ISN 0061           STOLD=STA
  ISN 0062           NOPT=J
  ISN 0063           GO TO 82
```

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ISN 0064         14 CALL CARD
ISN 0065            GO TO (40,15,40,35),ISTRP
ISN 0066         15 IF(JCARD.EQ.2) GC TO 40
ISN 0068         16 JCARD=1
ISN 0069         17 READ (59,20) XYBE
ISN 0070         20 FORMAT(13X,4F15.5)
ISN 0071            IF(IT.EQ.IYES) WRITE (SYSTP,1) IMAGE
ISN 0073            N1=NOSTR*4+1
ISN 0074            N2=N1+3
ISN 0075            J=0
ISN 0076            DO 25 I=N1,N2
ISN 0077            J=J+1
ISN 0078         25 DBREC(I)=XYBE(J)
ISN 0079            IF(NOSTR.EQ.0) GC TO 28
ISN 0081            I2REC(NOSTR)=NOSEC
ISN 0082            IARG=NCSTR+1
ISN 0083            N2=2*NCSEC
ISN 0084            IF(IP.EQ.MY) WRITE (6,27) (REC(I,1),I=1,N2)
ISN 0086         27 FORMAT(' XSECTICN ARRAY - INDEX',200(/1X,2I10))
ISN 0087            WRITE (15'IARG) (REC(I,1),I=1,MAX)
ISN 0088         28 NOSEC=0
ISN 0089            NOSTR=NOSTR+1
ISN 0090            IFRST=1
ISN 0091            IKEY=0
ISN 0092            IF(IC.NE.IYES) GC TO 10
ISN 0094            J=0
ISN 0095            GO TO 11
ISN 0096         30 I2REC(NOSTR)=NOSEC
ISN 0097            IF(IP.EQ.MY) WRITE (6,31) NOSTR,(DBREC(4*I-3),DBREC(4*I-2),
                   *                       DBREC(4*I-1),DBREC(4*I),I2REC(I),I=1,NOSTR)
ISN 0099         31 FORMAT(' NC. OF STRIPS=',I2/1X,'STRIP CCOR. LIMITS & INDICES',
                   *47(/1X,4F15.5,I5))
ISN 0100            WRITE (15'1) DBREC,I2REC
ISN 0101            IARG=NCSTR+1
ISN 0102            N2=2*NOSEC
ISN 0103            IF(IP.EQ.MY) WRITE (6,32) (REC(I,1),I=1,N2)
ISN 0105         32 FORMAT(' XSECTION ARRAY - INDEX',200(/1X,2I10))
ISN 0106            WRITE (15'IARG) (REC(I,1),I=1,MAX)
ISN 0107            IARG=IREC
ISN 0108            N2=INDX-1
ISN 0109            IF(N2.EQ.0) GO TC 39
ISN 0111            IF(IP.EQ.MY) WRITE (6,33) (REC(I,2),I=1,N2)
ISN 0113         33 FORMAT(' POINT ARRAY',34(/1X,12I11))
ISN 0114            WRITE (15'IARG) (REC(I,2),I=1,MAX)
ISN 0115            GO TO 39
ISN 0116         35 WRITE (6,38)
ISN 0117         38 FORMAT(' ERROR - UNRECOGNIZABLE NGI CARD - PROCESSING TERMINATES')
ISN 0118         39 IQUIT=ENDFL
ISN 0119            GO TO 200
ISN 0120         40 NX=2*NCPT
ISN 0121            IF(IP.EQ.MY) WRITE (6,13) NCPT,XSTA,(DATA(I),I=1,NX)
ISN 0123         13 FORMAT(' NOPT=',I3,' XSTA=',I10/5X,'DATA ARRAY',200(/1X,2I10))
ISN 0124            I=0
ISN 0125            J=-1
ISN 0126            N1=0
ISN 0127            N2=2-IFRST
ISN 0128         43 ICNT=1
ISN 0129         45 I=I+1
```

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ISN 0130        50 J=J+2
ISN 0131           IF(I.GT.NOPT) GO TO 80
ISN 0133           SDATA(I,N2)=(1000000-DATA(J+1))*1000+DATA(J)/10
ISN 0134           IF(I.EQ.1) GO TO 55
ISN 0136           IF(SDATA(I-1,N2).NE.SDATA(I,N2)) GO TO 60
ISN 0138           NOPT=NOPT-1
ISN 0139        55 ICNT=ICNT+1
ISN 0140           IF(I.EQ.1) GO TO 45
ISN 0142           GO TO 50
ISN 0143        60 IF(ICNT.LE.4) GO TO 70
ISN 0145           IF(ICNT/4*4.NE.ICNT) GO TO 65
ISN 0147           N1=ICNT/4-1
ISN 0148           ICNT=4
ISN 0149           GO TO 70
ISN 0150        65 IF(ICNT/3*3.NE.ICNT) GO TO 70
ISN 0152           N1=ICNT/3-1
ISN 0153           ICNT=3
ISN 0154        70 SDIND(I-1,N2)=ICNT
ISN 0155           IF(IP.EQ.MY) WRITE (6,72) I,J,N2,ICNT,SDATA(I-1,N2),SDIND(I-1,N2)
ISN 0157        72 FORMAT(' I=',I3,' J=',I3,' N2=',I1,' ICNT=',I2,' SDATA(I-1,N2)=',
                  *I11,' SDIND(I-1,N2)=',I2)
ISN 0158           IF(N1.EQ.0) GO TO 43
ISN 0160           DO 75 K=1,N1
ISN 0161           NOPT=NOPT+1
ISN 0162           SDATA(I+1,N2)=SDATA(I,N2)
ISN 0163           SDATA(I,N2)=SDATA(I-1,N2)
ISN 0164           SDIND(I,N2)=SDIND(I-1,N2)
ISN 0165        75 I=I+1
ISN 0166           N1=0
ISN 0167           GO TO 43
ISN 0168        80 SDIND(I-1,N2)=2
ISN 0169           IF(IP.EQ.MY) WRITE (6,72) I,J,N2,ICNT,SDATA(I-1,N2),SDIND(I-1,N2)
ISN 0171        82 NOSEC=NOSEC+1
ISN 0172           JNDX=NOSEC*2-1
ISN 0173           REC(JNDX,1)=XSTA
ISN 0174           REC(JNDX+1,1)=NOPT*10000000+INDX*10000+IREC
ISN 0175           N1=INDX+NOPT
ISN 0176           J=0
ISN 0177           IFL=1
ISN 0178        85 DO 95 I=INDX,N1
ISN 0179           IF(I.GT.MAX) GO TO 100
ISN 0181           J=J+1
ISN 0182           IF(I.NE.N1) GO TO 90
ISN 0184           REC(I,2)=0
ISN 0185           GO TO 95
ISN 0186        90 REC(I,2)=SDATA(J,N2)
ISN 0187        95 CONTINUE
ISN 0188           INDX=N1+1
ISN 0189           J=0
ISN 0190           IF(IFRST.EQ.1) GO TO 5
ISN 0192           GO TO 105
ISN 0193       100 INDX=1
ISN 0194           IARG=IREC
ISN 0195           IF(IP.EQ.MY) WRITE (6,103) (REC(I,2),I=1,MAX)
ISN 0197       103 FORMAT(' POINT ARRAY',34(/1X,12I11))
ISN 0198           WRITE (15'IARG)(REC(I,2),I=1,MAX)
ISN 0199           IREC=IREC+1
ISN 0200           N1=N1-MAX
```

```
ISN 0201            GO TO (85,175,179),IFL
ISN 0202        105 IFL=2
ISN 0203            NOCN=0
ISN 0204            DO 110 I=1,4
ISN 0205            FENCE(I)=1
ISN 0206        110 PNTR(I)=1
ISN 0207        115 FENCE(1)=FENCE(4)
ISN 0208            FENCE(2)=FENCE(3)
ISN 0209            N=TNOPT
ISN 0210            JFL=1
ISN 0211        120 N3=FENCE(JFL)+1
ISN 0212            DO 135 I=N3,N
ISN 0213            ITYPE=SDIND(I,JFL)
ISN 0214            GO TO (135,140,125,130),ITYPE
ISN 0215        125 IF(JFL.EQ.1) GO TO 140
ISN 0217            GO TO 135
ISN 0218        130 IF(JFL.EQ.2) GO TO 140
ISN 0220        135 CONTINUE
ISN 0221        140 FENCE(5-JFL)=I
ISN 0222            IF(JFL.EQ.2) GO TO 145
ISN 0224            JFL=2
ISN 0225            N=NOPT
ISN 0226            GO TO 120
ISN 0227        145 IF(FENCE(3).NE.NOPT) GO TO 150
ISN 0229            IF(FENCE(4).EQ.TNOPT) GO TO 155
ISN 0231            FENCE(4)=TNOPT
ISN 0232            GO TO 153
ISN 0233        150 IF(FENCE(4).NE.TNOPT) GO TO 155
ISN 0235            FENCE(3)=NOPT
ISN 0236        153 WRITE (6,154) NOSTR,NOSEC,XSTA
ISN 0237        154 FORMAT(' ERROR-UNEQUAL NO. OF FENCE MARKS FOR STRIP NO. ',I2,' SEC
                   *T. NO. ',I3,' AT STA. NO. ',I10,' EXTRA MARKS ELIMINATED-PROCESSIN
                   *G CONTINUES')
ISN 0238        155 IDIS(1)=SDATA(FENCE(1),1)/100000
ISN 0239            IDIS(2)=SDATA(FENCE(2),2)/100000
ISN 0240            DIST(1)=IDIS(1)-SDATA(FENCE(4),1)/100000
ISN 0241            DIST(2)=IDIS(2)-SDATA(FENCE(3),2)/100000
ISN 0242            IF(IP.EQ.MY) WRITE (6,156) IDIS,DIST,FENCE
ISN 0244        156 FORMAT(' IDIS=',2I6,' DIST=',2F8.2,' FENCES=',4I10)
ISN 0245        158 FRAC(1)=(IDIS(1)-SDATA(PNTR(1),1)/100000)/DIST(1)
ISN 0246            FRAC(2)=(IDIS(2)-SDATA(PNTR(2),2)/100000)/DIST(2)
ISN 0247            FRAC(3)=(IDIS(2)-SDATA(PNTR(3),2)/100000)/DIST(2)
ISN 0248            FRAC(4)=(IDIS(1)-SDATA(PNTR(4),1)/100000)/DIST(1)
ISN 0249            NOCN=NOCN+1
ISN 0250            IF(FRAC(4).GE.(FRAC(2)+FRAC(3))/2.0) GO TO 160
ISN 0252            CONECT(NOCN)=PNTR(2)*1000+PNTR(4)
ISN 0253            PNTR(1)=PNTR(4)
ISN 0254            GO TO 168
ISN 0255        160 IF(FRAC(3).GE.(FRAC(1)+FRAC(4))/2.0) GO TO 165
ISN 0257            CONECT(NOCN)=PNTR(3)*1000+PNTR(1)
ISN 0258            PNTR(2)=PNTR(3)
ISN 0259            IF(PNTR(3).LT.FENCE(3)) PNTR(3)=PNTR(3)+1
ISN 0261            GO TO 170
ISN 0262        165 CONECT(NOCN)=PNTR(3)*1000+PNTR(4)
ISN 0263            PNTR(1)=PNTR(4)
ISN 0264            PNTR(2)=PNTR(3)
ISN 0265            IF(PNTR(3).LT.FENCE(3)) PNTR(3)=PNTR(3)+1
ISN 0267        168 IF(PNTR(4).LT.FENCE(4)) PNTR(4)=PNTR(4)+1
```

```
ISN 0269       170 IF(IP.EQ.MY) WRITE (6,171) CONECT(NOCN),NOCN,PNTR,FRAC
ISN 0271       171 FORMAT(' CONNECTOR=',I6,' NOCN=',I2,' PNTRS=',4I3,' FRACS=',4F11.8
                  *)
ISN 0272           IF(PNTR(1).NE.FENCE(4).OR.PNTR(2).NE.FENCE(3)) GO TO 158
ISN 0274           PNTR(3)=PNTR(3)+1
ISN 0275           PNTR(4)=PNTR(4)+1
ISN 0276           IF(FENCE(4).LT.TNOPT.AND.FENCE(3).LT.NOPT) GO TO 115
ISN 0278           REC(N1,2)=NOCN
ISN 0279           N1=INDX+NOCN-1
ISN 0280           J=0
ISN 0281       175 IF(IP.EQ.MY) WRITE (6,174) INDX,N1
ISN 0283       174 FORMAT(' INDX=',I4,' N1=',I4)
ISN 0284           DO 178 I=INDX,N1
ISN 0285           IF(I.GT.MAX) GO TO 100
ISN 0287           J=J+1
ISN 0288           REC(I,2)=CONECT(J)
ISN 0289           IF(IP.EQ.MY) WRITE (6,177) I,REC(I,2),J
ISN 0291       177 FORMAT(' INDX=',I4,' CONNECTOR=',I6,' J=',I3)
ISN 0292       178 CONTINUE
ISN 0293           INDX=N1+1
ISN 0294           IF(INDX.LE.MAX) GO TO 179
ISN 0296           IFL=3
ISN 0297           GO TO 100
ISN 0298       179 J=0
ISN 0299           JFB=0
ISN 0300           JF=0
ISN 0301           JB=0
ISN 0302           DO 250 I=1,TNOPT
ISN 0303           IF(SDIND(I,1).EQ.2) JFB=JFB+1
ISN 0305           IF(SDIND(I,1).EQ.3) JF=JF+1
ISN 0307           IF(SDIND(I,1).EQ.4) JB=JB+1
ISN 0309           J=J+1
ISN 0310           IPTNO(J)=I
ISN 0311           ITYP(J)=SDIND(I,1)
ISN 0312           IDS=SDATA(I,1)/100000
ISN 0313           IDIST(J)=10000-IDS
ISN 0314           IELV(J)=SDATA(I,1)-IDS*100000
ISN 0315           ELEV(J)=IELV(J)/10.
ISN 0316           IF(J.LT.5.AND.I.NE.TNOPT) GO TO 250
ISN 0318           IF(LCNT.LT.56) GO TO 215
ISN 0320           LCNT=10
ISN 0321           IPG=IPG+1
ISN 0322           WRITE (16,210) IPG
ISN 0323       210 FORMAT(1H1,129X,I2/50X,'NUMERICAL GROUND IMAGE SYSTEM'//53X,
                  *'SCAN PROFILE DATA LIST'///6X,'STATION  ',5('   POINT    ELEV   DI
                  *ST')/6X, 'NUMBER  ',5('    NUMBER    IN     IN')/15X,5('   (TYPE)
                  *  FEET   FEET'))
ISN 0324           GO TO 220
ISN 0325       215 IF(I.GT.5) GO TO 230
ISN 0327       220 IST=OSTA/10000
ISN 0328           ST=ABS((OSTA-IST*10000)/100.)+.0005
ISN 0329           WRITE (16,225) IST,ST,(IPTNO(K),ITYP(K),ELEV(K),IDIST(K),K=1,J)
ISN 0330       225 FORMAT(/3X,I6,'+',F5.2,5(3X,I3,'(',I1,')',2X,F6.1,1X,I5))
ISN 0331           LCNT=LCNT+1
ISN 0332           GO TO 240
ISN 0333       230 WRITE (16,235) (IPTNO(K),ITYP(K),ELEV(K),IDIST(K),K=1,J)
ISN 0334       235 FORMAT(15X,5(3X,I3,'(',I1,')',2X,F6.1,1X,I5))
ISN 0335       240 IF(IT.NE.IYES) GO TO 248
```

```
ISN 0337          IF(J.EC.5) GO TO 244
ISN 0339          K1=J+1
ISN 0340          DO 243 K=K1,5
ISN 0341          IDIST(K)=0
ISN 0342          IELV(K)=0
ISN 0343      243 ITYP(K)=0
ISN 0344      244 WRITE(SYSTP,245) OSTA,(IDIST(K),IELV(K),ITYP(K),K=1,5),J
ISN 0345      245 FORMAT(I8,5(2(I5,1X,),I1,1X),1X,I1)
ISN 0346      248 LCNT=LCNT+1
ISN 0347          J=0
ISN 0348      250 CONTINUE
ISN 0349          IF(LCNT.LT.56) GC TO 252
ISN 0351          LCNT=10
ISN 0352          IPG=IPG+1
ISN 0353          WRITE (16,210) IPG
ISN 0354      252 IFORW=JFB+JF
ISN 0355          IREAR=JFB+JB
ISN 0356          WRITE (16,253) JFB,JF,JB,IREAR,IFORW
ISN 0357      253 FORMAT(/1X,'DISCCNTINUITIES-',I4,'(2)',I4,'(3)',I4,'(4)',I4,' BK',
                 *  I4,' FWD')
ISN 0358          LCNT=LCNT+2
ISN 0359          IF(IKEY.EQ.1) GO TC 300
ISN 0361          DO 180 I=1,NOPT
ISN 0362          SDIND(I,1)=SDIND(I,2)
ISN 0363      180 SDATA(I,1)=SDATA(I,2)
ISN 0364          TNOPT=NOPT
ISN 0365          OSTA=XSTA
ISN 0366          J=0
ISN 0367          DO 285 I=1,NOCN
ISN 0368          J=J+1
ISN 0369          IAHED(J)=CONECT(I)/1000
ISN 0370          IBACK(J)=CCNECT(I)-IAHED(J)*1000
ISN 0371          IF(J.LT.8.AND.I.NE.NCCN) GO TO 285
ISN 0373          IF(LCNT.LT.56) GC TO 255
ISN 0375          LCNT=10
ISN 0376          IPG=IPG+1
ISN 0377          WRITE (16,210) IPG
ISN 0378          GO TO 260
ISN 0379      255 IF(I.GT.8) GO TO 270
ISN 0381      260 WRITE (16,265) (IBACK(K),IAHED(K),K=1,J)
ISN 0382      265 FORMAT(/' POINT CCNNECTIONS ',8(3X,I3,' TO ',I3))
ISN 0383          LCNT=LCNT+1
ISN 0384          GO TO 280
ISN 0385      270 WRITE (16,275) (IBACK(K),IAHED(K),K=1,J)
ISN 0386      275 FORMAT(19X,8(3X,I3,' TO ',I3))
ISN 0387      280 LCNT=LCNT+1
ISN 0388          J=0
ISN 0389      285 CONTINUE
ISN 0390          IF(ISTRP.EQ.1) GC TO 10
ISN 0392          IKEY=1
ISN 0393          GO TO 179
ISN 0394      300 IF(ISTRP.EQ.2) GO TO 16
ISN 0396          IF(ISTRP.EQ.3) GC TO 30
ISN 0398          GO TO 10
ISN 0399      200 RETURN
ISN 0400          END
```

```
        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                           SOURCE,EBCDIC,LIST,DECK,LOAD,MAP,NOEDIT,NOID,XREF
ISN 0002           SUBROUTINE CARD                                                   CARD0005
             C ***      SUBROUTINE CARD READS THE TERRAIN EDIT AND STORE DATA CARDS, CARD0010
             C *** DETERMINES THEIR TYPES, REREADS THEM IN THE PROPER FORMAT, AND    CARD0015
             C *** PROCESSES THE NUMBERS SO THEY ARE IN THE FORM USABLE BY THE  T I ECARD0020
             C *** SYSTEM.  THE VARIOUS DATA CARDS ARE GIVEN THE FOLLOWING TYPES--   CARD0025
             C *** (NOTE--THE TERM 'NO' REFERS TO A 'NEGATIVE ZERO', OR A ZERO AND A CARD0030
             C *** MINUS SIGN PUNCHED IN THE SAME COLUMN.  SIMILARLY, 'N6' REFERS TO CARD0035
             C *** 6 AND A MINUS SIGN PUNCHED IN THE SAME COLUMN, ETC.)              CARD0040
ISN 0003           REAL*8 EQTAB,ET1,ET2                                              CARD0045
             C ***                                                                   CARD0050
             C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CARD0055
             C   * TYPE *          CHARACTERIZATION          *          DATA CARD    CARD0060
             C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CARD0065
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0070
             C   *                ELEVATION CARDS -- NEW THD FORMAT                  CARD0075
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0080
             C   *   1  * 1 IN COLUMN 13                     * ORIGINAL HI CARD      CARD0085
             C   *   2  * 2 IN COLUMN 13                     * ORIGINAL BIAS CARD    CARD0090
             C   *   3  * 3 IN COLUMN 13, BLANKS IN 26-32    * ORIGINAL TURNING POINTCARD0095
             C   *   4  * 3 IN COLUMN 13, DATA IN 26-32      * ORIGINAL BENCH MARK   CARD0100
             C   *   5  * 4 IN COLUMN 13                     * FINAL HI CARD         CARD0105
             C   *   6  * 5 IN COLUMN 13                     * FINAL BIAS CARD       CARD0110
             C   *   7  * 6 IN COLUMN 13, BLANKS IN 26-32    * FINAL TURNING POINT   CARD0115
             C   *   8  * 6 IN COLUMN 13, DATA IN 26-32      * FINAL BENCH MARK CARD CARD0120
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0125
             C   *                ELEVATION CARDS -- OLD THD FORMAT                  CARD0130
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0135
             C   *   1  * NO IN COLUMN 13                    * ORIGINAL HI CARD      CARD0140
             C   *   2  * N6 IN COLUMN 13                    * ORIGINAL BIAS CARD    CARD0145
             C   *   3  * 5 IN 13, NO IN 23, BLANKS IN 39-44 * ORIGINAL TURNING POINTCARD0150
             C   *   4  * 5 IN 13, NO IN 23, DATA IN 39-44   * ORIGINAL BENCH MARK CACARD0155
             C   *   5  * N1 IN COLUMN 13                    * FINAL HI CARD         CARD0160
             C   *   6  * N7 IN COLUMN 13                    * FINAL BIAS CARD       CARD0165
             C   *   7  * 5 IN 13, N1 IN 23, BLANKS IN 39-44 * FINAL TURNING POINT CACARD0170
             C   *   8  * 5 IN 13, N1 IN 23, DATA IN 39-44   * FINAL BENCH MARK CARD CARD0175
ISN 0004           INTEGER SYSIN,ENDFL,OF,FINAL,DATA,SNUMC,OVER,DT(8),EL1(8),        CARD0180
                  1     HIBI,FS,BS,BM,TYPE,SDATA(400),STA1,STA2,DEL1,DEL2,           CARD0185
                  2     OFD(3),PLUS,ASTA,BSTA,BLANK/'    '/,FAC,HB,IEQ(20),OLOR,     CARD0190
                  3     ONUM,OONUM,CORD,ORD,ORDCK,SNUM,EL2(8),FACTR,L/'L'/,OOJCS,    CARD0195
                  4     ISKIP/1/,         BMCK/0/,OSTA1/-1/,OSTA2/-1/,OJCST/-1/,     CARD0200
                  5     RCL,HB2,Z1/'0000'/,Z2/'00'/,TERR/'TERR'/,IM(8),TKEY(2)/0,0/, CARD0205
                  6     C13(9)/-801095616,'0','5','J','P','9','8','7','1'/,          CARD0210
                  7     CTYP(9)/1,2,3,5,6,9,11,12,13/,BT,RD55/'RD55'/,NGI/'NGI '/,   CARD0215
                  8     G/'G'/,RT60/'RT60'/,HPCL,MINUS/'-'/,RT30/'RT30'/,SKEY,       CARD0220
                  9     RT07/'RT07'/,RT08/'RT08'/,RT11/'RT11'/,RT70/'RT70'/,         CARD0225
                  A     RT40/'RT40'/,IJOB(20)/' FIN','AL C','D./T','APE','ORIG',     CARD0230
                  B     '. EX','TENS','IONS','FINA','L EX','TENS','IONS','   D',     CARD0235
                  C     'ELET','IONS',' ','MODI','F/HU','BS/P','RINT'/,SYSOT,        CARD0240
                  D     TEX/'TEX'/,CDTY,BPR/'BPR'/,THD/'THD'/,YES/'YES'/,NO/'NO'/    CARD0245
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0250
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0260
             C   *                ELEVATION CARDS -- TEX FORMAT                      CARD0255
             C   *   1  * 1 IN COLUMN 8                      * ORIGINAL HI CARD      CARD0265
             C   *   2  * 2 IN COLUMN 8                      * ORIGINAL BIAS CARD    CARD0270
             C   *   3  * 3 IN COLUMN 8, BLANKS IN 20-26     * ORIGINAL TURNING POINTCARD0275
             C   *   4  * 3 IN COLUMN 8, DATA IN 20-26       * ORIGINAL BENCH MARK   CARD0280
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             C   *   5  * 4 IN COLUMN 8                      * FINAL HI CARD         CARD0285
             C   *   6  * 5 IN COLUMN 8                      * FINAL BIAS CARD       CARD0290
             C   *   7  * 6 IN COLUMN 8, BLANKS IN 20-26     * FINAL TURNING POINT   CARD0295
             C   *   8  * 6 IN COLUMN 8, DATA IN 20-26       * FINAL BENCH MARK CARD CARD0300
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0305
             C   *                       CTHER TERRAIN CARDS                         CARD0310
             C   * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - CARD0315
             C   *   9  * 9 IN COLUMN 13                     * EQUATION CARD         CARD0320
             C   *  10  * 'TERR' IN COLUMNS 9-12             * RESET CARD            CARD0325
             C   *  11  * 'RT08' IN COLUMNS 8-11             * DELETE CARD           CARD0330
             C   *  12  * 'RT07' IN COLUMNS 8-11             * INTERPOLATED XSECTION CARD0335
             C   *  13  * /* IN COLUMNS 1-2 OR 1 IN COLUMN 13* END OF TERRAIN DATA CACARD0340
             C   *  14  * 'RD55' IN COLUMNS 8-11             *  T I E S  EQUATION CARCARD0345
             C   *  15  * 'RT60' IN COLUMNS 8-11             * HUB CARD              CARD0350
             C   *  16  * 'RT30' IN COLUMNS 8-11             * PRINT CARD            CARD0355
             C   *  17  * 'RT11' IN COLUMNS 8-11             * EQUATION DELETE       CARD0360
             C   *  18  * 'RT70' IN COLUMNS 8-11             * NGI PREPARATION CARD  CARD0365
             C   *  19  * 'RT40' IN COLUMNS 8-11             * X-SECTION MODIFICATIONCARD0370
             C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CARD0375
             C ***                                                                   CARD0380
ISN 0005           COMMON/CDATA/JCSTA,OF,DATA(400),SNUMC,KEY,INDEX(8),OVER(20)       CARD0385
ISN 0006           COMMON/CDELE/DEL1,DEL2,OFD,PLUS,HPCL(6),IRW,IHUB(6)               CARD0390
ISN 0007           COMMON/CERWK/KEYT,JTAPE,KSTA,KPAG,KBRG                            CARD0395
ISN 0008           COMMON/CMAIN/IRTYP,JRTYP,IRSET,JCARD,ITSTA,ODUMP,ISTRP,FINAL,     CARD0400
                  1     INTPL,LIST                                                   CARD0405
ISN 0009           COMMON/CPRNT/DT,EL1,NUMC,HIBI,FS,BS,BM,NUM,LOR,ICARD,TYPE,NEQ     CARD0410
ISN 0010           COMMON/CSORT/SDATA,N                                              CARD0415
ISN 0011           COMMON/CSTAT/STA1,STA2                                            CARD0420
ISN 0012           COMMON/EQBLK/NOEQ(26),EQTAB(7,20,2),NSET                          CARD0425
ISN 0013           COMMON/PARM/IMAGE(23)                                             CARD0430
ISN 0014           COMMON/QSAM/XOPEN,XCLOS,XGET,XSETL,XESTL,XPUT,XPUTX,ZERO,STAF,    CARD0435
                  1     NTIME,SKEY(2),STFIL(850)                                     CARD0440
ISN 0015           COMMON/SYSTM/SYSIN,SYSOT,SYSER,SYSTP,NINE,IQUIT,ENDFL,KNDEX       CARD0445
ISN 0016           COMMON/TITLE/IPAGE,IDATE(4),ICHWY(4),JCBNO(2)                     CARD0450
             C *** INITIALIZE VARIABLES.                                             CARD0455
ISN 0017           OF=1                                                              CARD0460
ISN 0018           IF (IRTYP.EQ.3.OR.IRTYP.EQ.5) OF=2                                CARD0465
ISN 0020        10 OLOR=L                                                            CARD0470
ISN 0021           ORD=0                                                             CARD0475
ISN 0022           ONUM=0                                                            CARD0480
ISN 0023           ISAVE=-1                                                          CARD0485
ISN 0024           SNUM=0                                                            CARD0490
ISN 0025           SNUMC=C                                                           CARD0495
ISN 0026           OONUM=0                                                           CARD0500
ISN 0027           OORD=0                                                            CARD0505
ISN 0028           JUMP=1                                                            CARD0510
ISN 0029           ISTRP=1
ISN 0030           IF (IRTYP.GT.5) JUMP=0                                            CARD0515
ISN 0032           IF (JCARD.EQ.2.AND.TYPE.EQ.12) GO TO 182                          CARD0520
ISN 0034           IF (JCARC.EQ.2) GC TO 430                                         CARD0525
ISN 0036           BT=0                                                              CARD0530
             C * * *   R E A D   A   C A R D   A N D   D E T E R M I N E   I T S   T CARD0535
             C *** GENERAL READ.                                                     CARD0540
ISN 0037        20 READ (SYSIN,30,END=60) IMAGE                                      CARD0545
ISN 0038        30 FORMAT(3A4,A1,2A4,2A1,2A4,A3,2A4,A2,9A4)                          CARD0550
ISN 0039        25 ICARD=ICARD+1                                                     CARD0555
             C *** DETERMINE THE TYPE OF CARD JUST READ.  FIRST CHECK FOR A RESET CARCARD0560
             C *** (A RESET CARD CONTAINS THE WORD 'TERRAIN' IN COLUMNS 9-15.)       CARD0565
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ISN 0040                  TYPE=10                                                           CARD0570
ISN 0041                  IF (IMAGE(3).EQ.TERR) GC TO 90                                    CARD0575
ISN 0043                  TYPE=20
ISN 0044                  IF(IMAGE(3).EQ.NGI) GC TO 90
ISN 0046                  READ(99,35) I                                                     CARD0580
ISN 0047               35 FORMAT(7X,A4)                                                     CARD0585
                C *** IF THE CARD HAS 'RT08' IN COLUMNS 8-11, IT IS A TERRAIN DELETION      CARD0590
                C *** CARD.                                                                 CARD0595
ISN 0048                  TYPE=11                                                           CARD0600
ISN 0049                  IF (I.EQ.RT08) GC TO 90                                           CARD0605
                C *** IF THE CARD HAS 'RT07' IN COLUMNS 8-11, IT IS AN INTERPOLATED         CARD0610
                C *** CROSS-SECTION CARD.                                                   CARD0615
ISN 0051                  TYPE=12                                                           CARD0620
ISN 0052                  IF (I.EQ.RT07) GC TO 90                                           CARD0625
                C *** IF THE CARD HAS 'RD55' IN COLUMNS 8-11, IT IS A  T I E S  FORMAT      CARD0630
                C *** EQUATICN CARD.                                                        CARD0635
ISN 0054                  TYPE=14                                                           CARD0640
ISN 0055                  IF (I.EQ.RD55) GO TO 90                                           CARD0645
                C *** IF THE CARD HAS 'RT60' IN COLUMNS 8-11, IT IS A HUB CARD.             CARD0650
ISN 0057                  TYPE=15                                                           CARD0655
ISN 0058                  IF (I.EQ.RT60) GC TO 90                                           CARD0660
                C *** IF THE CARD HAS 'RT30' IN COLUMNS 8-11, IT IS A PRINT CARD.           CARD0665
ISN 0060                  TYPE=16                                                           CARD0670
ISN 0061                  IF (I.EQ.RT30) GC TO 90                                           CARD0675
                C *** IF THE CARD HAS 'RT11' IN COLUMNS 8-11, IT IS AN EQUATION             CARD0680
                C *** DELETICN CARD.                                                        CARD0685
ISN 0063                  TYPE=17                                                           CARD0690
ISN 0064                  IF (I.EQ.RT11) GC TO 90                                           CARD0695
                C *** IF THE CARD HAS 'RT70' IN COLUMNS 8-11, IT IS AN NGI PREPARATION      CARD0700
                C *** CARD.                                                                 CARD0705
ISN 0066                  TYPE=18                                                           CARD0710
ISN 0067                  IF (I.EQ.RT70) GC TO 90                                           CARD0715
                C *** IF THE CARD HAS 'RT40' IN COLUMNS 8-11, IT IS A CROSS-SECTION         CARD0720
                C *** PUNCH REQUEST CARC.                                                   CARD0725
ISN 0069                  TYPE=19                                                           CARD0730
ISN 0070                  IF (I.EQ.RT40) GC TO 90                                           CARD0735
ISN 0072                  TYPE=0                                                            CARD0740
ISN 0073                  ITH=1                                                             CARD0745
ISN 0074                  IF (LIST.GE.100) GC TO 85                                         CARD0750
ISN 0076                  DO 37 I=1,6                                                       CARD0755
ISN 0077                  IF (IMAGE(4).EQ.CVER(I)) TYPE=I                                   CARD0760
ISN 0079               37 CONTINUE                                                          CARD0765
ISN 0080                  IF (TYPE.EQ.5.AND.(IMAGE(8).EQ.C13(1).OR.IMAGE(8).EQ.C13(4)))     CARD0770
                         1     TYPE=0                                                       CARD0775
ISN 0082                  IF (TYPE.NE.0) GC TO 82                                           CARD0780
                C *** CHECK CONTENTS CF COLUMN 13 AGAINST ARRAY C13.  ASSIGN                CARD0785
                C *** CORRESPONDING TYPE FROM ARRAY CTYP.                                   CARD0790
ISN 0084                  IB=0                                                              CARD0795
ISN 0085                  DO 40 I=1,9                                                       CARD0800
ISN 0086                  IF (IMAGE(4).EQ.C13(I)) TYPE=CTYP(I)                              CARD0805
ISN 0088               40 CONTINUE                                                          CARD0810
ISN 0089                  IF (TYPE.NE.3) GC TO 50                                           CARD0815
                C *** DIFFERENTIATE BETWEEN ORIGINAL AND FINAL BENCH MARK AND TURNING        CARD0820
                C *** POINT CARDS.  THE ORIGINAL CARDS HAVE C13(1) IN COLUMN 23.  THE       CARD0825
                C *** FINAL CARDS HAVE C13(4) IN COLUMN 23.                                 CARD0830
ISN 0091                  IF (IMAGE(8).EQ.C13(4)) TYPE=7                                    CARD0835
                C *** THE BENCH MARK CARDS HAVE VALID DATA IN COLUMNS 39-44.                CARD0840
ISN 0093                  IF ((IMAGE(13).NE.BLANK.AND.IMAGE(13).NE.Z1).OR.(IMAGE(14).NE.    CARD0845
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                   1     BLANK.AND.IMAGE(14).NE.Z2)) TYPE=TYPE+1                      CARD0850
ISN 0095         50 IF (TYPE.NE.0) GO TO 70                                           CARD0855
              C *** THE CARD IS UNRECOGNIZABLE.  PRINT AN ERROR MESSAGE AND END       CARD0860
              C *** CALCULATIONS.                                                     CARD0865
ISN 0097         57 KEY=8                                                             CARD0870
ISN 0098            ISTRP=4
ISN 0099            CALL PRNTR                                                        CARD0875
ISN 0100         60 TYPE=13                                                           CARD0880
ISN 0101            IQUIT=2                                                           CARD0885
              C *** USING IRTYP, THE RUN TYPE, DETERMINE WHETHER FINAL DATA CARDS ARE CARD0890
              C *** BEING RUN AS ORIGINALS, OR ORIGINALS AS FINALS.  (THIS APPLIES TO CARD0895
              C *** CARD TYPES 1 - 8.)  PRINT AN ERROR MESSAGE THE FIRST TIME THIS    CARD0900
              C *** OCCURS.                                                           CARD0905
ISN 0102         70 IF (TYPE.GT.8) GO TO 90                                           CARD0910
ISN 0104            IF (TYPE.LT.5.OR.IRTYP.EQ.3.OR.IRTYP.EQ.5) GO TO 80               CARD0915
              C *** FINAL CARDS ARE BEING RUN AS ORIGINALS.  PRINT AN ERROR MESSAGE   CARD0920
              C *** THE FIRST TIME THIS OCCURS.                                       CARD0925
ISN 0106            IF (TKEY(2).EQ.1) GO TO 80                                        CARD0930
ISN 0108            TKEY(2)=1                                                         CARD0935
ISN 0109            KEY=26                                                            CARD0940
ISN 0110            CALL PRNTR                                                        CARD0945
ISN 0111         80 IF (TYPE.GE.5.OR.IRTYP.LE.2.OR.IRTYP.EQ.4) GO TO 90               CARD0950
              C *** ORIGINAL CARDS ARE BEING RUN AS FINALS.  PRINT AN ERROR MESSAGE   CARD0955
              C *** THE FIRST TIME THIS OCCURS.                                       CARD0960
ISN 0113            IF (TKEY(1).EQ.1) GO TO 90                                        CARD0965
ISN 0115            TKEY(1)=1                                                         CARD0970
ISN 0116            KEY=27                                                            CARD0975
ISN 0117            CALL PRNTR                                                        CARD0980
ISN 0118            GO TO 90                                                          CARD0985
              C *** NEW THD FORMAT--FINISH DETERMINING TYPE                           CARD0990
ISN 0119         82 READ(99,83) BS,FS,BM,I                                            CARD0995
ISN 0120         83 FORMAT(17X,3A4,A3)                                                CARD1000
ISN 0121            IF (TYPE.GT.3) TYPE=TYPE+1                                        CARD1005
ISN 0123            IF ((TYPE.EQ.3.OR.TYPE.EQ.7).AND.(BM.NE.BLANK.OR.I.NE.BLANK))     CARD1010
                   1     TYPE=TYPE+1                                                  CARD1015
ISN 0125            IF (TYPE.EQ.1.AND.IMAGE(5).EQ.BLANK) TYPE=13                      CARD1020
ISN 0127            ITH=2                                                             CARD1025
ISN 0128            GO TO 70                                                          CARD1030
              C *** DETERMINE TYPE OF 'TEX' ROD READING CARD.                         CARD1035
ISN 0129         85 READ(99,87) TYPE,I,BM,BS                                          CARD1040
ISN 0130         87 FORMAT(7X,I1,4X,A1,6X,A4,A3)                                      CARD1045
ISN 0131            IF (TYPE.GT.3) TYPE=TYPE+1                                        CARD1050
ISN 0133            IF ((TYPE.EQ.3.OR.TYPE.EQ.7).AND.(BM.NE.BLANK.OR.BS.NE.BLANK))    CARD1055
                   1     TYPE=TYPE+1                                                  CARD1060
ISN 0135            IF (TYPE.EQ.0.AND.I.EQ.C13(9)) TYPE=13                            CARD1065
ISN 0137            STA1=0                                                            CARD1070
ISN 0138            IB=0                                                              CARD1075
ISN 0139            IF (TYPE.EQ.0) GO TO 57                                           CARD1080
ISN 0141            GO TO 70                                                          CARD1085
              C *** GO TO THE CORRECT CARD PROCESSING AREA.                           CARD1090
              C *** TYPE =  1   2   3   4   5   6   7   8   9  10  11  12  13  14     CARD1095
ISN 0142         90 GO TO (380,380,360,340,380,380,360,340,200,100,160,180,150,195,   CARD1100
              C ***       15  16   17  18   19   20                                   CARD1105
                   1     198,199,1300,205,1350,210), TYPE                             CARD1110
              C * * * * * *   T Y P E = 1 0 ,   R E S E T   C A R D S    * * * * * * *CARD1115
              C ***      RESET CARDS PERMIT MORE THAN ONE TYPE OF DATA TO BE PROCESSEDCARD1120
              C *** DURING ONE JOB.  IE, THE USER CAN ADD ORIGINALS, ADD FINALS, DO   CARD1125
              C *** ORIGINAL EXTENSIONS AND FINAL EXTENSIONS, ALL IN ONE RUN.  THE    CARD1130
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                  C *** DIFFERENT TYPES OF DATA MUST BE SEPARATED BY RESET CARDS.  JRTYP, CARD1135
                  C *** THE RESET RUN TYPE INDICATOR, INDICATES THE TYPE OF DATA FOLLOWINGCARD1140
                  C *** THE RESET CARD.  THE TABLE BELOW INDICATES THE MEANING OF JRTYP --CARD1145
                  C ***                                                                  CARD1150
                  C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CARD1155
                  C   * JRTYP * X IN COLUMN *          TERRAIN JOB TYPE           *      CARD1160
                  C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CARD1165
                  C   *   3   *      18     * FINAL SECTIONS                      *      CARD1170
                  C   *   4   *      19     * ORIGINAL EXTENSIONS AND CORRECTIONS *      CARD1175
                  C   *   5   *      20     * FINAL EXTENSIONS AND CORRECTIONS    *      CARD1180
                  C   *   7   *      22     * DELETIONS                           *      CARD1185
                  C   *   8   *      23     * MODIFICATIONS                       *      CARD1190
                  C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CARD1195
                  C ***                                                                  CARD1200
                  C *** NOTE THAT THE DIFFERENT TYPES OF DATA MUST BE RUN IN THE ORDER OF CARD1205
                  C *** THEIR JOB TYPES, AND EACH TYPE OF DATA MAY BE RUN ONLY ONCE.      CARD1210
ISN 0143            100 READ(99,110) IM,CDTY,LIST                                        CARD1215
ISN 0144            110 FORMAT(15X,8A1,2(6X,A3))                                         CARD1220
ISN 0145                DO 120 I=1,8                                                     CARD1225
ISN 0146                JRTYP=I                                                          CARD1230
ISN 0147                IF (IM(I).NE.BLANK) GO TO 140                                    CARD1235
ISN 0149            120 CONTINUE                                                         CARD1240
ISN 0150                KEY=7                                                            CARD1245
ISN 0151            130 CALL PRNTR                                                       CARD1250
ISN 0152                NEQ=1                                                            CARD1255
ISN 0153                IQUIT=ENDFL                                                      CARD1260
ISN 0154                RETURN                                                           CARD1265
ISN 0155            140 IRSET=2                                                          CARD1270
ISN 0156                JCARD=1                                                          CARD1275
ISN 0157                OJCST=-1                                                         CARD1280
ISN 0158                OSTA1=-1                                                         CARD1285
ISN 0159                OSTA2=-1                                                         CARD1290
ISN 0160                J=(JRTYP-JRTYP/7)*4-12                                           CARD1295
ISN 0161                IF (CDTY.NE.BPR.AND.CDTY.NE.TEX) CDTY=THD                        CARD1300
ISN 0163                IF (LIST.NE.YES) LIST=NO                                         CARD1305
ISN 0165                WRITE(SYSOT,145) IPAGE,IDATE,JOBNO,ICHWY,(IJOB(J+I),I=1,4),      CARD1310
                      1      CDTY,LIST                                                   CARD1315
ISN 0166            145 FORMAT(1H1,106X,I3/1X,'TEXAS HIGHWAY DEPARTMENT',8X,'T I E S  ROADCARD1320
                       1WAY DESIGN SUBSYSTEM    *** EARTHWORK ***'/1X,'TERRAIN EDIT AND STCARD1325
                       2ORE PROCESS',54X,4A4/1X,'CONTROL ',A4,' SECTION ',A3,43X,4A4/38X, CARD1330
                       3      'TERRAIN EDIT AND STORE REQUEST'//43X,'CROSS-SECTION',     CARD1335
                       4      9X,'LIST OF'/29X,'JOB TYPE',8X,'DATA CARD',8X,'CROSS-SECTION'KJ24SEP4
                       5      /48X,'TYPE',9X,'DATA INPUT CARDS'//25X,4A4,7X,A3,17X,A3)    CARD1345
ISN 0167                IPAGE=IPAGE+1                                                    CARD1350
ISN 0168                I=0                                                              CARD1355
ISN 0169                IF (LIST.EQ.YES) I=1                                             CARD1360
ISN 0171                IF (CDTY.EQ.TEX) I=I+100                                         CARD1365
ISN 0173                LIST=I                                                           CARD1370
ISN 0174                GO TO 530                                                        CARD1375
                  C * * * * * * * * *   T Y P E = 1 3 ,   E N D   O F   D A T A   * * * * * CARD1380
                  C ***       IF OTHER  T I E S  DATA IS TO BE RUN AFTER THE TERRAIN DATA, CARD1385
                  C *** AN END OF TERRAIN DATA CARD MUST COME AFTER THE TERRAIN DATA AND  CARD1390
                  C *** BEFORE THE OTHER  T I E S  DATA.  THE END OF TERRAIN DATA CARD HASCARD1395
                  C *** A 1 IN COLUMN 13.  IF THE TERRAIN DATA IS THE LAST DATA RUN, IT   CARD1400
                  C *** MUST BE FOLLOWED BY AN END OF FILE CARD, A CARD WITH A /* IN COLUMCARD1405
                  C *** 1 AND 2.                                                          CARD1410
ISN 0175            150 IRSET=3                                                           CARD1415
ISN 0176                IF(ISTRP.LT.3) ISTRP=3
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ISN 0178            GO TO 530                                                         CARD1420
              C * * * * * * * * * *   T Y P E = 1 1 ,   D E L E T E   C A R D S   * * * CARD1425
              C *** FOR AN EXPLANATICN OF THIS DATA, SEE SUBROUTINE DELETE.           CARD1430
ISN 0179        160 READ(99,170) DEL1,DEL2,OFD,PLUS,HPCL,IRW,IHUB                     CARD1435
ISN 0180        170 FORMAT(11X,2I9,17A1)                                              CARD1440
ISN 0181            IF (DEL2.EQ.0) DEL2=-1                                            CARD1445
ISN 0183            CALL DELET                                                        CARD1450
ISN 0184            GO TO 20                                                          CARD1455
              C * * *   T Y P E = 1 2 ,   I N T E R P O L A T E D   C R O S S - S E C CARD1460
              C * * *   C A R D S .   * * * * * * * * * * * * * * * * * * * * * * * * * CARD1465
              C *** FOR AN EXPLANATICN OF THIS DATA, SEE SUBROUTINE IXSEC.            CARD1470
ISN 0185        180 IF (JCARD.EQ.2) GC TC 530                                         CARD1475
ISN 0187        182 JCARD=1                                                           CARD1480
ISN 0188            IF (IRTYP.LE.2) GC TC 184                                         CARD1485
              C *** IF IRTYP IS NOT 1 OR 2 INTERPOLATED STATIONS CANNOT BE PROCESSED. CARD1490
              C *** PRINT AN ERROR MESSAGE AND SKIP THE CARD.                         CARD1495
ISN 0190            KEY=33                                                            CARD1500
ISN 0191            CALL PRNTR                                                        CARD1505
ISN 0192            GO TO 20                                                          CARD1510
              C *** READ THE INTERPOLATED CARD AND PREPARE TO SET UP A RECORD FOR IT. CARD1515
ISN 0193        184 READ(99,190) JCSTA,DATA(1),DATA(2)                                CARD1520
ISN 0194        190 FORMAT(11X,3I9)                                                   CARD1525
ISN 0195            DATA(3)=-1                                                        CARD1530
ISN 0196            DATA(4)=-1                                                        CARD1535
ISN 0197            SNUMC=2                                                           CARD1540
ISN 0198            INTPL=INTPL+1                                                     CARD1545
ISN 0199            IF (OJCST.LT.JCSTA) GO TO 192                                     CARD1550
              C *** IF THE STATION IS CUT OF ORDER PRINT AN ERROR MESSAGE AND SKIP IT.CARD1555
ISN 0201            KEY=24                                                            CARD1560
ISN 0202            CALL PRNTR                                                        CARD1565
ISN 0203            SNUMC=0                                                           CARD1570
ISN 0204            GO TO 20                                                          CARD1575
ISN 0205        192 OJCST=JCSTA                                                       CARD1580
ISN 0206            RETURN                                                            CARD1585
              C * * *   T Y P E = 1 8 ,   NGI PREPARATION CARD                        CARD1590
ISN 0207        205 CALL PREP                                                         CARD1595
ISN 0208            RETURN                                                            CARD1600
              C *** TYPE=20  STRIP HEADER CARD
ISN 0209        210 ISTRP=2
ISN 0210            GO TO 530
              C * * *   T Y P E = 1 4 ,   T   I   E   S   E Q U A T I O N   C A R D   * *CARD1605
ISN 0211        195 KEY=34                                                            CARD1610
ISN 0212            NEQ=5                                                             CARD1615
              C *** IF THERE ARE MORE THAN 20 EQUATIONS, PRINT AN ERROR MESSAGE AND ENCARD1620
ISN 0213            IF (NOEQ(7).GE.20) GO TC 130                                      CARD1625
ISN 0215            READ(99,196) NUM,IEQB1,IEQA                                       CARD1630
ISN 0216        196 FORMAT(11X,A1,1X,2I9)                                             CARD1635
ISN 0217            NEQ=1                                                             CARD1640
              C *** IF AN ATTEMPT IS MADE TO READ EQUATIONS FOR ANY ROADWAY EXCEPT    CARD1645
              C *** THE BASELINE, PRINT AN ERROR MESSAGE AND END.                     CARD1650
ISN 0218            IF (NUM.NE.G) GO TC 130                                           CARD1655
ISN 0220            IF (ICARD.EQ.2) ICK=NOEC(7)                                       CARD1660
ISN 0222            NOEQ(7)=NCEQ(7)+1                                                 CARD1665
ISN 0223            I=NOEQ(7)                                                         CARD1670
ISN 0224            IEQ(I)=0                                                          CARD1675
ISN 0225            GO TO 235                                                         CARD1680
              C * * *   T Y P E = 1 5 ,   H U B   C A R D   * * * * * * * * * * * * * CARD1685
ISN 0226        198 CALL HUB                                                          CARD1690
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ISN 0227          IF (IQUIT.EQ.ENDFL) GO TO 60                                    CARD1695
ISN 0229          GO TO 25                                                        CARD1700
            C * * *   T Y P E = 1 6 ,   P R I N T   C A R D   * * * * * * * * * * * CARD1705
ISN 0230      199 READ(99,1199) DEL1,DEL2,OFD,HPCL,IRW,IHUB                       CARD1710
ISN 0231     1199 FORMAT(11X,2I9,16A1)                                            CARD1715
ISN 0232          IHP=0                                                           CARD1720
ISN 0233          IH=0                                                            CARD1725
ISN 0234          DO 1200 I=1,3                                                   CARD1730
ISN 0235          IF (HPCL(I).NE.BLANK.OR.HPCL(3+I).NE.BLANK) IHP=1               CARD1735
ISN 0237          IF (IHUB(I).NE.BLANK.OR.IHUB(3+I).NE.BLANK) IH=1                CARD1740
ISN 0239          IF (OFD(I).EQ.BLANK) GO TO 1200                                 CARD1745
ISN 0241          KEY=99+I                                                        CARD1750
ISN 0242          IF (NTIME.EQ.1) CALL ISAM(XESTL,STAF)                           CARD1755
ISN 0244          NTIME=1                                                         CARD1760
ISN 0245          SKEY(1)=(I+1)/2                                                 CARD1765
ISN 0246          SKEY(2)=DEL1                                                    CARD1770
ISN 0247          CALL ISAM(XSETL,STAF,SKEY)                                      CARD1775
ISN 0248          CALL PRNTR                                                      CARD1780
ISN 0249     1200 CONTINUE                                                        CARD1785
ISN 0250          DO 1210 I=1,3                                                   CARD1790
ISN 0251          IF ((I.EQ.1.AND.IHP.EQ.0).OR.(I.EQ.2.AND.IRW.EQ.BLANK).OR.      CARD1795
                 1     (I.EQ.3.AND.IH.EQ.0)) GO TO 1210                           CARD1800
ISN 0253          KEY=102+I                                                       CARD1805
ISN 0254          IF (NTIME.EQ.1) CALL ISAM(XESTL,STAF)                           CARD1810
ISN 0256          NTIME=1                                                         CARD1815
ISN 0257          SKEY(1)=1                                                       CARD1820
ISN 0258          SKEY(2)=DEL1                                                    CARD1825
ISN 0259          CALL ISAM(XSETL,STAF,SKEY)                                      CARD1830
ISN 0260          CALL PRNTR                                                      CARD1835
ISN 0261     1210 CONTINUE                                                        CARD1840
ISN 0262          GO TO 20                                                        CARD1845
            C * * *   T Y P E = 1 7 ,   D E L E T E   E Q U A T I O N S   * * * *   CARD1850
ISN 0263     1300 READ(99,196) NUM,IEQB1,IEQA                                     CARD1855
ISN 0264          KEY=20                                                          CARD1860
ISN 0265          NEQ=1                                                           CARD1865
ISN 0266          IF (IRTYP.NE.2) GO TO 130                                       CARD1870
ISN 0268          KEY=35                                                          CARD1875
ISN 0269          IF (NUM.NE.G) GO TO 130                                         CARD1880
ISN 0271          ET1=IEQB1/1.0D2                                                 CARD1885
ISN 0272          ET2=IEQA/I.0D2                                                  CARD1890
ISN 0273          I2=NOEQ(7)                                                      CARD1895
ISN 0274          IF (I2.EQ.0) GO TO 20                                           CARD1900
ISN 0276     1310 DO 1320 I=1,I2                                                  CARD1905
ISN 0277          IF (DABS(EQTAB(7,I,1)-ET1).LT.2.0D-2.AND.DABS(EQTAB(7,I,2)-ET2)  CARD1910
                 1     .LT.2.0D-2) GO TO 1330                                     CARD1915
ISN 0279     1320 CONTINUE                                                        CARD1920
ISN 0280          GO TO 20                                                        CARD1925
ISN 0281     1330 NOEQ(7)=NOEQ(7)-1                                               CARD1930
ISN 0282          IF (I.EQ.I2) GO TO 20                                           CARD1935
ISN 0284          I2=I2-1                                                         CARD1940
ISN 0285          DO 1340 J=I,I2                                                  CARD1945
ISN 0286          EQTAB(7,J,1)=EQTAB(7,J+1,1)                                     CARD1950
ISN 0287     1340 EQTAB(7,J,2)=EQTAB(7,J+1,2)                                     CARD1955
ISN 0288          GO TO 1310                                                      CARD1960
            C * * *   T Y P E = 1 9 ,   P U N C H   C A R D   * * * * * * * * * * * CARD1965
ISN 0289     1350 CALL PNCH                                                       CARD1970
ISN 0290          GO TO 20                                                        CARD1975
            C * * *   T Y P E = 9 ,   E Q U A T I O N S   * * * * * * * * * * * * * CARD1980
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                C ***      EQUATION CARDS MAY ONLY BE RUN WHEN A NEW FILE IS BEING CREATCARD1985
                C *** CHECK IN COLUMN 16.  ONLY BASE LINE EQUATIONS MAY BE ENTERED IN THCARD1990
                C *** TERRAIN PROCESS.  THE  T I E S  TREATMENT OF EQUATIONS IS VERY    CARD1995
                C *** SIMILAR TO THAT USED BY THE FORMER EARTHWORK SYSTEM.  (SEE THE    CARD2000
                C *** EARTHWORK SYSTEM, TEXAS HIGHWAY DEPT., 1968, PP2-5--2-9.)         CARD2005
                C *** NOTE--                                                            CARD2010
                C ***    A) THERE CAN BE NO MORE THAN 9 OVERLAPPING EQUATIONS.          CARD2015
                C ***    B) THERE CAN BE NO MORE THAN 20 EQUATIONS.                     CARD2020
                C ***    C) THE EQUATION STATION MUST BE CALLED BY THE BACK STATION NAMECARD2025
                C ***    D) IN THE CASE OF AN OVERLAPPING EQUATION, THE BACK STATION MUSCARD2030
                C ***       BE OVERPUNCHED, AND THE OVERPUNCH MUST BE IN THE LAST COLUMNCARD2035
                C ***       OF THE STATION NUMBER.                                      CARD2040
                C ***    E) THERE CAN BE NO DOUBLE OVERLAPS.                            CARD2045
                C *** THE TERRAIN PROCESS CAN ALSO USE BASE LINE EQUATIONS STORED BY THECARD2050
                C *** DESIGN DATA PROCESS.                                              CARD2055
ISN 0291          200 KEY=20                                                            CARD2060
                C *** IF WE TRY TO PROCESS EQUATION CARDS FOR ANY RUN TYPE BUT          CARD2065
                C *** RUN TYPE 1, WE PRINT AN ERROR MESSAGE AND END.                    CARD2070
ISN 0292              IF (IRTYP.GT.1) GO TO 130                                         CARD2075
ISN 0294              READ(99,220) I,IEQB1,IEQB2,IEQA                                   CARD2080
ISN 0295          220 FORMAT(8X,I2,3X,I6,A1,I7)                                         CARD2085
ISN 0296              IF (ICARD.EQ.2) ICK=NOEQ(7)                                       CARD2090
                C *** CHECK THE EQUATION NUMBER PUNCHED ON THE EQUATION CARD, TO SEE IF CARD2095
                C *** CARDS ARE OUT OF ORDER.  IF SO, PRINT AN ERROR MESSAGE AND END.   CARD2100
ISN 0298              NEQ=4                                                             CARD2105
ISN 0299              IF (I.NE.NOEQ(7)-ICK+1) GO TO 130                                 CARD2110
ISN 0301              DO 230 J=1,20                                                     CARD2115
ISN 0302              IF (IEQB2.NE.OVER(J)) GO TO 230                                   CARD2120
ISN 0304              IEQB1=IEQB1*10+J-J/10*10                                          CARD2125
ISN 0305          230 CONTINUE                                                          CARD2130
ISN 0306              IEQB1=IEQB1*10                                                    CARD2135
ISN 0307              IEQA=IEQA*10                                                      CARD2140
ISN 0308              NOEQ(7)=NOEQ(7)+1                                                 CARD2145
                C *** CHECK TO SEE IF THERE ARE MORE THAN 20 EQUATIONS.  IF SO, PRINT ANCARD2150
                C *** ERROR MESSAGE AND END.                                            CARD2155
ISN 0309              NEQ=5                                                             CARD2160
ISN 0310              IF (NOEQ(7).GT.20) GO TO 130                                      CARD2165
ISN 0312              IF (I.EQ.1) IEQ(1)=0                                              CARD2170
ISN 0314              IF (I.GT.1) IEQ(I)=IEQ(I-1)                                       CARD2175
ISN 0316              IF (IEQA.LE.IEQB1) IEQ(I)=IEQ(I)+100000000                        CARD2180
                C *** CHECK TO SEE IF THERE ARE MORE THAN 9 OVERLAPPING EQUATIONS.  IF  CARD2185
                C *** SO, PRINT AN ERROR MESSAGE.                                       CARD2190
ISN 0318              NEQ=3                                                             CARD2195
ISN 0319              IF (IEQ(I).GT.900000000) CALL PRNTR                               CARD2200
ISN 0321          235 IF (NSET.EQ.1.OR.KPAG.EQ.0) GO TO 236                             CARD2205
                C *** READ THE EQUATION DATA FOR THE BASELINE.                          CARD2210
ISN 0323              KNDEX=39                                                          CARD2215
ISN 0324              READ(8'KNDEX) EQTAB                                               CARD2220
ISN 0325              KNDEX=0                                                           CARD2225
ISN 0326          236 NSET=1                                                            CARD2230
ISN 0327              IF (ICK.GT.0) GO TO 240                                           CARD2235
ISN 0329              EQTAB(7,I,1)=IEQB1/1.0D2                                          CARD2240
ISN 0330              IF (I.GT.1) EQTAB(7,I,1)=IEQ(I-1)/1.0D2+EQTAB(7,I,1)              CARD2245
ISN 0332              EQTAB(7,I,2)=(IEQA+IEQ(I))/1.0D2                                  CARD2250
                C *** PRINT THE EQUATION.                                               CARD2255
ISN 0333              NEQ=2                                                             CARD2260
ISN 0334              CALL PRNTR                                                        CARD2265
ISN 0335              NEQ=1                                                             CARD2270
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ISN 0336          GO TO 20                                                         CARD2275
ISN 0337      240 IF (ICARD.EQ.2) J1=1                                             CARD2280
ISN 0339          JKEEP=J1                                                         CARD2285
ISN 0340          J2=NOEQ(7)                                                       CARD2290
ISN 0341          IF (J1.EQ.J2) GO TO 260                                          CARD2295
ISN 0343          DO 250 J=J1,J2                                                   CARD2300
ISN 0344          IT1=EQTAB(7,J,1)*1.0D2+5.0D-1                                    CARD2305
ISN 0345          IT1=IT1/100000000*100000000                                      CARD2310
ISN 0346          IF (IEQB1.LT.IT1) GO TO 280                                      CARD2315
ISN 0348      250 CONTINUE                                                         CARD2320
ISN 0349      260 IT2=EQTAB(7,J2,2)*1.0D2+5.0D-1                                   CARD2325
ISN 0350          IT2=IT2/100000000*100000000                                      CARD2330
ISN 0351          IF (IEQB1.GT.IT2) GO TO 270                                      CARD2335
ISN 0353          IEQB1=IEQB1+100000000                                            CARD2340
ISN 0354          IEQA=IEQA+100000000                                              CARD2345
ISN 0355      270 J2=J2+1                                                          CARD2350
ISN 0356          EQTAB(7,J2,1)=(IEQB1+IT2)/1.0D2                                  CARD2355
ISN 0357          EQTAB(7,J2,2)=(IEQA+IT2)/1.0D2                                   CARD2360
ISN 0358          IF (IEQA.LE.IEQB1) EQTAB(7,J2,2)=EQTAB(7,J2,2)+1.0D6             CARD2365
ISN 0360          J1=J2+1                                                          CARD2370
ISN 0361          GO TO 310                                                        CARD2375
ISN 0362      280 J1=J                                                             CARD2380
ISN 0363          DO 290 J=J1,J2                                                   CARD2385
ISN 0364          K=J1+J2-J                                                        CARD2390
ISN 0365          EQTAB(7,K+1,1)=EQTAB(7,K,1)                                      CARD2395
ISN 0366      290 EQTAB(7,K+1,2)=EQTAB(7,K,2)                                      CARD2400
ISN 0367          EQTAB(7,J,1)=(IEQB1+IT1)/1.0D2                                   CARD2405
ISN 0368          EQTAB(7,J,2)=(IEQA+IT1)/1.0D2                                    CARD2410
ISN 0369          IF (IEQA.GT.IEQB1) GO TO 310                                     CARD2415
ISN 0371          EQTAB(7,J,2)=EQTAB(7,J,2)+1.0D6                                  CARD2420
ISN 0372          J1=J1+1                                                          CARD2425
ISN 0373          J2=J2+1                                                          CARD2430
ISN 0374          DO 300 J=J1,J2                                                   CARD2435
ISN 0375          EQTAB(7,J,1)=EQTAB(7,J,1)+1.0D6                                  CARD2440
ISN 0376      300 EQTAB(7,J,2)=EQTAB(7,J,2)+1.0D6                                  CARD2445
ISN 0377      310 NEQ=2                                                            CARD2450
ISN 0378          J2=J1-1                                                          CARD2455
ISN 0379          DO 320 J=JKEEP,J2                                                CARD2460
ISN 0380          NOEQ(7)=J                                                        CARD2465
ISN 0381      320 CALL PRNTR                                                       CARD2470
ISN 0382          NOEQ(7)=J2                                                       CARD2475
ISN 0383          NEQ=1                                                            CARD2480
ISN 0384          GO TO 20                                                         CARD2485
              C ***                                                                CARD2490
              C ***       E L E V A T I O N   C A R D S                            CARD2495
              C ***                                                                CARD2500
              C ***      THESE CARDS ARE IDENTICAL WITH THOSE USED BY THE FORMER EARTHCARD2505
              C *** SYSTEM.  (SEE THE EARTHWORK SYSTEM, TEXAS HIGHWAY DEPT., 1968,   CARD2510
              C *** PP 3-1--3-11.)                                                 CARD2515
              C * * * *    T Y P E = 4   A N D   8 ,   B E N C H   M A R K   C A R D S CARD2520
              C *** REREAD BENCH MARK CARDS.                                       CARD2525
ISN 0385      340 KEY=2                                                            CARD2530
ISN 0386          IF (LIST.GE.100) GO TO 355                                       CARD2535
ISN 0388          IF (ITH.EQ.2) GO TO 352                                          CARD2540
              C *** CHECK TO SEE IF THE FORE SIGHT IS BLANK.  IF IT IS NOT, THE     CARD2545
              C *** PRINTING ROUTINE CHECKS THE ENGINEER'S CALCULATIONS OF THE HIBIAS.CARD2550
ISN 0390          IF (IMAGE(12).NE.BLANK.AND.IMAGE(12).NE.Z1) KEY=3                CARD2555
ISN 0392          READ(99,350) STA1,STA2,NUM,BS,FS,BM                              CARD2560
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ISN 0393      350 FORMAT(6X,A1,I5,1X,I2,13X,I4,2X,I4,I6)                            CARD2565
ISN 0394          GO TO 370                                                         CARD2570
ISN 0395      352 IF (FS.NE.BLANK.AND.BM.NE.BLANK.AND.FS.NE.Z1) KEY=3               CARD2575
ISN 0397          READ(99,354) STA1,STA2,NUM,IB,BS,FS,BM                            CARD2580
ISN 0398      354 FORMAT(6X,A1,I5,1X,I2,1X,I1,2I4,I7)                               CARD2585
ISN 0399          IB=IB*100000                                                      CARD2590
ISN 0400          GO TO 370                                                         CARD2595
ISN 0401      355 READ(99,356) FS,BM                                                CARD2600
ISN 0402      356 FORMAT(30X,A4,A1)                                                 CARD2605
ISN 0403          IF (FS.NE.BLANK.AND.BM.NE.BLANK.AND.FS.NE.Z1) KEY=3               CARD2610
ISN 0405          READ(99,358) STA2,NUM,BM,BS,FS                                    CARD2615
ISN 0406      358 FORMAT(8X,I9,I1,1X,I7,I4,I5)                                      CARD2620
ISN 0407          GO TO 370                                                         CARD2625
            C * * *   T Y P E = 3   A N D   7 ,   T U R N I N G   P O I N T   C A R CARD2630
            C *** REREAD TURNING POINT CARDS.                                       CARD2635
ISN 0408      360 IF (LIST.LT.100.AND.ITH.EQ.1) READ(99,350)                        CARD2640
                 1     STA1,STA2,NUM,BS,FS                                          CARD2645
ISN 0410          IF (LIST.LT.100.AND.ITH.EQ.2) READ(99,354)                        CARD2650
                 1     STA1,STA2,NUM,IB,BS,FS,BM                                    CARD2655
ISN 0412          IF (LIST.GE.100) READ(99,358) STA2,NUM,I,BS,FS                    CARD2660
ISN 0414          IB=IB*100000                                                      CARD2665
ISN 0415          BMCK=0                                                            CARD2670
ISN 0416          HIBI=HIBI+BS-FS                                                   CARD2675
ISN 0417          KEY=1                                                             CARD2680
            C *** PRINT THE TURNING POINT AND BENCH MARK DATA.                      CARD2685
ISN 0418      370 JJCST=JCSTA                                                       CARD2690
ISN 0419          JCSTA=STA2                                                        CARD2695
ISN 0420          I=KEY                                                             CARD2700
ISN 0421          IF ((OSTA1.NE.STA1.OR.OSTA2.NE.STA2).AND.LIST.LT.100) CALL STANO  CARD2705
ISN 0423          KEY=I                                                             CARD2710
ISN 0424          IF (LIST-LIST/100*100.EQ.1) CALL PRNTR                            CARD2715
ISN 0426          JCSTA=JJCST                                                       CARD2720
ISN 0427          IF (KEY.GT.1) HIBI=HIBI-FS+BS                                     CARD2725
ISN 0429          IF (KEY.GT.1.AND.BM.NE.0) HIBI=BM+BS                              CARD2730
ISN 0431          BMCK=0                                                            CARD2735
ISN 0432          BT=1                                                              CARD2740
ISN 0433          GO TO 420                                                         CARD2745
            C * * *  T Y P E = 1,   2,   5,   A N D   6 ,   E L E V A T I O N   C A CARD2750
            C *** REREAD ELEVATION CARDS (HI AND BIAS CARDS), TYPES 1, 2, 5, AND 6. CARD2755
ISN 0434      380 IF (LIST.LT.100.AND.ITH.EQ.1) READ(99,385)                        CARD2760
                 1     STA1,STA2,NUM,ROL,HB,HB2,(EL1(I),EL2(I),DT(I),I=1,8)         CARD2765
ISN 0436      385 FORMAT(6X,A1,I5,1X,I2,A1,10X,I5,A1,8(I2,A1,I3))                   CARD2770
ISN 0437          IF (LIST.LT.100.AND.ITH.EQ.2) READ(99,390)                        CARD2775
                 1     STA1,STA2,NUM,ROL,IB,HB,HB2,(EL1(I),EL2(I),DT(I),I=1,8)      CARD2780
ISN 0439      390 FORMAT(6X,A1,I5,1X,I2,A1,I1,8X,I6,A1,8(I2,A1,I3))                 CARD2785
ISN 0440          IF (LIST.GE.100) READ(99,395) STA2,NUM,ROL,HB,HB2,(EL1(I),EL2(I), CARD2790
                 1     DT(I),I=1,6)                                                 CARD2795
ISN 0442      395 FORMAT(8X,I9,I1,A1,I6,A1,6(I3,A1,I5))                             CARD2800
ISN 0443          IB=IB*100000                                                      CARD2805
ISN 0444          IF ((HB2.NE.BLANK.AND.HB2.NE.OVER(10)).OR.HB.NE.0) BT=0           CARD2810
ISN 0446          IF (BT.EQ.1.AND.(STA1.NE.OSTA1.OR.STA2.NE.OSTA2)) BMCK=BMCK+1     CARD2815
            C *** IF BMCK .GE. 30, WE'VE GONE 30 STATIONS WITHOUT ENCOUNTERING A   CARD2820
            C *** BENCH MARK CARD.  (THIS ONLY APPLIES IF THE HB=0).  PRINT AN     CARD2825
            C *** ERROR MESSAGE.                                                    CARD2830
ISN 0448          IF (BMCK.LT.30) GO TO 400                                         CARD2835
ISN 0450          KEY=4                                                             CARD2840
ISN 0451          CALL PRNTR                                                        CARD2845
ISN 0452      400 FACTR=1                                                           CARD2850
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ISN 0453           IF (TYPE.EQ.1.OR.TYPE.EQ.5) FACTR=-1                              CARD2855
ISN 0455           IF (BT.EQ.1) GO TO 420                                            CARD2860
ISN 0457           DO 410 I=1,10                                                     CARD2865
ISN 0458           IF (HB2.NE.OVER(I)) GO TO 410                                     CARD2870
ISN 0460           J=I-I/10*10                                                       CARD2875
ISN 0461           HIBI=HB*10+ISIGN(J,HB)                                            CARD2880
ISN 0462       410 CONTINUE                                                          CARD2885
ISN 0463           IF (HB2.EQ.BLANK) HIBI=HB*10                                      CARD2890
ISN 0465           BT=1                                                              CARD2895
ISN 0466       420 IF (JCARD.EQ.1) GO TO 430                                         CARD2900
             C *** WE COME HERE TO PROCESS A GENERAL DATA CARD, EVERY TIME BUT THE FICARD2905
ISN 0468           IF (STA1.NE.OSTA1.OR.STA2.NE.OSTA2) GO TO 530                     CARD2910
ISN 0470           GO TO 460                                                         CARD2915
             C *** HERE WE INITIALIZE VARIABLES THE FIRST TIME WE DO AN ELEVATION CARCARD2920
ISN 0471       430 JCARD=2                                                           CARD2925
ISN 0472           IF (OSTA1.EQ.STA1.AND.OSTA2.EQ.STA2) GO TO 460                    CARD2930
ISN 0474           JCSTA=STA2                                                        CARD2935
ISN 0475           IF (LIST.LT.100) CALL STANO                                       CARD2940
ISN 0477           IF (ISKIP.EQ.0.OR.OJCST.LT.JCSTA) GO TO 450                       CARD2945
             C *** IF THE ELEVATION CARDS ARE OUT OF ORDER, ACCORDING TO THE STATION CARD2950
             C *** NUMBERS, WE PRINT AN ERROR MESSAGE AND SET ISKIP=0, SO WE'LL SKIP CARD2955
             C *** THE FINAL PROCESSING FOR THIS STATION.  OOJCS IS THE LAST 'IN ORDECARD2960
             C *** STATION, OJCST IS THE LAST STATION, AND JCSTA THE PRESENT STATION.CARD2965
ISN 0479           ISKIP=0                                                           CARD2970
ISN 0480           OOJCS=OJCST                                                       CARD2975
ISN 0481       450 IF (ISKIP.EQ.1.OR.OOJCS.LT.JCSTA) ISKIP=1                         CARD2980
             C *** IF THE PREVIOUS STATION NUMBER WAS OUT OF ORDER, AND THIS ONE IS, CARD2985
             C *** WE PRINT AN ERROR MESSAGE HERE.                                   CARD2990
ISN 0483           KEY=11                                                            CARD2995
ISN 0484           IF (ISKIP.EQ.0) CALL PRNTR                                        CARD3000
ISN 0486           OSTA1=STA1                                                        CARD3005
ISN 0487           OSTA2=STA2                                                        CARD3010
ISN 0488           OJCST=JCSTA                                                       CARD3015
             C * * * * * * * * *    I N I T I A L   P R O C E S S I N G   * * * * * * CARD3020
             C *** HERE WE DO THE INITIAL PROCESSING OF THE INDIVIDUAL SETS OF       CARD3025
             C *** ELEVATION CARDS, FOR A NEW STATION.                               CARD3030
ISN 0489       460 SNUM=SNUM+1                                                       CARD3035
             C *** IF THE ELEVATION CARDS ARE OUT OF ORDER, WE PRINT AN ERROR MESSAGECARD3040
ISN 0490           IF (NUM.EQ.SNUM) GO TO 470                                        CARD3045
ISN 0492           KEY=9                                                             CARD3050
ISN 0493           CALL PRNTR                                                        CARD3055
ISN 0494       470 IF (TYPE.EQ.3.OR.TYPE.EQ.4.OR.TYPE.GE.7) GO TO 20                 CARD3060
ISN 0496           LOR=ROL                                                           CARD3065
ISN 0497           IF (SNUMC.EQ.0.OR.OLOR.EQ.LOR) GO TO 480                          CARD3070
             C *** HERE WE'VE FINISHED INITIAL PROCESSING OF THE DATA FOR ONE SIDE OFCARD3075
             C *** CROSS-SECTION AND WE'RE PREPARING TO START INITIAL PROCESSING OF DCARD3080
             C *** FOR THE OTHER SIDE.                                               CARD3085
ISN 0499       475 OORD=ORD                                                          CARD3090
ISN 0500           OONUM=ONUM                                                        CARD3095
ISN 0501           ORD=0                                                             CARD3100
ISN 0502           ONUM=0                                                            CARD3105
ISN 0503           OLOR=LOR                                                          CARD3110
ISN 0504           ISAVE=SNUMC+1                                                     CARD3115
ISN 0505       480 ORDCK=2                                                           CARD3120
ISN 0506           NUMC=1                                                            CARD3125
             C *** HERE WE COUNT THE NUMBER OF PERTINENT POINTS ON THE CARD.         CARD3130
ISN 0507           I2=8                                                              CARD3135
ISN 0508           IF (LIST.GE.100) I2=6                                             CARD3140
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ISN 0510           IFAC=10-LIST/100*9                                              CARD3145
ISN 0511           DO 510 I=2,I2                                                   CARD3150
ISN 0512           IF (DT(I).EQ.0.AND.EL1(I).EQ.0.AND.(EL2(I).EQ.OVER(10).OR.      CARD3155
                  1     EL2(I).EQ.BLANK)) GO TO 510                                CARD3160
ISN 0514           NUMC=NUMC+1                                                     CARD3165
             C *** HERE WE CHECK THE ORDER OF THE DISTANCES ON THE CARD.           CARD3170
ISN 0515           IF (DT(I)-DT(I-1)) 490,510,500                                  CARD3175
             C *** WE ARRIVE HERE IF THE DISTANCES ARE DECREASING.                 CARD3180
ISN 0516       490 IF (ORDCK.EQ.2) ORDCK=-1                                        CARD3185
ISN 0518           IF (ORDCK.NE.-1) ORDCK=0                                        CARD3190
ISN 0520           GO TO 510                                                       CARD3195
             C *** WE ARRIVE HERE IF THE DISTANCES ARE INCREASING.                 CARD3200
ISN 0521       500 IF (ORDCK.EQ.2) ORDCK=1                                         CARD3205
ISN 0523           IF (ORDCK.NE.1) ORDCK=0                                         CARD3210
ISN 0525       510 CONTINUE                                                        CARD3215
             C *** WHEN WE REACH THIS POINT, ORDCK CAN HAVE THE FOLLOWING VALUES--   CARD3220
             C ***    ORDCK=1 IF DISTANCES ARE INCREASING,                         CARD3225
             C ***    ORDCK=0 IF DISTANCES BOTH INCREASE AND DECREASE,             CARD3230
             C ***    ORDCK=-1 IF DISTANCES ARE DECREASING,                        CARD3235
             C ***    ORDCK=2 IF DISTANCES ARE CONSTANT ON THE CARD.               CARD3240
             C *** FAC=1 FOR READINGS TO THE RIGHT OF THE CENTERLINE AND FAC =-1 FOR CARD3245
             C *** READINGS TO THE LEFT OF THE CENTERLINE.                         CARD3250
ISN 0526           FAC=1                                                           CARD3255
ISN 0527           IF (LOR.EQ.L) FAC=-1                                            CARD3260
ISN 0529           IF (ORDCK.NE.2) ORD=ORD+ORDCK*FAC                               CARD3265
ISN 0531           IF (ORDCK.NE.2) ONUM=ONUM+1                                     CARD3270
ISN 0533           I2=NUMC*2                                                       CARD3275
ISN 0534           IF (LOR.EQ.L) IB=-IB                                            CARD3280
ISN 0536           DO 520 I=1,I2,2                                                 CARD3285
ISN 0537           K=(I+1)/2                                                       CARD3290
             C *** HERE WE CONSIDER THE DISTANCES.                                 CARD3295
ISN 0538           IF (LOR.EQ.L) DT(K)=-DT(K)                                      CARD3300
ISN 0540           DATA(2*SNUMC+I+1)=IB+DT(K)*IFAC*IFAC                            CARD3305
             C *** HERE WE DECIPHER THE ELEVATIONS.                                CARD3310
ISN 0541           DO 520 J=1,20                                                   CARD3315
ISN 0542           IF (EL2(K).EQ.BLANK.AND.J.EQ.10) GO TO 515                      CARD3320
ISN 0544           IF (EL2(K).EQ.MINUS.AND.J.EQ.20) GO TO 515                      CARD3325
ISN 0546           IF (EL2(K).NE.OVER(J)) GO TO 520                                CARD3330
ISN 0548       515 EL1(K)=EL1(K)*10+J-J/10*10                                      CARD3335
ISN 0549           IF (J.GT.10) EL1(K)=FACTR*EL1(K)-(FACTR*5000+5000)/IFAC         CARD3340
ISN 0551           DATA(2*SNUMC+I)=HIBI+FACTR*EL1(K)*IFAC                          CARD3345
             C *** HERE WE INTERPRET THE ELEVATIONS PUNCHED AS NEGATIVE ZEROS.  SEE  CARD3350
             C *** THE COMMENTS IN ROUTINE NZERO FOR AN EXPLANATION OF THIS CONCEPT. CARD3355
             C *** NOTE--ELEVATIONS PUNCHED AS NEGATIVE ZEROS ON A CARD ARE SET EQUALCARD3360
             C *** -1 BY THE PROGRAM.  IE, A -1 INDICATES THE LOCATION OF A PUNCHED  CARD3365
             C *** NEGATIVE ZERO.                                                  CARD3370
ISN 0552           IF (J.EQ.20.AND.(EL1(K).EQ.-1000.OR.EL1(K).EQ.0))               CARD3375
                  1     DATA(2*SNUMC+I)=-1                                         CARD3380
ISN 0554           IF (DATA(2*SNUMC+I).EQ.-1) FINAL=FINAL+1                        CARD3385
ISN 0556       520 CONTINUE                                                        CARD3390
             C *** HERE WE PRINT THE DATA ON AN INDIVIDUAL CARD.                   CARD3395
ISN 0557           KEY=5                                                           CARD3400
ISN 0558           IF (LIST-LIST/100*100.EQ.1) CALL PRNTR                          CARD3405
ISN 0560           OLOR=LOR                                                        CARD3410
             C *** HERE WE ADD UP THE NUMBER OF POINTS IN THIS CROSS-SECTION.      CARD3415
ISN 0561           SNUMC=SNUMC+NUMC                                                CARD3420
ISN 0562           GO TO 20                                                        CARD3425
             C * * * * * * * * *   F I N A L   P R O C E S S I N G   * * * * * * * * CARD3430
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                  C *** NOW WE ARE READY TO DO THE FINAL PROCESSING FOR A STATION.          CARD3435
                  C *** HERE WE CHECK THE ORDER OF THE DATA ON THE WHOLE SET OF CARDS FOR CARD3440
                  C *** STATION, AND RECORDER THE DATA.                                     CARD3445
                  C ***       THERE ARE THREE WAYS IN WHICH THE ELEVATION CARDS OR          CARD3450
                  C *** READINGS MAY BE OUT OF ORDER.  IN TWO OF THOSE CASES, FINAL         CARD3455
                  C *** PROCESSING IS SKIPPED FOR THAT STATION.                             CARD3460
                  C ***    1) THE READINGS THEMSELVES MAY BE OUT OF ORDER (IE, THE READINGCARD3465
                  C ***        ON ONE SIDE OF THE CENTERLINE MAY FIRST INCREASE AND THEN    CARD3470
                  C ***        DECREASE, OR VICE VERSA, OR SOME READINGS MAY BE GIVEN FOR   CARD3475
                  C ***        THE RIGHT SIDE, THEN SOME FOR THE LEFT, THEN MORE FOR THE RICARD3480
                  C ***        FOR EXAMPLE.)  IN THIS CASE, OONUM.NE.IABS(OORD) OR ONUM.NE.CARD3485
                  C ***        IABS(ORD), AND FINAL PROCESSING IS SKIPPED FOR THIS STATION.CARD3490
                  C ***    2) THE CARDS FOR AN INDIVIDUAL STATION MAY BE OUT OF ORDER,      CARD3495
                  C ***        ACCORDING TO THE CARD NUMBERS PUNCHED ON THEM.  UNLESS       CARD3500
                  C ***        THE READINGS ARE OUT OF ORDER AS A RESULT, THE FINAL         CARD3505
                  C ***        PROCESSING IS NOT SKIPPED.                                   CARD3510
                  C ***    3) THE STATION NUMBERS MAY BE OUT OF ORDER--IE, NOT INCREASING.CARD3515
                  C ***        IN THIS CASE, SKIP=0, AND FINAL PROCESSING IS SKIPPED FOR ALCARD3520
                  C ***        STATIONS UNTIL ONE IS REACHED WITH A STATION NUMBER GREATER CARD3525
                  C ***        THAN THE LAST 'GOOD' STATION.                                CARD3530
ISN 0563             530 IF (JUMP.EQ.0.OR.ISKIP.EQ.0) GO TO 630                             CARD3535
ISN 0565                 IF (OONUM.EQ.IABS(OORD).AND.ONUM.EQ.IABS(ORD)) GO TO 540           CARD3540
                  C *** IF THE READINGS ON ONE SIDE OF THE CENTERLINE OR THE OTHER ARE      CARD3545
                  C *** OUT OF ORDER, PRINT AN ERROR MESSAGE AND SKIP THIS STATION.         CARD3550
ISN 0567                 KEY=10                                                             CARD3555
ISN 0568                 CALL PRNTR                                                         CARD3560
ISN 0569                 GO TO 630                                                          CARD3565
                  C *** IF ALL DISTANCE READINGS DO NOT INCREASE MONOTONICALLY, WE REORDERCARD3570
                  C *** THE READINGS.                                                       CARD3575
ISN 0570             540 IF ((ISAVE.EQ.-1.AND.ORD.GE.0).OR.(ISAVE.GT.-1.AND.OORD.GE.0))     CARD3580
                       1      GO TO 560                                                     CARD3585
                  C *** IF THE READINGS ON THE FIRST SIDE OF THE CENTERLINE DECREASE,       CARD3590
                  C *** REORDER THEM.                                                       CARD3595
ISN 0572                 I=ISAVE*2-3                                                        CARD3600
ISN 0573                 IF (ISAVE.EQ.-1) I=SNUMC*2-1                                       CARD3605
ISN 0575                 IF (I.EQ.1) GO TO 560                                              CARD3610
ISN 0577                 J=1                                                                CARD3615
ISN 0578             550 K1=DATA(I)                                                         CARD3620
ISN 0579                 K2=DATA(I+1)                                                       CARD3625
ISN 0580                 DATA(I)=DATA(J)                                                    CARD3630
ISN 0581                 DATA(I+1)=DATA(J+1)                                                CARD3635
ISN 0582                 DATA(J)=K1                                                         CARD3640
ISN 0583                 DATA(J+1)=K2                                                       CARD3645
ISN 0584                 I=I-2                                                              CARD3650
ISN 0585                 J=J+2                                                              CARD3655
                  C *** IF THE READINGS ON THE SECOND SIDE OF THE CENTERLINE DECREASE,      CARD3660
                  C *** REORDER THEM.                                                       CARD3665
ISN 0586                 IF (J.LT.I) GO TO 550                                              CARD3670
ISN 0588             560 IF (ORD.GE.0.OR.ISAVE.EQ.-1) GO TO 580                             CARD3675
ISN 0590                 I=SNUMC*2-1                                                        CARD3680
ISN 0591                 J=ISAVE*2-1                                                        CARD3685
ISN 0592             570 IF (I.LE.J) GO TO 580                                              CARD3690
ISN 0594                 K1=DATA(I)                                                         CARD3695
ISN 0595                 K2=DATA(I+1)                                                       CARD3700
ISN 0596                 DATA(I)=DATA(J)                                                    CARD3705
ISN 0597                 DATA(I+1)=DATA(J+1)                                                CARD3710
ISN 0598                 DATA(J)=K1                                                         CARD3715
ISN 0599                 DATA(J+1)=K2                                                       CARD3720
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ISN 0600          I=I-2                                                       CARD3725
ISN 0601          J=J+2                                                       CARD3730
ISN 0602          GO TO 570                                                   CARD3735
ISN 0603      580 IF (ISAVE.EQ.-1.OR.LOR.NE.L) GO TO 620                      CARD3740
            C *** IF WE'VE READ THE RIGHT READINGS BEFORE THE LEFT READINGS, REORDERCARD3745
ISN 0605          I3=ISAVE*2-2                                                CARD3750
ISN 0606          DO 590 I=1,I3                                               CARD3755
ISN 0607      590 SDATA(I)=DATA(I)                                            CARD3760
ISN 0608          I1=ISAVE*2-1                                                CARD3765
ISN 0609          I2=SNUMC*2                                                  CARD3770
ISN 0610          DO 600 I=I1,I2                                              CARD3775
ISN 0611      600 DATA(I-I1+1)=DATA(I)                                        CARD3780
ISN 0612          DO 610 I=1,I3                                               CARD3785
ISN 0613      610 DATA(I2-I1+1+I)=SDATA(I)                                    CARD3790
            C *** IF READINGS ARE OUT OF ORDER, REORDER THEM HERE.            CARD3795
ISN 0614      620 IF (SNUMC.LE.1) GO TO 629                                   CARD3800
ISN 0616          I2=SNUMC*2                                                  CARD3805
ISN 0617          DO 628 I=4,I2,2                                             CARD3810
ISN 0618          IF (DATA(I).GE.DATA(I-2)) GO TO 628                         CARD3815
ISN 0620          JJ2=I-4                                                     CARD3820
ISN 0621          DO 622 JJ=2,JJ2,2                                           CARD3825
ISN 0622          J=JJ2+2-JJ                                                  CARD3830
ISN 0623          IF (DATA(I).GT.DATA(J)) GO TO 624                           CARD3835
ISN 0625      622 CONTINUE                                                    CARD3840
ISN 0626          J=0                                                         CARD3845
ISN 0627      624 CONTINUE                                                    CARD3850
ISN 0628          K1=DATA(I)                                                  CARD3855
ISN 0629          K2=DATA(I-1)                                                CARD3860
ISN 0630          JJ1=J+2                                                     CARD3865
ISN 0631          JJ2=I-2                                                     CARD3870
ISN 0632          DO 626 JJ=JJ1,JJ2,2                                         CARD3875
ISN 0633          K=JJ1+JJ2-JJ                                                CARD3880
ISN 0634          DATA(K+2)=DATA(K)                                           CARD3885
ISN 0635      626 DATA(K+1)=DATA(K-1)                                         CARD3890
ISN 0636          DATA(J+2)=K1                                                CARD3895
ISN 0637          DATA(J+1)=K2                                                CARD3900
ISN 0638      628 CONTINUE                                                    CARD3905
            C *** IF THIS IS AN EXTENSION, BRANCH HERE.                       CARD3910
ISN 0639      629 IF (IRTYP.GE.4) CALL EXTND                                  CARD3915
ISN 0641          IF (IRTYP.GE.4.AND.IQUIT.NE.ENDFL.AND.IRSET.EQ.1) GO TO 10  CARD3920
ISN 0643          RETURN                                                      CARD3925
ISN 0644      630 IF (IRSET.NE.1) GO TO 640                                   CARD3930
ISN 0646          JCARD=2                                                     CARD3935
ISN 0647          GO TO 10                                                    CARD3940
ISN 0648      640 IF (IRTYP.LE.3) JCSTA=NINE                                  CARD3945
ISN 0650          RETURN                                                      CARD3950
ISN 0651          END                                                         CARD3955
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          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                             SOURCE,EBCDIC,LIST,DECK,LOAD,MAP,NOEDIT,NOID,XREF
  ISN 0002               SUBROUTINE PREP
                   C *** THIS ROUTINE PREPARES THE STATION FILE FOR THE NGI ROUTINES.
  ISN 0003               REAL*8 XSTA,EQTAB,XXTA(2),YNCR,XNCR
  ISN 0004               REAL*4 OWIDL/9999./,OWIDR/-9999./
  ISN 0005               INTEGER L/'L'/,OSTA/-1/,XPUT,STAF,SYSIN,SYSOT,SYSER,ENDFL,
                        1     RT70/'RT70'/,ESTA,ONE/'1'/,IMAGE(20),STFIL,OF,FINAL
  ISN 0006               INTEGER IYES/'YES'/,NGITP/16/,RECRD(400)
  ISN 0007               COMMON/CCEDI/IDUM2(25),KEYC,ICARD
  ISN 0008               COMMON/CDATA/JCSTA,OF,IDUM1(430)
  ISN 0009               COMMON/CERWK/KEYT,JTAPE,KSTA,KPAG
  ISN 0010               COMMON/CMAIN/IRTYP,JRTYP,IRSET,JCARD,ITSTA,ODUMP,FDUMP,FINAL,
                        1     INTPL,LIST
  ISN 0011               COMMON/EQBLK/NOEQ(26),EQTAB(7,20,2),NSET
  ISN 0012               COMMON/QSAM/XOPEN,XCLOS,XGET,XSETL,XESTL,XPUT,XPUTX,ZERO,STAF,
                        1     NTIME,STFIL(852)
  ISN 0013               COMMON/SYSTM/SYSIN,SYSOT,SYSER,SYSTP,NINE,IQUIT,ENDFL,INDEX,NGIDX
  ISN 0014               COMMON/TITLE/IPAGE,IDATE(4),ICHWY(4),JOBNO(2)
  ISN 0015               EQUIVALENCE (STFIL(1),RECRD(1))
                   C
  ISN 0016               IF (JCSTA.NE.NINE.OR.JTAPE.NE.0) GO TO 620
  ISN 0018               IF (IRTYP.NE.1) GO TO 500
                   C *** INITIALIZE VARIABLES.
  ISN 0020               LCNT=34
  ISN 0021               JKEY=0
  ISN 0022               JEQ=1
                   C *** REREAD THE DATA CARD.
  ISN 0023            20 READ(99,30) IBEG,IEND,XNCR,IWDL,LORL,IWDR,LORR,ITAPE
  ISN 0024            30 FORMAT(11X,2I9,F4.1,2(I3,A1),A3)
  ISN 0025               IF(ITAPE.NE.IYES) GO TO 35
  ISN 0027               NGIDX=1
  ISN 0028            31 READ (NGITP,END=32) RECRD
  ISN 0029               WRITE (15'NGIDX) RECRD
  ISN 0030               GO TO 31
  ISN 0031            32 REWIND NGITP
  ISN 0032               WRITE (SYSER,33)
  ISN 0033            33 FORMAT(/15X,' NGI FILE HAS BEEN TRANSFERRED FROM TAPE TO DISK.')
                   C *** PREPARE TO PRINT THE DATA CARD.
  ISN 0034            35 ISTA1=IBEG/10000
  ISN 0035               STA1=(IBEG-ISTA1*10000)/1.0D2+5.0D-4
  ISN 0036               ISTA2=IEND/10000
  ISN 0037               STA2=(IEND-ISTA2*10000)/1.0D2+5.0D-4
  ISN 0038               DO 10 I=7,852
  ISN 0039            10 STFIL(I)=NINE
  ISN 0040               STFIL(1)=1
                   C *** CHECK FOR DATA CARD ERRORS.
  ISN 0041               WIDL=IWDL
  ISN 0042               IF (LORL.EQ.L) WIDL=-WIDL
  ISN 0044               WIDR=IWDR
  ISN 0045               IF (LORR.EQ.L) WIDR=-WIDR
  ISN 0047               IF(WIDL.GE.WIDR.OR.IBEG.GT.IEND) GO TO 540
                   C *** PRINT DATA CARD AND PAGE HEADING.
  ISN 0049               IF (LCNT.LT.34) GO TO 55
  ISN 0051               WRITE(SYSOT,40) IPAGE,IDATE,JOBNO,ICHWY
  ISN 0052            40 FORMAT(1H1,106X,I3/6X,'TEXAS HIGHWAY DEPARTMENT',7X,'T I E S  ROAD
                        1WAY DESIGN SUBSYSTEM',4X,'*** EARTHWORK ***'/6X,'TERRAIN EDIT & ST
                        2ORE PROCESS',57X,4A4/6X,'CONTROL ',A4,' SECTION ',A3,42X,
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                     3      'COUNTY & HIGHWAY - ',4A4//)
ISN 0053              WRITE(SYSOT,50)
ISN 0054           50 FORMAT(21X,'FROM',15X,'TO',12X,'STATION',5X,'CROSS-SECTION LIMITS'
                     1      /15X,2('BASELINE STATION',2X),2X,'INCREMENT',7X,'LEFT',6X,
                     2      'RIGHT'/56X,'(FT)',9X,2('(FT)',7X)/)
ISN 0055              IPAGE=IPAGE+1
ISN 0056              LCNT=0
ISN 0057           55 WRITE(SYSOT,57) ISTA1,STA1,ISTA2,STA2,XNCR,IWDL,LORL,IWDR,LORR
ISN 0058           57 FORMAT(17X,2(I5,'+',F5.2,7X),2X,F5.1,9X,2(I3,A1,7X))
ISN 0059              LCNT=LCNT+1
ISN 0060              IF (IBEG.LT.OSTA) IBEG=OSTA
ISN 0062              IF (IEND.LT.OSTA) GO TO 570
ISN 0064              WIDEL=AMIN1(OWIDL,WIDL)
ISN 0065              WIDER=AMAX1(OWIDR,WIDR)
ISN 0066              JCSTA=IBEG
ISN 0067              IF (OSTA.GT.-1) JCSTA=OSTA
ISN 0069              YNCR=XNCR
ISN 0070              IF (IBEG.GT.OSTA.AND.OSTA.GT.-1) YNCR=(IBEG-OSTA)/1.0D2
ISN 0072              IF(IBEG.EQ.IEND) GO TO 200
ISN 0074           60 IF (JEQ.GT.NOEQ(7)) GO TO 80
ISN 0076              ESTA=EQTAB(7,JEQ,1)*1.0D2+5.0D-1
ISN 0077              IF (ESTA.GT.JCSTA) GO TO 80
ISN 0079              STFIL(2)=ESTA
ISN 0080              STFIL(3)=ESTA
ISN 0081              STFIL(4)=EQTAB(7,JEQ,2)*1.0D2+5.0D-1
ISN 0082              JEQ=JEQ+1
ISN 0083              IF (JCSTA.EQ.ESTA) GO TO 90
ISN 0085              STFIL(799)=NINE
ISN 0086              STFIL(5)=NINE
ISN 0087              STFIL(6)=NINE
                C *** STORE AN EQUATION RECORD ON THE ISAM FILE.
ISN 0088              CALL ISAM(XPUT,STAF,STFIL,3408)
ISN 0089              GO TO 60
ISN 0090           80 STFIL(2)=JCSTA
ISN 0091              STFIL(3)=JCSTA
ISN 0092              STFIL(4)=JCSTA
ISN 0093              IF (JCSTA.EQ.NINE) GO TO 240
ISN 0095              STFIL(5)=WIDEL*1.0D2
ISN 0096              STFIL(6)=WIDER*1.0D2
ISN 0097              STFIL(799)=1
ISN 0098           90 XSTA=JCSTA/1.0D2
                C *** STORE THE RECORD ON THE ISAM FILE.
ISN 0099              CALL ISAM(XPUT,STAF,STFIL,3408)
                C *** MOVE TO THE NEXT STATION.
ISN 0100              CALL STATN(XSTA,YNCR,7,XXTA)
ISN 0101              JCSTA=XXTA(1)*1.0D2+5.0D-1
ISN 0102              IF (JCSTA.GE.IEND) GO TO 200
                C *** THE NEXT STATION IS LESS THEN IEND, THE ENDING STATION.
ISN 0104              YNCR=XNCR
ISN 0105              WIDEL=WIDL
ISN 0106              WIDER=WIDR
ISN 0107              GO TO 60
                C *** THE NEXT STATION IS GREATER THAN OR EQUAL TO IEND, THE ENDING
                C *** STATION.
ISN 0108          200 IF (JKEY.GT.0) GO TO 230
ISN 0110              OSTA=IEND
ISN 0111              OWIDL=WIDL
ISN 0112              OWIDR=WIDR
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ISN 0113             READ(SYSIN,210,END=220) ITYPE,IC13
ISN 0114         210 FORMAT(7X,A4,1X,A1)
ISN 0115             IF (ITYPE.EQ.RT7C) GO TO 20
               C *** THE NEXT CARD DOES NOT BELONG TO THIS ROUTINE.
ISN 0117             IF (IC13.NE.ONE) GO TO 590
ISN 0119             JKEY=1
ISN 0120             GO TO 60
               C *** THE /* CARD HAS BEEN READ.
ISN 0121         220 IQUIT=2
               C *** PREPARE TO COMPUTE THE COORDINATES FOR THE VERY LAST STATION.
ISN 0122             JKEY=1
ISN 0123             GO TO 60
               C *** ALL COORDINATES HAVE BEEN COMPUTED.  FINISH AND RETURN TO THE
               C *** CALLING ROUTINE.
ISN 0124         230 IF (IQUIT.EQ.ENDFL) GO TO 900
               C *** PUT THE REMAINING EQUATION RECORDS, IF ANY, ON THE FILE.
ISN 0126             JCSTA=NINE
ISN 0127             GO TO 60
               C *** PUT THE LAST ORIGINAL RECORD (WITH STATION NUMBER NINE) ON
               C *** THE FILE.
ISN 0128         240 STFIL(5)=NOEQ(7)
ISN 0129             I2=NOEQ(7)
ISN 0130             IF (I2.EQ.0) GO TO 260
ISN 0132             DO 250 I=1,I2
ISN 0133             STFIL(5+I)=EQTAB(7,I,1)*1.0D2+5.0D-1
ISN 0134         250 STFIL(25+I)=EQTAB(7,I,2)*1.0D2+5.0D-1
ISN 0135         260 CALL ISAM(XPUT,STAF,STFIL,3408)
ISN 0136             IF (JKEY.EQ.2) IQUIT=ENDFL
ISN 0138             INDEX=12
ISN 0139             READ(8'INDEX) STFIL
ISN 0140             DO 270 I=1,26
ISN 0141         270 STFIL(52+I)=NOEQ(I)
ISN 0142             INDEX=12
ISN 0143             WRITE(8'INDEX) STFIL
ISN 0144             INDEX=39
ISN 0145             WRITE(8'INDEX) EQTAB
ISN 0146             INDEX=0
ISN 0147             GO TO 900
               C
               C *** ERROR MESSAGES
               C
ISN 0148         500 WRITE(SYSER,510) IRTYP
ISN 0149         510 FORMAT(/15X,'NGI PREPARATION DATA MAY ONLY BE RUN UNDER TERRAIN OP
                    1TION ''ORIGINAL CARDS'' -- IE, WITH',23X,'PREP'/15X,'JOB TYPE 1.
                    2INSTEAD, IT WAS RUN WITH JOB TYPE ',I1,'.  CALCULATIONS CEASE.',
                    3     39X,'PREP')
ISN 0150             IQUIT=ENDFL
ISN 0151             GO TO 900
ISN 0152         540 IF (WIDL.GE.WIDR) WRITE(SYSER,550)
ISN 0154         550 FORMAT(/15X,'THE CROSS-SECTION LIMITS ON THE FOLLOWING CARD ARE OU
                    1T OF ORDER.  CALCULATIONS CEASE.',24X,'PREP')
ISN 0155             IF (IBEG.GE.IEND) WRITE(SYSER,560)
ISN 0157         560 FORMAT(/15X,'THE STATION NUMBERS ON THE FOLLOWING CARD ARE OUT OF
                    1ORDER.  CALCULATIONS CEASE.',29X,'PREP')
ISN 0158             WRITE(SYSER,57) ISTA1,STA1,ISTA2,STA2,XNCR,IWDL,LORL,IWDR,LORR
ISN 0159             IQUIT=ENDFL
ISN 0160             GO TO 900
ISN 0161         570 WRITE(SYSCT,580) ISTA1,STA1,ISTA2,STA2,XNCR,IWDL,LORL,IWDR,LORR
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ISN 0162        580 FORMAT(/15X,'THE FOLLOWING NGI PREPARATION DATA CARD IS OUT OF ORD
                   1ER.  THE ENDING STATION IS BEFORE',23X,'PREP'/15X,'THE ENDING STAT
                   2ION ON THE PREVIOUS CARD.  CALCULATIONS CEASE.',48X,'PREP')
ISN 0163            IEND=CSTA
ISN 0164            GO TO 220
ISN 0165        590 READ(99,600) IMAGE
ISN 0166        600 FORMAT(20A4)
ISN 0167            WRITE(SYSER,610) IMAGE
ISN 0168        610 FORMAT(/15X,'THE NGI PREPARATION DATA IS FOLLOWED BY THE FOLLOWING
                   1 CARD.  THIS IS AN ERROR.  IT',27X,'PREP'/15X,'MUST BE FOLLOWED BY
                   2 A /* CARD OR A CARD WITH A 1 IN COLUMN 13.  CALCULATIONS CEASE.',
                   3      26X,'PREP'/20X,20A4)
ISN 0169            JKEY=2
ISN 0170            GO TO 60
ISN 0171        620 IF (KEYT.NE.0) WRITE(SYSER,630)
ISN 0173        630 FORMAT(/15X,'NGI PREPARATION DATA CANNOT BE RUN AS AN OLD JOB.  CA
                   1LCULATIONS CEASE.',39X,'PREP')
ISN 0174            IF (JCSTA.NE.NINE) WRITE(SYSER,640)
ISN 0176        640 FORMAT(/15X,'NO OTHER TERRAIN DATA CAN BE RUN WITH NGI PREPARATION
                   1 DATA.  CALCULATIONS CEASE.',29X,'PREP')
ISN 0177            IQUIT=ENDFL
ISN 0178        900 IRSET=3
ISN 0179            IRTYP=5
ISN 0180            IF (IQUIT.EQ.ENDFL) RETURN
ISN 0182            KEYC=2
ISN 0183            RETURN
ISN 0184            END
```

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          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                         SOURCE,EBCDIC,LIST,DECK,LOAD,MAP,NOEDIT,NOID,XREF
  ISN 0002            SUBROUTINE PLIST
  ISN 0003            REAL*8 PI2/1.570796326794896D0/,BX1,BY1,BX2,BY2,BDIST,BAZ,
                     1     XTFIL(6),XSTA,HASTA
  ISN 0004            INTEGER STAF,SYSCT,SYSER,ENDFL,STFIL,XOPEN,XCLOS,XGET,XSETL,
                     1     XESTL,XPUTX,ZERO
  ISN 0005            COMMON/CBRDIS/BX1,BY1,BX2,BY2,BDIST,BAZ
  ISN 0006            COMMON/CERWK/KEYT,JTAPE,KSTA,KPAG
  ISN 0007            COMMON /HARLN/ DUM1(1000),HASTA(100),DUM2(300),NOEL,NALS
  ISN 0008            COMMON/QSAM/XOPEN,XCLOS,XGET,XSETL,XESTL,XPUT,XPUTX,ZERO,STAF,
                     1     NTIME,STFIL(852)
  ISN 0009            COMMON/SYSTM/SYSIN,SYSOT,SYSER,SYSTP,NINE,IQUIT,ENDFL,INDEX
  ISN 0010            COMMON/TITLE/IPAGE,IDATE(4),ICHWY(4),JOBNO(2)
  ISN 0011            EQUIVALENCE (STFIL(3),XTFIL(1))
                C
                C *** INITIALIZE VARIABLES.
  ISN 0012            WRITE(SYSER,10)
  ISN 0013         10 FORMAT(1X,'PLIST')
  ISN 0014            DUM2(152)=0.0
  ISN 0015            LCNT=34
  ISN 0016            ISTRP=0
  ISN 0017            IQFLG=0
                C *** RETRIEVE BASELINE ALIGNMENT
  ISN 0018            IF (KPAG.EQ.0) GC TO 520
  ISN 0020            CALL ALGET(7)
  ISN 0021            IF (HASTA(1).EQ.-1.0D0) GO TO 520
  ISN 0023            CALL ISAM(XOPEN,STAF,0)
  ISN 0024            IF (NTIME.EQ.1) CALL ISAM(XESTL,STAF)
  ISN 0026            NTIME=1
  ISN 0027            CALL ISAM(XSETL,STAF,ZERO)
                C *** RETRIEVE A CROSS-SECTICN RECORD FROM THE STATION FILE.
  ISN 0028        910 CALL ISAM(XGET,STAF,STFIL,3400,IEF)
  ISN 0029            IF (STFIL(1).EQ.NINE.OR.IEF.NE.0) GO TO 130
  ISN 0031            WRITE(SYSER,20) STFIL(1),STFIL(797)
  ISN 0032         20 FORMAT(1X,2I9)
  ISN 0033            IF (STFIL(797).NE.1) GC TO 910
  ISN 0035            XSTA=STFIL(1)/1.0D2
  ISN 0036            IF(XSTA.LE.HASTA(NOEL)) GO TO 25
  ISN 0038            XSTA=HASTA(NOEL)
  ISN 0039            STFIL(1)=XSTA*100.+.5
  ISN 0040            IQFLG=1
  ISN 0041         25 WIDEL=STFIL(3)/1.0D2
  ISN 0042            WIDER=STFIL(4)/1.0D2
                C *** FIND THE STATE PLANE COORDINATES FOR THE LEFT, CENTERLINE AND
                C *** RIGHT POINTS.
  ISN 0043            CALL CALXY(XSTA,7,BX1,BY1,BAZ)
  ISN 0044            BAZ=BAZ-PI2
  ISN 0045            BDIST=WIDEL
  ISN 0046            CALL BRDIS(2)
  ISN 0047            XTFIL(1)=BX2
  ISN 0048            XTFIL(2)=BY2
  ISN 0049            XTFIL(3)=BX1
  ISN 0050            XTFIL(4)=BY1
  ISN 0051            BDIST=WIDER
  ISN 0052            CALL BRDIS(2)
  ISN 0053            XTFIL(5)=BX2
  ISN 0054            XTFIL(6)=BY2
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                      C *** PRINT THE STATE PLANE COORDINATES.
ISN 0055                    IF (LCNT.LT.34) GO TO 110
ISN 0057                    WRITE(SYSOT,40) IPAGE,IDATE,JOBNO,ICHWY
ISN 0058                 40 FORMAT(1H1,106X,I3/6X,'TEXAS HIGHWAY DEPARTMENT',7X,'T I E S  ROAD
                           1WAY DESIGN SUBSYSTEM',4X,'*** EARTHWORK ***'/6X,'TERRAIN EDIT & ST
                           2ORE PROCESS',57X,4A4/6X,'CONTROL ',A4,' SECTION ',A3,42X,
                           3     'COUNTY & HIGHWAY - ',4A4//)
ISN 0059                    IPAGE=IPAGE+1
ISN 0060                    WRITE(SYSOT,100)
ISN 0061                100 FORMAT(3X,'STATION',9X,'LEFT POINT COORDINATES',5X,'CENTERLINE POI
                           1NT COORDINATES',6X,'RIGHT POINT COORDINATES'/3X,'NUMBER',14X,
                           2     3('X',12X,'Y',16X)/)
ISN 0062                    LCNT=0
ISN 0063                110 ISTA1=STFIL(1)/10000
ISN 0064                    STA1=(STFIL(1)-ISTA1*10000)/1.0D2+5.0D-4                              DW3OCT74
ISN 0065                    WRITE(SYSOT,120) ISTA1,STA1,XTFIL
ISN 0066                120 FORMAT(1X,I5,'+',F5.2,3(4X,2F13.4))
ISN 0067                    LCNT=LCNT+1
ISN 0068                    CALL XBILD (ISTRP)
                      C *** REPLACE THE CROSS-SECTION RECORD ON THE STATION FILE.
ISN 0069                    CALL ISAM(XPUTX,STAF,STFIL,3400)
ISN 0070                    IF(STFIL(797).NE.NINE) GO TO 30
ISN 0072                    WRITE (SYSER,29) STFIL(1)
ISN 0073                 29 FORMAT(/15X,' XBILD FAILED TO BUILD A XSECTION FOR STATION ',I11,
                           *' CALCULATIONS CONTINUE WITH NEXT STATION')
ISN 0074                    GO TO 36
ISN 0075                 30 N=STFIL(797)*2+3
ISN 0076                    WRITE (SYSER,35) STFIL(1),(STFIL(I),I=4,N)
ISN 0077                 35 FORMAT(1X,I10/,(1X,10I10))                                            DW3OCT74
ISN 0078                 36 IF(IQFLG.EQ.0) GO TO 910
ISN 0080                130 CALL ISAM(XCLOS,STAF)
ISN 0081                    RETURN
ISN 0082                520 WRITE(SYSER,530)
ISN 0083                530 FORMAT(/15X,'NO ALIGNMENT DATA IS AVAILABLE FOR ROADWAY G.  CALCUL
                           1ATIONS CEASE.',43X,'PREP')
ISN 0084                    IQUIT=ENDFL
ISN 0085                900 CONTINUE
ISN 0086                    RETURN
ISN 0087                    END
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          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=60,SIZE=0000K,
                                    SOURCE,EBCDIC,LIST,DECK,LOAD,MAP,NOEDIT,NOID,XREF
  ISN 0002              SUBROUTINE XBILD (ISTRP)
  ISN 0003              COMMON /SYSTM/ SYSIN,SYSOT,SYSER,SYSTP,NINES,IQUIT,ENDFL,INDEX,
                       .              JARG,IBNDX,DLAMB
  ISN 0004              COMMON/QSAM/XOPEN,XCLOS,XGET,XSETL,XESTL,XPUT,XPUTX,ZERO,STAF,
                       1     NTIME,STFIL(852)
  ISN 0005              REAL*8 XTFIL(2,3),XB(47),YB(47),XE(47),YE(47),XDIS,ANGL,X,Y,X1,Y1,
                       *D,D1,D2,DIST,DIST1,DIST2,ANG,PI/3.14159265357280O/,DELTX,DELTY,
                       *SQDIS,SINA,COSA,STRX(3),STRY(3),DIFF,XSECX(200),XSECY(200),
                       *XSECZ(200),FRAC,XI,YI,ZI,XJ,YJ,ZJ,YD1,YD2,YDELT,YY(2),EPS,DLAMB
  ISN 0006              REAL*8 XFRAC,YMAX,YMIN
  ISN 0007              INTEGER*2 NOSEC(47),NOSTR,CCNECT(250,2,2)
  ISN 0008              INTEGER XSTA(200),INDX(200),STORE(400),SYSIN,SYSOT,SYSER,SYSTP,
                       *ENDFL,XOPEN,XCLCS,XGET,XSETL,XESTL,XPUT,XPUTX,ZERO,STAF,STFIL
  ISN 0009              DIMENSION YDIST(200,2),ZELV(200,2),NOPT(2),NOCN(2)
  ISN 0010              EQUIVALENCE (STFIL(3),XTFIL(1,1))
  ISN 0011              DATA IREC/0/
  ISN 0012              XDIS(X,Y,X1,Y1)=(X-X1)*(X-X1)+(Y-Y1)*(Y-Y1)
  ISN 0013              ANGL(D,D1,D2)=DARCOS((D1+D-D2)/(2.0D0*DSQRT(D1)*DSQRT(D)))
                  C**** CHECK FOR INITIAL READ IN OF STRIP INDEX
  ISN 0014              IQFLG=0
  ISN 0015              NGIFL=0
  ISN 0016              IXCNT=1
  ISN 0017              I1=1
  ISN 0018              IF(ISTRP.NE.0) GO TO 20
  ISN 0020              IREC=0
  ISN 0021              JARG=1
  ISN 0022              READ (15'JARG) (XB(I),YB(I),XE(I),YE(I),I=1,47),(NOSEC(I),I=1,47),
                       *              NCSTR
                  C**** DETERMINE WHICH STRIP CONTAINS INPUT XSECT
  ISN 0023              EPS=5.0D-3
  ISN 0024              MAX=400
  ISN 0025              IBEG=1
  ISN 0026              IBIAS=10000
  ISN 0027              ISGN=1
  ISN 0028              WRITE (17,4) NCSTR,(NOSEC(I),I=1,NOSTR)                        DW3OCT74
  ISN 0029            4 FORMAT(25I5)
  ISN 0030            5 I=IBEG
  ISN 0031            6 IF(I.GT.NOSTR.OR.I.LE.0) GO TO 13
  ISN 0033              WRITE (17,3) XB(I),YB(I),XE(I),YE(I),XTFIL                     DW3OCT74
  ISN 0034            3 FORMAT(1X,10F12.4)
  ISN 0035              DIST=XDIS(XB(I),YB(I),XE(I),YE(I))
  ISN 0036              DIST1=XDIS(XB(I),YB(I),XTFIL(1,1),XTFIL(2,1))
  ISN 0037              DIST2=XDIS(XE(I),YE(I),XTFIL(1,1),XTFIL(2,1))
  ISN 0038              WRITE (17,7) DIST,DIST1,DIST2                                  DW3OCT74
  ISN 0039            7 FORMAT(1X,3F20.5)
  ISN 0040              IF(DIST.EQ.0.0D0) GO TC 10
  ISN 0042              IF(DIST1.EQ.0.0D0.OR.DIST2.EQ.0.0D0) GO TO 9
  ISN 0044              ANG=ANGL(DIST,DIST1,DIST2)
  ISN 0045              WRITE (17,8) ANG                                               DW3OCT74
  ISN 0046            8 FORMAT(1X,F20.5)
  ISN 0047              IF(ANG.GT.PI/2.0D0) GO TO 10
  ISN 0049              ANG=ANGL(DIST,DIST2,DIST1)
  ISN 0050              WRITE (17,8) ANG                                               DW3OCT74
  ISN 0051              IF(ANG.GT.PI/2.0D0) GO TO 10
  ISN 0053            9 ISTRP=I
  ISN 0054              GO TO 15
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ISN 0055         10 I=I+ISGN
ISN 0056            GO TO 6
ISN 0057         13 WRITE (SYSER,11)
ISN 0058         11 FORMAT(' ERROR - NGI UNABLE TO FIND LT. POINT ON ANY STRIP')
ISN 0059         12 STFIL(797)=NINES
ISN 0060            RETURN
              C**** FOUND WHICH STRIP XSECT IS ON
ISN 0061         15 N=NOSEC(ISTRP)
ISN 0062            JARG=ISTRP+1
ISN 0063            READ (15'JARG) (XSTA(I),INDX(I),I=1,N)
ISN 0064            WRITE (17,16) (XSTA(I),INDX(I),I=1,N)                    DW3OCT74
ISN 0065         16 FORMAT(1X,12I10)
ISN 0066            JARG=IREC+1
              C**** CALC. DELTAS AND TRIG CONSTANTS FOR THE GIVEN STRIP
ISN 0067            DELTX=XE(ISTRP)-XB(ISTRP)
ISN 0068            DELTY=YE(ISTRP)-YB(ISTRP)
ISN 0069            SQDIS=DSQRT(DIST)
ISN 0070            SINA=DELTY/SQDIS
ISN 0071            COSA=DELTX/SQDIS
ISN 0072            IFLG=0
              C**** TRANSLATION AND ROTATION OF INPUT COOR TO STRIP COOR
ISN 0073         20 DO 25 J=1,3
ISN 0074            DELTX=XTFIL(1,J)-XB(ISTRP)
ISN 0075            DELTY=XTFIL(2,J)-YB(ISTRP)
ISN 0076            STRX(J)=DELTX*COSA+DELTY*SINA+XSTA(1)/1.0D2
ISN 0077         25 STRY(J)=-DELTX*SINA+DELTY*COSA+IBIAS
ISN 0078            WRITE (17,27) STRX,STRY,IFLG                             DW3OCT74
ISN 0079         27 FORMAT(' STRX=',3F12.4/,' STRY=',3F12.4,' IFLG=',I2)
ISN 0080            IF(IFLG.NE.0) GO TO 80
ISN 0082            IFIND=0
ISN 0083            IFLG=1
ISN 0084            I=2
ISN 0085            ILAST=N
ISN 0086         28 DIFF=STRX(1)-XSTA(I)/1.0D2
ISN 0087            IF(DABS(DIFF).GE.EPS) GO TO 31
ISN 0089            NGIFL=2
ISN 0090            IF(DABS(STRX(1)-STRX(3)).LT.EPS) GO TO 38
ISN 0092            IF(STRX(1).GT.STRX(3)) GO TO 38
ISN 0094            NGIFL=1
ISN 0095            IF(ISGN.LT.0) GO TO 34
ISN 0097            GO TO 32
ISN 0098         31 IF(DSIGN(1.0D0,DIFF).NE.ISGN) GO TO 34
ISN 0100         32 IF(I.EQ.ILAST) GO TO 33
ISN 0102            I=I+ISGN
ISN 0103            GO TO 28
ISN 0104         33 IBEG=ISTRP+ISGN
ISN 0105            IQFLG=0
ISN 0106            IXCNT=1
ISN 0107            I1=1
ISN 0108            NGIFL=0
ISN 0109            IF(IBEG.GT.NOSTR.OR.IBEG.LE.0) GO TO 13
ISN 0111            GO TO 5
ISN 0112         34 IF(ISGN.LT.0) I=I+1
ISN 0114         38 J=I-1
ISN 0115            WRITE (6,39) J,XSTA(J)                                   DW3OCT74
ISN 0116         39 FORMAT(' J=',I3,'STATION=',I10)                          DW3OCT74
ISN 0117            K=1
ISN 0118         40 IB=1
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ISN 0119            IKEY=1
ISN 0120            NOPT(K)=INDX(J)/10000000
ISN 0121            L =  (INDX(J)-NOPT(K)*10000000)/10000
ISN 0122            JREC=INDX(J)-INDX(J)/10000*10000
ISN 0123            WRITE (17,41) NOPT(K),L,JARG,IREC                          DW3OCT74
ISN 0124         41 FORMAT(' FOLLOWING JARG INDEX COMPUTATION',4I10)
ISN 0125            IF(JREC.EQ.IREC) GO TO 45
ISN 0127            JARG=JREC
ISN 0128            WRITE (17,42) NOPT(K),L,JARG,IREC                          DW3OCT74
ISN 0129         42 FORMAT(' PRECEDING DISK READ USING JARG',4I10)
ISN 0130         43 IREC=JARG
ISN 0131            READ (15'JARG) STORE
ISN 0132            GO TO (45,60,70),IKEY
ISN 0133         45 YDIST(IB,K)=STORE(L)/100000
ISN 0134            IDIST=YDIST(IB,K)
ISN 0135            IELV=STORE(L)-IDIST*100000
ISN 0136            ZELV(IB,K)=IELV/10.
ISN 0137            WRITE (17,48) YDIST(IB,K),ZELV(IB,K)                       DW3OCT74
ISN 0138         48 FORMAT(1X,2F15.4)
ISN 0139            IB=IB+1
ISN 0140            L=L+1
ISN 0141            IF(IB.GT.NOPT(K)) GO TO 55
ISN 0143            IF(L.LE.MAX) GO TO 45
ISN 0145         50 L=1
ISN 0146            GO TO 43
ISN 0147         55 IF(L.LE.MAX) GO TO 60
ISN 0149            IKEY=2
ISN 0150            GO TO 50
ISN 0151         60 NOCN(K)=STORE(L)
ISN 0152            WRITE (17,63) NOCN(K)                                      DW3OCT74
ISN 0153         63 FORMAT(1X,I5)
ISN 0154            IF(NOCN(K).EQ.0) GO TO 75
ISN 0156            IB=1
ISN 0157         65 L=L+1
ISN 0158            IF(IB.GT.NOCN(K)) GO TO 75
ISN 0160            IF(L.LE.MAX) GO TO 70
ISN 0162            IKEY=3
ISN 0163            GO TO 50
ISN 0164         70 CONECT(IB,1,K)=STORE(L)/1000
ISN 0165            CONECT(IB,2,K)=STORE(L)-CONECT(IB,1,K)*1000
ISN 0166            WRITE (17,73) (CONECT(IB,NNN,K),NNN=1,2)                   DW3OCT74
ISN 0167         73 FORMAT(1X,2I5)
ISN 0168            IB=IB+1
ISN 0169            GO TO 65
ISN 0170         75 IF(K.GT.1.OR.IQFLG.EQ.1) GO TO 125
ISN 0172         78 J=I
ISN 0173            WRITE (6,79) J,XSTA(J)                                     DW3OCT74
ISN 0174         79 FORMAT(' J=',I3,'STATION=',I10)                            DW3OCT74
ISN 0175            K=2
ISN 0176            GO TO 40
ISN 0177         80 ISGN=-1
ISN 0178            IFIND=0
ISN 0179            WRITE (17,81) STRX(1),XSTA(I-2),XSTA(I-1),XSTA(I),XSTA(I+1)      DW3OCT74
ISN 0180         81 FORMAT(' WHERE DOES ',F11.4,' FALL BETWEEN,',4I12)
ISN 0181            IF(DABS(STRX(1)-XSTA(I-1)/1.0D2).LT.EPS) GO TO 98
ISN 0183            IF(STRX(1).LT.XSTA(I-1)/1.0D2) GO TO 102
ISN 0185            ISGN=1
ISN 0186            IF(DABS(STRX(1)-XSTA(I)/1.0D2).LT.EPS) GO TO 86
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ISN 0188             IF(STRX(1).LT.XSTA(I)/1.0D2) GO TO 125
ISN 0190             GO TO 92
ISN 0191          86 NGIFL=2
ISN 0192             IF(STRX(1).GT.STRX(3).OR.DABS(STRX(1)-STRX(3)).LT.EPS) GO TO 125
ISN 0194             NGIFL=1
ISN 0195          90 IF(I.GE.N) GC TC 33
ISN 0197             I=I+1
ISN 0198             L1=1
ISN 0199             L2=2
ISN 0200             GO TO 105
ISN 0201          92 IF(I.GE.N) GO TO 33
ISN 0203             IF(DABS(STRX(1)-XSTA(I+1)/1.0D2).GE.EPS) GO TO 97
ISN 0205             NGIFL=2
ISN 0206             IF(STRX(1).GT.STRX(3).OR.DABS(STRX(1)-STRX(3)).LT.EPS) GO TO 90
ISN 0208          96 IF(I+1.GE.N) GO TO 33
ISN 0210             I=I+1
ISN 0211             ILAST=N
ISN 0212             GO TO 28
ISN 0213          97 IF(STRX(1).LT.XSTA(I+1)/1.0D2) GO TO 90
ISN 0215             GO TO 96
ISN 0216          98 IF(STRX(1).LT.STRX(3).OR.DABS(STRX(1)-STRX(3)).LT.EPS) GO TC 99
ISN 0218             NGIFL=2
ISN 0219          95 IF(I.LE.2) GO TO 33
ISN 0221             I=I-1
ISN 0222             L1=2
ISN 0223             L2=1
ISN 0224             GO TO 105
ISN 0225          99 NGIFL=1
ISN 0226             GO TO 125
ISN 0227         102 IF(I.LE.2) GO TO 33
ISN 0229             IF(DABS(STRX(1)-XSTA(I-2)/1.0D2).GE.EPS) GO TO 104
ISN 0231             IF(STRX(1).LT.STRX(3).OR.DABS(STRX(1)-STRX(3)).LT.EPS) GO TO 103
ISN 0233         101 IF(I-1.LE.2) GO TO 33
ISN 0235             WRITE (17,106) XSTA(I),XSTA(I-1),XSTA(I-2),I,J,K,STRX(1)          DW30CT74
ISN 0236         106 FORMAT(' XSTA(I-I-2)=',3I10,' I-J-K=',3I3,' STRX(1)=',F15.4)
ISN 0237             I=I-2
ISN 0238             ILAST=1
ISN 0239             GO TO 28
ISN 0240         103 NGIFL=1
ISN 0241             GO TO 95
ISN 0242         104 IF(STRX(1).LT.XSTA(I-2)/1.0D2) GO TO 101
ISN 0244             GO TO 95
ISN 0245         105 IQFLG=1
ISN 0246             WRITE (17,107) L1,L2                                                DW30CT74
ISN 0247         107 FORMAT(' L1=',I3,' L2=',I3)
ISN 0248             NOPT(L1)=NOPT(L2)
ISN 0249             M=NOPT(2)
ISN 0250             DO 110 L=1,M
ISN 0251             YDIST(L,L1)=YDIST(L,L2)
ISN 0252         110 ZELV(L,L1)=ZELV(L,L2)
ISN 0253             NOCN(L1)=NOCN(L2)
ISN 0254             M=NOCN(2)
ISN 0255             DO 120 L=1,M
ISN 0256             CONECT(L,1,L1)=CCNECT(L,1,L2)
ISN 0257         120 CONECT(L,2,L1)=CCNECT(L,2,L2)
ISN 0258             GO TO (38,78),L2
ISN 0259         125 IF(IFIND.EQ.1) GC TO 128
ISN 0261             IF(NGIFL.EQ.0) GC TO 126
```

```
ISN 0263            XFRAC=0.0D0
ISN 0264            IF(NGIFL.EQ.2) XFRAC=1.0D0
ISN 0266            GO TO 127
ISN 0267        126 XFRAC=(STRX(1)-XSTA(I-1)/1.0D2)/(XSTA(I)/1.0D2-XSTA(I-1)/1.0D2)
ISN 0268        127 YMAX=YDIST(1,1)+(YDIST(1,2)-YDIST(1,1))*XFRAC
ISN 0269            YMIN=YDIST(NOPT(1),1)+(YDIST(NOPT(2),2)-YDIST(NOPT(1),1))*XFRAC
ISN 0270            WRITE (17,131) XFRAC,YMAX,YMIN,NOPT,STRY(1)                         DW3OCT74
ISN 0271        131 FORMAT(' XFRAC=',F6.4,' YMAX=',F10.4,' YMIN=',F10.4,' NOPT=',2I3,
                   *   ' STRY(1)=',F10.4)
ISN 0272            IFIND=1
ISN 0273            IF(STRY(1).GT.YMAX.OR.STRY(1).LT.YMIN) GO TO 33
ISN 0275        128 WRITE (6,129)
ISN 0276        129 FORMAT(' DATA ARRAYS NOW CONTAIN PROPER NGI XSECTS.')
ISN 0277            IF(DABS(STRX(1)-STRX(3)).GE.EPS) GO TO 210
ISN 0279            IF(NGIFL.EQ.0) GO TO 170
              C**** XSECT IS ON NGI XSECT, DO SPECIAL XSECT CALCULATIONS
ISN 0281            M=NGIFL
ISN 0282            K=1
ISN 0283            I1=1
ISN 0284            IF(STRY(1).LT.STRY(3)) GO TO 130
ISN 0286            L=1
ISN 0287            ILAST=NOPT(1)
ISN 0288            ISGN=1
ISN 0289            GO TO 135
ISN 0290        130 L=NOPT(1)
ISN 0291            ILAST=1
ISN 0292            ISGN=-1
ISN 0293        135 DIFF=YDIST(L,M)-STRY(K)
ISN 0294            IF(DABS(DIFF).GE.EPS) GO TO 140
ISN 0296            K=K+1
ISN 0297            GO TO 145
ISN 0298        140 IF(DSIGN(1.0D0,DIFF).NE.ISGN) GO TO 165
ISN 0300            IF(L.EQ.ILAST) GO TO 155
ISN 0302            IF(K.EQ.1) GO TO 150
ISN 0304        145 XSECX(I1)=XSTA(I-1)/1.0D2
ISN 0305            XSECY(I1)=YDIST(L,M)
ISN 0306            XSECZ(I1)=ZELV(L,M)
ISN 0307            I1=I1+1
ISN 0308            IF(L.NE.ILAST) GO TO 150
ISN 0310            IF(K.LE.3) GO TO 155
ISN 0312            GO TO 325
ISN 0313        150 L=L+ISGN
ISN 0314        153 IF(K.LE.3) GO TO 135
ISN 0316            GO TO 325
ISN 0317        155 WRITE (SYSER,160)
ISN 0318        160 FORMAT(' ERROR - NGI UNABLE TO FIND LT. & RT. PTS. ON NGI XSECT')
ISN 0319            GO TO 12
ISN 0320        165 FRAC=(STRY(K)-YDIST(L,M))/(YDIST(L-ISGN,M)-YDIST(L,M))
ISN 0321            XSECX(I1)=XSTA(I-1)/1.0D2
ISN 0322            XSECY(I1)=STRY(K)
ISN 0323            XSECZ(I1)=ZELV(L,M)+FRAC*(ZELV(L-ISGN,M)-ZELV(L,M))
ISN 0324            IF(K.EQ.2) ICLFL=I1
ISN 0326            K=K+1
ISN 0327            I1=I1+1
ISN 0328            GO TO 153
              C**** VERTICAL LINE NOT ON NGI XSECT
ISN 0329        170 DELTX=XSTA(I)/1.0D2-XSTA(I-1)/1.0D2
ISN 0330            YJ=-1
```

```
ISN 0331          K=1
ISN 0332          I1=1
ISN 0333          IF(STRY(1).LT.STRY(3)) GO TO 175
ISN 0335          L=1
ISN 0336          ILAST=NOCN(2)
ISN 0337          ISGN=1
ISN 0338          GO TO 180
ISN 0339      175 L=NOCN(2)
ISN 0340          ILAST=1
ISN 0341          ISGN=-1
ISN 0342      180 IFWD=CCNECT(L,1,2)
ISN 0343          IBAC=CCNECT(L,2,2)
ISN 0344          YD1=YDIST(IBAC,1)
ISN 0345          DELTY=YDIST(IFWD,2)-YD1
ISN 0346          YI=YD1+DELTY/DELTX*(STRX(K)-XSTA(I-1)/1.0D2)
ISN 0347          DIFF=YI-STRY(K)
ISN 0348          IF(DABS(DIFF).GE.EPS) GC TO 185
ISN 0350          IF(K.EQ.2) ICLFL=I1
ISN 0352          K=K+1
ISN 0353          IF(DELTY.NE.0.0D0) GO TC 184
ISN 0355          ZI=ZELV(IBAC,1)
ISN 0356          GO TO 194
ISN 0357      184 ZI=ZELV(IBAC,1)+(YI-YD1)/DELTY*(ZELV(IFWD,2)-ZELV(IBAC,1))
ISN 0358          GO TO 194
ISN 0359      185 IF(DSIGN(1.0D0,DIFF).NE.ISGN) GO TO 200
ISN 0361          IF(L.EC.ILAST) GC TO 155
ISN 0363          IF(K.EC.1) GO TO 195
ISN 0365          IF(DELTY.NE.0.0D0) GO TO 192
ISN 0367          ZI=ZELV(IBAC,1)
ISN 0368          GO TO 193
ISN 0369      192 ZI=ZELV(IBAC,1)+(YI-YD1)/DELTY*(ZELV(IFWD,2)-ZELV(IBAC,1))
ISN 0370      193 IF(K.GT.3) GO TO 325
ISN 0372      194 XSECX(I1)=STRX(1)
ISN 0373          XSECY(I1)=YI
ISN 0374          XSECZ(I1) = ZI
ISN 0375          YJ=YI
ISN 0376          ZJ=ZI
ISN 0377          I1=I1+1
ISN 0378          IF(L.NE.ILAST) GC TO 195
ISN 0380          IF(K.LE.3) GO TO 155
ISN 0382          GO TO 325
ISN 0383      195 L=L+ISGN
ISN 0384          IF(K.LE.3) GO TO 180
ISN 0386          GO TO 325
ISN 0387      200 IF(DELTY.NE.0.0D0) GO TC 205
ISN 0389          ZI=ZELV(IBAC,1)
ISN 0390          GO TO 207
ISN 0391      205 ZI=ZELV(IBAC,1)+(YI-YD1)/DELTY*(ZELV(IFWD,2)-ZELV(IBAC,1))
ISN 0392      207 IF(YJ.GE.0.0D0) GO TC 209
ISN 0394          IFD=CONECT(L-ISGN,1,2)
ISN 0395          IBC=CCNECT(L-ISGN,2,2)
ISN 0396          YD2= YDIST(IBC,1)
ISN 0397          YDELT=YDIST(IFD,2)-YD2
ISN 0398          YJ=YD2+YDELT/DELTX*(STRX(K)-XSTA(I-1)/1.0D2)
ISN 0399          IF(YDELT.NE.0.0D0) GO TO 208
ISN 0401          ZJ=ZELV(IBC,1)
ISN 0402          GO TO 209
ISN 0403      208 ZJ=ZELV(IBC,1)+(YJ-YD2)/YDELT*(ZELV(IFD,2)-ZELV(IBC,1))
```

```
ISN 0404       209 XSECX(I1) =  STRX(K)
ISN 0405           XSECY(I1) =  STRY(K)
ISN 0406           XSECZ(I1) =  ZJ+(STRY(K)-YJ)/(YI-YJ)*(ZI-ZJ)
ISN 0407           IF(K.EQ.2) ICLFL=I1
ISN 0409           I1=I1+1
ISN 0410           K=K+1
ISN 0411           GO TO 193
             C**** NON-VERTICAL XSECT
ISN 0412       210 YY(1)=STRY(1)+(STRY(3)-STRY(1))/(STRX(3)-STRX(1))*(XSTA(I-1)/1.0D2
                  *                                                        -STRX(1))
ISN 0413           YY(2)=STRY(1)+(STRY(3)-STRY(1))/(STRX(3)-STRX(1))*(XSTA(I)/1.0D2-
                  *                                                         STRX(1))
ISN 0414           WRITE (17,213) (YY(L),L=1,2),NGIFL                              DW30CT74
ISN 0415       213 FORMAT(' NONVERTICAL XSECT',2F15.4,' NGI FLAG=',I3)
ISN 0416           IF(NGIFL.NE.0) GO TO 211
ISN 0418           K=2
ISN 0419           IF(STRX(1).LT.STRX(3)) K=1
ISN 0421           GO TO 212
ISN 0422       211 K=NGIFL
ISN 0423       212 LINE=1
ISN 0424           IONFL=0
ISN 0425           K1=1
ISN 0426           IF(K.EQ.1) K1=2
ISN 0428           ILAST=NOPT(K)
ISN 0429           IF(YY(K).GT.YDIST(1,K)) GO TO 214
ISN 0431           IF(YY(K).LT.YDIST(NOPT(K),K)) GO TO 215
ISN 0433           GO TO 217
ISN 0434       214 IF(YY(K1).GT.YDIST(1,K1)) GO TO 288
ISN 0436           M=1
ISN 0437           L1=1
ISN 0438           M1=1
ISN 0439           GO TO 255
ISN 0440       215 IF(YY(K1).LT.YDIST(NOPT(K1),K1)) GO TO 288
ISN 0442           M=NOCN(2)+1
ISN 0443           L2=NOPT(K)
ISN 0444           M2=NOPT(K1)
ISN 0445           GO TO 265
ISN 0446       217 DO 218 L=2,ILAST
ISN 0447           IF(DABS(YY(K)-YDIST(L,K)).LT.EPS) GO TO 220
ISN 0449           IF(YY(K).GT.YDIST(L,K)) GO TO 225
ISN 0451       218 CONTINUE
ISN 0452       220 IONFL=1
ISN 0453           ZI=ZELV(L,K)
ISN 0454           GO TO 230
ISN 0455       225 ZI=ZELV(L,K)+(YY(K)-YDIST(L,K))/(YDIST(L-1,K)-YDIST(L,K))*
                  *  (ZELV(L-1,K)-ZELV(L,K))
ISN 0456       230 XI=XSTA(I-2+K)/1.0D2
ISN 0457           YI=YY(K)
ISN 0458           WRITE (17,231) XI,YI,ZI,IONFL,IXCNT,ICLFL                       DW30CT74
ISN 0459       231 FORMAT(' XI-YI-ZI',3F15.4,' IONFL=',I2,' IXCNT=',I2,' ICLFL=',I2)
ISN 0460           IF(NGIFL.EQ.0) GO TO 233
ISN 0462           XSECX(I1)=XI
ISN 0463           XSECY(I1)=YI
ISN 0464           XSECZ(I1)=ZI
ISN 0465           IF(IXCNT.EQ.2) ICLFL=I1
ISN 0467           IF(DABS(STRX(IXCNT)-XI).LT.EPS) IXCNT=IXCNT+1
ISN 0469           I1=I1+1
ISN 0470       233 ILAST=NOCN(2)
```

```
ISN 0471          DO 235 M=2,ILAST
ISN 0472          IF(CONECT(M,K1,2).EQ.L.AND.CONECT(M-1,K1,2).EQ.L-1) GO TO 240
ISN 0474      235 CONTINUE
ISN 0475      240 M1=CONECT(M,K,2)
ISN 0476          M2=CONECT(M-1,K,2)
ISN 0477          L1=CONECT(M,K1,2)
ISN 0478          L2=CONECT(M-1,K1,2)
ISN 0479          WRITE (17,243) M1,M2,L1,L2                                    DW3OCT74
ISN 0480      243 FORMAT(' M1-M2-ML1-L2',4I4)
ISN 0481          GO TO (245,250,260),LINE
ISN 0482      245 IF(DABS(YY(K1)-YDIST(M1,K1)).LT.EPS) GO TO 295
ISN 0484          IF(YY(K1).LT.YDIST(M1,K1).AND.IONFL.NE.1) GO TO 255
ISN 0486          IF(DABS(YY(K1)-YDIST(M2,K1)).LT.EPS) GO TO 295
ISN 0488          IF(YY(K1).GT.YDIST(M2,K1)) GO TO 265
ISN 0490          IF(IONFL.EQ.0) GO TO 295
ISN 0492          IF(IONFL.EQ.2) GO TO 247
ISN 0494          IONFL=2
ISN 0495          M=M+1
ISN 0496          GO TO 240
ISN 0497      247 IF(YY(K1).GT.YDIST(M1,K1).AND.YY(K1).LT.YDIST(M2,K1)) GO TO 295
ISN 0499          IONFL=0
ISN 0500          M=M-1
ISN 0501          GO TO 240
ISN 0502      250 IF(DABS(YY(K1)-YDIST(M1,K1)).LT.EPS) GO TO 295
ISN 0504          IF(YY(K1).LT.YDIST(M1,K1)) GO TO 257
ISN 0506          GO TO 295
ISN 0507      255 LINE=2
ISN 0508          NCR=1
ISN 0509          LAST=NCON(2)
ISN 0510      257 LX=L1
ISN 0511          MX=M1
ISN 0512          GO TO 270
ISN 0513      260 IF(DABS(YY(K1)-YDIST(M2,K1)).LT.EPS) GO TO 295
ISN 0515          IF(YY(K1).GT.YDIST(M2,K1)) GO TO 267
ISN 0517          GO TO 295
ISN 0518      265 LINE=3
ISN 0519          NCR=-1
ISN 0520          LAST=2
ISN 0521      267 LX=L2
ISN 0522          MX=M2
ISN 0523      270 XJ=XSTA(I-2+K)/1.0D2+(YY(K)-YDIST(LX,K))/(YY(K)-YDIST(LX,K)-YY(K1)
                 *  +YDIST(MX,K1))*(XSTA(I+1-K)/1.0D2-XSTA(I-2+K)/1.0D2)
ISN 0524          YJ=YDIST(LX,K)+(XJ-XSTA(I-2+K)/1.0D2)/(XSTA(I+1-K)/1.0D2-
                 * XSTA(I-2+K)/1.0D2)*(YDIST(MX,K1)-YDIST(LX,K))
ISN 0525          ZJ=ZELV(LX,K)+(XJ-XSTA(I-2+K)/1.0D2)/(XSTA(I+1-K)/1.0D2
                 *-XSTA(I-2+K)/1.0D2)*(ZELV(MX,K1)-ZELV(LX,K))
ISN 0526          WRITE (17,273) XJ,YJ,ZJ                                       DW3OCT74
ISN 0527      273 FORMAT(' XJ-YJ-ZJ',3F15.4)
ISN 0528      275 DIFF=STRX(IXCNT)-XJ
ISN 0529          IDFLG=0
ISN 0530          IF(DABS(DIFF).GE.EPS) GO TO 280
ISN 0532          IDFLG=1
ISN 0533          GO TO 290
ISN 0534      280 IF(DSIGN(1.0D0,DIFF).NE.K1-K) GO TO 290
ISN 0536          IF(NGIFL.EQ.0) GO TO 285
ISN 0538          XSECX(I1)=XJ
ISN 0539          XSECY(I1)=YJ
ISN 0540          XSECZ(I1)=ZJ
```

```
ISN 0541                I1=I1+1
ISN 0542            285 XI=XJ
ISN 0543                YI=YJ
ISN 0544                ZI=ZJ
ISN 0545                IF(M.EQ.LAST) GO TO 288
ISN 0547                M=M+NCR
ISN 0548                GO TO 240
ISN 0549            288 WRITE (SYSER,289)
ISN 0550            289 FORMAT(' ERROR - XSECT IS OFF ONE SIDE OF THE STRIP')
ISN 0551                GO TO 33
ISN 0552            290 XSECX(I1)=STRX(IXCNT)
ISN 0553                XSECY(I1)=STRY(IXCNT)
ISN 0554                XSECZ(I1)=ZI+(STRX(IXCNT)-XI)/(XJ-XI)*(ZJ-ZI)
ISN 0555                IF(IXCNT.EQ.2) ICLFL=I1
ISN 0557                I1=I1+1
ISN 0558                IXCNT=IXCNT+1
ISN 0559                IF(IXCNT.GT.3) GO TO 325
ISN 0561                IF(NGIFL.NE.0) GO TO 293
ISN 0563                NGIFL=1
ISN 0564                IF(K.EQ.2) NGIFL=2
ISN 0566            293 IF(IDFLG.EQ.1) GO TO 285
ISN 0568                GO TO 275
ISN 0569            295 XJ=XSTA(I+1-K)/1.0D2
ISN 0570                YJ=YY(K1)
ISN 0571                ZJ=ZELV(M1,K1)+(YY(K1)-YDIST(M1,K1))/(YDIST(M2,K1)-YDIST(M1,K1))*
                       *  (ZELV(M2,K1)-ZELV(M1,K1))
ISN 0572                GO TO 312
ISN 0573            300 DIFF=STRX(IXCNT)-XJ
ISN 0574                IF(DABS(DIFF).LT.EPS) GO TO 315
ISN 0576                IF(DSIGN(1.0D0,DIFF).EQ.K1-K) GO TO 315
ISN 0578                XSECX(I1)=STRX(IXCNT)
ISN 0579                XSECY(I1)=STRY(IXCNT)
ISN 0580                XSECZ(I1)=ZI+(STRX(IXCNT)-XI)/(XJ-XI)*(ZJ-ZI)
ISN 0581                IF(IXCNT.EQ.2) ICLFL=I1
ISN 0583                I1=I1+1
ISN 0584                IXCNT=IXCNT+1
ISN 0585            312 IF(IXCNT.GT.3) GO TO 325
ISN 0587                GO TO 300
ISN 0588            315 IF(K.EQ.2) GO TO 320
ISN 0590                NGIFL=1
ISN 0591                ISGN=1
ISN 0592                GO TO 90
ISN 0593            320 NGIFL=2
ISN 0594                ISGN=-1
ISN 0595                GO TO 95
                  C**** COMPUTE DISTANCES FOR FINAL XSECT
ISN 0596            325 MM=I1-1
ISN 0597                STFIL(797)=MM
ISN 0598                ISGN=-1
ISN 0599                WRITE (17,328) MM,ICLFL,(XSECX(L),XSECY(L),XSECZ(L),L=1,MM)        DW3OCT74
ISN 0600            328 FORMAT(1X,2I5,'XSECXYZ',(3F15.5))
ISN 0601                DO 340 L=1,MM
ISN 0602                IF(L.NE.ICLFL) GO TO 330
ISN 0604                ISGN=1
ISN 0605                DIST=0.0D0
ISN 0606                GO TO 335
ISN 0607            330 DIST=DSQRT(XDIS(XSECX(L),XSECY(L),XSECX(ICLFL),XSECY(ICLFL)))
ISN 0608                WRITE (17,333) DIST                                                DW3OCT74
```

```
ISN 0609        333 FORMAT(' DIST=',F20.10)
ISN 0610        335 STFIL(2*L+2)=XSECZ(L)*1.0D2+.5
ISN 0611            STFIL(2*L+3)=ISGN*(DIST*1.0D2+.5)
ISN 0612        340 CONTINUE
ISN 0613            STFIL(3)=NINES
ISN 0614            RETURN
ISN 0615            END
```

NGI/RDS Run Procedure

```
          // REGION=120K,CLASS=C,TIME=1
          //NGI EXEC FORTGLG,PARM.LKED='LIST,LET,MAP'
          //LKED.SYSIN DD *

                OBJECT DECKS GO HERE

          /*
          //GO.FT02F001 DD DSNAME=NGICARDS,VOL=SER=RDS200,DISP=(NEW,KEEP),
NGI       // UNIT=(TAPE9,,DEFER),LABEL=(1,SL),DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
tape  ----//GO.FT02F002 DD DSNAME=NGIFILE1,VOLUME=SER=RDS200,DISP=(NEW,KEEP),
file      // UNIT=(TAPE9,,DEFER),LABEL=(2,SL),
          // DCB=(RECFM=VS,BLKSIZE=408,LRECL=404,BUFNO=1)
NGI       //GO.FT15F001   DD   DSN=&&NGIFILE,UNIT=SYSDA,SPACE=(CYL,(18,1)),
disk  ----// DISP=(NEW,PASS),DCB=(BUFNO=1)
file      //GO.FT16F001 DD SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //GO.SYSIN DD *

                NGI HEADER CARD GOES HERE
                NGI STRIP HEADER CARD GOES HERE
                REMAINDER OF NGI DATA GOES HERE

          /*
          //DATA   EXEC   PGM=RDS400,REGION=190K
          //STEPLIB   DD DSN=D19.RDS3LINK,DISP=SHR
          //FT02F001 DD VOLUME=SER=RDS201,DSNAME=DIV045.T007308B,
          // DISP=(OLD,KEEP),UNIT=(TAPE9,,DEFER),LABEL=(1,SL),
          //   DCB=(RECFM=VS,LRECL=3404,BLKSIZE=3408,BUFNO=1)
          //FT02F002 DD DSNAME=DATA3,VOLUME=REF=*.FT02F001,DISP=(OLD,KEEP),
          //    UNIT=(TAPE9,,DEFER),LABEL=(2,SL),
          //   DCB=(RECFM=VS,LRECL=3404,BLKSIZE=3408,BUFNO=1)
          //FT02F003 DD DSNAME=DATA4,VOLUME=REF=*.FT02F001,DISP=(OLD,KEEP),
          //    UNIT=(TAPE9,,DEFER),LABEL=(3,SL),
          //    DCB=(RECFM=VS,BLKSIZE=1096,LRECL=1092,BUFNO=1)
          //FT03F001 DD DSNAME=PERSPLOT,VOLUME=SER=RDS202,DISP=(NEW,KEEP),
          //    UNIT=(TAPE9,,DEFER),LABEL=(1,SL),
          //    DCB=(RECFM=VS,BLKSIZE=3408,LRECL=3404,BUFNO=1)
          //FT05F001 DD   DDNAME=CARDS
          //FT06F001 DD   SYSOUT=A
          //FT07F001 DD   SYSOUT=B
          //FT08F001 DD DSN=&&PAGES,UNIT=SYSDA,SPACE=(TRK,(27,1)),
          //   DISP=(NEW,DELETE),DCB=(BUFNO=1)
          //FT09F001 DD DSN=&&BPAGES,UNIT=SYSDA,SPACE=(TRK,(36,1)),
          //   DISP=(NEW,DELETE),DCB=(BUFNO=1)
```

NGI/RDS Run Procedure (continued)

```
          //FT10F001  DD  SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT11F001  DD  SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT12F001  DD  SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT13F001  DD  SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT14F001  DD  SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT71F001 DD UNIT=(TAPE9,,DEFER),DISP=(NEW,KEEP),LABEL=(1,SL),
          //  DCB=(LRECL=484,BLKSIZE=488,RECFM=VS)
          //STACFILE DD DSNAME=D59.PLTSTAC,DISP=SHR
          //STAF DD DSNAME=&&STAF,UNIT=SYSDA,SPACE=(CYL,27,,CONTIG),
          //  DISP=(NEW,DELETE),DCB=(BLKSIZE=3400,RECFM=F,DSORG=IS,LRECL=3400,
NGI       //  KEYLEN=8,RKP=0,BUFNO=1)
disk  ---[//FT15F001 DD DSN=&&NGIFILE,UNIT=SYSDA,SPACE=(CYL,(18,1)),
file     [// DISP=(OLD,DELETE),DCB=(BUFNO=1)
         [//FT16F001 DD DSNAME=NGIFILE1,VOLUME=SER=RDS200,DISP=(OLD,KEEP),
NGI   ---[// UNIT=(TAPE9,,DEFER),LABEL=(2,SL),
tape     [// DCB=(RECFM=VS,BLKSIZE=408,LRECL=404,BUFNO=1)
file      //FT17F001  DD  SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //CARDS DD *

               RDS SYSTEM CARD GOES HERE
               REMAINDER OF RDS DATA CARDS GO HERE

          /*
```

NGI Run Procedure

```
        // REGION=120K,CLASS=C,TIME=1
        //NGI EXEC FORTGLG,PARM.LKED='LIST,LET,MAP'
        //LKED.SYSIN DD *

             OBJECT DECKS GO HERE

        /*
        //GO.FT02F001 DD DSNAME=NGICARDS,VOL=SER=RDS200,DISP=(NEW,KEEP),
NGI     // UNIT=(TAPE9,,DEFER),LABEL=(1,SL),DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
tape  — //GO.FT02F002 DD DSNAME=NGIFILE1,VOLUME=SER=RDS200,DISP=(NEW,KEEP),
file    // UNIT=(TAPE9,,DEFER),LABEL=(2,SL),
        // DCB=(RECFM=VS,BLKSIZE=408,LRECL=404,BUFNO=1)
NGI   — //GO.FT15F001  DD  DSN=&&NGIFILE,UNIT=SYSDA,SPACE=(CYL,(18,1)),
disk    // DISP=(NEW,DELETE),DCB=(BUFNO=1)
file    //GO.FT16F001 DD SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
        //GO.SYSIN DD *

             NGI HEADER CARD GOES HERE
             NGI STRIP HEADER CARD GOES HERE
             REMAINDER OF NGI DATA GOES HERE

        /*
```

RDS Run Procedure for Accessing NGI Tape File

```
          //   REGION=190K,CLASS=C,TIME=1
          //DATA   EXEC   PGM=RDS400,REGION=190K
          //STEPLIB   DD DSN=D19.RDS3LINK,DISP=SHR
          //FT02F001 DD VOLUME=SER=RDS201,DSNAME=DIV045.T007308B,
          // DISP=(OLD,KEEP),UNIT=(TAPE9,,DEFER),LABEL=(1,SL),
          //   DCB=(RECFM=VS,LRECL=3404,BLKSIZE=3408,BUFNO=1)
          //FT02F002 DD DSNAME=DATA3,VOLUME=REF=*.FT02F001,DISP=(OLD,KEEP),
          //    UNIT=(TAPE9,,DEFER),LABEL=(2,SL),
          //   DCB=(RECFM=VS,LRECL=3404,BLKSIZE=3408,BUFNO=1)
          //FT02F003 DD DSNAME=DATA4,VOLUME=REF=*.FT02F001,DISP=(OLD,KEEP),
          //    UNIT=(TAPE9,,DEFER),LABEL=(3,SL),
          //    DCB=(RECFM=VS,BLKSIZE=1096,LRECL=1092,BUFNO=1)
          //FT03F001 DD DSNAME=PERSPLOT,VOLUME=SER=RDS202,DISP=(NEW,KEEP),
          //    UNIT=(TAPE9,,DEFER),LABEL=(1,SL),
          //    DCB=(RECFM=VS,BLKSIZE=3408,LRECL=3404,BUFNO=1)
          //FT05F001 DD  DDNAME=CARDS
          //FT06F001 DD  SYSOUT=A
          //FT07F001 DD  SYSOUT=B
          //FT08F001 DD DSN=&&PAGES,UNIT=SYSDA,SPACE=(TRK,(27,1)),
          //   DISP=(NEW,DELETE),DCB=(BUFNO=1)
          //FT09F001 DD DSN=&&BPAGES,UNIT=SYSDA,SPACE=(TRK,(36,1)),
          //   DISP=(NEW,DELETE),DCB=(BUFNO=1)
          //FT10F001   DD   SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT11F001   DD   SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT12F001   DD   SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT13F001   DD   SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT14F001   DD   SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //FT71F001 DD UNIT=(TAPE9,,DEFER),DISP=(NEW,KEEP),LABEL=(1,SL),
          //   DCB=(LRECL=484,BLKSIZE=488,RECFM=VS)
          //STACFILE DD DSNAME=D59.PLTSTAC,DISP=SHR
          //STAF DD DSNAME=&&STAF,UNIT=SYSDA,SPACE=(CYL,27,,CONTIG),
          //   DISP=(NEW,DELETE),DCB=(BLKSIZE=3400,RECFM=F,DSORG=IS,LRECL=3400,
NGI       //   KEYLEN=8,RKP=0,BUFNO=1)
disk     ┌//FT15F001 DD DSN=&&NGIFILE,UNIT=SYSDA,SPACE=(CYL,(18,1)),
file  ───└// DISP=(NEW,DELETE),DCB=(BUFNO=1)
         ┌//FT16F001 DD DSNAME=NGIFILE1,VOLUME=SER=RDS200,DISP=(OLD,KEEP),
NGI   ───┤// UNIT=(TAPE9,,DEFER),LABEL=(2,SL),
tape     └// DCB=(RECFM=VS,BLKSIZE=408,LRECL=404,BUFNO=1)
file      //FT17F001   DD   SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)
          //CARDS DD *

                 RDS SYSTEM CARD GOES HERE
                 REMAINDER OF RDS DATA CARDS GO HERE

          /*
```

Appendix D. Glossary

GLOSSARY

Algorithm - A mathematical process. The NGI algorithm is used to determine which points are to be connected on adjacent scan profiles.

Core - Internal computer storage.

Discontinuity - Significant break in the terrain surface.

Discontinuity Boundary - Line connecting two discontinuity points on adjacent scan profiles. It divides the terrain into discrete areas.

Discontinuity Point - A point on a scan profile which locates a discontinuity boundary.

Discrete Area - The area between two discontinuity boundaries.

Faceted Model - Terrain surface represented by a series of adjacent three and four sided figures which cover the entire surface.

NGI - Numerical Ground Image.

Numerical Ground Image - Approximation of the terrain surface with a digital terrain model.

Scan Profile - A series of X, Z coordinate points which describe the surface of the ground and which are perpendicular to an arbitrary baseline Y.