

Wapello County Courthouse
BOARD OF SUPERVISORS



101 West Fourth Street
Ottumwa, Iowa 52501
Phone 683-0015

TO: Firms and Government Entities receiving the Wapello County,
Iowa GPS Countywide Survey Report

On July 20, 1993, the Wapello County Board of Supervisors committed to a Countywide Geographic Information System (GIS) supported by Global Positioning System survey (GPS) set throughout the County.

We are pleased to provide you a finished GPS survey report. The total network was comprised of eight NGS horizontal control stations, thirteen benchmarks, and sixty-seven new Wapello County GPS monuments, or eighty-eight points in all.

The purpose of furnishing you a copy of the report is to encourage the use of this control information in all future surveying done within the County. Our goal is to tie found section corners and surveys into this control network.

JE & Associates, Inc. of West Chicago, Illinois will be involved in providing the GIS mapping services. Aerial Services, Inc. of Cedar Falls, Iowa provided and set the GPS points as contained within this book. Should you have any questions concerning this project, we encourage you to contact any of the people listed below:

Merrold S. Johnson
JE & Associates, Inc.
Phone: 708-231-6421

Gary Brown
Aerial Services, Inc.
Phone: 319-277-0436


Mary A. Gaskill
Wapello County Auditor
Phone: 515-683-0024


Wendell Folkerts
Wapello County Engineer
Phone: 515-684-5425


We appreciate your interest, and encourage this information be used in conjunction with future surveying within Wapello County, Iowa.

Sincerely,

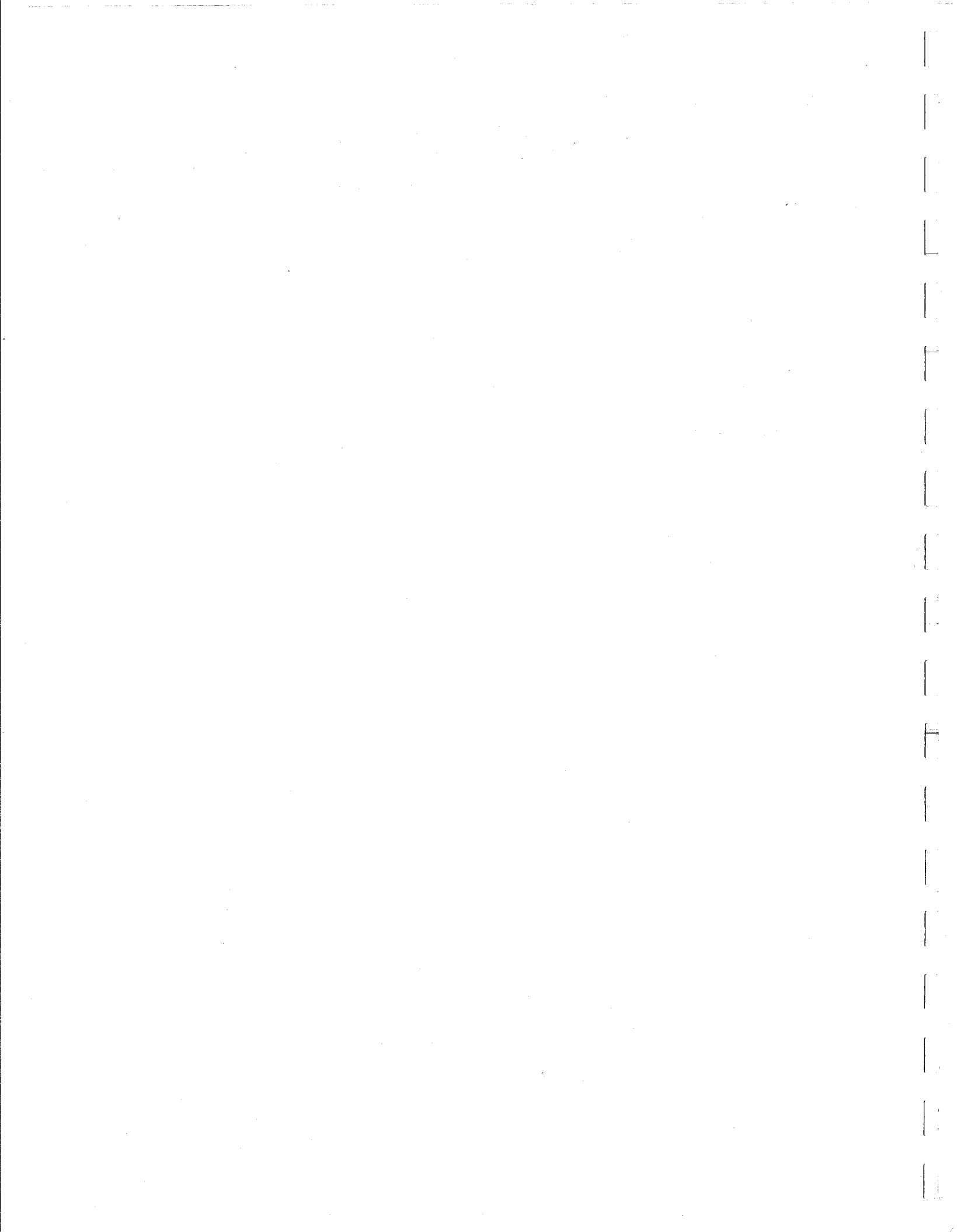
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Wapello County
Iowa

G.P.S.
Countywide Survey

Control Network
for
Support of
Cadastral Mapping
Project

1993

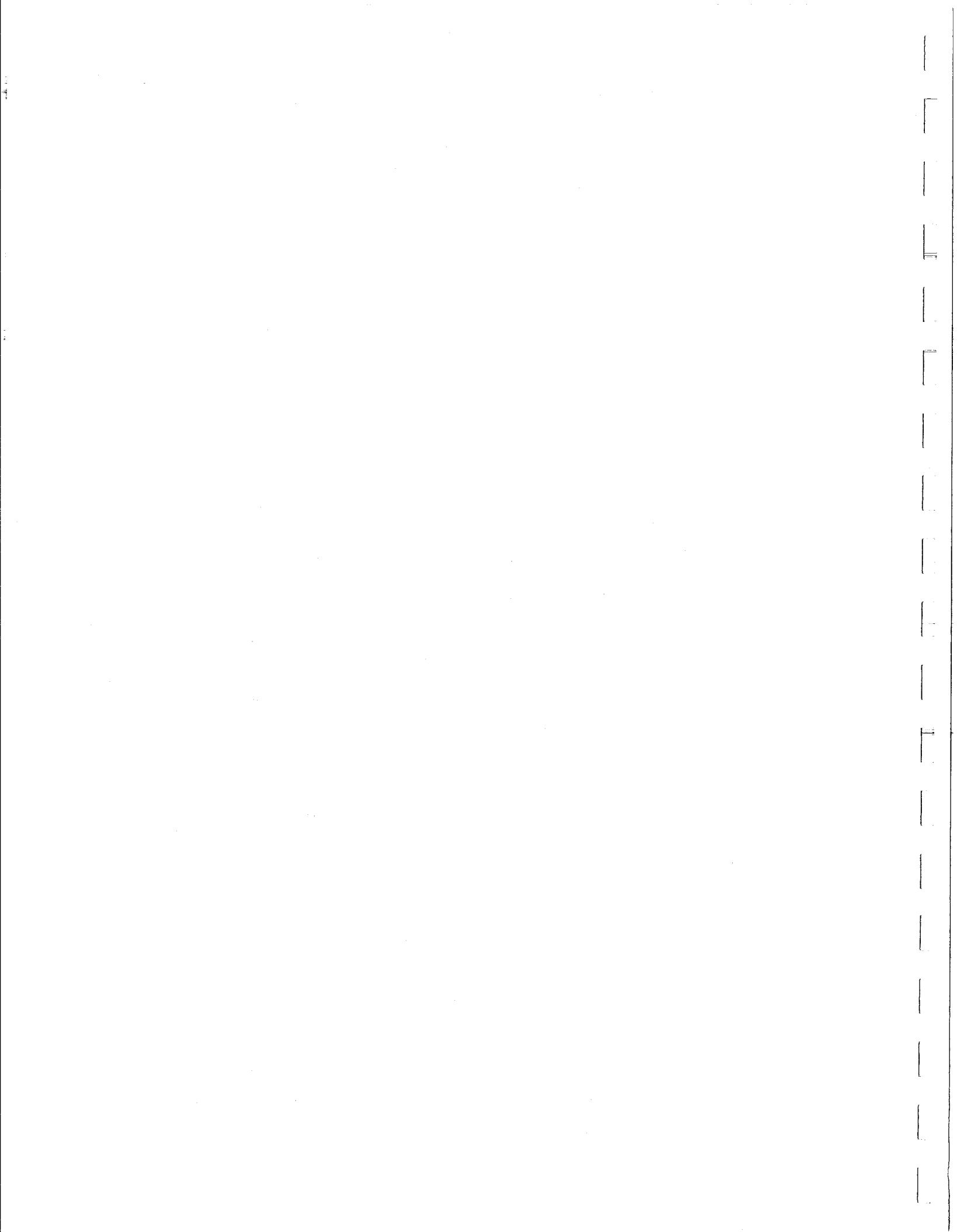


TABLE OF CONTENTS

SECTION 1
Project Report pages 1-1... 1-6

SECTION 2
Monument Records NAD83 pages 2-1... 2-88

SECTION 3
Measurement Period Summary pages 3-1... 3-3

SECTION 4
Adjustment Statistics Summary NAD83 pages 4-1... 4-4

SECTION 5
Observation Adjustment Summary NAD83 pages 5-1... 5-44

SECTION 6
Summary of Covariances NAD83 pages 6-1... 6-10

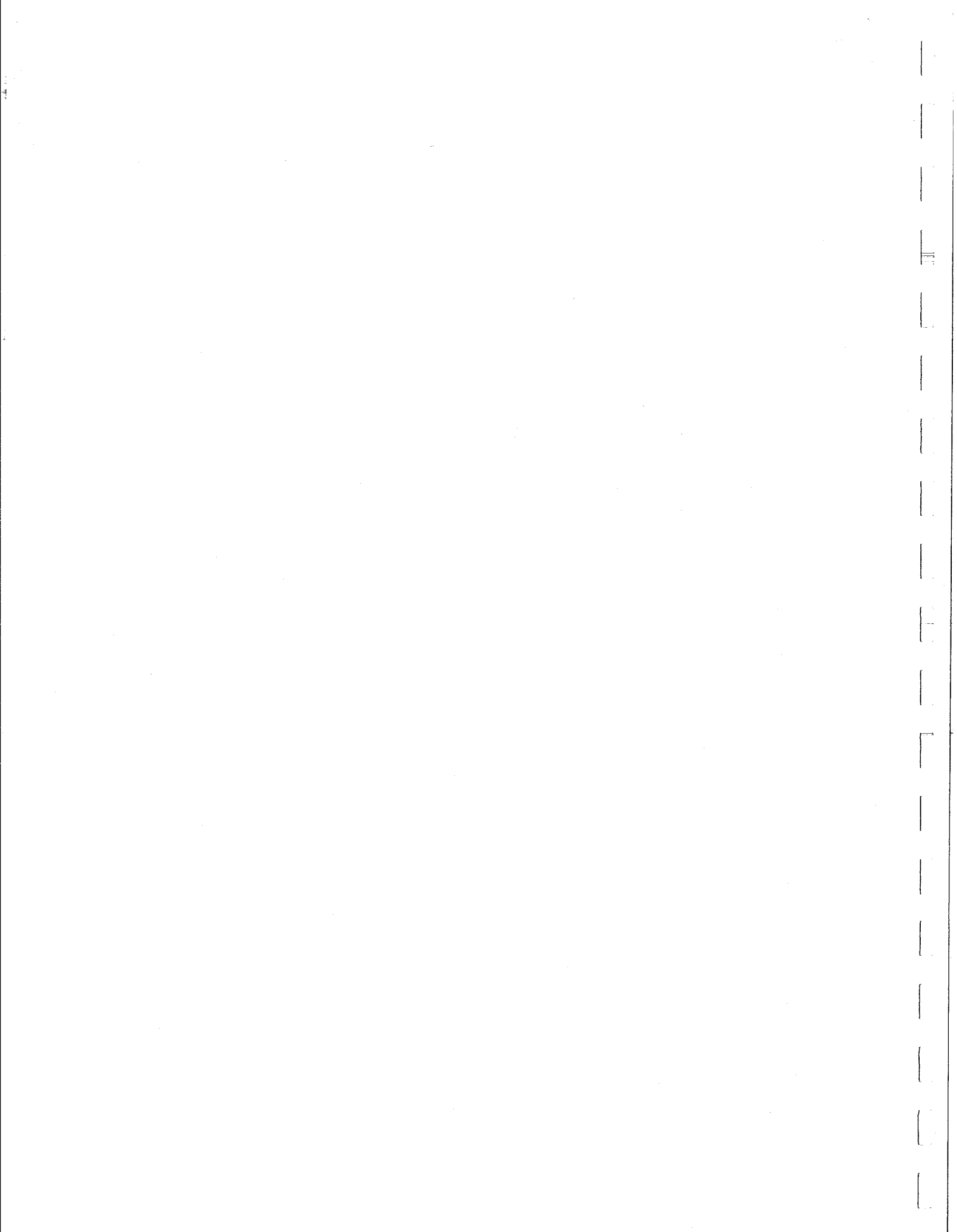
SECTION 7
Adjusted Geographic Coordinates NAD83 pages 7-1... 7-5

SECTION 8
Final Coordinate Listing NAD83 page 8-1... 8-2

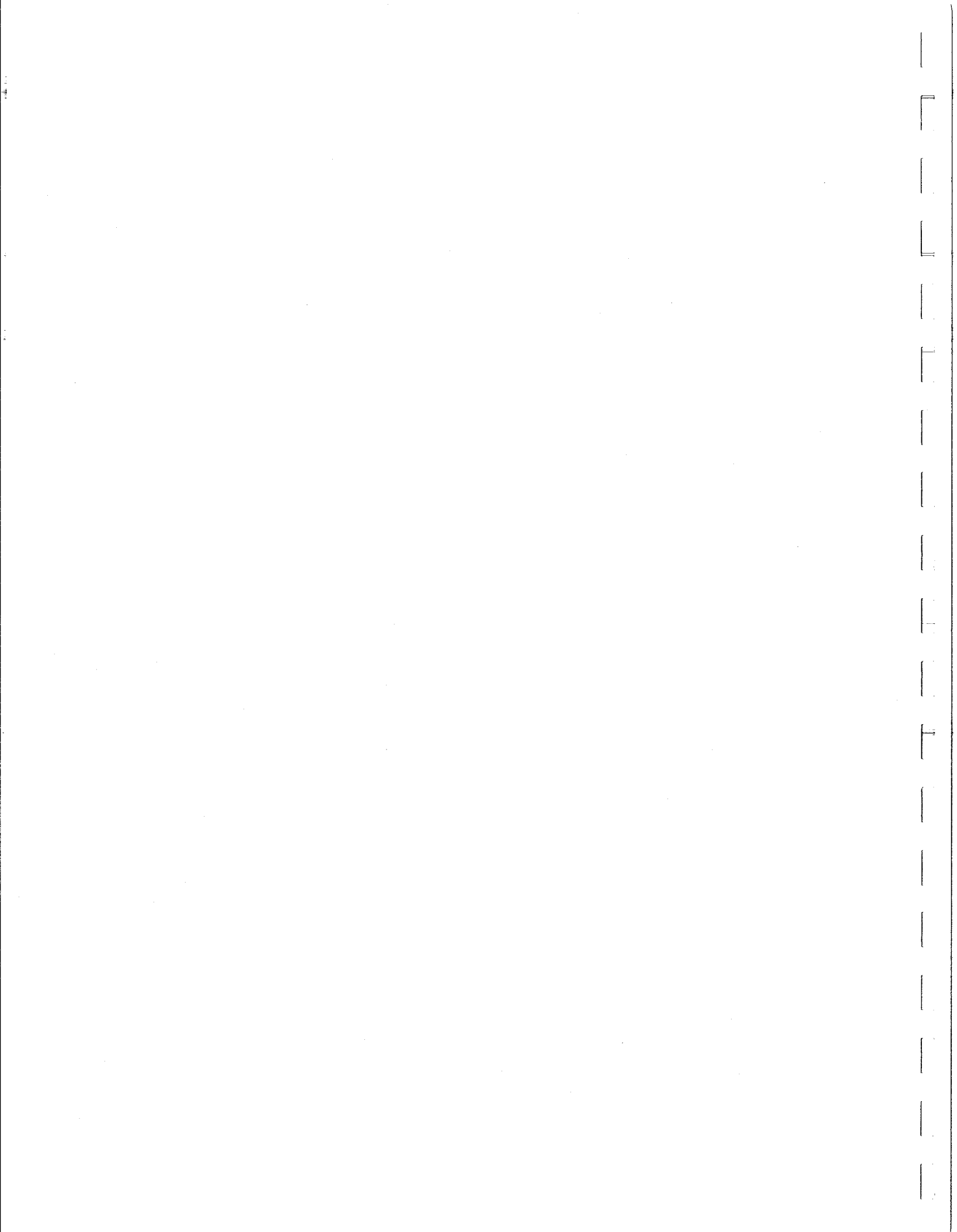
SECTION 9
Point Map page 9-1
Histogram page 9-2
Error Ellipse of each Station pages 9-3... 9-24

SECTION 10
Final Coordinate Listing NAD27 page 10-1... 10-2

PROJECT MAP



Section 1
Project Report



INTRODUCTION

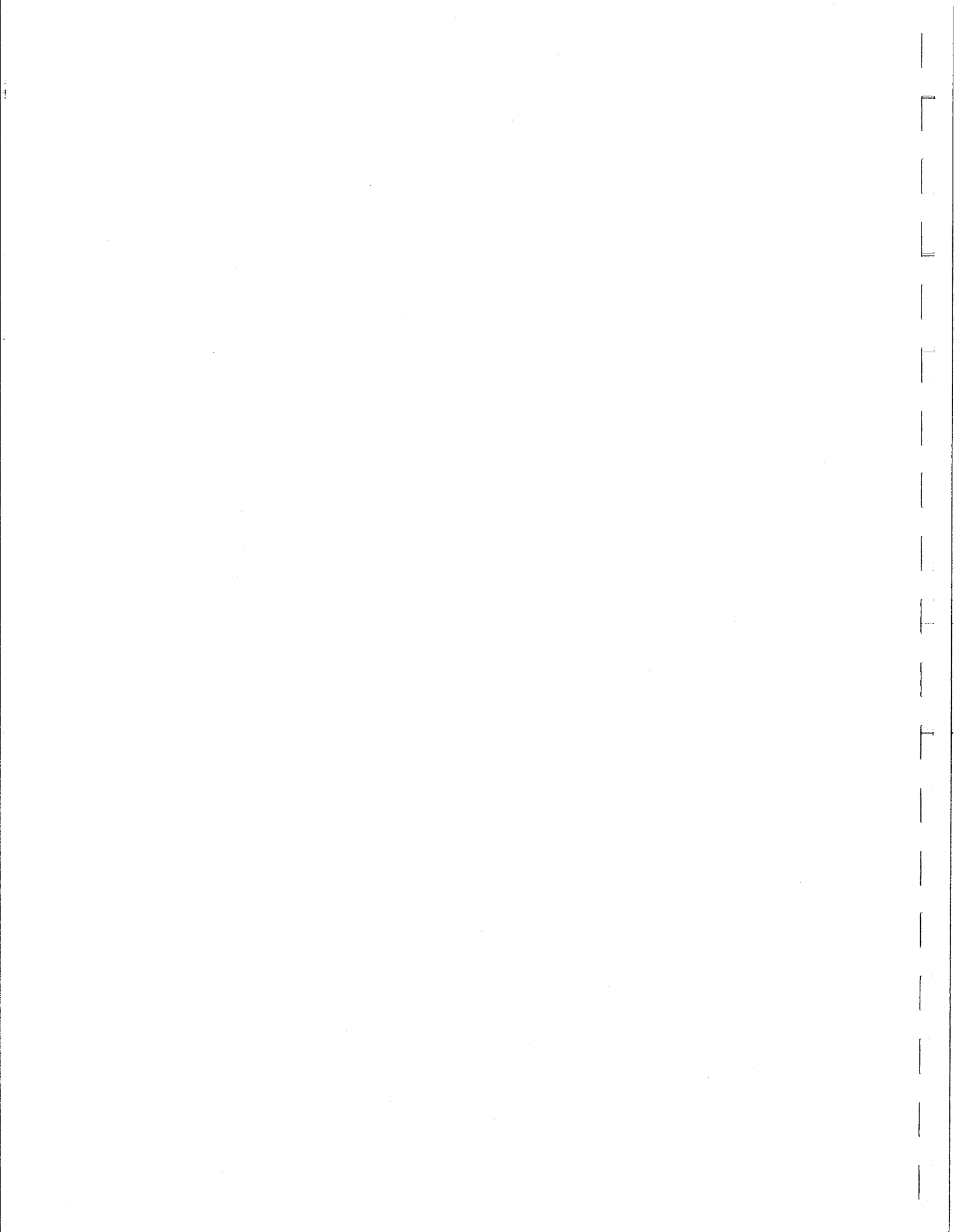
Wapello County, Iowa chose to embark on a county wide high accuracy cadastral survey. To complete the new survey, specific products and map accuracies were selected to support the project. The final line cadastral overlays were to be based on accurate orthophoto based maps. To accomplish this task as accurately as possible, photo flights were designed for coverage of rural and urban areas to produce 1"=400' scale and 1"=100' scale orthophoto maps respectively. For the best control, a Global Positioning System Survey was selected to densify very sparse existing first order control. Sixty-seven targeted control stations were selected to control the orthophotography.

PROJECT REQUIREMENTS

The purpose of this survey was to establish throughout Wapello County, Iowa a new horizontal control network using GPS survey equipment and techniques. This network was to be tied to existing NGS NAD83 first-order horizontal control. It was also the intent of the County to obtain elevations on each new monument which would be tied to NGVD 1929. Because this control would be utilized to control the analytical triangulation of the aerial photography, the network geometry was ideal for a strong GPS survey. All point locations for control were selected with the needs of both the analytical triangulation and GPS survey needs in mind. In some instances all of the criterion could not be met due to physical obstructions or existing land features. In these instances the needs of the analytical triangulation were held primary and the GPS survey needs were satisfied second.

MONUMENTATION

To perpetuate the new control measurements, the sixty-seven new control stations were monumented to provide permanence and future survey accessibility for conventional survey ties. Bernsten driven rod monuments were selected for each station. Each station



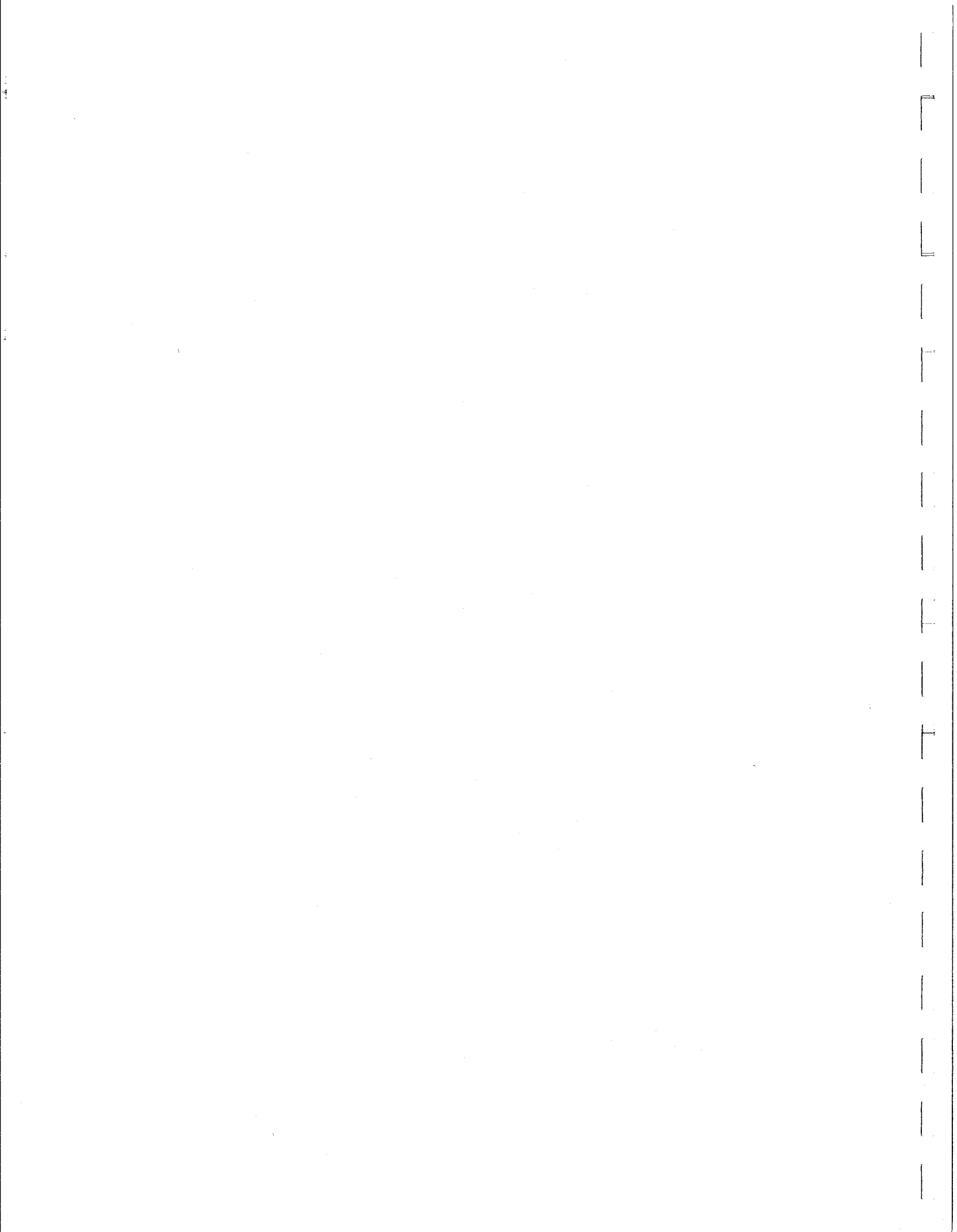
monument consisted of one three foot smooth rod section and one three foot top security fluted rod section with a stamped cap driven approximately 6" below the existing ground surface. For easy access and protection, a two foot long 5" PVC pipe was placed over each rod monument along with a precast aluminum hinged access cover and backfilled with sand to facilitate drainage and to minimize frost movement. All monuments were set and will be targeted prior to the aerial photography. Approximately 30 days elapsed between the setting of the monuments in late October and the GPS measurements made in the last week of November and the first week of December 1993. This time period contributed to excellent monument stability by the time the GPS survey was started.

RECONNAISSANCE

The most important criterion for GPS observations at any given location is a clear view to the sky. With this in mind, a number of existing NGS NAD83 first-order horizontal control stations were recovered in or near Wapello County. In terms of network design, it is desirable that the control be located as near the perimeter of the area as possible. For these reasons, NGS stations Parker (300), Monroe (301), Ottumwa (302), Wapello (303), Davis (304), Agency (305), Hedrick (306) and Copeland (307) were selected as primary horizontal control stations for this survey.

Vertical control was selected to provide as much coverage as possible, both at the periphery and in the interior of the job area. Thirteen existing NGS and USGS benchmarks were recovered and included in this survey. Two of the horizontal control points Parker and Wapello were also utilized as additional vertical control. Two of the 3rd order USGS benchmarks were found to be questionable and were not utilized in the final adjustment. A third USGS benchmark was found to not have a published elevation and was also not utilized in the final adjustment.

Sixty-seven new County monuments were set. The total network, then, was comprised of eight (8) NGS horizontal control stations, thirteen (13) benchmarks, and sixty-seven (67)



new County monuments , or eighty-eight (88) points in all.

FIELD SURVEY

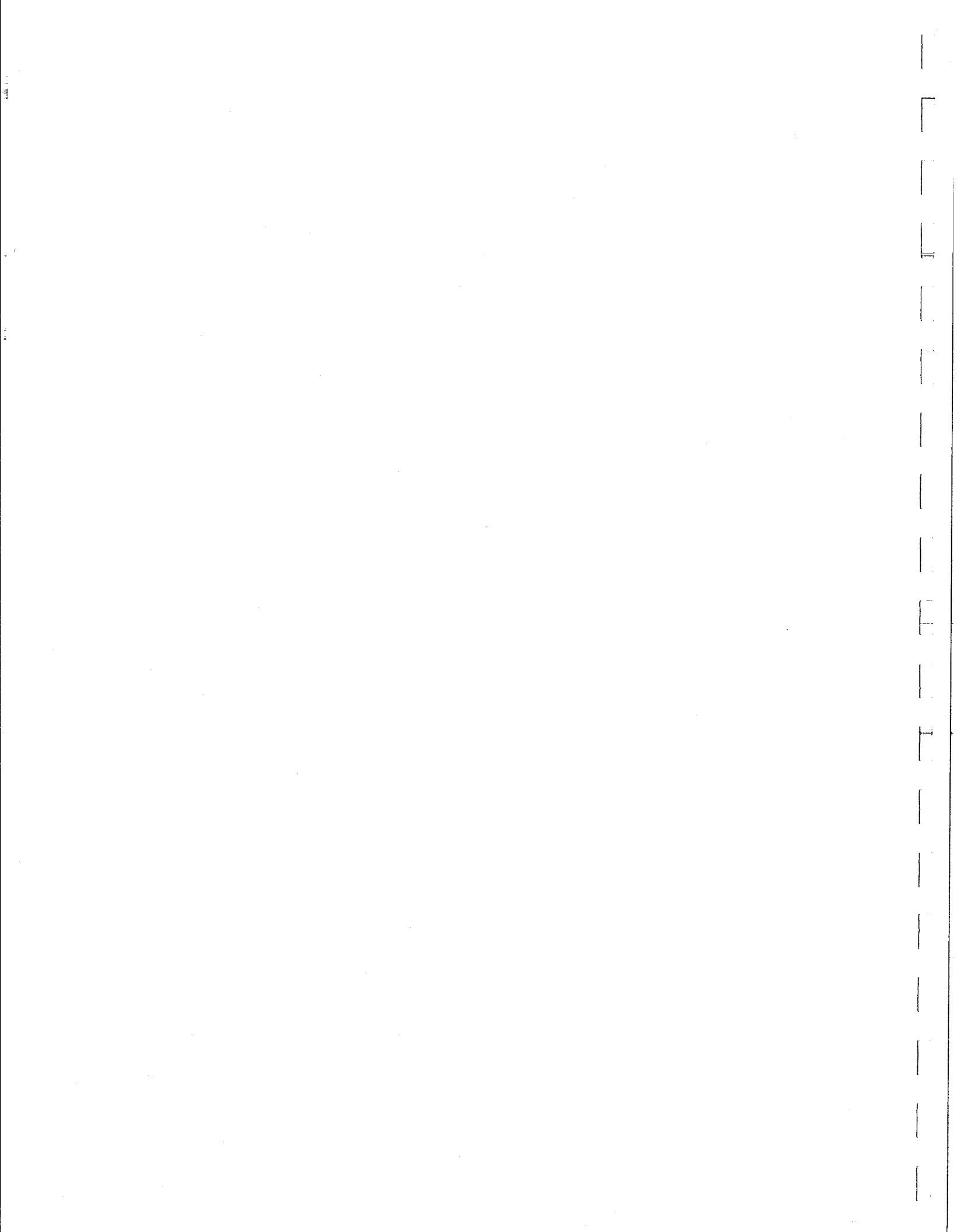
Three Trimble 4000SSE dual frequency receivers were used in this survey. GPS observations began on Monday morning, November 27, 1993 and continued through Friday afternoon, December 3, 1993. Fast static GPS techniques were utilized to minimize the time and cost of the project. The satellite "window", where at least five satellites were observable, was open for much of the day and night with small breaks in the coverage. Observations could be made from 1 a.m. to 12:40 p.m. A second acceptable window existed from 1:30 p.m. to 4:50 p.m. A third acceptable window existed from 6:30 p.m. until 12:00 a.m. Each measurement period, during which all receivers observe satellites simultaneously, lasted from 8 minutes to 20 minutes depending upon the distance being measured.

A total of 63 measurement periods were observed using three receivers and one measurement period with two receivers. Of the total 88 points in the network, 25 were occupied once, 37 were occupied twice, 19 were occupied three times, 6 were occupied four times and 1 was occupied five times. It should be noted here that nine of the benchmarks were occupied directly and four, which were not suitable for direct occupation, were tied to temporary points by direct third-order closed level loops.

See Section 3 for a complete listing of measurement periods and observation times.

DATA ADJUSTMENT

The total number of lines observed and processed was 188. Based on statistical indicators from the Trimble processing utility and analysis of loop closures, 18 lines were rejected and deleted prior to data adjustment. Most of these rejections occurred on duplicate baseline measurements.



All data adjustment was performed using the Trimnet software. An initial free adjustment was performed in NAD83 to check the overall quality of the GPS data and the nature of the control. The initial unconstrained (free) adjustment yielded baseline precisions which ranged from 1: 1,000,000 to 1: 4,000,000. Once the horizontal and vertical control was verified, subsequent adjustments were performed to arrive at the optimal solutions for each datum.

NAD83

The initial free adjustment was performed holding point 302 (Ottumwa) fixed horizontally with the vertical adjustment disabled. Coordinate values on the other horizontal control stations were then checked against the published values to verify the first-order status. A second adjustment was then performed by holding all eight of the 1st order horizontal control points. By holding all eight of the existing horizontal control the extraordinary baseline precisions of the "free" adjustment degraded severely, although the network still yielded results well in excess of 1st order control. Several additional adjustments were performed releasing and then holding onto point 304 (Davis). A decision was made to include point 304 (Davis) even though the GPS network missed the published northing of point 304 (Davis) by approximately 1 foot. This would allow the best fit to all existing network control.

Once we were satisfied with the horizontal adjustment, we locked the horizontal positions and concentrated on the vertical adjustment. The Geoid 90 Central zone was utilized to provide a model of the height of the geoid. An adjustment was then performed with the vertical control held only to point 206 (B7 NGS 1st order). Elevations on the remaining twelve benchmarks were then checked against the published values. Two of the 3rd order benchmarks (200 & 201) were off 0.8 foot and did not fit with the other existing vertical control. The remaining vertical control points fit very well.

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A final adjustment of both horizontal and vertical was then performed. Because the control was so reliable, the final adjustment in NAD83 was very straight forward. All horizontal control was held fixed in two dimensions, and all vertical control except points 200 and 201 were held fixed in one dimension. This fully constrained adjustment solved for scale and rotation.

The results are well in excess of first order precision. 95% of the baselines have an estimated error of 1: 100,000 or less. 36% of the baselines have an estimated error of 1: 200,000 or less and 18% have an estimated error of 1: 300,000 or less.

The error ellipses for each point are listed in Section 9.

NAD27

The same free adjustment was run on NAD27, holding 302 in two dimensions and 206 vertically. Again, a comparison of coordinates was made to published values on the other stations. The GPS work done here suggests that the NAD27 datum adjustment was not nearly as accurate as the NAD83 adjustment. The NAD27 adjustment still falls within first order accuracies.

Because the NAD83 data was so clearly superior to the NAD27, it was decided not to force the elevations in the NAD27 adjustment any more than necessary. Furthermore, elevations do not appear in the NAD27 coordinate listing, to avoid confusion.

The final adjustment in NAD27 was performed holding all eight of the existing 1st order horizontal control fixed in two dimensions and fixing only 202, 203, 204, 205, 206, 207, 208, 209, 210, 212, 300 and 303 vertically.

See Section 10 for a complete listing of the coordinate information for each point in NAD27.



GENERAL FORMAT INFORMATION

In Sections 5, 6 and 7, are the results of the adjustment showing the residuals, and they can be loosely interpreted as the error in each line.

CONCLUSION

The initial control accuracy specification for the project was established as $0.3' \pm$ in x, y and z. Because of existing control point strength, geometric network layout and vertical datum stability, it was possible to well exceed this specification. All measured points will be usable for better than First order control in horizontal position and within $\pm .10'$ vertically for bench mark use.

