DEPARTMENT OF NATIONAL DEVELOPMENT
Secretary: A. J. Woods

DIVISION OF NATIONAL MAPPING
Director: A. G. Bomford

TECHNICAL REPORT 21

THE AUSTRALIAN DOPPLER SATELLITE SURVEY 1975-1977

by
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CANBERRA AUSTRALIA
1978

THE AUSTRALIAN DOPPLER SATELLITE SURVEY 1975-77

ABSTRACT

Beginning in early 1975 Commonwealth and State Survey Authorities carried out a Doppler satellite survey of junction points of the Australian Geodetic Survey and of other stations on Australian territory. This report describes the purpose of this survey, specified survey methods, field operations and the reduction of Doppler data. The relationship between the Australian Geodetic Datum (AGD) and the geocentric, WGS72 datum, is given in form of contours of differences in latitude and longitude. The relationship between the AGD and the geocentric NWL9D datum is given in form of contours of differences in X, Y and Z. Contours of geoid heights are provided for both of these geocentric datums to facilitate the conversion of satellite derived spheroidal heights to Australian Height Datum (AHD) heights. Differences in chord distances between AGD values and WGS72 and NWL9D values are listed for a number of selected lines including the two baselines measured for the Pageos world triangulation in 1965-70.

THE AUSTRALIAN DOPPLER SATELLITE SURVEY 1975-77

CONTENTS

THE AUSTRALIAN DOPPLER SATELLITE SURVEY 1975-77

1. INTRODUCTION

The observations of Doppler satellites at junction points and other stations of the geodetic network in Australia and on some islands was begun in January 1975 under the guidance of the Division of National Mapping utilising the US Navy Navigational Satellite System (NNSS).

This survey, completed in mid-1977, was carried out with the assistance of the State Lands Departments of Western Australia, South Australia and Tasmania, the Queensland Department of Mapping and Surveying and the Royal Australian Survey Corps. Figure 1 shows the location of stations included in the survey. In addition stations on Lord Howe, Norfolk and Macquarie islands were occupied.

Most of the observations were obtained with JMR-1 satellite survey sets of which up to four were in use at the same time. Seven stations were observed with Geoceivers and five with a Marconi CMA 722B.

The purpose of this survey was:

1) To test the accuracy of the 1966 Australian Geodetic Datum (AGD).

2) To provide parameters to users of the NNSS system in Australia to transform satellite derived coordinates to the AGD and and AHD; and vice versa, to transform coordinates on the AGD and AHD to the geocentric world datum of the NNSS system, WGS72, and that of the US Defense Mapping Agency, NWL9D.

3) To provide a number of well spaced Doppler derived positions to be combined in a future adjustment with terrestrial observations of the Australian Geodetic Survey.

2. DESCRIPTION OF THE NAVY NAVIGATION SATELLITE SYSTEM

The US Navy Navigation Satellite System was developed between 1958 and 1963 for the US Navy by the Applied Physics Laboratory of the Johns Hopkins University and became generally available to non-military users in 1967.

The position of a Doppler satellite receiver is determined from a series of observations of the Doppler shift of signals received from a satellite during the period it passes through the observer's field of view. The satellite also transmits predicted orbital parameters giving its position every two minutes. This predicted ephemeris, also referred to as on-board or broadcast ephemeris, together with the Doppler shift observation is then used to determine the position of the electrical centre of the receiving antenna in terms of the geocentric coordinate system of the satellite ephemeris.

There are at present (March 1978) five operational satellites in orbit at altitudes of about 1100 kilometres. They are equipped with stable oscillators which generate two frequencies; one about 400 Mz and the other exactly three-eights of the first one. These frequencies are also used as carriers in the transmission of time marks and the satellite ephemeris.

Navy navigation satellites are tracked by the worldwide system of TRANET stations. This system consists of thirteen permanent tracking stations, from which a precise ephemeris for each of the satellites can be calculated. At present the precise ephemeris of only two of the five satellites is being determined due to the high cost of computation. Normally this ephemeris is available to the user two to four weeks after the satellite data has been collected. It is available through defence channels but is only provided for that part of the orbit which is visible from the station for which it is desired.

The on-board ephemeris for each of the five satellites is determined from observations taken at four tracking stations in the USA. Its predicted values and timing information are transmitted to the satellites from one of the stations. Satellites receive this updated information every twelve hours.

3. SPECIFICATIONS FOR THE AUSTRALIAN DOPPLER SURVEY

Specifications for the civilian organisations taking part in this survey were:

1) All stations to be observed as single points.

2) On arrival at the selected survey station check that the views from the centre of the antenna's ground plane is unobstructed above 10° elevation and clear vegetation if necessary.

3) Avoid stations in the vicinity of large metal objects such as active communication and power transmission towers, wire fences etc. even if these objects are below 10° elevation.

4) Erect the antenna of the Doppler receiver accurately over the ground mark of the selected survey station preferebly on its own tripod. If the antenna has to be elevated above the ground mark keep the amount of elevation to a minimum.

5) The survey truck not to be parked within sight of the antenna when signals from a Doppler satellite are being received.

6) Observe all passes of precise ephemeris satellites above 10° elevation at time of closest approach. Forty-five of these passes to be above 15° elevation.

7) Dry and wet temperatures and atmospheric pressure to be taken at the instrument site at least once per day but more often if possible and to be recorded with the time of observation.

4. FIELD OPERATIONS

Access to most stations was by truck. Four stations were reached by helicopter and one by boat.

The civilian survey parties mostly consisted of two officers. In remote areas there were up to four officers equipped with two four-wheel drive vehicles.

The Doppler survey sets were usually set up inside a small tent when not otherwise sheltered. It was the practice of National Mapping parties to operate the sets connected to two 12 volt batteries in parallel with two batteries being charged in the meantime. Batteries were usually changed every 24 hours.

Delays due to malfunctioning of JMR satellite survey sets were few. Replacement sets were quickly provided when necessary by the Australian JMR agent under the maintenance or hire agreement.

The short antenna cables supplied with JMR sets were used exclusively. Faulty antenna connections accounted for most of the malfunctionings of JMR sets and a more robust antenna and more durable connector at the antenna would improve this weak component of the otherwise robust JMR survey system.

The antenna should always be used with its tripod legs extended, as in this form they are part of the antenna design which determine the location of the electrical centre of the antenna.

The one Marconi 722B receiver which was on hire for a period of six months during 1975 developed a number of faults causing long delays. It is the opinion of the surveyors who operated this equipment that it was not suitable to the hot and dusty conditions of the Australian inland.

Part of the duties of Doppler parties was to carry out a third order two-way levelling connection from the nearest two permanent bench marks to the Doppler station if no such connection existed. Due to a number of factors, including excessive distance of permanent bench marks from Doppler stations, this was not done at the time of the Doppler survey at twenty-seven stations.

5. REDUCTION OF DOPPLER DATA

All observations were reduced in terms of the precise ephemerides provided by the US Defense Mapping Agency Topographic Command (DMATC) through the Director of Survey of the Australian Department of Defence. These ephemerides were in terms of the NWL9D Datum. All Doppler fixes have subsequently been transformed to the WGS72 Datum as described in the next chapter.

Data at the six stations observed with the Marconi CMA 722B set were reduced by the Surveys and Mapping Branch of the Department of Energy, Mines and Resources in Ottawa, Canada, through their program GEODOP.

Data observed at the seven stations by the Royal Australian Survey Corps with their Geoceivers was reduced by them through program DOPPLR, provided by DMATC, on a Univac 1110 computer.

All data observed with JMR-1 receivers was reduced by National Mapping as follows:

1) A computing file was opened for each Doppler station with Satellite alerts, field notes and station summary attached.

2) The precise ephemeris of Doppler satellites observed at the station for the period of observation was requested from DMATC. A period of at least four weeks lapsed before this data was received through the Directorate of Survey. It was provided on 7-track tape.

3) The data recorded on cassette tape was majority-voted through the JMR cassette reader on a HP 21MX minicomputer. This took two hours per tape for as many as seven tapes per station where all satellites were recorded or two tapes per station where satellites were recorded in the pass-selected-mode.

4) The majority-voted, edited JMR data, and the precise ephemeris data was then put on 9-track tape in UPDATE form on two different files and processed through program DOPPLR on the CSIRO CYBER 76 computer in Canberra. It usually took 4-6 iterations to produce the final coordinates of the Doppler station in terms of the NWL 9D datum.

After all reductions of a Doppler fix are complete a Doppler Station Analysis sheet is prepared for the station concerned. This together with the Horizontal Control Station Summary provides a full record of surveys taken at the station. Figures 12 and 13 refer.

6. RELATIONSHIP BETWEEN WGS72 AND AGD

For the benefit of those who take Doppler fixes in Australia in terms of the WGS72 on-board ephemeris, parameters have been obtained to transform these Doppler Satellite derived coordinates to the Australian Geodetic Datum based on the geoid being 6 metres below the spheroid (N = -6 m) at the Johnston Origin.

The parameters of the various datums are as follows:

AGD : a = 6378160 m; 1/f = 298.25
NWL9D: a = 6378145 m; 1/f = 298.25
WGS72: a = 6378135 m; 1/f = 298.26

To convert from the precise ephemeris NWL9D datum to the on-board ephemeris WGS22 datum the following applies (Seppelin, 1974):

$$\Delta\phi = \Delta f \sin 2\phi / \sin 1''$$
$$\Delta\lambda = 0''.26$$
$$\Delta H = a\Delta f \sin^2\phi - \Delta a + \Delta r$$

with $\Delta r = -5.27$ m
$\Delta a = -10.0$ m
$\Delta f = -0.112415 \times 10^{-6}$
$a = 6378135$ m

To obtain WGS72 coordinates, add $\Delta\phi$, $\Delta\lambda$ and ΔH algebraically to the NWL9D coordinates. Latitude is positive north and longitude is positive east.

Table 1 lists stations observed in the survey giving established AGD values, AHD and spheroidal heights, observed NWL9D values and derived WGS72 values and their spheroidal heights. Observations taken on four islands for which AGD values do not exist show height values only.

Figure 2 shows contours of differences in latitude to be added algebraically to the negative south latitudes of WGS72 to obtain AGD latitudes (absolute values of WGS72 decrease when adding these differences).

Figure 3 shows contours of differences in longitude to be added algebraically to the positive east longitudes of WGS72 to obtain AGD longitudes (absolute values of WGS72 increase when adding these differences).

Figure 4 shows the contours of N, the separation of the geoid above the spheroid in terms of the WGS72 datum over Australia determined from the differences between the (H + N) of the WGS72 values and AHD height. This enables anyone who has obtained a (H + N) height from the on-board ephemeris to convert it to an AHD height anywhere in Australia.

These values in contour form provide a much better transformation between the two datums then one set of unique transformation parameters. This becomes apparent when looking at figure 5 which has been derived as follows:

The difference in cartesian coordinates at the Johnston Origin between the AGD values and the WGS72 values were applied to the WGS72 cartesian coordinates of all Doppler stations, subsequently transformed to ϕ, λ and (N + H) with AGD parameters and compared with AGD values. The difference between these two sets of geographical coordinates are shown in vector form together with differences in height.

The size and direction of vectors differ between large regions of the Australian continent.

These differences arise from the combined effect of various factors such as systematic errors in the satellite ephemerides; poor coverage of the southern hemisphere with TRANET stations which are used to determine the precise ephemerides of satellites; atmospheric conditions at the time of Doppler observation; the performance of Doppler satellite receivers; systematic errors in the ground survey; and the adjustment procedures used to form the Australian Geodetic Datum in 1966.

7. RELATIONSHIP BETWEEN NWL9D and AGD

Doppler fixes for geodetic control purposes are best made by observing satellites for which the precise ephemerides are available. The results of such observations are then computed in terms of the NWL9D datum.

A set of figures has been prepared showing translations in X, Y and Z between the two datums in contour form over Australia (figures 6, 7 and 8).

Figure 9 shows contours of the Geoid-Spheroid separations in reference to the NWL9D datum. This enables one to convert a satellite determined H + N height to the respective AHD height.

The differences in X, Y and Z between NWL9D and AGD coordinates at Johnston were applied to all NWL9D coordinates, then transformed to ϕ, λ and H + N with AGD parameters and compared with AGD values.

Figure 10 shows the difference between the two sets of geographical coordinates in vector form and differences in height.

It is evident from figures 5 and 10 that WGS72 provides a better fit to the AGD than NWL9D as vector differences with the former are smaller.

8. COMPARISON OF CHORD DISTANCES

Table 2 lists chord distances between selected Doppler stations in terms of AGD, NWL9D and WGS72. Differences between the AGD values and the respective NWL9D and WGS72 values are listed in metres and in parts per million. The results are also shows in figure 11. Again the comparison with WGS72 is better than with NWL9D, the largest difference being -9.2 ppm between two stations in northern Australia.

During 1965-70 the Division of National Mapping measured two baselines for the Pageos world triangulation. The results are recorded in Technical Report 11 (Leppert, 1972).

The comparison given below is in terms of chord distances obtained from sets of cartesian coordinates on the Baseline Datum (BLD), AGD1966, NWL9D and WGS72 the latter two obtained from Doppler satellite observations.

Again the WGS72 value from Doppler observations fit the better.

COMPARISON OF CHORD DISTANCES BETWEEN TERMINALS OF THE TWO AUSTRALIAN BASELINES MEASURED FOR THE PAGEOS WORLD TRIANGULATION, 1965-70

	BLD m	AGD m	NWL9D m	WGS72 m
Caversham R371 - Culgoora NMC60	3 163 618.22	616.37	621.90	619.29
Culgoora NMC60 - Green C-251	2 300 211.83	207.52	214.18	212.29
Green C-251 - Caversham R371	3 533 151.60	145.96	157.70	154.79

DIFFERENCES BETWEEN BASELINE AND OTHER DATUMS

	BLD-AGD	BLD-NWL9D	BLD-WGS72
Caversham R371 - Culgoora NMC60	1.85 m; 0.6 ppm	-3.68 m; 1.2 ppm	-1.07 m; 0.3 ppm
Culgoora NMC60 - Green C-251	4.31 "; 1.9 "	-2.35 "; 1.0 "	-0.46 "; 0.2 "
Green C-251 - Caversham R371	5.64 "; 1.6 "	-6.10 "; 1.7 "	-3.19 "; 0.9 "

9. FUTURE ADJUSTMENTS

The Division of National Mapping carries out adjustments of the geodetic survey of Australia from time to time, incorporating all the latest geodetic information available, including Doppler satellite fixes. These adjustments are not adopted for mapping control or for survey coordination, and as a rule only the coordinates of junction points of the geodetic network are determined. They are distinguished from the geodetic adjustment of 1966 (AGD 66) on which all mapping in Australia is currently based, by being called Geodetic Models of Australia (GMA 73, GMA 75 etc). The object is to provide the best available estimate of the accuracy of the 1966 adjustment and to confirm that the new data fits the previous data without strain.

It is not the present intention of the National Mapping Council of Australia to replace coordinates on AGD 66 as a basis for mapping.

10. ACKNOWLEDGEMENTS

The Division of National Mapping is grateful to the State Lands Departments of Western Australia, South Australia and Tasmania, to the Queensland Department of Mapping and Surveying and the Royal Australian Survey Corps for their assistance in the survey.

The author acknowledges the careful work done by field staff, often in remote parts of Australia, and the reduction and editing of data by office staff to obtain the best possible coordinates from Doppler observations for stations in Australia on which this report is based.

11. REFERENCES

Leppert, K "Two Australian Baselines for the Pageos World Triangulation", Technical Report 11, Division of National Mapping, Canberra March 1972.

Seppelin, T.O. "The Department of Defense World Geodetic System 1972". Defense Mapping Agency, Washington, D.C., May 1974.

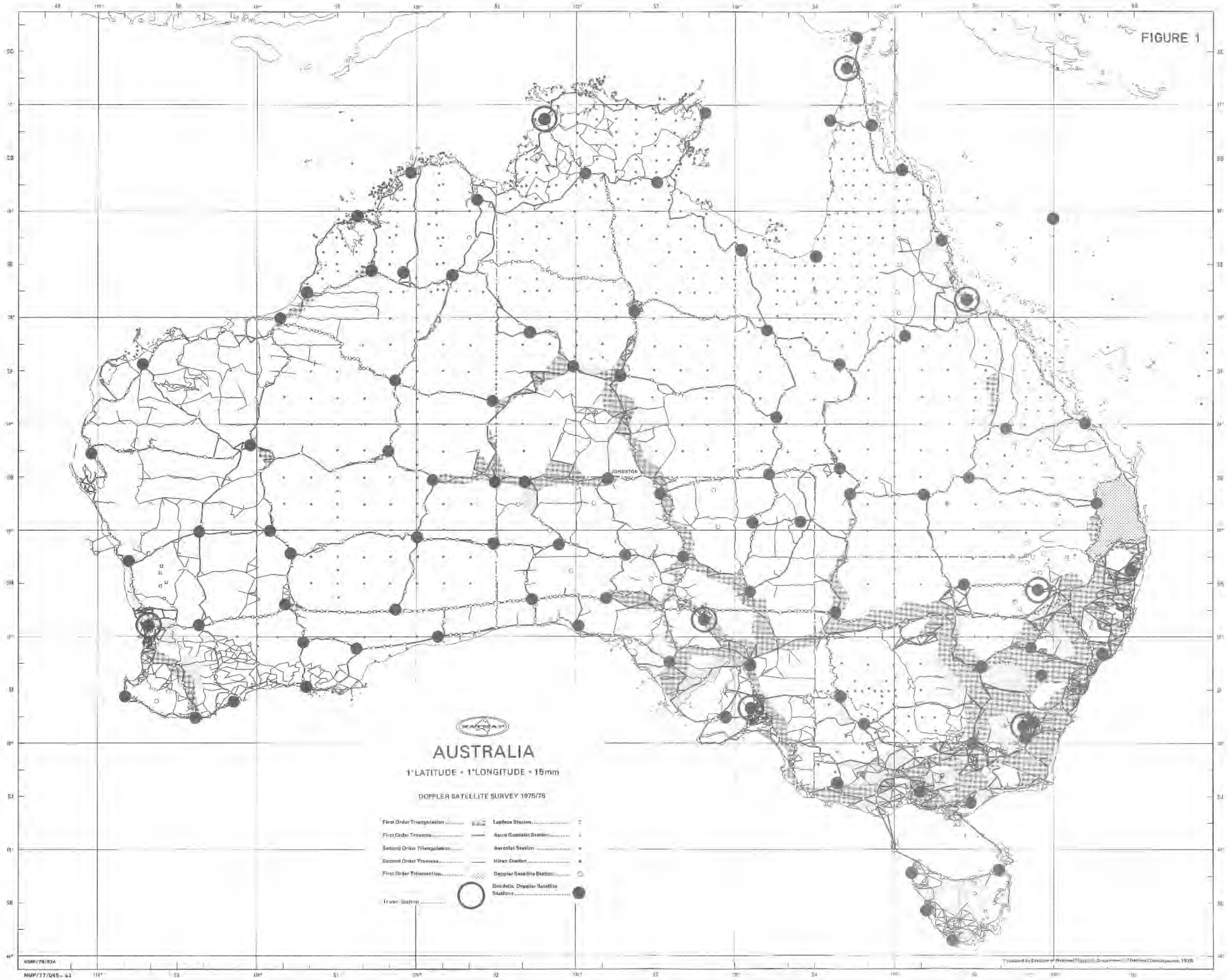


FIGURE 1
JOHNSTON
AUSTRALIA
1°LATITUDE = 1°LONGITUDE = 15mm
DOPPLER SATELLITE SURVEY 1975/76
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Trans Station
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
Geodetic Doppler Satellite Stations
NMP/78/074
NMP/77/095-43

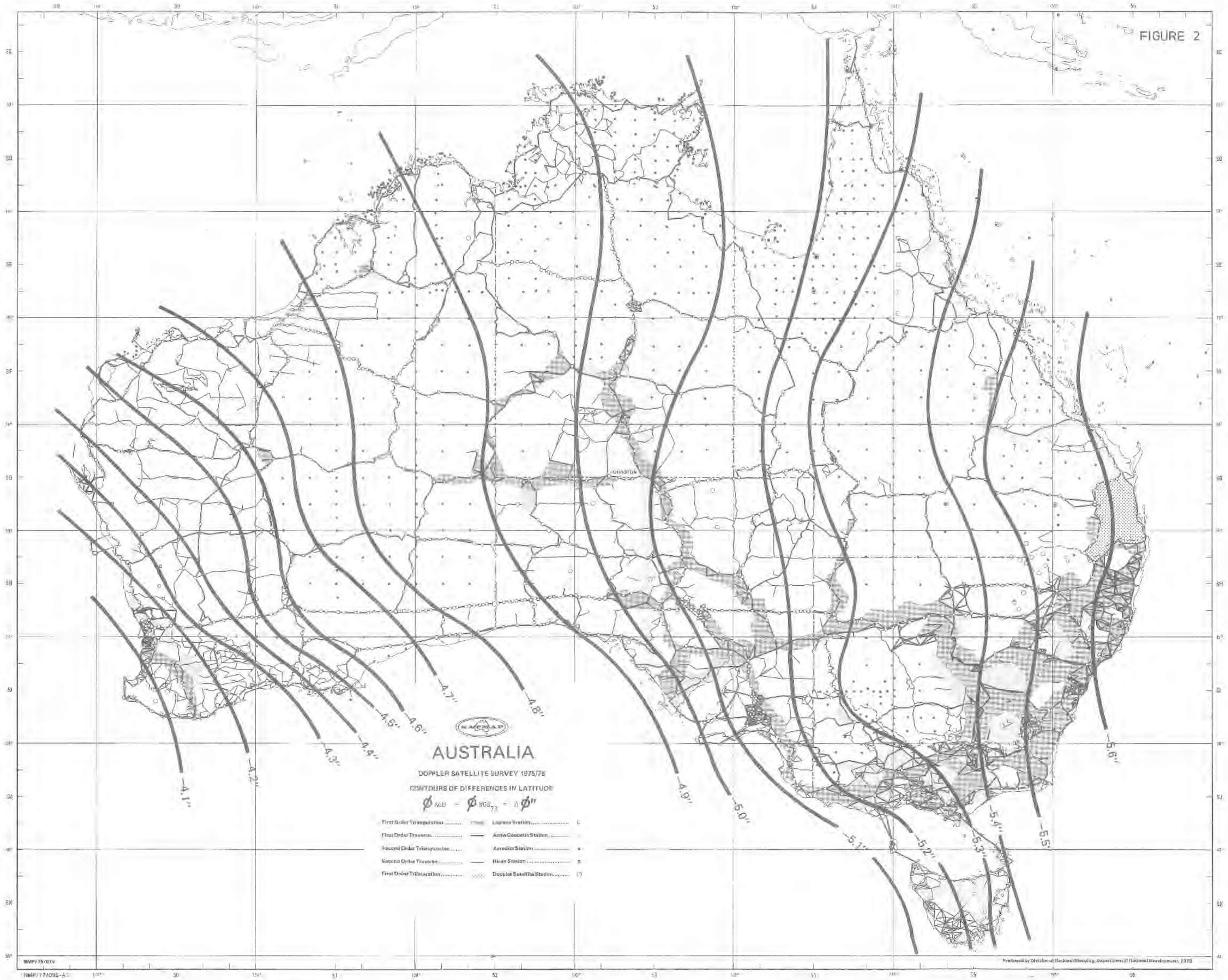


FIGURE 2
AUSTRALIA
DOPPLER SATELLITE SURVEY 1975/76
CONTOURS OF DIFFERENCES IN LATITUDE
$\phi_{AGD} - \phi_{WGS_{72}} = \Delta\phi''$
-4.1''
-4.2''
-4.3''
-4.4''
-4.5''
-4.6''
-4.7''
-4.8''
-4.9''
-5.0''
-5.1''
-5.2''
-5.3''
-5.4''
-5.5''
-5.6''
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
NMP/75/074
NMP/77/095-A2
Produced by Division of National Mapping, Department of National Development, 1978

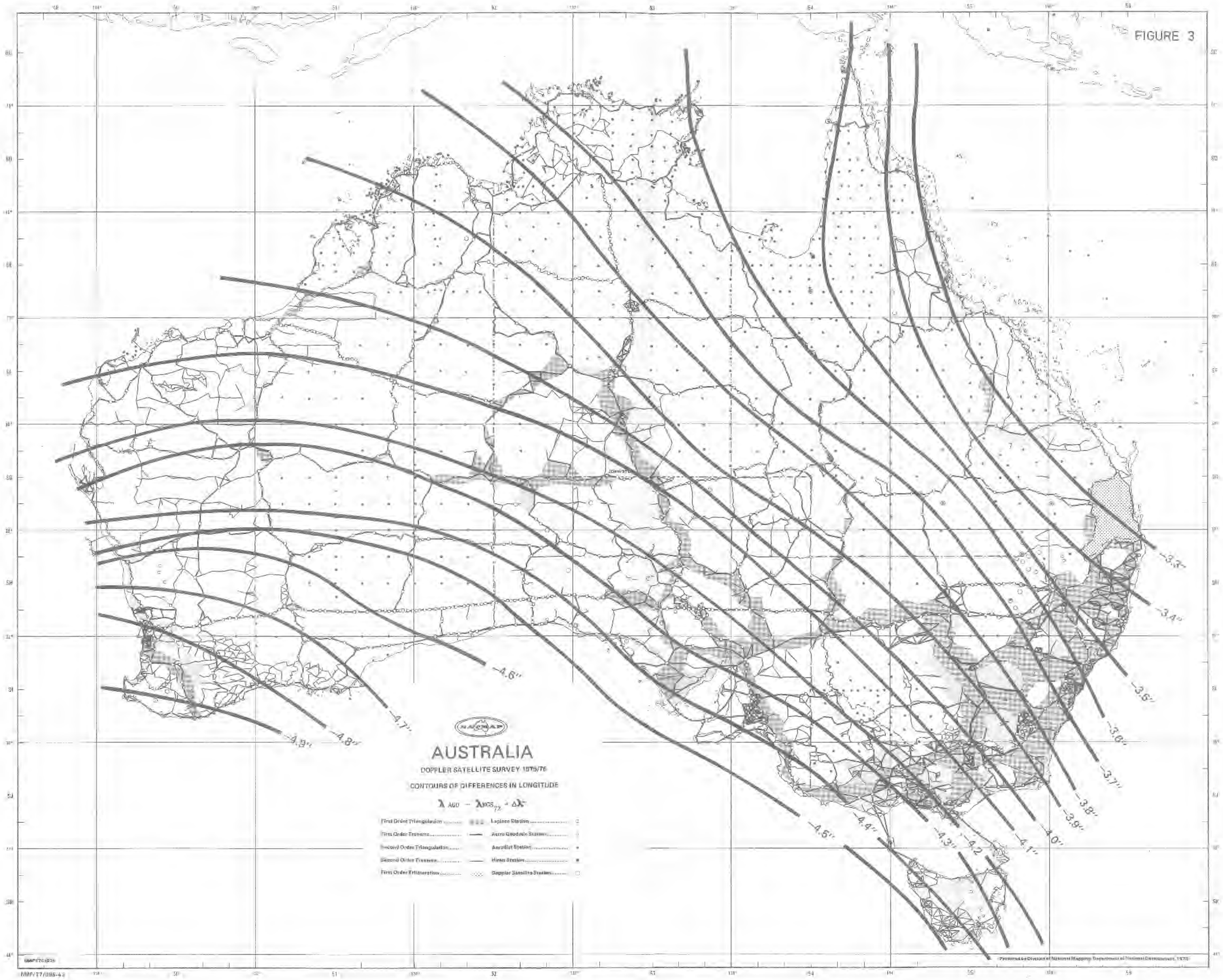


FIGURE 3
AUSTRALIA
DOPPLER SATELLITE SURVEY 1975/76
CONTOURS OF DIFFERENCES IN LONGITUDE
$\lambda_{AGD} - \lambda_{WGS_{72}} = \Delta\lambda''$
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
-4.6''
-4.7''
-4.8''
-4.9''
-4.5''
-4.4''
-4.3''
-4.2
-4.1''
-4.0''
-3.9''
-3.8''
-3.7''
-3.6''
-3.5''
-3.4''
MMF/77/996-43

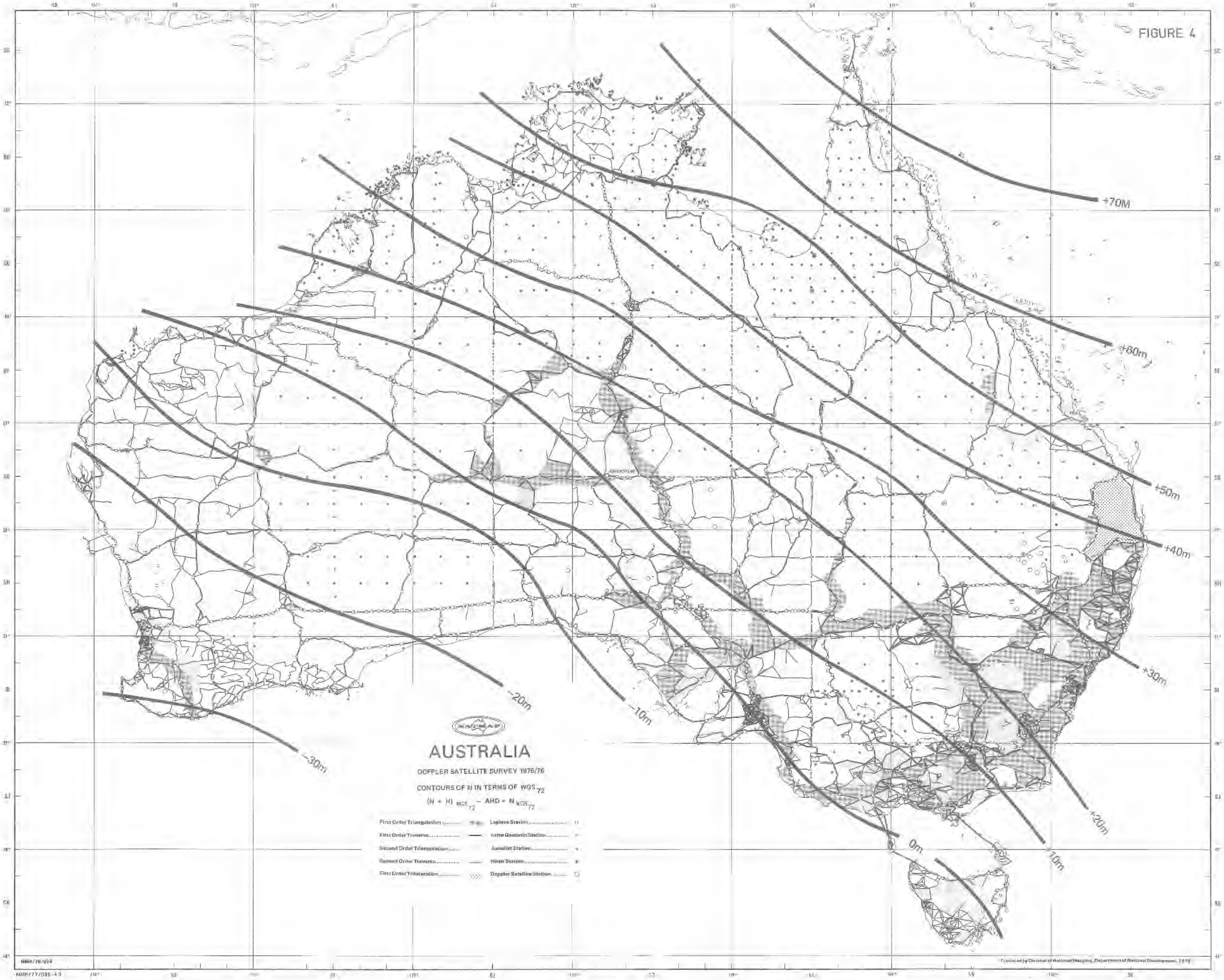


FIGURE 4
+70M
+60m
+50m
+40m
+30m
+20m
+10m
0m
-10m
-20m
-30m
AUSTRALIA
DOPPLER SATELLITE SURVEY 1976/76
CONTOURS OF N IN TERMS OF WGS-72
(N + H) WGS-72 − AHD = N WGS-72
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
NMP/76/024
NMP/77/035-43

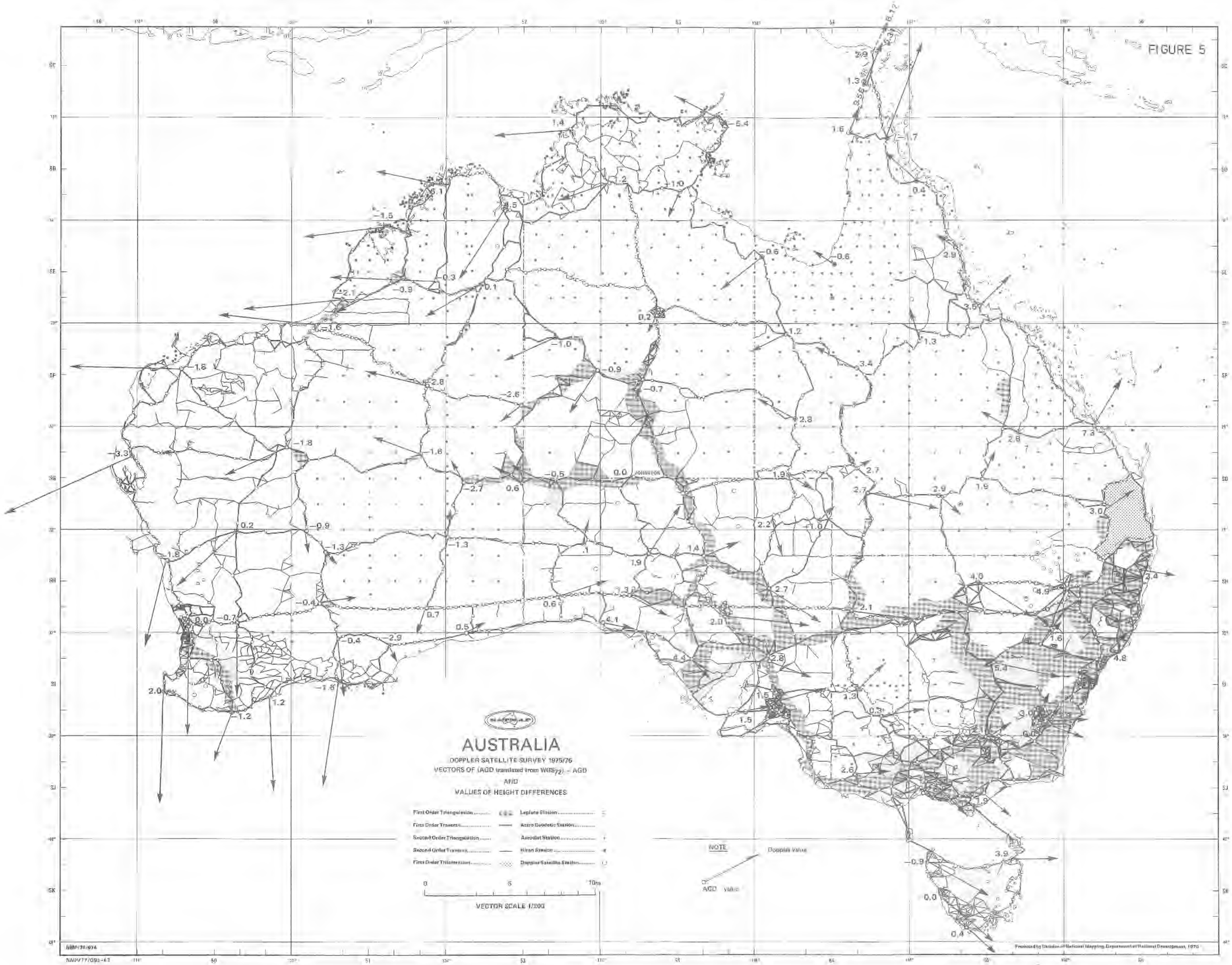


FIGURE 5
AUSTRALIA
DOPPLER SATELLITE SURVEY 1975/76
VECTORS OF (AGD translated from WGS72) – AGD
AND
VALUES OF HEIGHT DIFFERENCES
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
0
5
10m
VECTOR SCALE 1/200
NOTE
Doppler Value
AGD value
JOHNSTON
NMP/76/074
NMP77/095-63
Produced by Division of National Mapping, Department of National Development, 1976

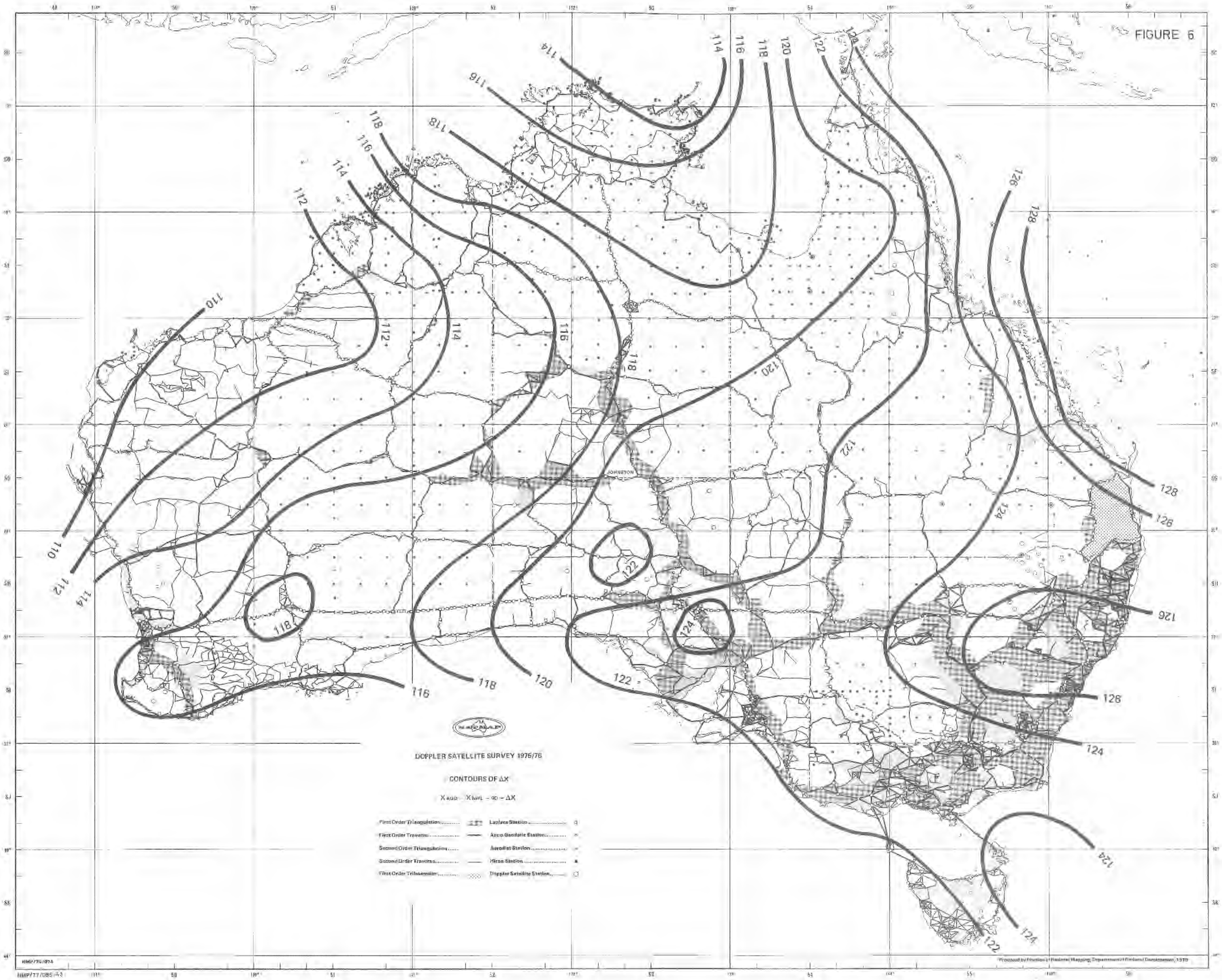


FIGURE 6
DOPPLER SATELLITE SURVEY 1976/76
CONTOURS OF ΔX
JOHNSTON
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
HMP/79/074
HMP/77/085/43

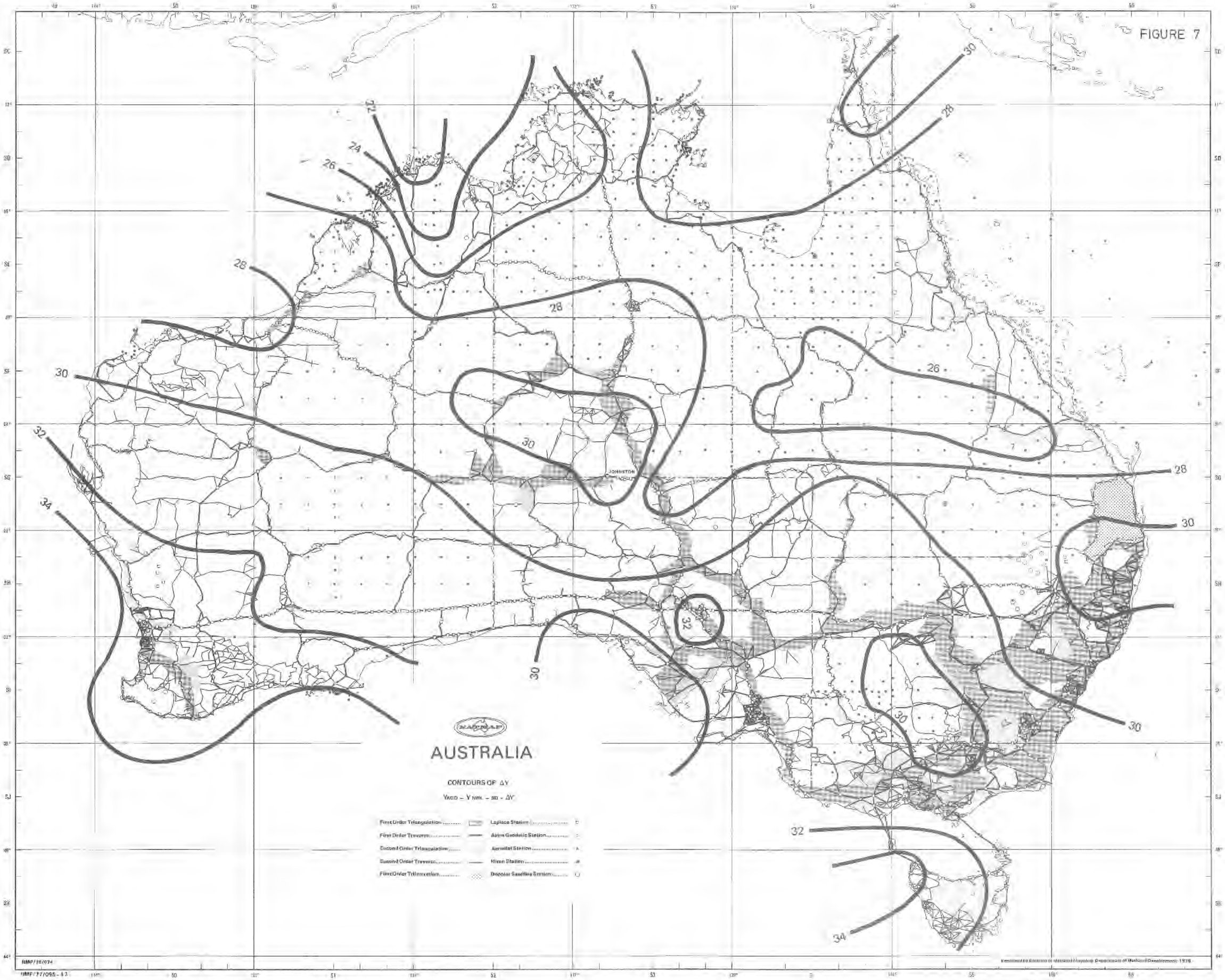


FIGURE 7
AUSTRALIA
CONTOURS OF ΔY
JOHNSTON
22
24
26
28
30
32
34

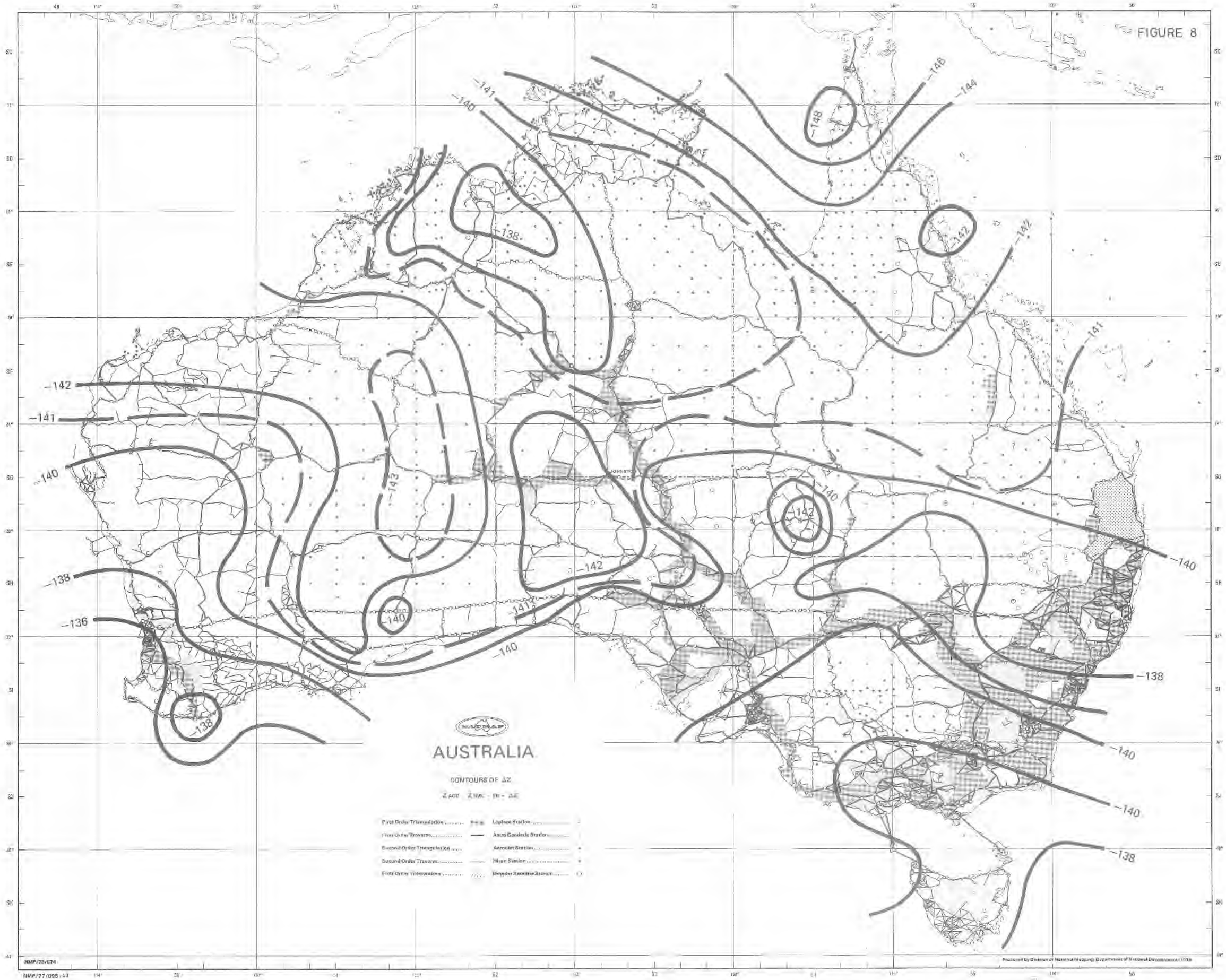


FIGURE 8
AUSTRALIA
CONTOURS OF ΔZ
Z AGD Z NWL - m - ΔZ
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
-148
-146
-144
-142
-141
-140
-138
-136
-143
NMP/77/095 43

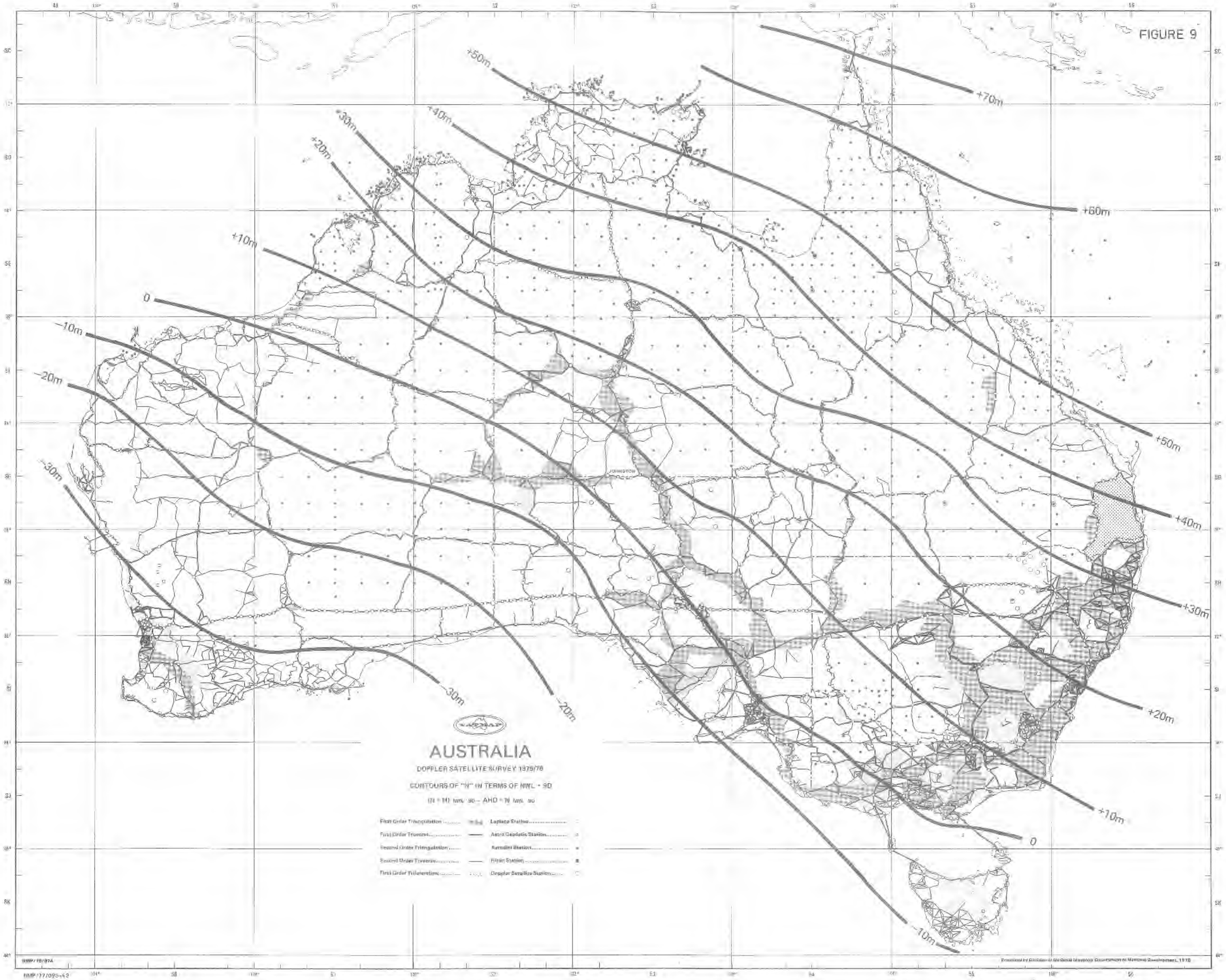
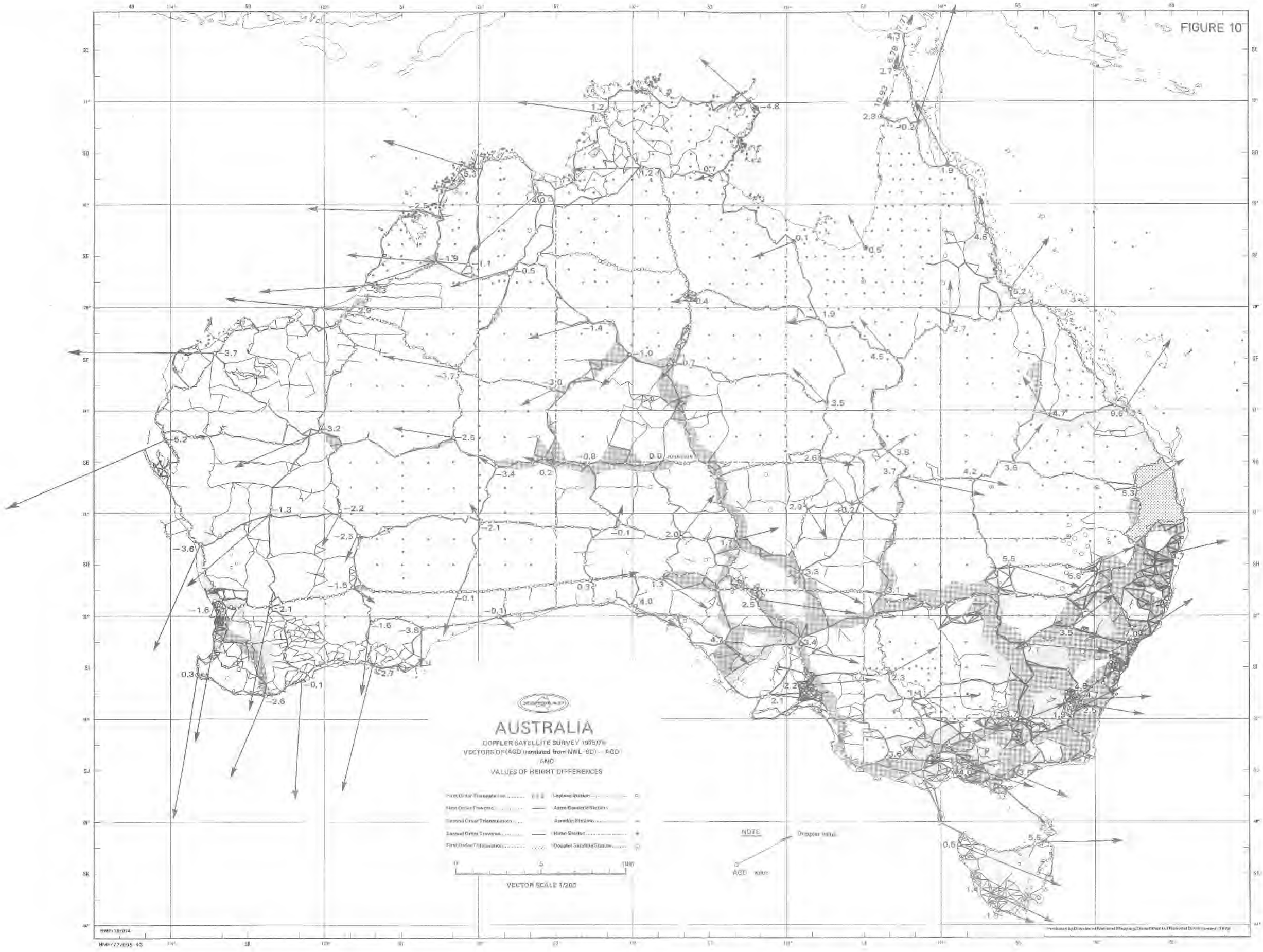


FIGURE 9
+70m
+60m
+50m
+40m
+30m
+20m
+10m
0
-10m
-20m
-30m
AUSTRALIA
DOPPLER SATELLITE SURVEY 1979/78
CONTOURS OF "N" IN TERMS OF NWL - 90
(N = H) NWL 90 - AHD = N NWL 90
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Firstn Station
Doppler Satellite Station
NMP/78/97A
NMP/77/095-43

FIGURE 10


AUSTRALIA
DOPPLER SATELLITE SURVEY 1975/76
VECTORS OF (AGD translated from NWL-80) - AGD
AND
VALUES OF HEIGHT DIFFERENCES
First Order Triangulation
Lapland Station
Aaron Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
VECTOR SCALE 1/200
NOTE
Doppler value
AGD value
NMP/78/074
NMP/77/095-43

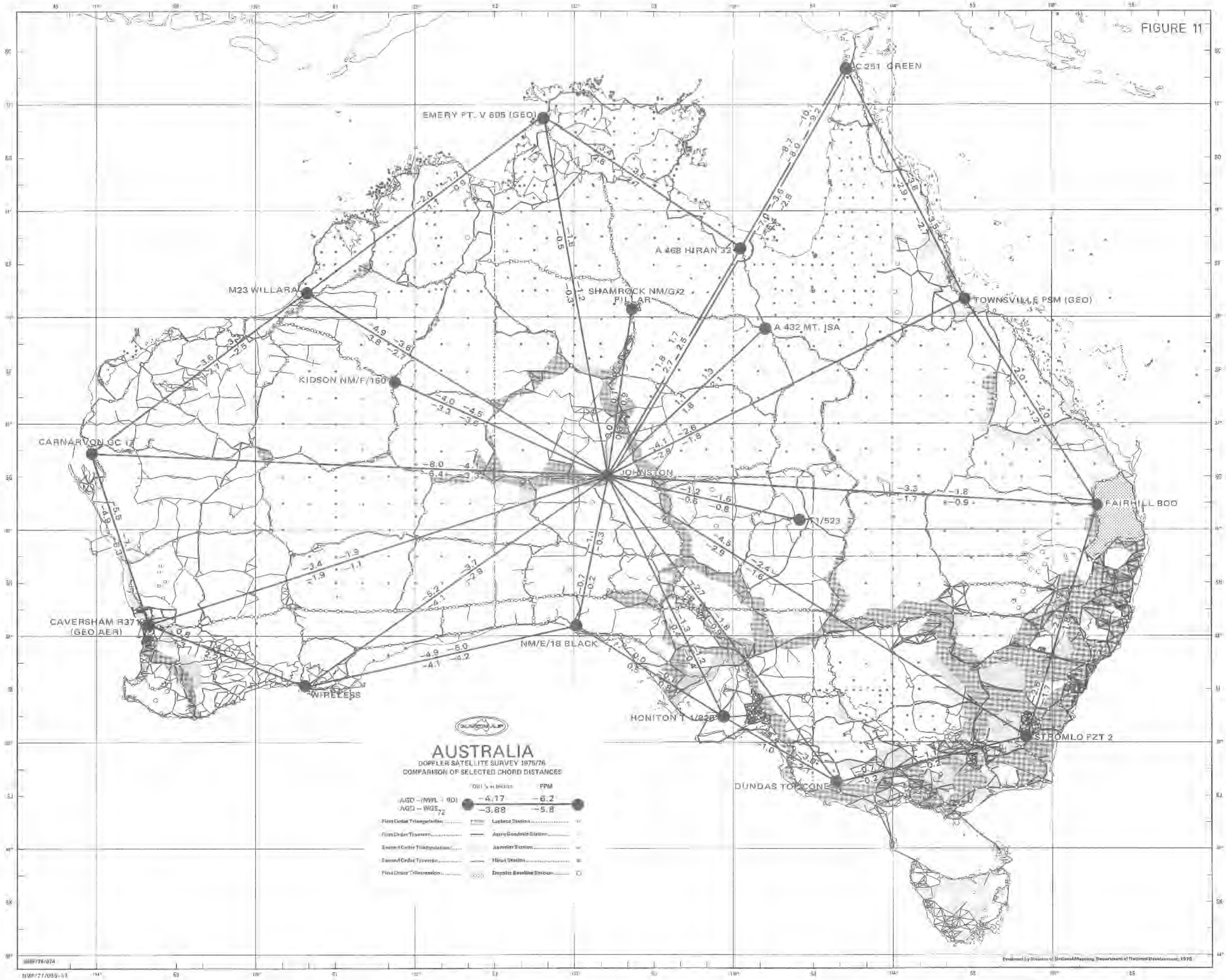


FIGURE 11
C251 GREEN
EMERY PT. V 605 (GEO)
A 468 HIRAN 32
M23 WILLARA
SHAMROCK NM/G/2
PILLAR
TOWNSVILLE PSM (GEO)
A 432 MT. ISA
KIDSON NM/F/160
CARNARVON GC 17
JOHNSTON
FAIRHILL BOO
T1/523
CAVERSHAM R371
(GEO AER)
NM/E/18 BLACK
WIRELESS
HONITON T 1/228
STROMLO PZT 2
DUNDAS TOWCONE
AUSTRALIA
DOPPLER SATELLITE SURVEY 1975/76
COMPARISON OF SELECTED CHORD DISTANCES
DIFF's in Metres
PPM
AGD – (NWL + 9D)
AGD – WGS72
−4.17
−3.88
−6.2
−5.8
First Order Triangulation
First Order Traverse
Second Order Triangulation
Second Order Traverse
First Order Trilateration
Laplace Station
Astro Geodetic Station
Aerodist Station
Hiran Station
Doppler Satellite Station
NMP/76/074
Produced by Division of National Mapping, Department of National Development, 1978

DOPPLER SATELLITE STATION ANALYSIS

FIGURE 12

OBSERVING AUTHORITY: DIV. OF NATIONAL MAPPING

STATION: GREEN C-251 THURSDAY ISLAND

OBSERVER: K. LEPPERT & J. GUILFOYLE

STATE: QLD

Type and number of Satellite receiver:

JMR-1, 75 202

Date of occupation:

DAYS 237-245, 1976

Field Books:

NIL: LOG SHEETS ON COMPUTING FILE ONLY
*STN. MARK IS R.A. SURVEY PLAQUE, 9 CM DIA, STAMPED "C251" SET ON TOP OF A CONCRETE PILLAR.

The Satellite observations were taken at STATION MARK, the height of the electrical centre of the aerial was 0.518 m above this mark.

All values shown on this summary refer to the station mark, and are quoted in either seconds of arc or metres.

Geodetic Datum:

Australian Geodetic (AGD) OR Derived Australian Geodetic (AGD)

Geoidal heights H are referred to the Australian Height Datum (AHD).

N values are in terms of N = -6.0 m at Johnston Geodetic Station.

φ:	-10	35	08.0381	X:	- 4 955	237.001
λ:	142	12	35.6545	Y:	+ 3 842	304.077
H:			59.09	Z:	- 1 163	990.159
N:			1.176			

Ephemeris coordinates converted to AGD using either 1, 2 or 3

φ:
λ:
AHD:

X: -
Y: +
Z: -

1) xyzcord:
Δx=
Δy=
Δz=

2) Pointra:
Δx=
Δy=
Δz=
λppm=
ω =
ψ =
ε =

SATELLITE DATUM:

				Internal Accuracy
φ:	-10	35	02.803	0.34
λ:	142	12	38.887	0.42
N + H:			126.732	0.27
X:	-4	955	361.459	
Y:	3	842	276.233	
Z:	-1	163	841.731	

Station uncertainty relating to AGD and AHD

Estimate: ± m

3) Graphical Interpol

Δφ =
Δλ =
N_{corr} =

COMPUTER PROGRAM USED

DOPPLER (JMR VERSION)

SATELLITES OBSERVED	NO. OF PASSES	EPHEMERIS
SAT 58 (30120)	19	PRECISE IN TERMS OF NWL9D
SAT 68 (30190)	20	

Compiled by: M.H. DOUCH Date: 24.10.77

Certified free of transcription errors: J. Howard Date: 24.11.77

Approved by: Date: 8/3/78

NATIONAL MAPPING COUNCIL OF AUSTRALIA
STATION SUMMARY

Serial No

Authority: DIVISION OF NATIONAL MAPPING

Station Number and Name: C 251 GREEN

Order: SECOND

Original Station Established by: Royal Australian Survey Corps Date: 1942

Existing Station Marked by: Royal Australian Survey Corps Date: 1942

Reference Books: Army trig 1942 1Fd Svy: Torres Strait 1973
NM 5063, 9883, 10047, 10181, 10182, 13119, 13723, 13874, 14042, 14118, 14513, 14712, 14754, 14776, 14777, 14804.

Cadastral Location: State Queensland County/District

Parish/Hundred Allotment/Section/Portion

Access and Locality Sketch: Particulars of station marking and beacon

Station Mark: R.A. Survey bronze plaque, 9cm diam, stamped "C251", set on top of a concrete pillar (70x 47cm for 1.29m, then 30 x 30cm for 0.82m).

Beacon : None.

Other Marks : THURSDAY B04/023 is a bronze disc, 9cm diam, set in concrete stamped "USC & GS SAT TRI STA 023 JUNE 1967".

Lands Dept. PSM is a 10cm diam survey mark set in a 4 gallon drum of concrete; top 2cm above G.L.,

Astro Ecce is a 2cm diam drill hole in concrete floor of bunker.

R.M. 1 is a bronze disc, 9cm diam, set in concrete retaining wall, stamped "SAT TRI STA 023 R.M.1 1967".

R.M.4 is a bronze disc, 9cm diam, set in concrete retaining wall, stamped " ROYAL AUST. SURVEY CORPS R.M.4 INT SAT TRI STA 023 1970".

Access : By vehicle from the township to the top of the hill.

Station revisited by:
National Mapping 1976.

Map Name: Torres Strait Map Number: SC 54-12 Scale 1: 250,000

DATUM: Australian Geodetic Datum 1966

RECTANGULAR COORDINATES: Australian Map Grid: In Metres

GRID BEARING = ADJ AZIMUTH + CONVERGENCE HEIGHTS: In Metres on the Australian Height Datum

GREEN SECTION THURSDAY SERIAL 6

SOUTH LATITUDE	EAST LONGITUDE	ZONE	EASTING	NORTHING	CONVERGENCE	HEIGHT
10 35. 8.0381	142 12 35.0545	54	632385.475	8829583.296	+0 13 20.27	59.09

TO	SERIAL	ADJ AZIMUTH	ADJ LENGTH	OBS
MILMAN	5	71 39 38.27	1825.465	

SECTION NMTORRES SERIAL 11

DOUBLE	C 143	18	189 34 48.55	5547.486
SCOTT HIRAN 25	B 128	2	178 11 23.01	7656.340
GOODE	C 255	14	287 59 1.16	6776.805
ENTRANCE	B 090	1	144 29 21.75	17165.769

Cadastral Connections & Reference Marks

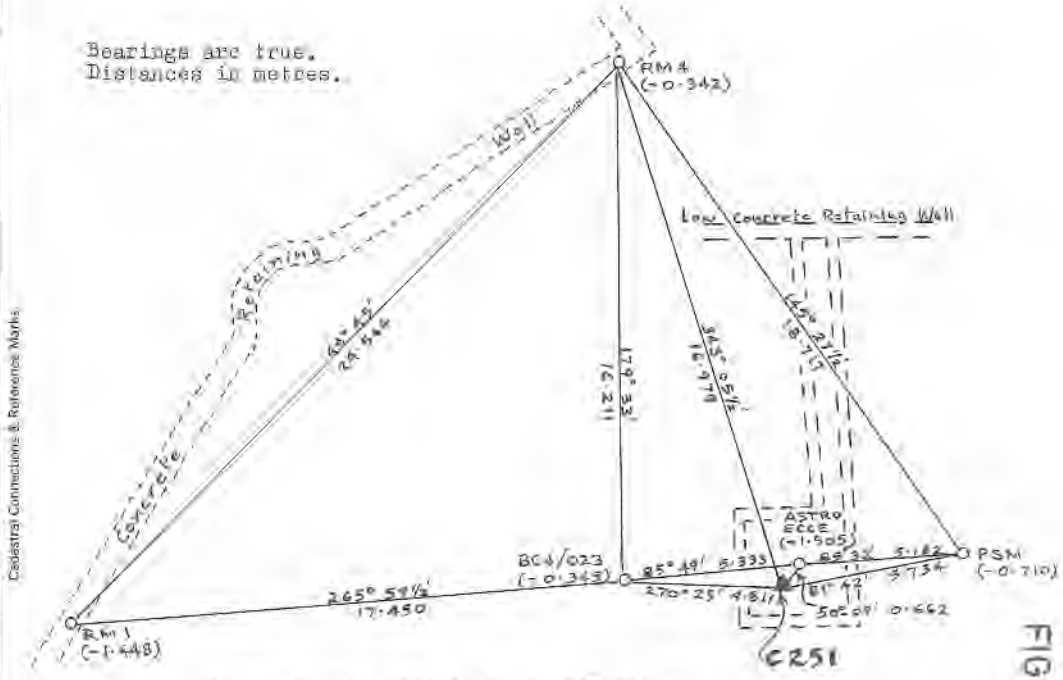


Photo Identification: Torres Strait IT. 6 No.6 CAB 388
Spot Photography CAB 3021 Nos. 43, 45

Certified free of transcription errors: Date: 20-11-74

Approved by: Date: 30 5 75

FIGURE 13

AMQ/DET/1094

TABLE 1

STATION	AGD LATITUDE S	AGD LONGITUDE E	H + N	AHD HEIGHT	NWL-9D LATITUDE S	NWL-9D LONGITUDE E	H + N	WGS-72 LATITUDE S	WGS-72 LONGITUDE E	H + N
A432 MT ISA	20 20 40.2862	139 12 18.1789	513.803	510.603	20 20 35.129	139 12 21.565	548.060	20 20 35.114	139 12 21.825	552.703
A420 KERRS TABLE	21 44 03.0630	141 57 54.9250	304.229	304.229	21 43 57.773	141 57 58.224	341.580	21 43 57.757	141 57 58.484	346.212
A 468 HIRAN 32	17 24 27.3790	138 15 00.0508	246.100	241.100	17 24 22.294	138 15 03.397	285.040	17 24 22.281	138 15 03.657	289.706
AGNEW BLUFF NM/F/135	28 01 41.7682	120 32 01.5604	559.640	556.940	28 01 37.191	120 32 05.827	536.810	28 01 37.172	120 32 06.087	541.382
AIRSTRIP RISE	43 25 14.4442	146 09 47.0609	19.700	7.500	43 25 09.292	146 09 51.256	-1.340	43 25 09.269	146 09 51.516	3.051
ANARE NM/D/28	37 50 55.1789	144 58 37.8683	30.994	24.994	37 50 49.960	144 58 41.785	26.340	37 50 49.938	144 58 42.045	30.800
ANARE (GEO)-(AERIAL)	37 50 55.1789	144 58 37.8683	31.600	25.600	37 50 49.958	144 58 41.772	28.900	37 50 49.936	144 58 42.032	33.360
ANGELO R016	18 25 43.3900	127 25 26.1217	455.875	449.442	18 25 38.513	127 25 29.812	472.203	18 25 38.499	127 25 30.072	476.858
B058 GREEN	17 02 31.7431	145 48 26.5053	132.046	130.830	17 02 26.452	145 48 29.566	188.564	17 02 26.439	145 48 29.826	193.228
B 069 HIRAN 27	14 23 40.1695	144 15 21.0413	268.200	267.200	14 23 34.918	144 15 24.096	327.060	14 23 34.907	144 15 24.356	331.746
B 077 TOZER HIRAN 26	12 45 12.9261	143 12 33.4036	545.500	542.500	12 45 07.602	143 12 36.611	605.020	12 45 07.592	143 12 36.871	609.715
B 096	12 34 14.3749	141 35 55.4215	23.100	21.600	12 34 08.965	141 35 58.740	82.020	12 34 08.955	141 35 59.000	86.716
B 145 STAIRCASE	24 11 56.8384	148 11 50.2745	577.194	574.694	24 11 51.385	148 11 53.323	616.920	24 11 51.368	148 11 53.583	621.530
BEADELL NM/E/52	26 09 57.0631	130 04 40.3763	678.568	679.793	26 09 52.093	130 04 44.237	678.822	26 09 52.075	130 04 44.497	683.411
BOMOBBIN PILLAR TOP	33 05 58.4606	147 18 25.3668	235.480	233.680	33 05 53.086	147 18 28.991	250.580	33 05 53.065	147 18 29.251	255.096
BURGESS E75	30 50 11.8757	121 05 41.7812	556.009	554.009	30 50 07.308	121 05 46.234	527.873	30 50 07.288	121 05 46.494	532.414
C-251 GREEN	10 35 08.0381	142 12 35.6545	60.270	59.090	10 35 02.803	142 12 38.887	126.732	10 35 02.795	142 12 39.147	131.436
CAMERON WEST	40 51 55.9516	144 42 28.7524	176.900	167.800	40 51 50.812	144 42 32.942	159.920	40 51 50.789	144 42 33.202	164.343
CAMPBELL NM/G/48	21 47 05.5204	131 52 02.2225	611.909	611.309	21 47 00.575	131 52 05.920	626.830	21 47 00.559	131 52 06.180	631.461
CARNARVON GC17	25 06 54.9364	113 43 48.7935	19.597	13.309	25 06 50.563	113 43 52.770	-11.775	25 06 50.545	113 43 53.030	-7.169
CAVERSHAM R371 (GEO AER)	31 50 28.9922	115 58 26.6176	31.400	25.086	31 50 24.859	115 58 31.123	-8.257	31 50 24.838	115 58 31.383	-3.720
CHARMOUTH	40 45 18.1031	147 58 09.1426	57.300	51.500	40 45 12.776	147 58 13.088	49.600	40 45 12.753	147 58 13.348	54.024
CORNWALLIS	9 25 28.3660	142 31 59.7664	298.400	297.400	9 25 23.133	142 32 02.984	369.412	9 25 23.126	142 32 03.244	374.121
COSY CORNER	34 15 19.8188	115 01 29.6488	52.228	41.628	34 15 15.824	115 01 34.294	7.210	34 15 15.802	115 01 34.554	11.713
CULGOORA NM/C/60	30 18 39.6117	149 33 36.7242	210.888	210.188	30 18 34.107	149 33 40.049	236.790	30 18 34.087	149 33 40.309	241.337
DILLON	26 34 11.4540	135 11 58.5300	223.000	228.100	26 34 06.394	135 12 02.387	237.790	26 34 06.375	135 12 02.647	242.377
DOODLAKINE	31 34 46.4958	117 50 41.8979	335.788	329.088	31 34 42.216	117 50 46.369	299.550	31 34 42.195	117 50 46.629	304.083
DRIUD	29 58 53.4262	146 33 49.8335	162.300	162.300	29 58 48.097	146 33 53.352	183.890	29 58 48.077	146 33 53.612	188.441
DUNDAS TOP CONE	37 27 37.5595	141 54 51.3892	473.355	467.755	37 27 32.388	141 54 55.457	465.480	37 27 32.366	141 54 55.717	469.945
EMERY PT U605 (GEO)	12 27 19.7050	130 48 53.8816	19.500	11.700	12 27 14.746	130 48 57.323	59.680	12 27 14.736	130 48 57.583	64.377
ESA 10 (MARCONI)	34 27 22.5697	119 08 40.9145	226.225	220.200	34 27 18.374	119 08 45.528	187.400	34 27 18.353	119 08 45.788	191.900
FAIRHILL B002	27 03 29.4632	151 43 36.8653	749.821	748.421	27 03 23.920	151 43 39.931	786.500	27 03 23.901	151 43 40.191	791.082
GAP	31 06 21.2053	141 43 36.4034	283.377	282.577	31 06 15.976	141 43 40.223	292.570	31 06 15.955	141 43 40.483	297.109
GEORGE JHR5	28 49 12.6035	121 17 58.3499	459.252	458.252	28 49 07.999	121 18 02.647	435.510	28 49 07.979	121 18 02.907	440.073
HILL 1037 NM/B/174	26 38 16.7150	145 07 48.1097	327.995	329.495	26 38 11.392	145 07 51.510	355.900	26 38 11.373	145 07 51.770	360.486
HINCKLEY NM/F/7	26 07 41.4411	128 55 45.9430	1013.173	1012.800	26 07 36.505	128 55 49.873	1012.555	26 07 36.486	128 55 50.133	1017.141
HIRAN 30 ECCE	17 40 33.3353	141 05 18.8998	12.440	11.440	17 40 28.113	141 05 22.174	57.230	17 40 28.100	141 05 22.434	61.894
HOLEY HILL	38 14 00.0832	146 56 19.4618	223.670	217.770	38 13 54.791	146 56 23.270	219.890	38 13 54.768	146 56 23.530	224.345
HONITON T1/828	35 05 03.7281	137 38 48.8534	40.400	38.700	35 04 58.660	137 38 52.961	31.580	35 04 58.638	137 38 53.221	36.073
HOWITT NM/B/34	26 32 09.3642	142 23 00.5596	198.515	202.215	26 32 04.132	142 23 04.186	222.200	26 32 04.113	142 23 04.446	226.787
HP 33 TALBOT	26 06 49.8223	126 39 54.5841	618.260	618.776	26 06 44.945	126 39 58.607	610.140	26 06 44.927	126 39 58.867	614.731
JOHNSTON	25 56 54.5515	133 12 30.0771	560.300	566.300	25 56 49.516	133 12 33.914	567.290	25 56 49.498	133 12 34.174	571.883
K660 HAWKS NEST	28 54 17.6327	133 52 47.9538	224.838	228.187	28 54 12.519	133 52 51.947	226.930	28 54 12.499	133 52 52.207	231.492
KIDSON NM/F/160	22 23 50.0630	125 15 16.9767	355.503	355.032	22 23 45.183	125 15 20.812	354.220	22 23 45.167	125 15 21.072	358.846
KOOLAN ISLAND R160	16 07 52.2389	123 46 13.6500	180.700	174.700	16 07 47.393	123 46 17.318	194.140	16 07 47.381	123 46 17.578	198.815
LARRYS NEW	35 24 29.8449	148 58 29.7893	739.836	731.336	35 24 24.368	148 58 33.298	748.032	35 24 24.346	148 58 33.558	752.519
LIANIDUCK	35 15 18.0307	142 53 37.8553	96.613	92.013	35 15 12.780	142 53 41.769	94.015	35 15 12.758	142 53 42.029	98.501
LINCOLN	32 25 39.6693	149 06 07.8859	746.928	742.737	32 25 34.175	149 06 11.284	762.715	32 25 34.154	149 06 11.544	767.234
LOCK	33 05 34.8506	138 34 31.3521	749.493	746.693	33 05 29.757	138 34 35.360	748.800	33 05 29.736	138 34 35.620	753.316
LOW CLIFF	29 00 50.0384	136 02 22.5120	150.304	153.200	29 00 44.924	136 02 26.427	155.312	29 00 44.905	136 02 26.687	159.871
LYNDHURST	30 12 12.2768	138 34 23.9345	290.300	290.200	30 12 07.186	138 34 27.826	296.770	30 12 07.166	138 34 28.086	301.319
M9 (MARCONI)	20 02 32.2731	120 56 48.3384	146.204	138.122	20 02 27.480	120 56 52.126	143.660	20 02 27.465	120 56 52.386	148.306
M23 WILLARA	19 02 22.4655	121 54 35.9236	120.215	113.508	19 02 17.682	121 54 39.674	121.680	19 02 17.668	121 54 39.934	126.334
MAURICE B017	23 56 09.9257	151 14 29.1007	224.059	224.500	23 56 04.359	151 14 32.119	273.590	23 56 04.342	151 14 32.379	278.202
MC 4	32 26 57.8225	123 48 20.2284	167.103	167.103	32 26 53.240	123 48 24.641	137.420	32 26 53.219	123 48 24.901	141.944
MORRISSETT BLDG (APPROX)	35 21 14.4759	149 13 52.2184	597.860	589.560	35 21 09.034	149 13 55.796	606.485	35 21 09.012	149 13 56.056	610.970
MULLEY TS	33 25 52.4505	149 33 57.2336	731.500	731.500	33 25 46.975	149 34 00.708	750.420	33 25 46.954	149 34 00.968	754.932
NM/B/38	25 36 31.4978	141 59 21.2100	188.504	192.405	25 36 26.213	141 59 24.701	214.223	25 36 26.195	141 59 24.961	218.816
NM/B/168 WHISKY	25 59 43.1485	146 50 10.7168	502.289	501.541	25 59 37.709	146 50 13.991	533.790	25 59 37.691	146 50 14.251	538.382
NM/B/186	23 40 58.5907	139 36 58.6857	165.156	164.156	23 40 53.340	139 37 02.132	192.390	23 40 53.323	139 37 02.392	197.004
NM/E/18 BLACK	31 34 29.8067	132 04 51.3254	78.663	85.263	31 34 24.890	132 04 55.501	72.680	31 34 24.869	132 04 55.761	77.213
NM/C/106 ORRORAL	35 38 16.6101	148 56 17.9111	1336.486	1327.086	35 38 11.147	148 56 21.451	1341.043	35 38 11.125	148 56 21.711	1345.527
NM/E/174	28 31 44.0023	131 19 00.4117	342.500	351.500	28 31 39.008	131 19 04.421	339.300	28 31 38.989	131 19 04.681	343.866
NM/E/190	30 37 32.2775	130 20 40.7321	116.638	124.738	30 37 27.360	130 20 44.962	106.670	30 37 27.340	130 20 45.222	111.214
NM/F/267	28 30 38.8980	128 53 05.5470	347.640	356.140	28 30 33.932	128 53 09.651	338.520	28 30 33.912	128 53 09.911	343.087
OLWOLGIN NM/F/111	32 00 50.1040	126 49 15.1350	99.508	102.208	32 00 45.354	126 49 19.465	79.640	32 00 45.333	126 49 19.725	84.168
PASCHENDALE T1/787	34 12 28.9388	142 00 31.6571	67.284	65.084	34 12 23.667	142 00 35.528	67.290	34 12 23.645	142 00 35.788	71.793
PECKHAM NM/G/34	14 26 22.3043	132 19 43.5843	172.023	166.700	14 26 17.330	132 19 47.049	209.676	14 26 17.319	132 19 47.309	214.355
PEEDAMULLAH KAP7	21 44 26.8777	115 41 10.4080	116.040	109.000	21 44 22.257	115 41 14.290	98.300	21 44 22.241	115 41 14.550	102.932
PINNACLES	29 33 25.9873	152 56 10.5353	185.233	184.233	29 33 20.434	152 56 13.636	215.476	29 33 20.414	152 56 13.896	220.026
PIVOT R028	15 36 25.5417	128 16 30.5120	52.953	49.953	15 36 20.722	128 16 34.132	82.845	15 36 20.710	128 16 34.392	87.518
QUARTZ NM/G/60	20 29 58.7833	130 14 11.6966	390.310	386.310	20 29 53.836	130 14 15.365	405.420	20 29 53.821	130 14 15.625	410.062
R001 G.L.	18 08 52.6073	124 18 02.6399	96.036	89.335	18 08 47.803	124 18 06.378	105.827	18 08 47.789	124 18 06.638	110.480
R009 CAMPBELL	18 17 29.8549	125 35 14.5059	156.783	150.686	18 17 24.958	125 35 18.147	169.400	18 17 24.944	125 35 18.407	174.059
R112 WARRENDER	14 31 41.1696	125 49 03.6708	244.900	242.900	14 31 36.241	125 49 07.297	274.290	14 31 36.230	125 49 07.557	278.975
R183 NEALE	28 17 23.9052	126 02 47.0528	377.175	381.355	28 17 19.071	126 02 51.206	363.610	28 17 19.052	126 02 51.466	368.179
RAWLINNA NM/F/67 (MARC)	31 01 11.5870	125 14 49.7213	184.227	187.177	31 01 06.934	125 14 53.991	164.300	31 01 06.913	125 14 54.251	168.840
ROPER U120	14 50 31.7669	135 03 38.2298	95.667	90.167	14 50 26.744	135 03 41.692	135.246	14 50 26.732	135 03 41.952	139.929
SEAHAM TRIG	32 40 54.7798	151 46 48.1317	178.528	176.228	32 40 49.210	151 46 51.385	200.367	32 40 49.189	151 46 51.645	204.881
SHAMROCK NM/G/2 PILLAR	19 37 07.4831	134 11 14.1987	438.250	436.450	19 37 02.426	134 11 17.809	464.480	19 37 02.411	134 11 18.069	469.129
SMITHFIELD 112 (JMRMARK)	34 40 31.3651	138 39 12.3752	30.700	28.600	34 40 26.236	138 39 16.490	24.560	34 40 26.214	138 39 16.750	29.058
SOLITARY NTS 057	22 11 05.7893	133 38 44.8549	679.861	678.961	22 11 00.757	133 38 48.544	697.110	22 11 00.741	133 38 48.804	701.738
STRAHAN AIRPORT RM3	42 09 15.8211	145 17 28.0972	33.000	22.000	42 09 10.702	145 17 32.305	14.040	42 09 10.679	145 17 32.565	18.447
STRAWBERRY	29 13 33.1199	115 11 49.1595	210.226	203.235	29 13 28.878	115 11 53.510	173.380	29 13 28.858	115 11 53.770	177.939
STROMLO PZT2	35 19 21.0226	149 00 19.2319	777.640	769.140	35 19 15.625	149 00 22.819	783.860	35 19 15.603	149 00 23.079	788.350
T1/451	25 49 25.6878	139 21 14.4710	93.800	96.800	25 49 20.509	139 21 18.117	113.720	25 49 20.491	139 21 18.377	118.314
T1/523	27 36 59.2644	140 28 36.2903	70.200	73.200	27 36 54.009	140 28 39.928	84.040	27 36 53.990	140 28 40 188	88.616
T1/530	27 43 30.2285	138 44 31.1165	31.000	34.000	27 43 25.112	138 44 34.826	44.920	27 43 25.093	138 44 35.086	49.495
TALGARNO	36 05 06.6509	147 05 43.4265	650.642	644.942	36 05 01.259	147 05 47.098	653.450	36 05 01.237	147 05 47.358	657.931
TIETKENS NM/F/145	23 09 14.1901	128 53 57.1293	541.823	542.523	23 09 09.277	128 54 00.973	545.810	23 09 09.260	128 54 01.233	550.429
TOBRAY R241 PILLAR	35 04 46.3062	117 37 11.6538	279.597	269.797	35 04 42.108	117 37 16.280	234.190	35 04 42.086	117 37 16.540	238.683
TOWNSVILLE PSM (GEO)	19 15 30.4768	146 42 56.0532	8.553	6.753	19 15 25.094	146 42 59.202	60.860	19 15 25.080	146 42 59.462	65.512
U214 DUNDAS	12 13 09.0090	136 51 46.1549	80.800	71.800	12 13 03.908	136 51 49.446	127.202	12 13 03.898	136 51 49.706	131.898
WARRAMBOO K5	28 01 57.3955	117 49 24.0614	548.410	545.410	28 01 52.971	117 49 28.244	521.530	28 01 52.952	117 49 28.504	526.102
WILD	30 32 15.0636	133 10 17.4740	230.409	234.309	30 32 10.124	133 10 21.577	226.280	30 32 10.104	133 10 21.837	230.825
WIRELESS	33 52 43.3903	121 53 20.9415	91.783	88.583	33 52 39.085	121 53 25.419	56.860	33 52 39.064	121 53 25.679	61.367
WONGALEE A407	20 38 00.6411	144 24 29.3583	517.699	515.199	20 37 55.297	144 24 32.569	560.140	20 37 55.282	144 24 32.829	564.781
WONYULGUNNA L15	24 49 04.7922	119 45 46.4759	774.501	768.058	24 49 00.181	119 45 50.504	757.280	24 49 00.163	119 45 50.764	761.884
WOOLYEENYER B22	32 15 41.2292	121 47 09.2388	486.673	485.673	32 15 36.785	121 47 13.683	456.245	32 15 36.764	121 47 13.943	460.766
WOOMERA E148	31 23 30.7827	136 52 37.8871	136.462	137.462	31 23 25.707	136 52 41.989	136.970	31 23 25.686	136 52 42.249	141.506
WIDINNA T1/769	32 59 20.3842	135 32 53.6207	256.661	260.661	32 59 15.389	135 32 57.691	253.000	32 59 15.368	135 32 57.951	257.518
YOUNG NM/F/22	25 03 02.3108	124 58 57.1525	546.638	546.784	25 02 57.470	124 59 01.112	539.190	25 02 57.453	124 59 01.372	543.792
JMR 1975 MACQUARIE IS				7.400			-14.290			-9.560
M NORFOLK IS.				61.574			109.898			114.620
NM/OS/19				6.962			66.310			71.040
PM2192 LD. HOWE IS.				10.424			42.630			47.360

STATIONS		DISTANCES			DIFFERENCES			
INITIAL	TERMINAL	AGD	NWL-9D	WGS 72	AGD-NWL	PPM	AGD-WGS	PPM
JOHNSTON								
	A 432 MT ISA	872 208.711	872 207.609	872 206.880	1.102	1.26	1.831	2.10
	A 468 HIRAN 32	1 078 520.765	1 078 518.980	1 078 518.081	1.785	1.66	2.684	2.49
	C 251 GREEN	1 939 374.778	1 939 381.828	1 939 380.210	-7.050	-3.64	-5.432	-2.80
	CARNARVON GC 17	1 950 574.309	1 950 582.319	1 950 580.686	-8.010	-4.11	-6.377	-3.27
	DUNDAS TOP CONE	1 514 817.399	1 514 820.092	1 514 818.826	-2.693	-1.78	-1.427	-0.94
	EMERY PT V605 (GEO)	1 511 062.699	1 511 064.475	1 511 063.217	-1.776	-1.18	0.518	0.34
	FAIRHILL BOO2	1 842 234.224	1 842 237.477	1 842 235.933	-3.253	-1.77	-1.709	-0.93
	KIDSON NM/F/160	897 884.879	897 888.889	897 888.137	-4.010	-4.47	-3.258	-3.63
	M 23 WILLARA	1 387 961.787	1 387 966.717	1 387 965.556	-4.930	-3.55	-3.769	-2.72
	NM/E/18 BLACK	632 996.976	632 997.679	632 997.151	-0.703	-1.11	-0.175	-0.28
	SHAMROCK NM/G/2 PILLAR	707 817.416	707 817.368	707 816.778	0.048	0.07	0.638	0.90
	STROMLO PZT 2	1 826 670.000	1 826 674.471	1 826 672.942	-4.471	-2.45	-2.942	-1.61
	T1/523	745 535.275	745 536.500	745 535.875	-1.225	-1.64	0.600	0.80
	TOWNSVILLE PSM (GEO)	1 568 661.303	1 568 665.424	1 568 664.111	-4.121	-2.63	-2.808	-1.79
	WIRELESS	1 398 275.911	1 398 281.147	1 398 279.978	-5.236	-3.74	-4.067	-2.91
C-251 GREEN								
	A468 HIRAN 32	866 801.776	866 810.502	866 809.789	-8.726	-10.07	-8.013	-9.24
	TOWNSVILLE PSM (GEO)	1 073 611.915	1 073 615.680	1 073 614.797	-3.765	-3.51	-2.882	-2.68
FAIRHILL BOO2								
	TOWNSVILLE PSM (GEO)	1 003 428.799	1 003 430.838	1 003 430.011	-2.039	-2.03	-1.212	-1.21
	STROMLO PZT 2	951 403.141	951 405.603	951 404.820	-2.462	-2.59	-1.679	-1.76
DUNDAS TOP CONE								
	STROMLO PZT 2	678 500.762	678 501.495	678 500.934	-0.733	-1.08	-0.172	-0.25
	HONITOM T1/828	465 168.318	465 169.688	465 169.304	-1.370	-2.95	-0.986	-2.12
NM/E/18 BLACK								
	HONITON T1/828	647 643.059	647 643.097	647 642.563	-0.038	-0.06	0.496	0.77
	WIRELESS	987 483.068	987 487.985	987 487.168	-4.917	-4.98	-4.100	-4.15
CAVERSHAM R 371 (GEO AER)								
	WIRELESS	597 645.365	597 644.511	597 644.018	0.854	1.43	1.347	2.25
CARNARVON GC17								
	CAVERSHAM R 371 (GEO AER)	776 604.654	776 610.164	776 609.526	-5.510	-7.10	-4.872	-6.27
	M 23 WILLARA	1 077 673.815	1 077 677.378	1 077 676.490	-3.563	-3.31	-2.675	-2.48
EMERY PT U605 (GEO)								
	A 468 HIRAN 32	968 386.067	968 389.507	968 388.708	-3.440	-3.55	-2.641	-2.73
	M 73 WILLARA	1 198 321.452	1 198 323.500	1 198 322.511	-2.048	-1.71	-1.059	-0.88
SUPPLEMENTARY DISTANCES								
JOHNSTON								
	CAVERSHAM R 371 (GEO AER)	1 794 816.669	1 794 820.109	1 794 818.607	-3.440	-1.92	-1.938	-1.08
	HONITON T1/828	1 097 098.675	1 097 099.976	1 097 099.060	-1.301	-1.19	-0.385	-0.35

TABLE 2