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M. Jia, J. Dawson

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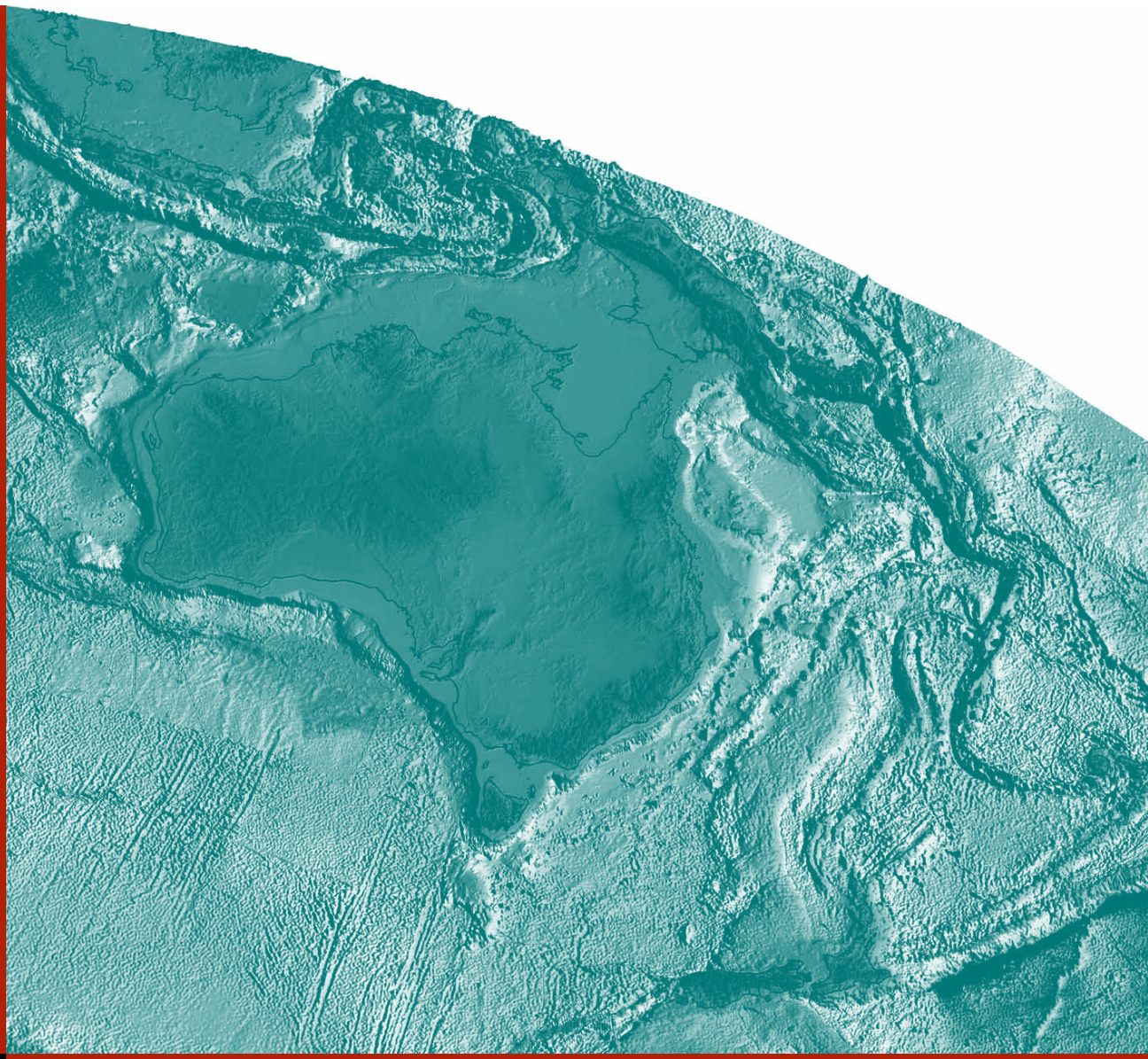

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by

M. Jia, J. Dawson

This report is accredited for compliance with ISO/IEC 17025:2005 and issued in accordance with NATA accreditation requirements.

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5 years after authorisation date.

Abbreviations:

AFN	Australian Fiducial Network
ARGN	Australian Regional GNSS Network
CORS	Continuously Operating Reference Stations
GDA94	Geocentric Datum Australia 1994
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRS80	Geodetic Reference System 1980
IGS	International GNSS Service
ITRF	International Terrestrial Reference Frame
ITRF92	International Terrestrial Reference Frame 1992
ITRF2005	International Terrestrial Reference Frame 2005

Introduction:
In Jia, M., and Dawson, J., 2010, Determination of GDA94 coordinates for eleven Queensland Department of Environment and Resource Management CORS stations using the August 2010 GPS data set the antenna types adopted for station BEE2, CBLT, CLEV and GATT, were incorrectly assigned. This report supersedes this earlier work completely.

An application dated 25 August 2010 for verification of a reference standard of measurement under Regulation 12 of the National Measurement Regulations 1999 was received from the Department of Environment and Resource, QLD for verification of GDA94 position on their Queensland Department of Environment and Resource Management CORS station monuments. This report documents the processing and analysis of GPS data observed by the Department of Environment and Resource Management CORS stations during a 7-day period from 15 August to 21 August 2010 (day of year 227 to 233) for 8 stations (BDST, DALB, GATT, IPS2, ROBI, TOOW, WARW and WOOL) from 24 April to 30 April 2011 (day of year 114 to 120) for 3 stations BEE2, CBLT, CLEV) to satisfy the position verification requirements.

Measurand:

Station position, at the time of measurement and stated instrumentation, of a GPS monument with respect to the Geocentric Datum of Australia (GDA94) referred to the GRS80 ellipsoid being in the ITRF92 reference frame at the epoch 1994.0.

Measurand Traceability:

Measurement traceability was ensured by comparing the computed solution against the recognised value standard for position of the Australian Fiducial Network stations. Additionally, the computed solution was checked against the ITRF based solutions computed by the IGS and the individual global analysis centres of the IGS. The validity and traceability of the entire GPS system was ensured via its link to the global Satellite Laser Ranging (SLR) and Very Long Baseline Interferometry (VLBI) observing networks through the ITRF. The validity and traceability of our internal computation processes were ensured by undertaking standard benchmark analysis prior to this analysis.

Measurand Uncertainty:

Position uncertainties were calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, *k*, of 2.

Type A uncertainty sources were evaluated by adopting an *a priori* sigma of **0.001** metre for the precision (1 sigma) of the L1-frequency, one-way, phase observation, at zenith. The corresponding uncertainties of all parameters were determined, by standard error propagation theory, in the least-squares estimation process used in the GPS analysis. Since the formal (internal) precision estimates of GPS solutions are well known to be optimistic, a factor of **10** (i.e. variance scale factor of 100) was subsequently applied to the variance-covariance matrix of the computed GDA94 coordinates.

Type B uncertainty sources, which in practice contribute to position uncertainty, cannot be estimated from the statistical analysis of short-period (i.e. 7-day) observations; these include environmental effects, such as long-period station loading (deformation) processes. Table 1 shows the major **Type B** uncertainty sources for GPS analysis.

Table 1. **Type B** uncertainty sources (95% C.L.) for position, determined from GPS, and the total uncertainty, assuming the normal distribution of the uncertainty sources, high degrees of freedom and a coverage factor, *k*, of 2.

Uncertainty Source	**Position Uncertainty Horizontal (mm)**	**Position Uncertainty Vertical (mm)**
Satellite orbits	5	10
Station deformation	5	15
Antenna phase centre	3	3
Monument stability	5	10
Reference Frame (ITRF)	3	5
Reference Frame (GDA94)	30	50
Total	**32**	**54**

GPS Data:

GPS RINEX data was supplied for eleven Department of Environment and Resource Management CORS stations spanning a 7-day period from 15 August to 21 August 2010 (day of year 227 to 233). Four character names of the stations are BDST, BEE2, CBLT, CLEV, DALB, GATT, IPS2, ROBI, TOOW, WARW and WOOL. Figure 1 shows the distribution of these stations. Table 2 lists the GPS receiver and antenna type at each site. The GPS receiver and antenna types, and GPS antenna heights to the Antenna Reference Point (ARP) as supplied in the amended summary file dated 25 August 2010 submitted with the application for verification of position have been adopted for the GPS data processing. The ARP is the reference point as defined by IGS and the RINEX specifications.

Figure 2 shows the AFN network sites used in the GPS data processing. Table 3 lists the GPS receiver and antenna type used in the GPS data processing for each of the AFN network sites. Table 4 lists the GPS antenna heights used in the GPS data processing for all sites.

GPS Data Irregularities:

A short GPS data set on 18 August 2010 (day of year 230) from the GPS station BEE2 was mentioned in the application letter. However, the analysis showed that the daily solution on that day for BEE2 wasn't irregular.

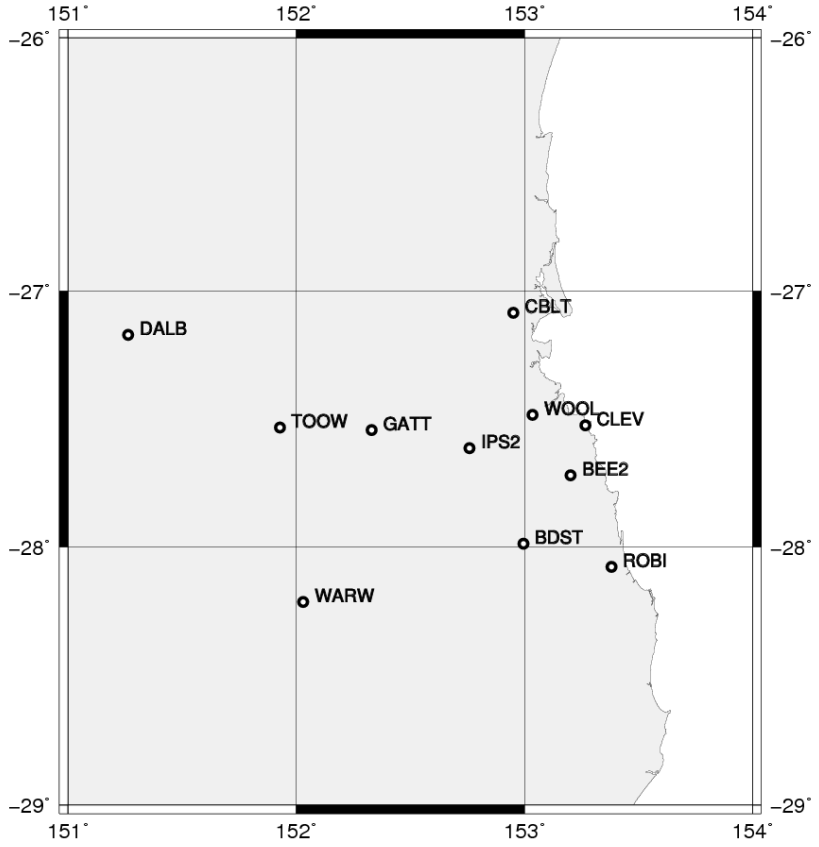

Figure 1: Department of Environment and Resource Management CORS stations used in GPS data processing.

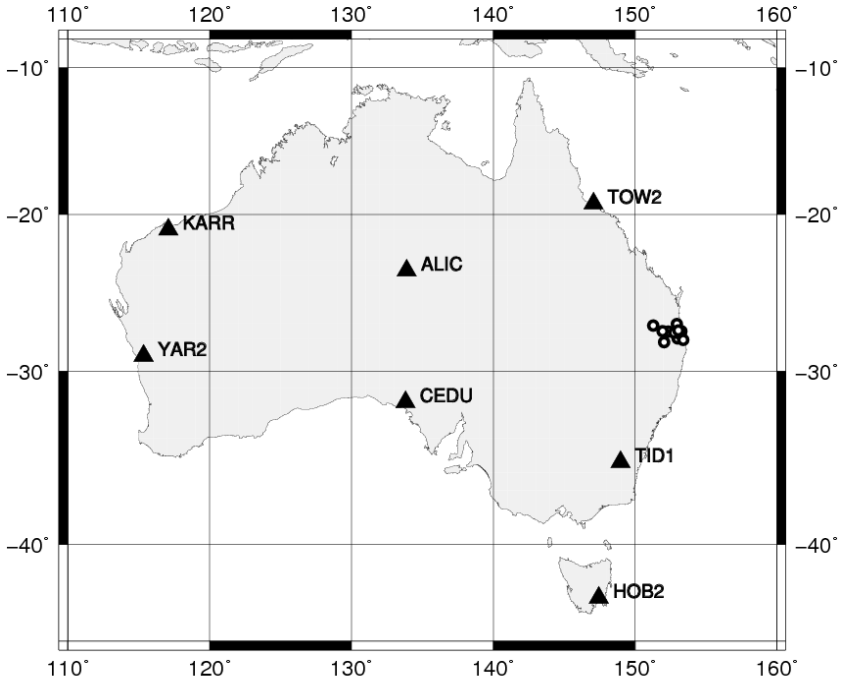

Figure 2: AFN (black triangles) stations used in GPS data processing.

Table 2: GPS receiver and antenna types for Department of Environment and Resource Management CORS stations.

QLD DERM CORS base station	4-char. ID	GPS receiver type	GPS antenna serial number	IGS antenna type and dome type
Beaudesert	BDST	LEICA GRX1200GGPRO	103226	LEIAT504GG NONE
Beenleigh	BEE2	TRIMBLE 4700	0220231946	TRM57971.00 NONE
Caboolture	CBLT	TRIMBLE NETR5	1440947134	TRM57971.00 NONE
Cleveland	CLEV	TRIMBLE NETR5	1440904813	TRM57971.00 NONE
Dalby	DALB	TRIMBLE NETR5	4822A53935	TRM59800.00 NONE
Gatton	GATT	TRIMBLE NETR5	30473612	TRM55971.00 NONE
Ipswich	IPS2	LEICA GRX1200GGPRO	103242	LEIAT504GG NONE
Robina	ROBI	LEICA GRX1200GGPRO	200712	LEIAT504GG NONE
Toowoomba	TOOW	LEICA GRX1200GGPRO	103231	LEIAT504GG NONE
Warwick	WARW	LEICA GRX1200GGPRO	200725	LEIAT504GG NONE
Woolloongabba	WOOL	TRIMBLE R7	0220164017	TRM29659.00 NONE

Table 3: GPS receiver and antenna types for the AFN sites.

GPS Network	4-char. ID	GPS receiver type	GPS antenna serial number	IGS antenna type and dome type
AFN	ALIC	LEICA GRX1200GGPRO	318	AOAD/M_T NONE
AFN	CEDU	ASHTECH UZ-12	194	AOAD/M_T AUST
AFN	HOB2	LEICA GRX1200GGPRO	203	AOAD/M_T NONE
AFN	KARR	TRIMBLE NETR8	53444	TRM59800.00 NONE
AFN	TIDB	ASHTECH UZ-12	205	AOAD/M_T JPLA
AFN	TOW2	LEICA GRX1200GGPRO	326	AOAD/M_T AUST
AFN	YAR2	ASHTECH UZ-12	371	AOAD/M_T JPLA

Table 4: GPS antenna heights to ARP used in GPS processing and site dome numbers.

QLD DERM CORS Site 4-char. ID	Domes number	Antenna height to ARP (M)	AFN site 4-char. ID	Domes number	Antenna height to ARP (M)
BDST	59981M001	0.0000	ALIC	50137M001	0.0070
BEE2	59980M001	0.0000	CEDU	50138M001	0.0060
CBLT	59979M001	0.0000	HOB2	50116M004	0.0000
CLEV	59978M001	0.0150	KARR	50139M001	0.0010
DALB		0.0060	TIDB	50103M108	0.0614
GATT	59977M001	0.0000	TOW2	50140M001	0.0035
IPS2	AUM000007	0.0000	YAR2	50107M004	0.0814
ROBI	59976M001	0.0000			
TOOW	59982M001	0.0000			
WARW		0.0030			
WOOL	50143M003	0.0000			

Method:

Analysis was undertaken following the procedures detailed in Geoscience Australia's GPS Analysis Manual for the Verification of Position Issue 1.5.

In summary, daily solutions of the Department of Environment and Resource Management CORS and AFN/ARGN/IGS/other site data were processed using Bernese GPS Processing Software version 5.0. The Bernese GPS Software conforms to the IERS2003 conventions. IGS final GPS satellite ephemerides and earth orientation parameters were used in the computations. The double difference carrier phase observables at 30-second epoch intervals were used for GPS data processing. Other measurement modelling and parameter estimation included:

- Receiver clock corrections.
- Absolute antenna elevation-dependent phase centre variation corrections.
- Solid earth tide displacements.
- Ocean loading displacements.
- Elevation cutoff of 10°for all observations.
- QIF integer ambiguity resolution strategy.
- Elevation dependent observation weighting.
- Troposphere zenith delays estimated at 1-hour intervals for all stations.
- Minimum constraint condition for daily network solution in terms of the ITRF2005 using subset of the IGS05 reference stations.

Daily solutions were combined to provide a weekly solution. This solution was transformed to GDA94 using a seven parameter transformation.

Results:

Table 5 lists the Root Mean Square (RMS) of the daily station coordinate values. Table 6 lists the GDA94 station coordinates resulting from the combination together with the position recognised-value standard GDA94 coordinates held fixed in the adjustment.

Table 5: Root Mean Square (RMS) of daily Department of Environment and Resource Management CORS and minimally constrained AFN (bold station names) station coordinates.

Station	North (mm)	East (mm)	Up (mm)	Station	North (mm)	East (mm)	Up (mm)
ALIC	0.9	0.6	3.7	BDST	1.4	0.7	7.1
CEDU	1.5	1.0	4.0	BEE2	0.9	1.3	4.3
HOB2	1.0	0.8	2.9	CBLT	0.8	1.4	4.3
KARR	0.3	0.4	2.6	CLEV	1.0	0.9	2.8
TIDB	2.9	3.6	3.8	DALB	0.8	0.9	2.9
TOW2	0.9	1.1	2.1	GATT	0.7	0.7	4.3
YAR2	0.6	0.7	4.1	IPS2	0.6	0.8	3.2
				ROBI	1.3	0.6	2.9
				TOOW	0.9	1.0	2.9
				WARW	0.6	0.6	2.9
				WOOL	1.1	1.1	4.4

Table 6: Computed Geocentric Datum of Australia (GDA94) geodetic coordinates and their uncertainty for the Department of Environment and Resource Management CORS stations. The uncertainties are calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, k, of 2.

Station	Longitude (DMS east)			Latitude (DMS south)			Ellipsoidal height (M)
			Std (M)			Std (M)	Std (M)
BDST	152	59	42.27826	27	59	13.56948	101.0977
			0.0315			0.0315	0.0544
BEE2	153	12	9.07846	27	43	13.21557	54.8085
			0.0315			0.0315	0.0544
CBLT	152	57	5.45863	27	5	3.97247	83.9408
			0.0315			0.0315	0.0544
CLEV	153	15	59.52253	27	31	34.17665	66.9984
			0.0315			0.0315	0.0544
DALB	151	15	49.65036	27	10	13.97521	394.6899
			0.0315			0.0315	0.0544
GATT	152	19	51.99971	27	32	38.17787	140.5840
			0.0315			0.0315	0.0544
IPS2	152	45	33.62949	27	36	53.76278	88.6529
			0.0315			0.0315	0.0544
ROBI	153	22	52.50844	28	4	37.08913	65.3012
			0.0315			0.0315	0.0544
TOOW	151	55	42.43299	27	32	4.00315	685.7784
			0.0315			0.0315	0.0544
WARW	152	1	49.40188	28	12	48.54181	507.4349
			0.0315			0.0315	0.0544
WOOL	153	2	6.96448	27	29	5.88829	91.0602
			0.0315			0.0315	0.0544

END OF REPORT