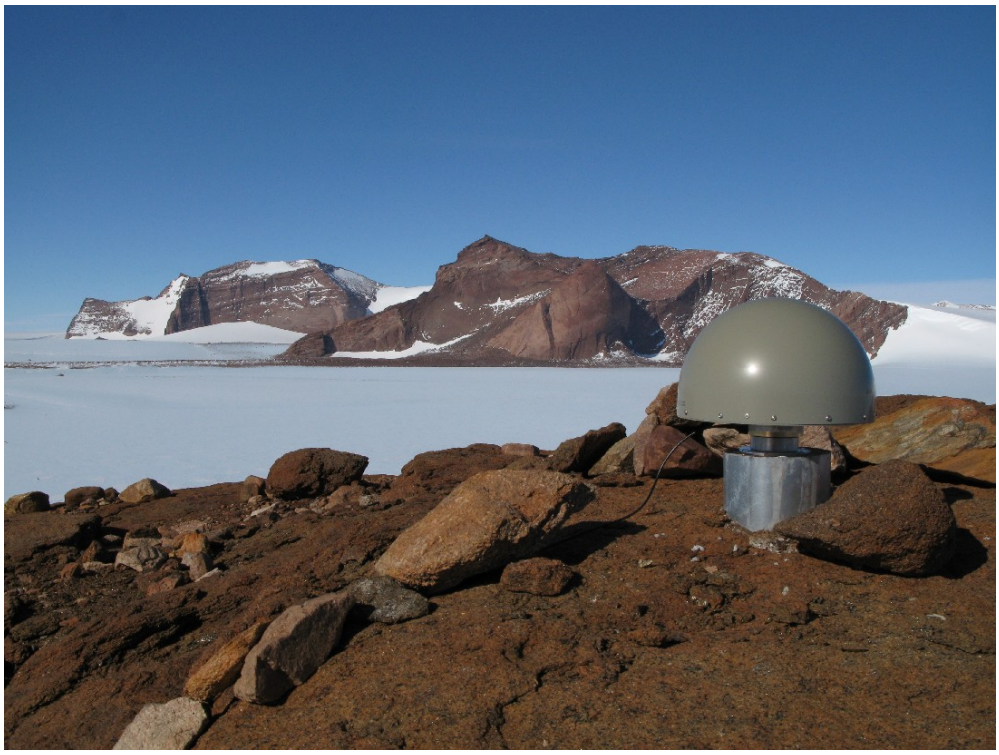
Antarctic Geodesy Field Report 2008/09



GEOSCIENCE AUSTRALIA
RECORD 2009/33

by

Ryan Ruddick, Alex Woods and Nick Brown[1]

Australian Government
Geoscience Australia

1. National Geospatial Reference Systems Project, c-/ Geoscience Austalia GPO Box 378 Canberra ACT 2601

Department of Resources, Energy and Tourism
Minister for Resources and Energy: The Hon. Martin Ferguson, AM MP
Secretary: Dr Peter Boxall

Geoscience Australia
Chief Executive Officer: Dr Neil Williams PSM

ISSN 1448-2177
ISBN web 9781921672262

GeoCat # 69571

Bibliographic reference: Ruddick, R., Woods, A. and Brown, N., 2009. Antarctic Geodesy Field Report 2008/09. Geoscience Australia, Record 2009/33. 118pp.

Contents

Executive Summary

During the 2008/09 Antarctic summer, Geoscience Australia surveyors undertook fieldwork at the Davis, Casey, Mawson and Macquarie Island research stations, as well as several remote sites in Eastern Antarctica. At each of the research stations, upgrades and local deformation monitoring surveys were performed at the continuously operating reference stations, which form part of the Australian Antarctic GNSS Network and the Australian Regional GNSS Network. Remote GPS sites in the Grove Mountains, Bunger Hills and Wilson Bluff were visited for equipment upgrades and data retrieval. Additional surveys were undertaken which focussed on enhancing the spatial infrastructure around the Larsemann Hills, Rauer Group, Vestfold Hills and Davis station. Support was also provided to a number of different Australian Antarctic Division projects and university research groups.

Introduction

During the 2008/09 Antarctic summer, Geoscience Australia surveyors, Ryan Ruddick and Alex Woods, undertook a comprehensive upgrade of each of the Australian Antarctic GNSS Network (AAGN) stations. Equipment upgrades were performed at the Casey, Davis, Mawson and Macquarie Island continuously operating reference stations (CORS), as well as remote sites in the Bunger Hills, Grove Mountains and Southern Prince Charles Mountains. Survey work was also undertaken to enhance the geodetic infrastructure across the Australian Antarctic Territory (AAT). This work included the coordination of GPS campaigns on targeted survey marks in the Larsemann Hills, Rauer Group and Vestfold Hills to improve coordinate precision, the transfer of orthometric height across survey networks in the Larsemann Hills and high precision surveys between survey marks at Davis, Casey and Macquarie Island station. Support was also provided to a number of other Australian Antarctic Division (AAD) and Australian National University (ANU) projects, including the observation of lake levels in the Vestfold Hills and the removal of GPS and seismic installations from Wilson Bluff, Dalton Corner, Landing Bluff and Beaver Lake.

AUSTRALIAN ANTARCTIC GEODETIC NETWORK

Geoscience Australia currently operates four CORS in the AAT that contribute to both the Australian Regional GNSS Network (ARGN) and the International GNSS Service (IGS), who inturn use the data to assist in the derivation of the International Terrestrial Reference Frame (ITRF). In addition to these four remote sites, remote GPS installations are also managed in the Grove Mountains, Bunger Hills and at Wilson Bluff and Mount Creswell in the Southern Prince Charles Mountains (Figure 1). Combined, these sites help to provide a reference frame for the Antarctic continent, and enable monitoring of the long-term movement of the Antarctic plate. Data from these sites is also made available for research into geophysical phenomena such as post-glacial rebound and global ice sheet modelling. In order to maintain the GNSS network, bi-annual visits are generally made to upgrade equipment and retrieve data (remote sites only).

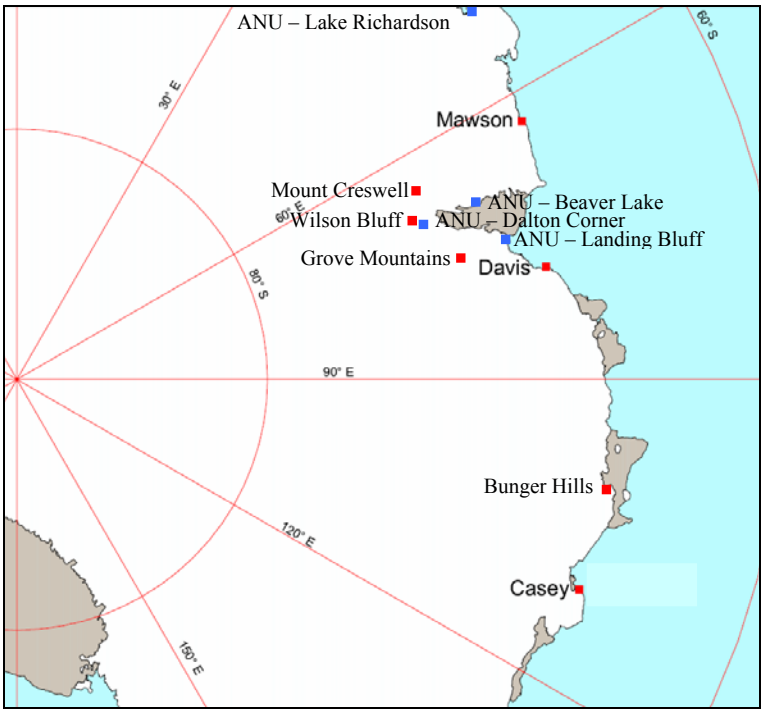


Figure 1: *Map showing the location of GA CORS and remote GPS sites in the AAT.*

Australian Regional GNSS Network

Geoscience Australia operates four CORS in the AAT at each of the Australian research stations. These sites contribute to both the ARGN and the IGS. During the 2008/09 summer upgrades were made to the equipment at all sites and local deformation monitoring surveys were undertaken at Casey, Davis and Macquarie Island. The purpose of the reference mark survey is to monitor for local deformation at the site and is intended to support the distinction of localised site deformation from large-scale continental movement.

CASEY

The Casey (CAS1) GNSS site was visited twice during the 2008/09 season; first by Ryan Ruddick and Alex Woods and then by Nick Brown. During these visits the equipment was upgraded to fit within the standard ARGN equipment model, and a reference mark monitoring survey was undertaken.

Equipment Upgrade

The Casey ARGN equipment is located in the Summer Logistics Room of the Operations Building and the GPS antenna is approximately 200m to the south west. The stations communication and technical officer is the local contact and routinely monitors the state of the equipment. The 2009 winter contact is Ian Phillips (ian_phi@casey.aad.gov.au or ext. 8809). A request has been made to move the ARGN equipment from the Summer Logistics Room into the main communications rack – this request has been approved and should occur during the 2009 winter. Ryan Ruddick and Alex Woods undertook the equipment upgrade on the 3rd of December 2008, with the major change being the installation of a *Leica* GRX1200GG Pro receiver. Details of the Casey installation are provided in Figures 2 and 3.

Figure 2: *Casey GNSS Equipment Rack from the front (left) and back (right) (December 2008).*

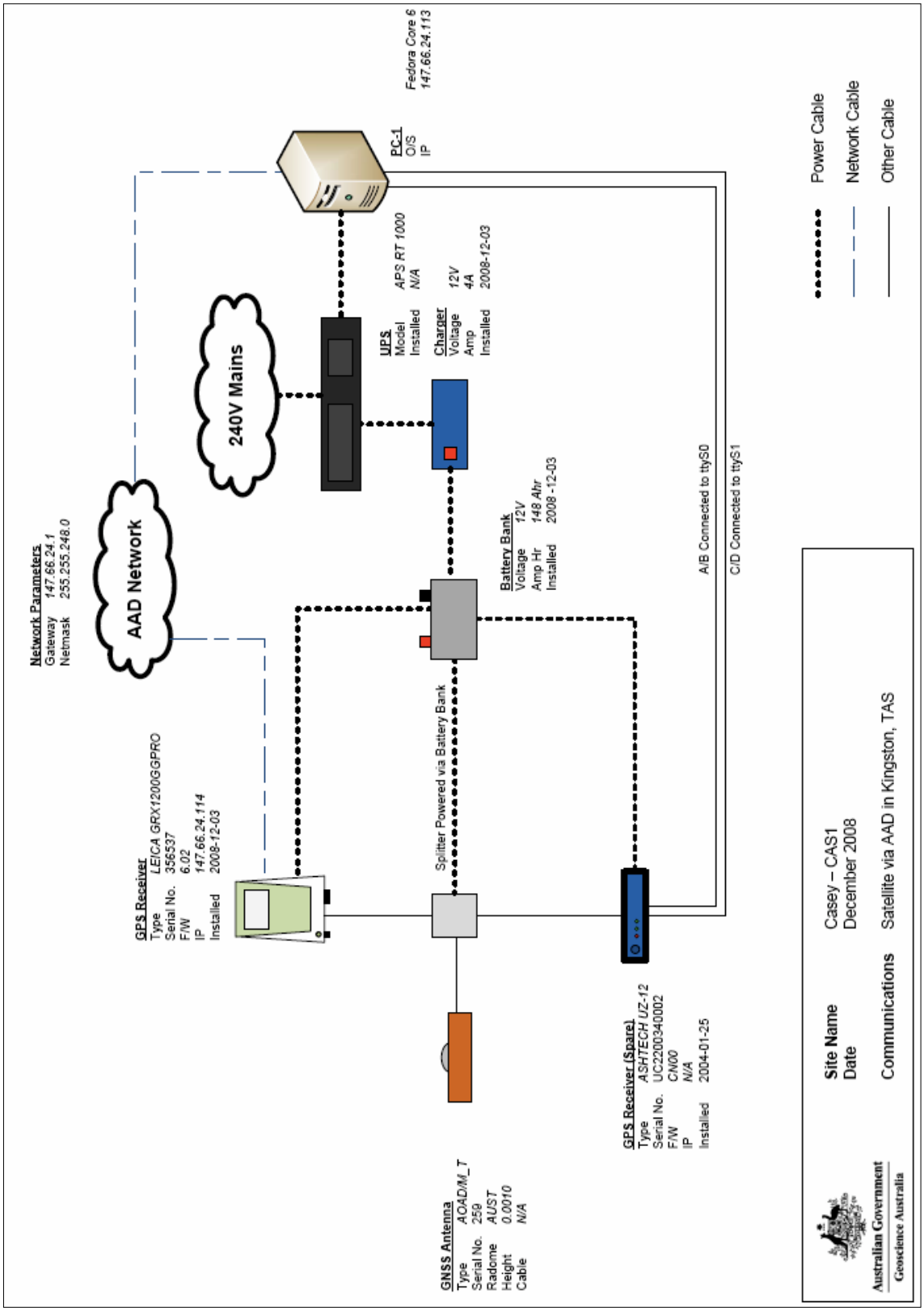


Figure 3: *Casey ARGN Equipment Diagram (December 2008).*

Reference Mark Survey

A reference mark monitoring survey was conducted at the Casey ARGN site (AUS100) on the 4th February 2009 by Nick Brown. The survey was performed using a Leica TCA1800 and the method described in Appendix A, with observations made between AUS100 and the three RMs. To set the instruments up over the AUS100 survey monument the antenna and dome had to be removed. The dome was unscrewed from its connection onto the survey plate and set aside. The GNSS antenna orientation was noted before the antenna was disconnected and unscrewed from the plate. In addition, the GNSS antenna had one shim underneath it of 1mm thickness. After the survey the antenna and shim were repositioned and the antenna was directed on the same alignment (0° True). The dome was refitted and sealed with silicon.

Survey Results

The reference mark survey observations were run through the least squares survey network adjustment program (GeoLab 2.4d). Observation precisions were specified based on previous experience with the instrumentation and survey techniques applied. Vertical and horizontal angle precision of 1 second, slope distance precision of 1mm + 1ppm, levelling precision of 0.2mm and azimuth error of 0.1 seconds were applied. The network was fixed using the known ITRF2000@2000.00 coordinates of AUS100 from the Antarctic Geodesy 2000/01 Casey report (Johnston & Digney, 2001) and was aligned with an azimuth to AUS100 RM1 (derived using coordinates supplied in 2000/01 report). These coordinates were set upon the GRS80 reference ellipsoid.

Table 1: *Latitude, longitude and ellipsoidal height with standard deviations for the reference marks from the 2009 survey. GRS80 ellipsoid and ITRF2000 at epoch 2000.0 coordinates are adopted for AUS100 from the 2001 survey for comparison. Uncertainties are in millimetres and ellipsoidal heights are given in metres.*

MARK	LATITUDE	σ	LONGITUDE	σ	HEIGHT (ELLIP)	σ
AUS100	-66 17 00.09240	0.0	110 31 10.94090	0.0	22.4630	0.0
RM1	-66 16 59.91304	0.1	110 31 11.91102	0.2	21.6922	0.0
RM2	-66 17 00.36749	0.2	110 31 11.56014	0.2	21.3643	0.0
RM3	-66 16 59.91044	0.2	110 31 10.36704	0.2	23.1410	0.0

Table 2: *Latitude, longitude and ellipsoidal height with standard deviations for the reference marks from the 2001 survey. GRS80 ellipsoid and ITRF2000 at epoch 2000.0 coordinates are adopted for AUS100 from the 2001 survey for comparison. Uncertainties given are in millimetres and ellipsoidal heights are given in metres.*

MARK	LATITUDE	σ	LONGITUDE	σ	HEIGHT (ELLIP)	σ
AUS100	-66 17 00.09240	0.0	110 31 10.94090	0.0	22.4630	0.0
RM1	-66 16 59.91304	0.2	110 31 11.91100	0.2	21.6930	0.0
RM2	-66 17 00.36752	0.2	110 31 11.55989	0.2	21.3644	0.0
RM3	-66 16 59.91039	0.2	110 31 10.36703	0.2	23.1406	0.0

Orthometric heights (MSL reduced levels) were derived for each of the survey marks relative to the RAN 1991 MSL of HBM1 (7.171m). A comparison of the orthometric height differences observed between AUS100 and each of it's RMs is shown in Table 3.

Table 3: *Comparison of orthometric height differences between the ARGN pillar and the reference marks observed between 2001 and 2009.*

AUS100 TO ...	2001	2009	RL (40.8824)
RM1	-0.7700	-0.7709	40.1115
RM2	-1.0984	-1.0987	39.7837
RM3	0.6774	0.6780	41.5604

The results show relatively good agreement between the consecutive reference mark surveys.. Height differences agree at the 1mm level and horizontal positions are also markedly similar. The longitudinal position of RM2 appears to have decreased between surveys. This should continue to be monitored although it would seem there has not been any significant vertical or horizontal movement at the ARGN station.

DAVIS

The Davis (DAV1 and DAVR) ARGN site was visited between January and February 2009 by Ryan Ruddick and Alex Woods. During this visit the equipment was upgraded to fit within the standard ARGN equipment model, and a reference mark survey was performed.

Equipment Upgrade

The Davis ARGN equipment is located in the Atmospheric and Space Physics Building and the GPS antenna is approximately 100m to the south east in the magnetic quiet zone (MQZ). The station communication and technical officer is the local contact and routinely monitors the state of the equipment. The 2009 winter contact is Dave Davies (david_dav@davis.aad.gov.au or ext. 6609). The equipment upgrade was undertaken on the 7th of January 2009, with the major change being the installation of a *Leica* GRX1200GG Pro receiver on DAV1. Davis installation specifics are detailed in the setup diagram provided in Figures 4 and 5. Due to a new *Paroscientific* MET3 cable not being delivered in time the *Ashtech* UZ-12 (previously DAV1) was left in place as a spare receiver and to interface with the meteorological sensor. The need for a separate GLONASS receiver (DAVR) is no longer required but it has been left in place as German researchers are using it for an ionospheric experiment that requires the native T01 real-time stream. A small chip was found in the windward side of the GPS antenna dome, this was repaired using silicon and should be replaced during a future visit. There are also significant signs of abrasion on the windward side of the dome.

***Figure 4*:** Davis GNSS Equipment Rack (Front and Back) (February 2009)

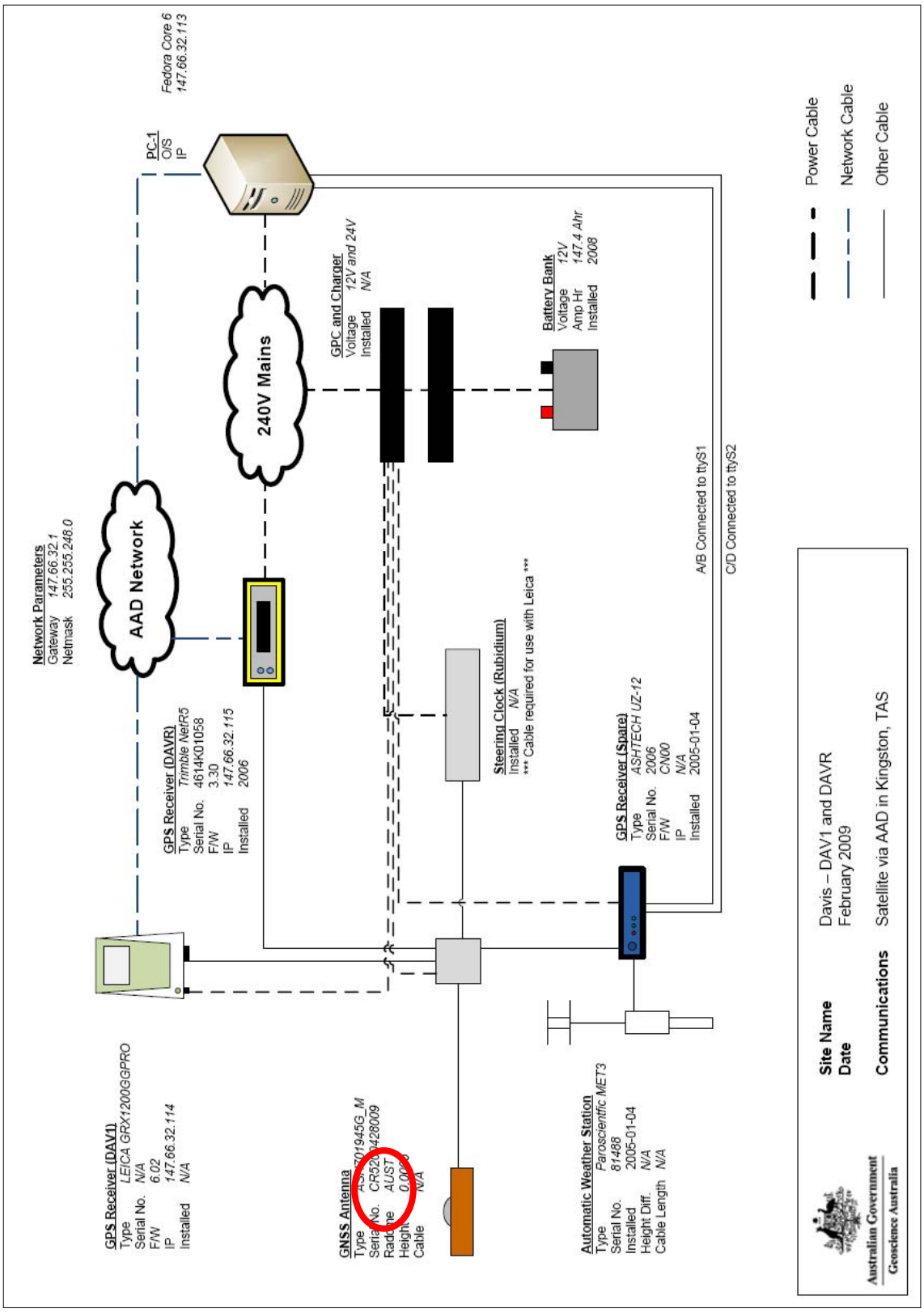


Figure 5: *Davis ARGN Equipment Diagram (February 2009)*

Reference Mark Survey

A reference mark survey was conducted at the Davis ARGN site on the 30th of January 2009 in near nil-wind conditions. The survey was performed using the method described in Appendix A with observations made between AUS099 and the three RMs. To set the instruments up over the AUS099 survey monument the antenna and dome had to be removed. The dome was unscrewed from its connection onto the survey plate and set aside. The GNSS antenna orientation was noted before the antenna was disconnected and unscrewed from the plate. In addition, the GNSS antenna had one shim underneath it of 0.5mm thickness. After the survey the antenna and shim were repositioned and the antenna was directed on the same alignment (0° True). The dome was refitted and sealed with silicon.

Survey Results

The reference mark survey observations were run through the least squares survey network adjustment program (SNAP). Observation precisions were specified based on previous experience with the instrumentation and survey techniques applied. Vertical and horizontal angle precision of 1 second, slope distance precision of 1mm + 1ppm, levelling precision of 0.2mm and azimuth error of 0.1 seconds were applied. The network was fixed using the known ITRF2000@2000.00 coordinates of AUS099 from the Antarctic Geodesy 2000/01 report (Johnston & Digney, 2001) and was aligned with an azimuth to AUS099 RM1 (derived using coordinates supplied in 2000/01 report). These coordinates were set upon the GRS80 reference ellipsoid.

Table 4: *Latitude, longitude and ellipsoidal height with standard deviations for the reference marks from the 2009 survey. GRS80 ellipsoid and ITRF2000 at epoch 2000.0 coordinates are adopted for AUS099 from the 2001 survey for comparison. Uncertainties are in millimetres and ellipsoidal heights are given in metres.*

MARK	LATITUDE	σ	LONGITUDE	σ	HEIGHT (ELLIP)	σ
AUS099	-68 34 38.36207	0.0	77 58 21.40903	0.0	44.4160	0.0
RM1	-68 34 36.94420	0.2	77 58 21.69995	0.0	42.0891	0.1
RM2	-68 34 38.69743	0.2	77 58 22.27438	0.0	43.9720	0.0
RM3	-68 34 38.63382	0.1	77 58 21.17214	0.0	43.4683	0.0

Table 5: *Latitude, longitude and ellipsoidal height with standard deviations for the reference marks from the 2007 survey. GRS80 ellipsoid and ITRF2000 at epoch 2000.0 coordinates are adopted for AUS099 from the 2001 survey for comparison. Uncertainties given are in millimetres and ellipsoidal heights are given in metres.*

MARK	LATITUDE	σ	LONGITUDE	σ	HEIGHT (ELLIP)	σ
AUS099	-68 34 38.36207	0.0	77 58 21.40903	0.0	44.4160	0.0
RM1	-68 34 36.94417	0.4	77 58 21.69996	0.0	42.0895	0.1
RM2	-68 34 38.69745	0.4	77 58 22.27439	0.2	43.9723	0.0
RM3	-68 34 38.63385	0.3	77 58 21.17207	0.1	43.4687	0.0

Table 6: *Latitude, longitude and ellipsoidal height with standard deviations for the reference marks from the 2001 survey. Coordinates are given in reference to the GRS80 ellipsoid and ITRF2000 at epoch 2000.0. Uncertainties given are in millimetres and ellipsoidal heights are given in metres.*

MARK	LATITUDE	σ	LONGITUDE	σ	HEIGHT (ELLIP)	σ
AUS099	-68 34 38.36207	0.0	77 58 21.40903	0.0	44.4160	0.0
RM1	-68 34 36.94416	0.4	77 58 21.69996	0.5	42.0894	0.2
RM2	-68 34 38.69741	0.3	77 58 22.27440	0.3	43.9718	0.1
RM3	-68 34 38.63380	0.3	77 58 21.17200	0.1	43.4684	0.1

A misclosure of 0.2mm was obtained in the 2009 level survey, well within zero-order specifications. This indicated that the height difference observations were very precise and that no gross errors were made during the survey. Orthometric heights (MSL reduced levels) were derived for each of the survey marks relative to the 1983 MSL of NMV/S/4 (2.179m). A comparison of the orthometric height differences observed between AUS099 and each of it's RMs is shown in Table 7.

Table 7: *Comparison of orthometric height differences between the ARGN pillar and the reference marks observed between 1996 and 2009.*

AUS099 TO ...	1996	2001	2005	2007	2009	RL (27.8629)
RM1	-2.3270	-2.3271	-2.3266	-2.3265	-2.3269	25.5358
RM2	-0.4440	-0.4440	-0.4435	-0.4437	-0.4440	27.4187
RM3	-0.9480	-0.9485	-0.9474	-0.9473	-0.9477	26.9150

The results show very good agreement between the consecutive reference mark surveys, with discrepancies within the precision of the measurements. Height differences agree at the 1mm level and horizontal positions are also markedly similar. The longitudinal position of RM3 appears to be increasing with each survey epoch. This should continue to be monitored although it would seem there has not been any significant vertical or horizontal movement at the ARGN station. It is also noted that care should be taken when comparing the results between separate years as different adjustment software packages have been used.

MACQUARIE ISLAND

The Macquarie Island (MAC1) ARGN site was visited during March 2009 by Ryan Ruddick and Alex Woods. During this visit the equipment was upgraded to fit within the standard ARGN equipment model, and a reference mark survey was undertaken.

Equipment Upgrade

The Macquarie Island ARGN equipment is located in the Science Building and the GPS antenna is approximately 25m to the north on a large rock. The station communication and technical officer is the local contact and routinely monitors the state of the equipment. The 2009 winter contact is Brett (macca_comms@macca.aad.gov.au). The equipment upgrade was undertaken on the of 21st March 2009, with the major change being the installation of a *Trimble NetR5* receiver. Macquarie Island installation specifics are detailed in the setup diagram provided in Figures 6 and 7.

Figure 6: *Macquaire Island GNSS Equipment Rack (Front and Back) (March 2009)*

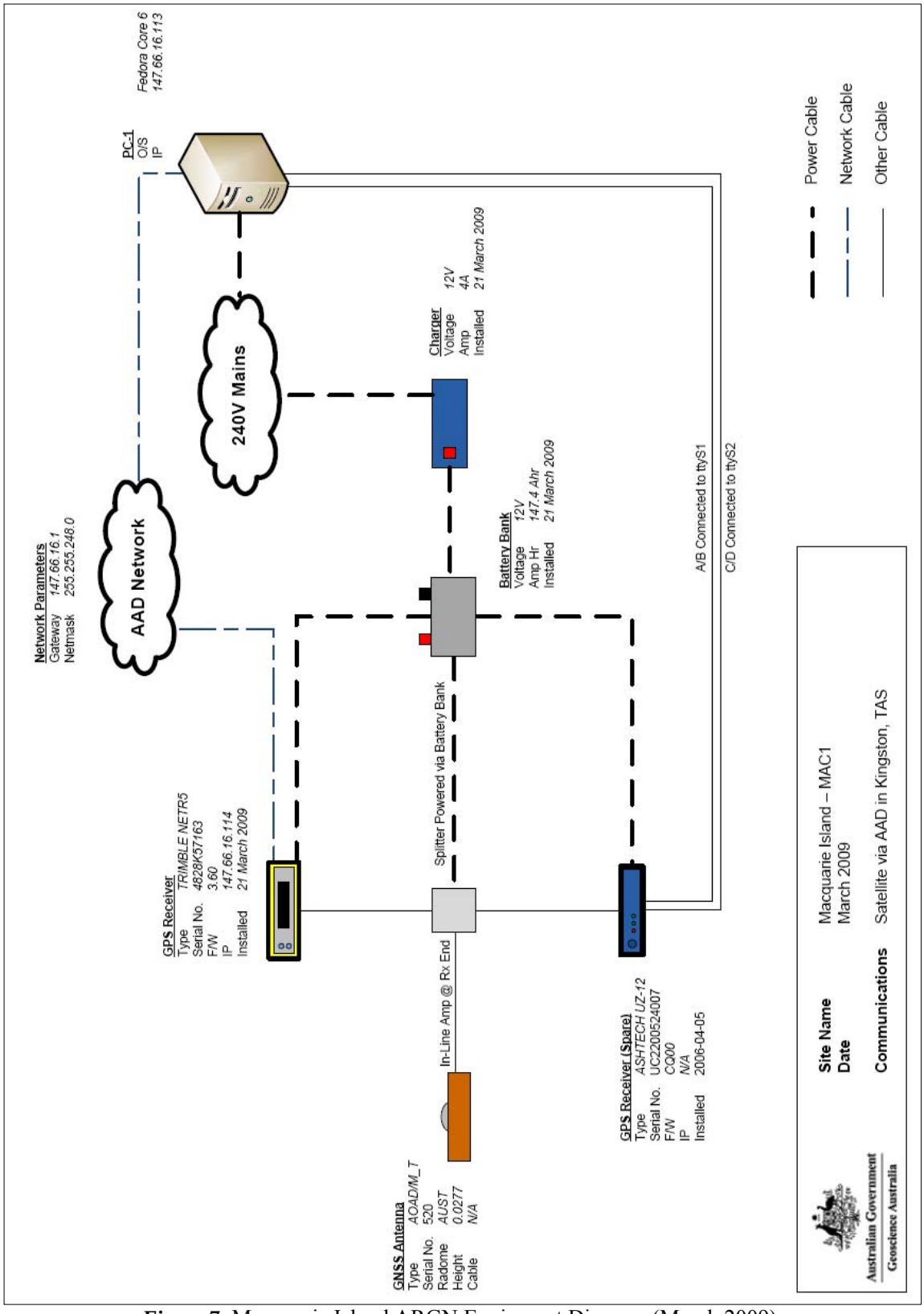


Figure 7: Macquarie Island ARGN Equipment Diagram (March 2009)

Reference Mark Survey

A reference mark survey was conducted at the Macquarie Island ARGN site on the 20th of March 2009 in slightly windy conditions. The ARGN station (AUS211) is located to the west of the station and is surrounded by three reference marks, NMX/RM1, RM3 and RM4. There are several survey marks connected with the GPS antenna pillar (AUS211 HT RM1, AUS211 HT RM2, AUS211 Spigot). The GPS antenna is positioned directly over the top of the AUS211 spigot, however, the height for AUS211 is recognized as the height of AUS211 HT RM1. The survey was performed using the method described in Appendix A with observations made between the three RMs and to a target placed over the AUS211 spigot. It was not possible to setup a tribrach over the AUS211 spigot due to the design of the pillar. Rather, a small stainless steel stub mount with a prism was attached to the AUS211 monument so direct observations could be made to the AUS211 spigot. The total station was not setup over AUS211, reducing the redundancy of the RM survey. Further, it should be noted that the line between RM3 and RM4 is obstructed and could not be observed.

To directly observe the survey marks on the AUS211 GPS pillar the antenna and dome had to be removed (Figure 8). The dome was unscrewed from its connection onto the survey plate and set aside. A small allen key and knife were required to unscrew the connections and remove the silicon at the base of the dome. The height of the GPS antenna was observed before removal and again when re-attached to ensure there was no change in antenna height after moving the antenna. The GPS antenna orientation was also noted before the antenna was disconnected and unscrewed from the plate. A shifter was used to disconnect the antenna and holding mount from the bracing rods. After the survey the antenna was repositioned and the antenna was directed on the same alignment. The dome was refitted and sealed with silicon.

GPS Antenna Reference Point Height

The GPS antenna had to be removed to perform the reference mark survey. Due to the design of the GPS pillar, care had to be taken to ensure the height of the GPS antenna reference point (ARP) did not change. The height of the GPS antenna was observed before and after movement of the antenna, to monitor for any height displacement (Table 8).

Table 8: *Height of Antenna before and after the removal of GPS Antenna*

Before	Height of antenna (top of choke ring) above AUS211 HT RM2	1.3290 m
After	Height of antenna (top of choke ring) above AUS211 HT RM2	1.3291 m

The height of the antenna has not changed and the difference of 0.1 mm is within the leveling errors.

Figure 8: *Macquarie Island ARGN GPS antenna, dome and bracing mount*

Survey Results

The reference mark survey observations were run through the least squares survey network adjustment program (SNAP) to determine final coordinates, and also to evaluate the quality of the measurements. Observation precisions were specified based on previous experience with the instrumentation and survey techniques applied. Vertical and horizontal angle precision of 0.8 second, slope distance precision of 0.4mm + 1ppm, levelling precision of 0.2mm and azimuth error of 0.1 seconds were applied. The network was fixed using the known ITRF1997@1997.00 coordinates of AUS211 and aligned with the computed azimuth between RM3 and AUS211 of 207º 32' 08.4085" (derived using coordinates supplied in 2002 survey report). These coordinates were set upon the GRS80 reference ellipsoid. The orthometric heights were derived with respect to the Macquarie Island mean sea level (MSL) height determined for benchmark AAE BM1 RM2 (2.598m).

Table 9: *Latitude, longitude and orthometric height with standard deviations for the reference marks from the 2009 survey. ITRF1997 coordinates at epoch 1997.0 (GRS80 ellipsoid) were adopted for AUS211 from the 2002 survey for comparison. Uncertainties are in millimetres and orthometric heights are given in metres.*

MARK	LATITUDE	σ	LONGITUDE	σ	HEIGHT (ORTHO)	σ
AUS211	-54° 59' 58.318110"	0.0	158 ° 56' 09.001370"	0.0	12.8810	0.0
NMX/RM1	-54° 29' 57.288919"	0.2	158 ° 56' 08.355393"	0.1	9.1631	0.1
RM3	-54° 29' 56.611377"	0.2	158 ° 56' 10.530195"	0.0	5.5995	0.1
RM4	-54° 29' 59.427022"	0.3	158 ° 56' 10.736696"	0.2	5.8413	0.1

Table 10: *Latitude, longitude and orthometric height with standard deviations for the reference marks from the 2006 survey. GRS80 ellipsoid and ITRF1997 at epoch 1997.0 coordinates are adopted for AUS211 from the 2002 survey for comparison. Uncertainties are in millimetres and orthometric heights are given in metres.*

MARK	LATITUDE	σ	LONGITUDE	σ	HEIGHT (ORTHO)	σ
AUS211	-54° 59' 58.31811"	0.0	158 ° 56' 09.00137"	0.0	12.8813	0.0
NMX/RM1	-54° 29' 57.28896"	0.3	158 ° 56' 08.35536"	0.2	9.1627	0.2
RM3	-54° 29' 56.61136"	0.2	158 ° 56' 10.53019"	0.1	5.5990	0.3
RM4	-54° 29' 59.42701"	0.4	158 ° 56' 10.73665"	0.4	5.8409	0.3

A misclosure of 0.1mm was obtained in the 2009 level survey, well within zero-order specifications. This indicated that the height difference observations were very precise and that no gross errors were made during the survey. A comparison of the orthometric height differences observed between AUS211 and each of the RMs, from 1996 to 2009, is shown in Table 11.

Table 11: *Comparison of orthometric height differences between the ARGN pillar and the reference marks observed between 1996 and 2009. All units are in metres*

AUS211 HT RM1 TO	1996	1998	2002	2006	2009	RL (12.8810)
AUS211 HT RM2	-1.2020	-1.2020	-1.2020	-1.2003	-1.1993	11.6817
RM3	-	-	-7.2850	-7.2823	-7.2815	5.5995
RM4	-	-	-7.0430	-7.0405	-7.0397	5.8413
NMX/RM1	-3.7220	-3.7220	-3.721	-3.7187	-3.7179	9.1631

The results show generally good agreement between the consecutive reference mark surveys. The heights observed in 2009 and 2006 differ by approximately 1mm. This is attributed to the height difference between AUS211 HT RM1 and AUS211 HT RM2 being 1mm different. There may have been error in the 2006 survey when applying corrections for the different heighting rods on the two reference marks. The height differences from the AUS211 HT RMs to the three surrounding RMs

seem to be progressively decreasing. This may imply that the large isolated rock, which the GPS antenna pillar is setup on, may be sinking into the surrounding wallow.

It was not possible to setup a total station of the AUS211 spigot in 2009. Therefore, observations were not made from AUS211 to each of the RMs, reducing the redundancy in the survey. The 2009 RM survey relies on the intersection of observations from the RMs to AUS211. The reduced number of observations in the 2009 introduce uncertainty when comparing survey results against previous years. There is generally close agreement between final coordinates obtained in the 2009 and 2006 surveys. Differences are noted as being within the precision of the observations. It is also noted that care should be taken when comparing the results between separate years as different adjustment software packages have been used.

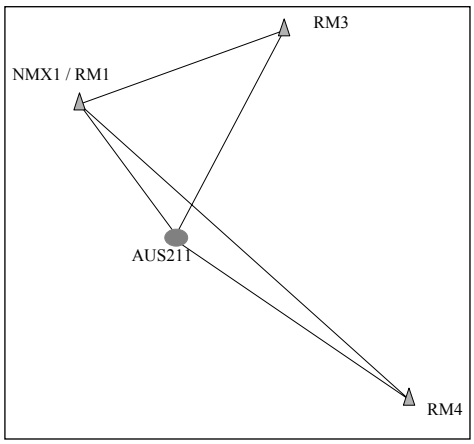


Figure 9: *Macquarie Island RM Survey network*

MAWSON

The Mawson (MAW1) ARGN site was not visited by Geoscience Australia officers during the 2008/09 season. Kym Newberry from the Australian Antarctic Division undertook some minor equipment upgrades. No reference mark survey was undertaken.

Equipment Upgrade

The Mawson ARGN equipment is located in the Cosray Building and the GPS antenna is positioned 50m to the south west, in the materials free zone. The station communication and technical officer is the local contact and routinely monitors the state of the equipment. The communications officier can be contacted on (mawson_comms@mawson.aad.gov.au). The equipment upgrade was undertaken on the 5th of January 2009, with the major change being the installation of a *Leica* GRX1200GG Pro receiver. The Mawson GNSS equipment details are provided in figure 10.

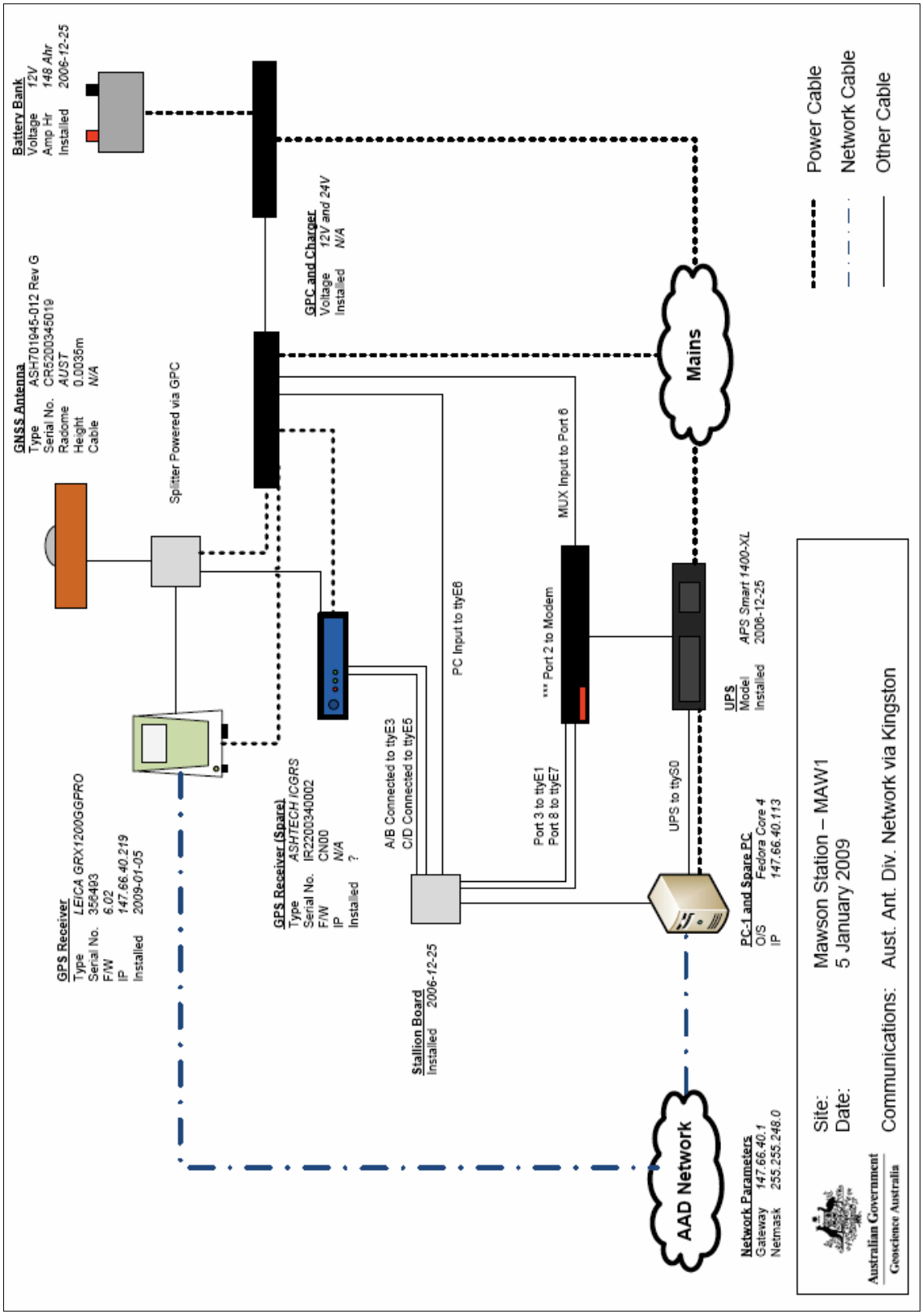


Figure 10*: *Mawson ARGN Equipment Diagram (January 2009).

Geoscience Australia Deep Field GPS Sites

Geoscience Australia operates four CORS in remote areas of Eastern Antarctica. The sites are located in the Grove Mountains, Bunger Hills and the Southern Prince Charles Mountains at Mt Creswell and Wilson Bluff. The data collected at these sites is combined in network processing routines, enhancing the density of GPS sites across the AAT. This data also enables research into plate motion and the response of the Earth's crust to ice-loading or unloading.

REMOTE SITE DESIGN

Continuous operation of GPS sites in Antarctica is difficult, particularly in the winter months when there is little or no sunlight available for solar energy. Sites need to be well designed to withstand the strong winds and overcome the extreme cold. Previously, remote sites were powered during winter using *Air Industrial* wind turbines. These worked occasionally, but generally the wind turbines failed and were destroyed. This season a new system was designed and installed at the Grove Mountains and Wilson Bluff.

Structural System

During the winter months the remote sites experience strong winds, which have at times blown over or snapped the structures that house the equipment boxes and support the solar panels. To overcome this, a new structure was designed and built by *Baxter Engineering* in Canberra. The structure was designed with a stable footprint of 1.6 x 1.6m and enclosed on the windward side (south) by aluminium panels angled at 60 degrees the leeward side (north) holds three solar panels also at 60 degrees to pick up sunlight low on the horizon. The base is slightly elevated to reduce snow build-up. Mounts on either side of the structure allow for the addition of an iridium antenna or vertical axis wind turbine (5/8" spigot). A large insulated space-case contains all of the equipment, including the batteries and rests on a mesh grid within the frame. The structure weighs 55kg and can be put together with a 13mm ratchet spanner.

***Figure 11**: Solar panel frame structure, as installed at the Grove Mountains (December2009).*

Power System

A *Plasmatronics* PL20 regulator controls the power, provided by three 60W solar panels and a 12V 296Ahr battery bank. The regulator is programmed (Figure 12) to restrict the flow of power to the battery bank during the intense solar periods of the summer and monitor the batteries during the winter months, switching off the load when the voltage drops to 11.1V. The load is disconnected preserving charge in the batteries until the solar system charges the battery voltage to 12.6V. This protects the batteries from being drained completely, leaving some charge so that they can recover when there is sufficient sunlight after winter. The system is designed to support wind turbines, such as *Forgen* 500 vertical axis wind turbines, however, none were installed in the 2008/09 season. It is encouraged that such wind turbines be incorporated into the setup in future expeditions.

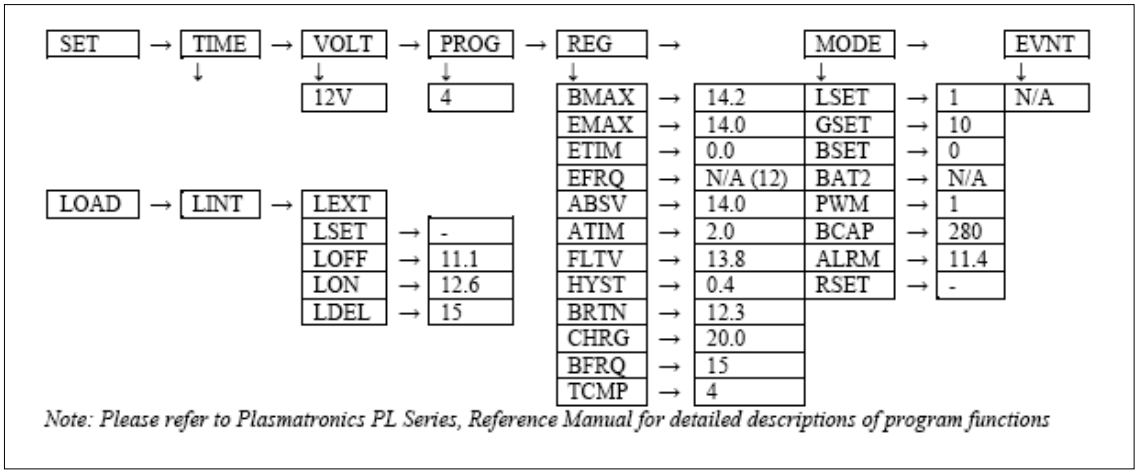


Figure 12: *Configuration of Plasmatronics PL20 regulator.*

Communication System

The expense of transmitting data back to Australia has prevented download of data via satellite. Rather, the system has been setup to allow communication to the remote systems using iridium satellite to check on system status, but not download data. Data is retrieved every two to three years when maintenance and upgrades are undertaken on site. Each remote site is equipped with a NAL Research AL3A-MPT iridium modem, which is connected to Port 1 of the *Leica* GRX1200 Pro GPS receiver by a *Leica* GEV-162 Lemo to 9 Pin serial and M-M null modem cable. The modem is configured with the following AT commands:

AT S0=1 K3 D3 +IPR=6 &W &Y &X

BUNGER HILLS

The Bunger Hills GPS site is located approximately 275 m south west from the Edgeworth David apple huts. The site was installed during December 2006 and has not been visited by Geoscience Australia surveyors since. GA surveyors were again unable to visit the site this season but the CASA C212 made several visits over the summer. The pilots and support personnel from Casey evaluated the site operation. Prior to each visit instructions were passed onto the pilots on how to retrieve the data card and re-establish the site to operation status. After several visits it was decided that the batteries were dead and that the site equipment (GPS receiver) be retrieved for return to Australia (RTA)

Site Assessment

Robb Clifton (AAD) made the first site visit, with instruction to replace the data card in the receiver and check the status of all equipment. On inspection the site was found to be non-operational.

We checked the GA site at Bunger hills yesterday, 8/12/08. The Leica GPS was not showing any signs of power. The data card was changed and the power cable removed and replaced as per the instruction, however, this was to no effect on the power situation. Terminal connections on the batteries were checked as were cable entries into the box and all appeared in order. The wind generator appears not to be functioning, with the turbine/bearing feeling loose where it enters the main housing. All the blades are still fixed and in good condition. The remaining equipment all appeared in very good condition. The retrieved data card has been sent to the Geoscience Australia surveyors.

Alistair Wallach (*Sky Traders*, C212 Pilot) made the second visit, with instruction to check battery voltages and remove any faulty batteries. On inspection all batteries were found to not be holding charge.

After taking the multimeter to Bunger Hills with us on 13/12, the readings that we got across each of the batteries of approximately 13.6V. The amps that we read going into the GPS recording unit were extremely low, around the 0.1 A mark. After disconnecting then reconnecting the power to the unit, there was a brief sign of life with the power light illuminating momentarily and then going out again.

Also noteworthy was the condition of the wind turbine situated adjacent to the site. At the time of this second visit wind was light but the turbine still had not turned itself in to whatever wind was there. On closer inspection, the propeller hub appeared to be off centre and when spun showed this to be the case. It seems that the bearings of the hub have given out which would explain the turbines inability to charge the batteries.

Figure 13: *Bunger Hills GPS site taken during site visit 2 (2008/09).*

Equipment Upgrade

Given that the power system for the site was faulty the decision was made to remove the *Leica* GRX1200 Pro GPS receiver, NAL Iridium modem, solar panels, expired batteries and equipment boxes for RTA. This was done during a third visit to the site on 31 December 2009. The removed equipment was sent back to Canberra on Voyage 4. The wind turbine, wind turbine frame and solar panel frame were left on site.

Recovered Data

The data card from the Bunger Hills was recovered during the first site visit. It was discovered that the data was recorded in hourly files and that the *Leica* did not create a new file for each year, hence each hourly file had data from multiple years concatenated to it. This made RINEX file creation a hassle (scripts to do this have been written and are contained on the included CD). From the data recovered it appears that the GPS site ran for most of 2007 and most of 2008, where during the winter it is assumed that the wind turbine was destroyed and the batteries drained completely. Figure 14 shows the days for which data was recovered.

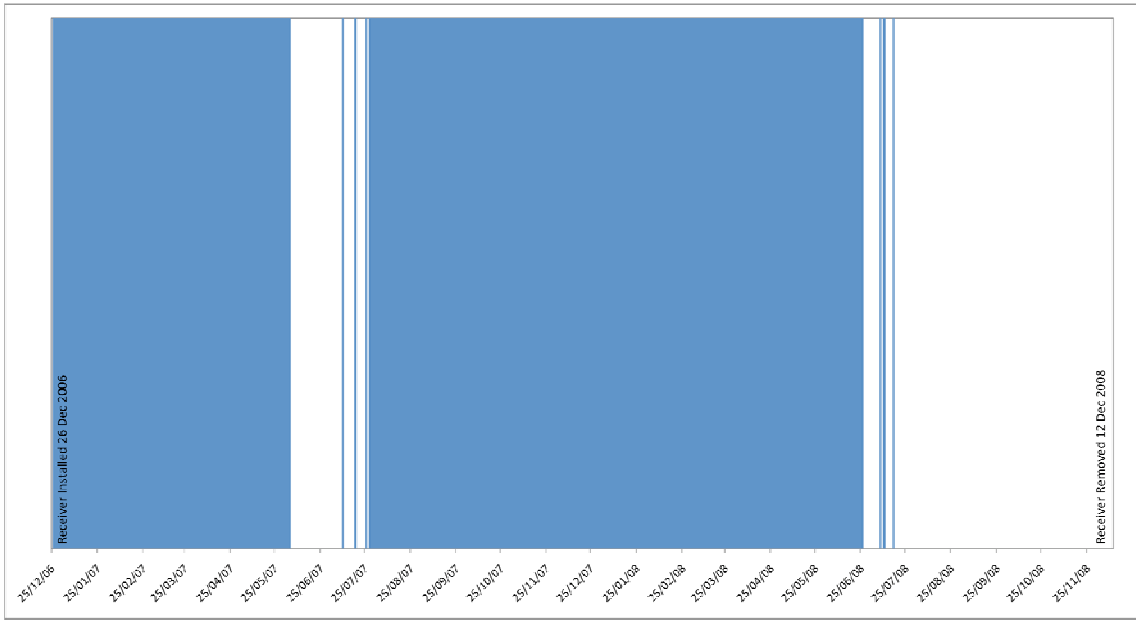
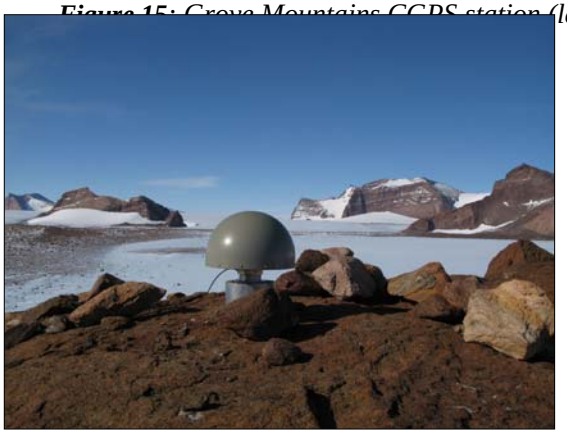


Figure 14: *Days for which data has been recovered from the Bunger Hills.*

GROVE MOUNTAINS

The Grove Mountains are a scattered group of mountains and nunataks located approximately 500km south west of Davis station and 160km east of the Mawson escarpment. After a best effort repair to the site two years ago, the purpose of the trip was to completely upgrade the CGPS site

***Figure 15:** Grove Mountains CGPS station (left) and Nunatak on which it is located (right)*



A C212 aircraft transported a cargo of freight and personnel to the site, landing on blue ice approximately 1km west of the camp site which was established at the base of a broad snow bank adjoining the western flank of a nunatak west of Mount Harding (see Appendix B for site coordinates). The pilots taxied the aircraft to within a few hundred metres of the campsite.

The campsite was located approximately 500m west of the CGPS station that is on a flat ledge at the northern side of the nunatak. Travel to the CGPS site involved a 20-minute walk north up the snow bank, and then north east over terrain strewn with large boulders and loose rocks around the nunatak to the opposite side.

The survey monument (AUS351) is a stainless steel plate with a 5/8” spigot set into a concrete pillar (~200mm diameter) and was established directly into rock in the summer of 2000/01 by Geoscience Australia surveyors. Adrian Corvino and Henk Brolsma installed the continuous GPS station in late-December 2003. Geoscience Australia surveyors re-visited the site in early 2005 and 2007 to repair the station and install new equipment.

On arrival in December 2008, the GPS receiver was observed to be shutdown and the batteries were in bad condition. The GPS receiver contained data up until the winter of 2007, when it seemed the power system failed. Sporadic data sessions were logged in the receiver for the next year and a half. The old equipment was completely withdrawn, apart from the GPS antenna, and the new site equipment was installed.

Site Assessment

On the 19 December 2008 a brief site analysis was undertaken. A number of photographs were taken. A detailed list of the state of equipment on arrival is provided below.

Air Industrial wind turbine:

- Turbine broken off frame and found on the ground several metres away with blades shattered and missing. These wind turbines seem insufficient for the environment;
- Frame not disturbed, rocks in place over supports and still rigid, nuts and bolts still attached and tight;
- Positive and negative cables still running into battery box, earth cable still buried under rocks and earth, alongside wind turbine stand.

Figure 16: *Wind turbine stand (left) and damaged wind turbine (right).*

Solar panel frame:

- Frame still upright with receiver and modem box still attached and rocks piled on top;
- Frame still in relatively good condition;
- Three solar panels attached to frame and in good condition;
- Solar panel cables all operational and in good condition;
- Junction box still in good condition, junction box cable to battery box in good condition;
- Iridium modem antenna and pole support still firmly attached to solar panel frame with stainless steel cable ties;
- Cables and connection into and within box all in good condition.

Figure 17: *Solar panel frame on arrival at the site.*

Receiver Pelican case:

- Pelican case still secured to solar panel frame with rope;
- All GPS receiver and modem cables connected within box;
- *Ashtech* Micro-Z UZCGRS receiver (s/n: UC2200524009) still connected to over/under voltage protection, no lights flashing on receiver. Receiver found to be 65% full of data.

Figure 18: *Modem and Receiver on arrival at the site.*

The *Ashtech* Micro-Z UZCGRS receiver (s/n: UC2200524009) was removed from the station and returned to Australia. The data on the GPS receiver was downloaded successfully and RINEX'd for later processing. It should be noted that the observation interval in the *Ashtech* receiver was set to 90 second epochs, as opposed to the standard 30 second epochs. This was done in 2007 in order to reduce the daily file size, allowing the receiver to store more data.

Survey monument (AUS351) and GPS antenna:

- Survey monument stable, not disturbed;
- Shim flush with survey plate and tight;
- GPS antenna (*Thales* 701945-02 Rev E1, s/n: CR6200327018) attached to 30mm shim, tightly and orientated north;
- SCIGN snow dome still in good condition, firmly attached to choke ring antenna with all bolts connected tightly.

Figure 19: Survey Monument (AUS351) and GPS antenna

Meteorological station:

- Met station and mount still firmly attached to wind turbine stand;
- Nuts and bolts and U-bolt connections all in good condition;
- Plastic wrap around met station cable still in place and cable running into receiver/computer box in good condition;
- Met station did not appear to be functioning, or communicating with GPS receiver.

Primary battery box:

- Stable with rocks stacked on top;
- Turbine switch toggled to charge;
- Batteries leaked with bulged and busted sides;
- Connections within box still attached although cables discoloured due to battery leak;
- All cable entries into box in good condition;
- No signs of snow drift or moisture build up within box;
- *Xantrex* power regulator off;
- Direct power connection to Iridium modem on;
- Dump box connected with cables in good condition and dump box not disturbed a few metres away from site.

***Figure 20**: Inside the primary battery box.* ***Figure 21**: Inside the secondary battery box.*

Secondary battery box:

- Stable with rocks still stacked on top;
- Snow drift build up within box;
- Batteries leaked with bulged and busted sides;
- Connections within box still attached although cables discoloured due to battery leak.

Equipment Upgrade

After analysis of the site condition, all the old equipment, excluding the GPS antenna and antenna cable, was set aside for RTA. Tasks performed in the site upgrade between 20 and 21 December 2008 are detailed below.

The stainless steel survey plate, concrete pillar, shim and *Thales* antenna (ASH701945E_M S/N: CR6200327018) with SCIGN snow dome were not disturbed and noted to be stable and in good condition. The 10m long GPS antenna cable attached to the antenna with self-amalgamation tape to form a watertight seal was noted to be in good condition and was maintained in the site setup.

Figure 22: *Survey monument (AUS351) and GPS antenna.*

A new solar panel frame was erected in the same position as the previous frame, approximately five metres west of the GPS antenna on a relatively flat area of rock. The frame supports three 50W BP solar panels, an iridium modem antenna and equipment box. Rocks were piled on top of the frame before leaving the site; to ensure wind forces would not disturb it.

Figure 23*: Groves new solar panel frame).*

Three 50W *BP* solar panels (500mm x 1000mm x 50mm) all connect to a simple, closed solar junction box, which sits on the base of the solar frame with a connection entering the equipment box. The solar panel cables are protected from the weather with flexible conduit. The Iridium antenna screws directly onto a threaded pipe section attached to the solar panel frame. The antenna cable passes through the pipe, along part of the solar frame (attached with steel cable ties) and into the equipment box. The GPS antenna cable runs along the ground between the antenna and equipment box and was covered with rocks to keep it secure. All cable connections into the equipment box glands were wrapped with self-amalgamation tape.

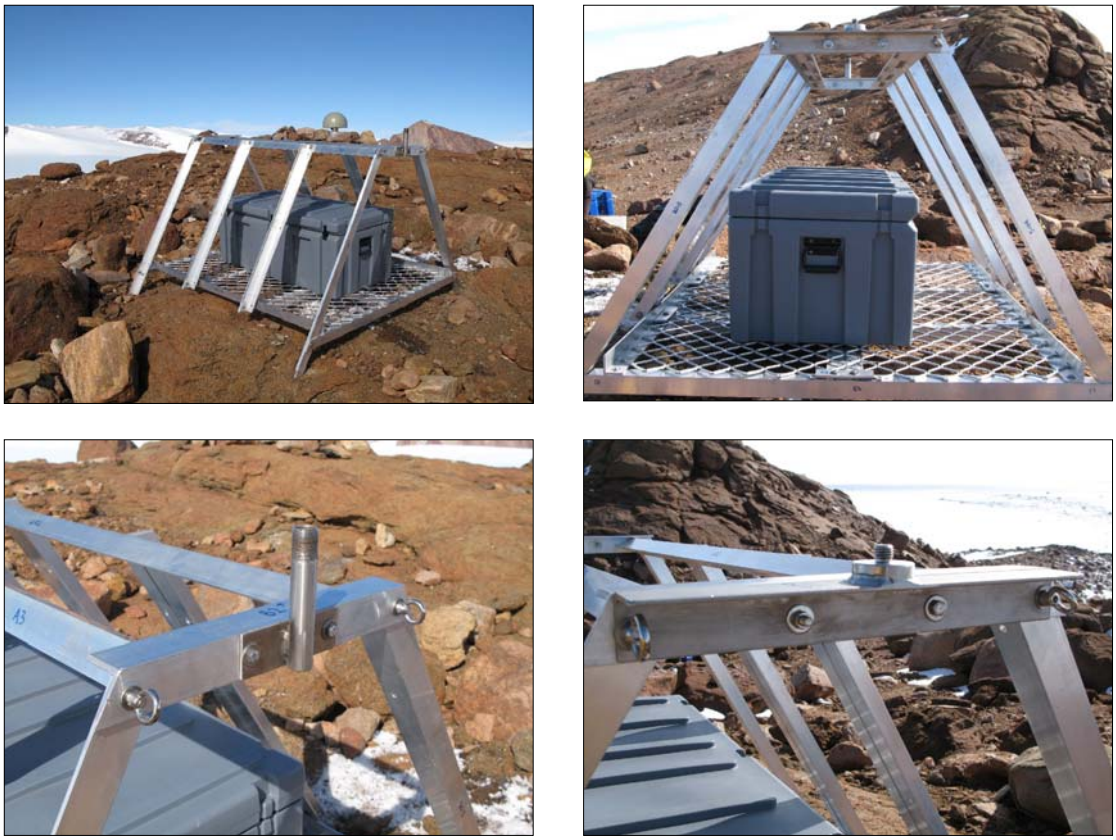


***Figure 24**: Top Left and right: Solar panel frame and equipment box; Bottom Left: Iridium antenna support and connection; Bottom Right: Wind turbine connection, with adjustable support.*

The equipment box is heavily insulated with isoboard insulation of 50mm and 75mm thickness. There are four 74AmpH *Gel Tech*, closed cell batteries connected in parallel within the equipment box. Silicon coated cables are used to connect the batteries.

The system electronics were also designed to accommodate a wind turbine with a separate dump box and solid state relay device to redistribute any excess charge. Unfortunately, wind turbines were not installed at the site this season. However, the electronic hardware to support a *Forgen* 1000 or *Forgen* 500 wind turbine were still included at the site, to accommodate the installation of a wind turbine in the future. The system power design is outlined in Figure 26.

A new *Leica* GRX1200 Pro GPS receiver (s/n: 462891) was installed at the site. The new receiver has a 4Gb compact flash memory card which should be able to support the recording of as much as four years of continuous GPS data.

Figure 25: *Inside Grove Mountains equipment box.*

A *NAL Research Iridium* data modem with 12V power supply was installed at the site to allow one-way communication from Canberra. The sim-card is provided by **TC communications.**

The number of the Grove Mountains *Iridium* is:

Data phone number: 0011 8816 931 13964

Upon installation, the receiver made a successful communication link to the Geoscience Australia office in Canberra. Prior to leaving the site, all appropriate lights were flashing and two days of data were downloaded from the receiver.

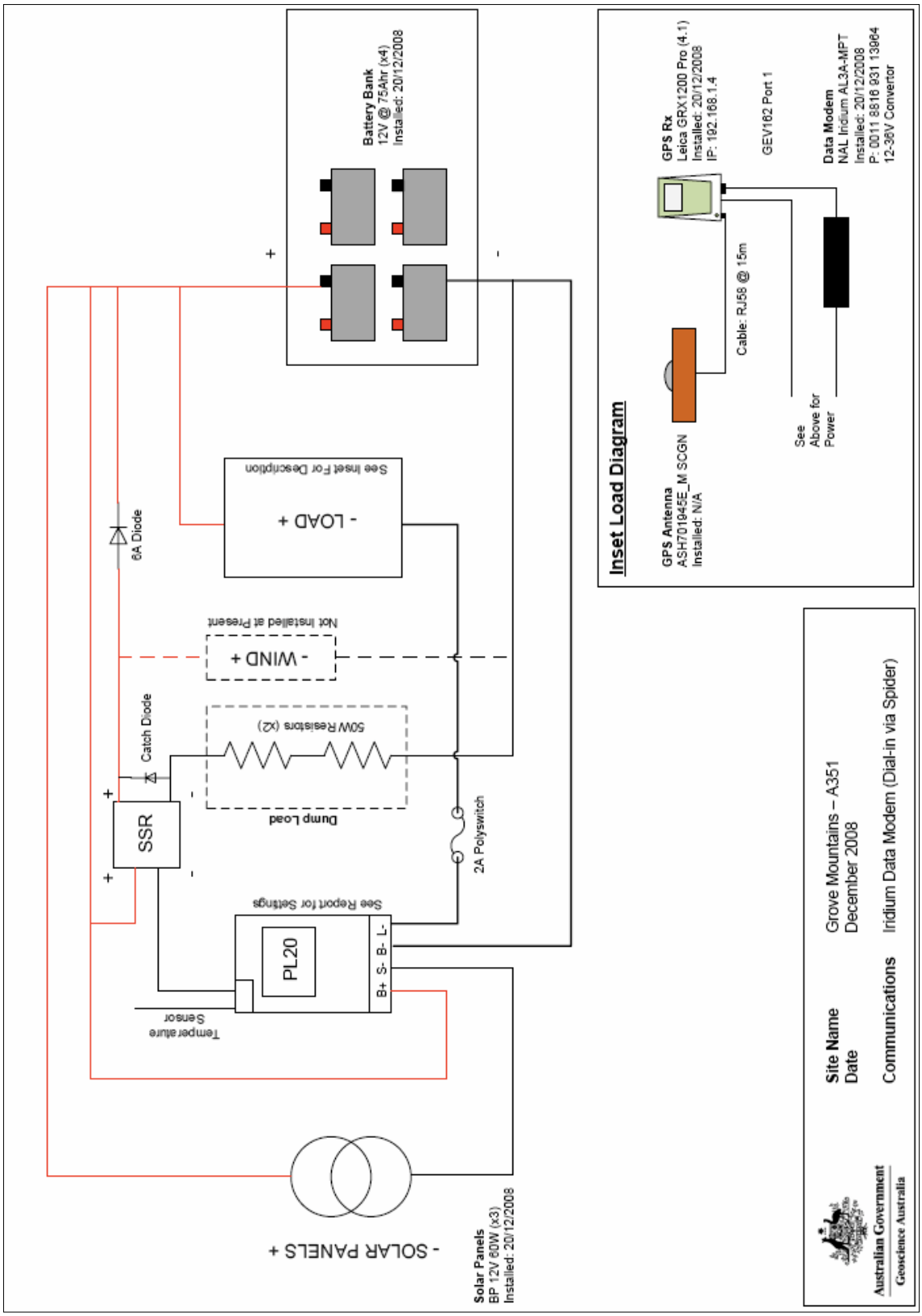


Figure 26: *Network diagram of the Grove Mountains.*

Recovered Data

The data from the *Ashtech* Micro-Z UZCGRS was downloaded at the site. The receiver contained 99 days of data between 9 March 2007 and 24 August 2008. It appears that the power system failed during the winter of 2007 and since then data recording occurred sporadically. The receiver had been set to record at an epoch of 90 seconds to reduce the daily file size. Figure 27 shows the days for which data is available.

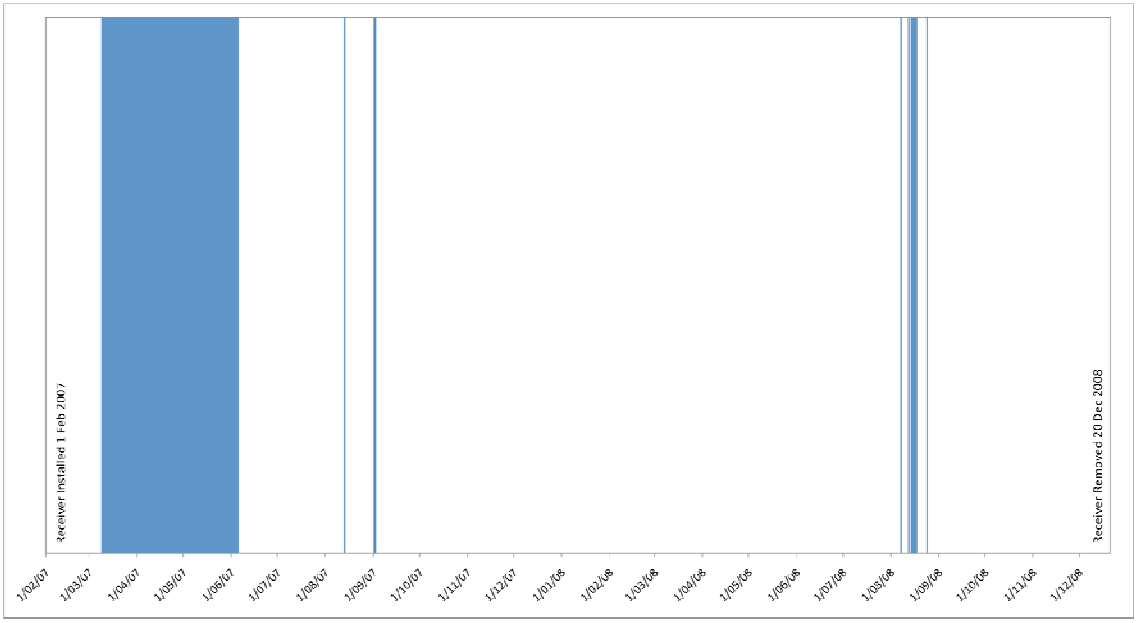


Figure 27: *Days for which data has been recovered from the Grove Mountains (AUS351).*

WILSON BLUFF

Wilson Bluff is located in the Southern Prince Charles Mountains at the southern end of the Lambert Glacier, approximately 750km south west of Davis station. A site visit was made to retrieve GPS data collected over the last two years and upgrade the continuous GPS (CGPS) station. In addition, the seismic station established by Anya Reading (UTAS) was withdrawn from the seismic site, approximately 100m north of the CGPS station.

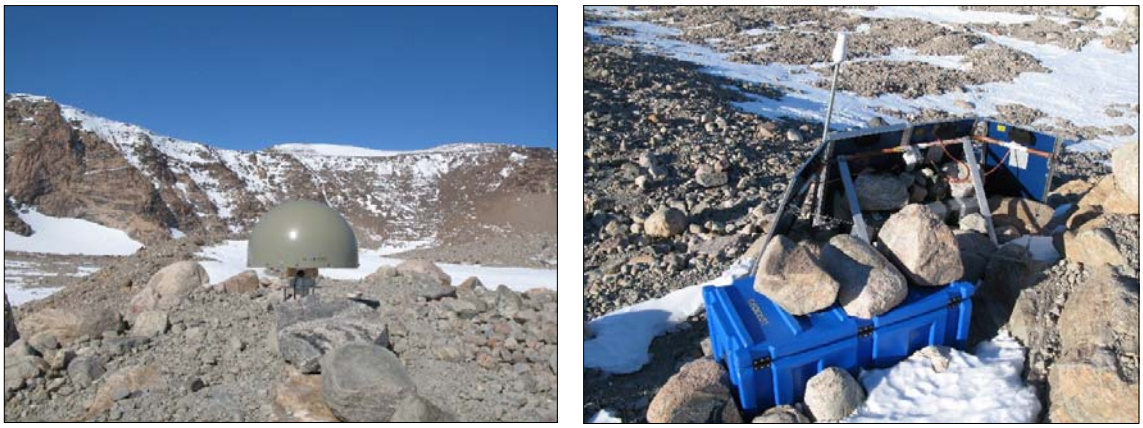


***Figure 28**: Wilson Bluff CGPS station (left) and view north of the site on arrival (right).*

A C212 fixed-wing aircraft transported freight and personnel to the site, landing on blue ice, free of crevasses several kilometres north east of the site, alongside a moraine line. The pilots taxied the aircraft to within a few hundred metres of the campsite that was set-up approximately 50m east of the CGPS station in a depression between two ridges of moraine, which provided shelter from the wind (see Appendix B for coordinates).

The CGPS survey monument (AUS368) is a stainless steel plate with a 5/8" spigot and three stabilising screws drilled into bedrock. The monument is located on a small rise within an undulating moraine field, midway along the northern area of Wilson Bluff. Established in the summer of 2002/03 by Geoscience Australia surveyors during the Prince Charles Mountains Expedition of Germany and Australia (PCMEGA), the site was fitted with continuous GPS equipment the following summer by Adrian Corvino and Henk Brolsma. In early 2007 Geoscience Australia surveyors performed repairs and equipment upgrades to the site.

On arrival in late December 2008, the GPS receiver was observed to be running and tracking satellites, however, the memory card was full so the receiver had stopped logging. The GPS receiver contained data up until November 2008 with a brief break in data collection over the winter of 2008, when it seems the wind turbine was no longer operating and the power system shutdown until there was sufficient sunlight to charge the batteries. A general upgrade was undertaken at the site with several items withdrawn and replaced.

Site Assessment

On the 29th of December 2008 a brief site analysis was undertaken. A number of photographs were taken of the site. A detailed list of the state of equipment on arrival is provided below.

Air Industrial wind turbine:

- Turbine still attached to frame, though bearings failed and rotation was restricted. Two blades attached, but unable to turn. These wind turbines seem insufficient for the environment;
- Frame not disturbed, rocks in place over supports and still rigid, nuts and bolts still attached and tight;
- Positive and negative cables still running into battery box, earth cable still buried under rocks alongside wind turbine stand.


***Figures 29**: Wind turbine stand (left) and damaged wind turbine (right).*

Solar panel frame:

- Frame still upright with battery box and rocks piled on top;
- Guy wire supports for solar frame still secure and tight;
- Frame still in relatively good condition;
- Four solar panels attached to frame, with three in good condition. One shattered panel was left in place in 2007;
- Solar panel cables all operational and in good condition;
- Junction box still in good condition, junction box cable to battery box in good condition;
- *Iridium* modem antenna and pole support still firmly attached to solar panel frame with stainless steel cable ties.

Primary equipment and battery box:

- Box stable with rocks stacked on top;
- All cable entries into box in good condition, no signs of snow drift or moisture within box;
- Turbine switch toggled to charge;
- Batteries leaked with bulged and busted sides;
- Connections within box still attached although cables discoloured due to battery leak;
- All GPS receiver and modem cables connected within box;
- *Leica* GRX1200 GPS receiver (s/n: 462980) on and tracking satellites. Receiver found to be full of GPS data and no longer logging;
- *Xantrex* power regulator not on;
- Direct power connection to *Iridium* modem on;

- Dump box connected with cables in good condition and dump box not disturbed a few metres away from site.

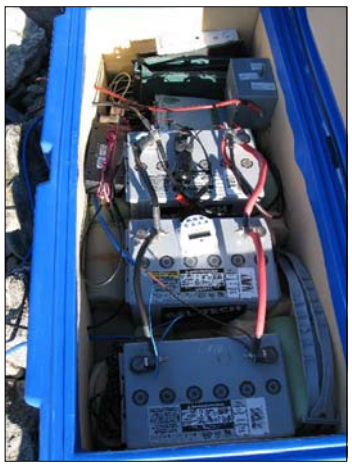


Figure 30: *Primary equipment box.*

Figure 31*: Secondary battery box.*

The Leica GRX1200 GPS receiver (s/n: 462980) was replaced and returned to Australia. The data on the GPS receiver was downloaded successfully and RINEX'd for later processing.

Secondary battery box:

- Stable with rocks still stacked on top;
- Batteries leaked with bulged and busted sides;
- Connections within box still attached.

Survey monument (AUS368) and GPS antenna and snow dome:

- Survey monument stable, not disturbed;
- Shim flush with survey plate and tight;
- GPS antenna (Thales 701945-02 Rev E1, s/n: CR6200326012) attached to 30mm shim, tightly and orientated north (-75 degrees magnetic bearing);
- SCIGN snow dome still in good condition, firmly attached to choke ring antenna with all bolts connected tightly.

Equipment Upgrade

Once analysis of the site condition was complete, several items of equipment were withdrawn and set aside for return to Australia. Tasks performed in the site upgrade on the 30th of December 2008 are detailed below.

The CGPS survey monument (AUS368) is a stainless steel plate with a 5/8" spigot and three stabilising screws drilled into bedrock. The shim and Thales antenna (701945-02 Rev E1, s/n: CR6200326012) with SCIGN snow dome (s/n: 0362) were not disturbed and noted to be stable and in good condition. The 10m long GPS antenna cable attached to the antenna with self-amalgamation tape was noted to be in good condition and was maintained in the site setup.

A new solar panel frame was taken to the site. However, the pre-existing solar frame was observed to be in good condition and had successfully survived two Antarctic winters. It was decided to leave the existing solar panel frame in place and keep the new solar panel frame for installation at another remote location some time in the future. Minor adjustments were made to the existing solar frame. The shattered solar panel that had been left on the solar frame in 2007 was replaced with a new 50W *BP* solar panel. The frame now supports four 50W *BP* solar panels (two of the slide in design and

two that bolt in) all in good condition. 13mm (1/2") ratchet spanners are required to tighten nuts and bolts on the frame. The bolt in solar panels are secured with extra stainless steel cable ties. The guy wire support, anchoring the solar frame to the rock was re-tightened. The old secondary battery box was removed from the back of the solar frame and rocks were stacked on the mesh base to prevent the frame from being disturbed.

The frame dimensions are approximately 1000mm X 1500mm X 1000mm. The solar frame is relatively lightweight of approximately 25kg and separates into several segments which make it easier to transport. The frame is aligned so that the solar panels face to true north with the two outer panels angled slightly either side of north to capture more of the solar energy. The four 50W BP solar panels all connect to a simple, closed solar junction box, which is attached to one of the backing supports of the solar frame with a connection entering the equipment box.

The GPS antenna cable, running along the ground between the antenna and equipment box was covered with rocks to keep it secure. The *Iridium* antenna screws directly onto a threaded pipe which is attached to the solar panel frame. The antenna cable passes through the pipe (attached with steel cable ties) and into the equipment box. All cable connections into the battery box glands were wrapped with self-amalgamation tape.

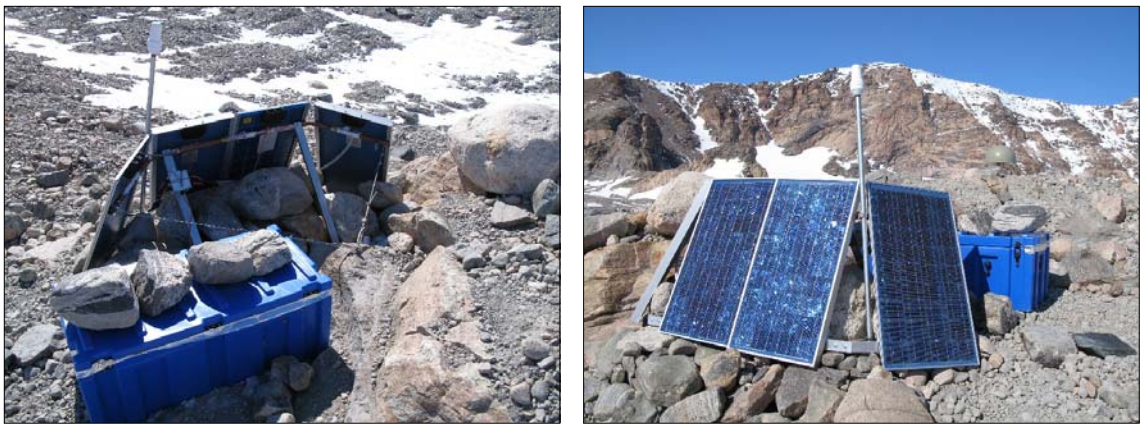


Figure 32: *GPS site layout looking north (left) and south (right).*

The equipment box for the site was assembled from a recycled case from a previous remote site, with insulation foam packed within. There are four 74AmpH *Gel Tech*, closed cell batteries connected in parallel within the equipment box. Silicon coated cables are used to connect the batteries.

A *Plasmatronics* PL20 power regulator serves as the primary power control device for the system. The PL20 is configured (see Figure 12) to control the solar power to the batteries and to protect the load. The system requires additional electronic devices, connectors and a dump load to accommodate the inclusion of a wind turbine in the future. For a detailed description on the wiring and setup of the site see Figure 34.

A new *Leica* GRX1200 GT Pro GPS receiver (s/n: 462887) was installed at the site. The new receiver has a 4Gb compact flash memory card which should be able to support the recording of as much as four years of continuous GPS data.

IP number: 192.168.1.4

A *NAL Research Iridium* data modem with 12V power supply was installed at the site to allow one-way communication from Canberra. The sim-card is provided by **TC Communications.**

The number of the Wilson Bluff *Iridium* is:

Data phone number: 0011 8816 931 13965

Figure 33: *Receiver and Iridium Data Modem (left) and equipment box after equipment upgrade (right).*

Upon installation, the receiver made a successful communication link to the *Iridium* modem and short text messages were successfully sent out. It was not possible to check communication back to Geoscience Australia in Canberra over the New Year break. Prior to leaving the site, all appropriate lights were flashing and three days of data were downloaded from the receiver.

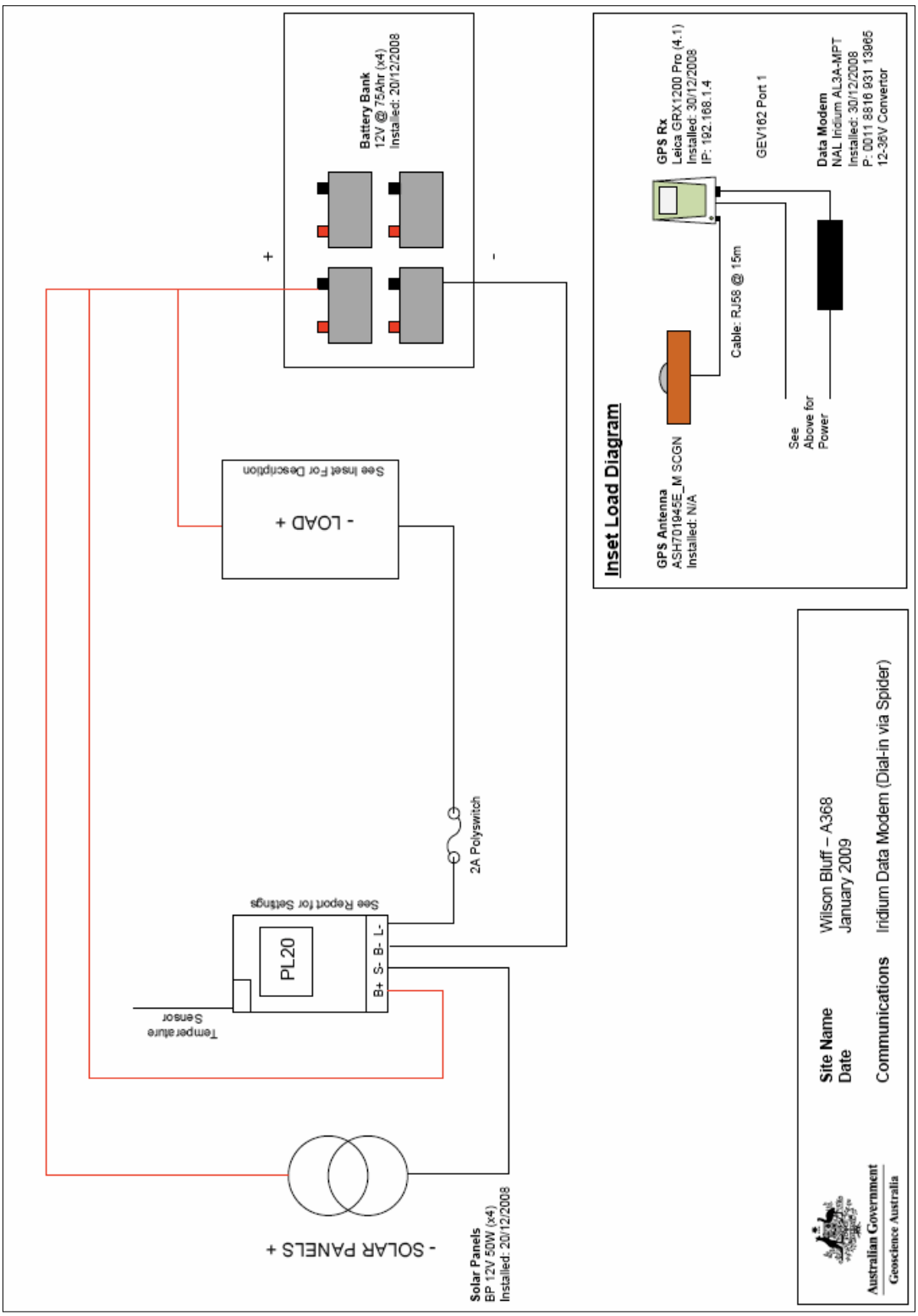


Figure 34: *Wilson Bluff equipment setup diagram.*

Recovered Data

The data card from Wilson Bluff was full on arrival at the site. It was discovered that the data was recorded in hourly files and that the *Leica* did not create a new file for each year, hence each hourly file had data from multiple years concatenated to it. This made RINEX file creation a hassle (scripts to do this have been written and are contained on the included CD). From the data recovered it appears that the GPS site ran for all of 2007 and most of 2008, where during the winter it is assumed that the wind turbine failed. Figure 35 shows the days for which data was recovered.

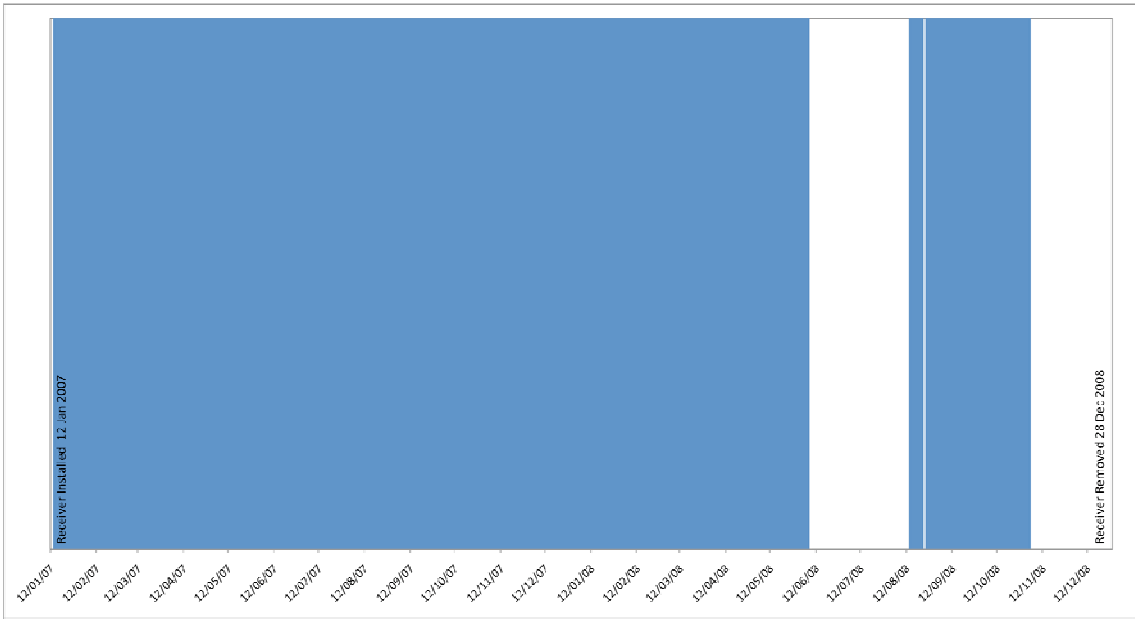


Figure 35: *Days for which data has been recovered from the Wilson Bluff (A368).*

GPS Campaign Survey

During the summer season a number of GPS campaign surveys were undertaken to obtain improved coordinate precision on survey marks, densify network coverage and to assist in the adjustment of the Davis station network onto the ITRF2005. Campaigns were undertaken in the Vestfold Hills, Davis Station, Rauer Group and the Larsemann Hills (Table 12).

***Table 12*:** GPS observations sites and observation times.

SITE	REGION	LOCATION	DAY OF YEAR, 2009
NMS278 (N278)	Larsemann Hills	Law Base	016 - 023
AUS334 (A334)	Larsemann Hills	Nella Fjord TGBM	016 - 019
ZS02	Larsemann Hills	Law Base (CHINARE)	016 - 019
AUS350 (A350)	Larsemann Hills	Nella Fjord TGBM	020 - 021
AUS335 (A335)	Larsemann Hills	Nella Fjord TGBM	022 - 023
C1 (C1__)	Larsemann Hills	Glacio Mark	020 - 023
NMS153 (N153)	Raurer Group	Filla Island	010 - 014
NMVS4 (NMV4)	Davis	Davis TGBM	013 – 015, 030 - 034
AUS186 (A186)	Davis	Davis TGBM	010 – 015, 030 - 034
NMS273 (N273)	Vestfold Hills	Tarbuck Crag	044 - 048
NMV/S/66 (NM66)	Vestfold Hills	Lake McNeil	044 - 048
NMV/S/8 (DEEP)	Vestfold Hills	Deep Lake	048 - 051
NMV/S/83 (NM83)	Vestfold Hills	Lake Druhzby East	048 - 051
NMV/S/84 (NM84)	Vestfold Hills	Crooked Lake West	048 - 051
D5 (D5__)	Davis	Station PSM	053 - 056
D9 (D9__)	Davis	Station PSM	053 - 056
RM1 (DRM1)	Davis	AUS099 Reference Mark 1	053 - 056

VESTFOLD HILLS AND RAUER GROUP

GPS units were setup and left to run for several days over survey marks in the Vestfold Hills, Rauer Group and around Davis statiopn. Details of the observation stations are provided in individual instrument station setup sheets (Appendix B). Data will be processed in relation to local IGS sites to obtain ITRF2005 coordinates for each site. This information will be used to strengthen the Australian Antarctic Geodetic Network.

LARSEMANN HILLS

GPS units were setup and left to run for several days over several survey marks around Law Base and adjacent to the Nella Fjord tide gauge. Details of the observation stations are provided in individual instrument station setup sheets (Appendix B). In addition, GPS data for the week was obtained from the continuous GNSS station at Zhong Shan station (ZHON), see Figure 36. All data will be processed, together with the Davis and Mawson continuous GNSS data, using the Bernese processing software. The GNSS positions will be used to strengthen the Australian Antarctic Geodetic Network (AAGN) in the region, and added to a collection of GNSS data observed on survey marks in the Larsemanns over the last decade. The GPS derived ellipsoidal heights will be used together with observed orthometric height differences to develop a geoid/ellipsoid separation model for the East Broknes Peninsula. Repeat campaign surveys, over particular survey marks, also allows monitoring of any displacement between epochs. It should be noted that a new CGNSS station was erected by the Russians to the west of Progress II station at the beginning of 2009 (see Figure 37). It is not certain whether they intend to incorporate this site into the international network. Unfortunately, data was not available for this site at the time of the survey.

Figure 36: *New CHINARE CORS ZHON at Zhong Shan (left) and old Zhong Shan CORS, it was moved due to the obstruction of the new atmospheric physics building (right).*

Figure 37*: New Russian CORS at Progress II (left) and close up view (bottom right).*

Tide Gauge Benchmark Levelling

Orthometric levelling is routinely undertaken at each of the Australian Antarctic stations to monitor the precise orthometric height differences from the tide gauge benchmarks to the ARGN station. A "leap frog" EDM heighting technique was used in which differences in height between change points were determined from zenith angle and slope distance observations. This precise levelling method is similar to the common technique of precise spirit levelling, however, it allows longer sighting lengths, of as much as 50m, over steep terrain.

The equipment used for the levelling surveys included a *Leica* TCA2003 total station on *Leica* tripod and a single fixed height stainless steel survey rod with bi-pole supports and a *Leica* precision prism. This prism pole was held over particular change points throughout the survey for back-sight (BS) and fore-sight (FS) observations. Efforts were made to pick up as many permanent survey marks during the survey run to check against previous survey results and update coordinate records for these points. At each instrument setup 4 rounds of face left (FL), face right (FR) observations were taken to the BS and FS. In addition, every survey mark was observed at least twice.

The intention for the levelling surveys was to work within zero-order specifications. To ensure this was achieved several criteria were followed, namely:

- Misclosures were to comply with allowable maximum of $2\sqrt{k}$, where k is the distance between the beginning and end points;
- Sighting lengths kept to a maximum of approximately 50m and BS/FS sights kept to approximately equal lengths;
- Temperature, pressure and humidity measurements were taken from the station Meteorological Office throughout the level run, at 60min intervals, and entered into the total station to allow corrections to be applied to slope distances;
- Work conducted in near windless conditions

Casey

Precise orthometric height differences were observed from the tide gauge reference mark at Casey wharf (TG RM) to the ARGN station (AUS100) and its reference marks. The orthometric heights were derived with respect to the RAN 1991 mean sea level (MSL) height of HBM1 (7.171m). Each survey mark was observed at least twice as the level run went from AUS100 down to the tide gauge benchmarks and back up to AUS100.

The route taken for the Casey tide gauge levelling survey is shown in Figure 38. The survey ran from the ARGN station (AUS100) to the tide gauge benchmarks (TG RM, AUS2009 and AUS2010). Efforts were made to observe level connections to all other survey marks along the route, namely HBM1, HBM2, HBM4, ISTS BM052, BM5, AUS395 and AUS396. The levels determined for these survey marks are shown in Table 13. Table 13 provides a comparison of the 2009 level survey results with levels obtained in previous surveys. It should be noted that all heights shown in Table 13 are based on the RAN 1991 MSL value for HBM1.

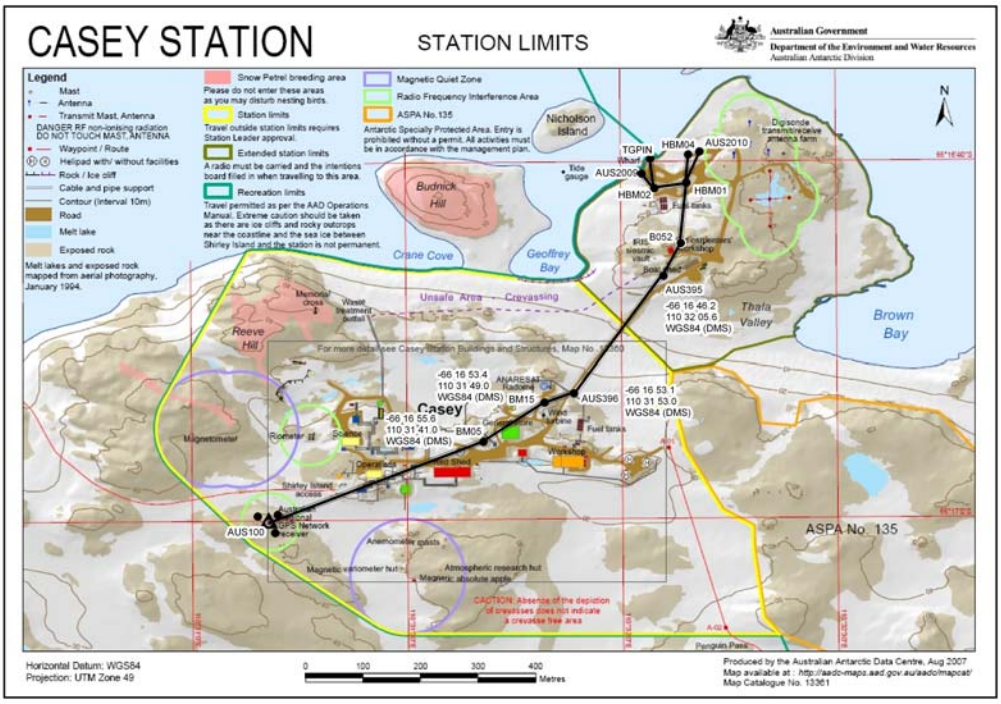


Figure 38: *2009 Casey station levelling route and location of survey marks observed*

Table 13: *Comparison of Reduced Levels obtained for survey marks at Casey Station in 2009 with previous survey results. All heights in metres and relative to HBM1*

Survey mark	2001	2006	2009
AUS100	40.8798		40.8824
AUS100 RM1	40.1098	40.1076	40.1115
AUS100 RM2	39.7814		39.7837
AUS100 RM3	41.5572		41.5604
BM05	38.5491	38.5489	38.5497
BM15			31.3279
AUS396	26.8843		26.8830
AUS395	19.3345	19.3335	19.3327
BM052			20.4683
HBM1	7.1710	7.1710	7.1710
HBM2	5.5172	5.5172	5.5171
HBM4	2.4247	2.4240	2.4242
AUS2009			1.7500
AUS2010			2.2117
TGPIN		1.7261	1.7260

Davis

Precise orthometric height differences were observed from the tide gauge benchmarks (AUS186 and NMV/S/4) to the ARGN station (AUS099) and its reference marks. The orthometric heights were derived with respect to the Davis 1983 mean sea level (MSL) height of NMV/S/4 (2.179m). Each survey mark was observed at least twice as the level run went from AUS099 down to the tide gauge benchmarks and back up to AUS099.

The Davis station tide gauge levelling survey was conducted on the 29th of January 2009. The route taken for the levelling survey is shown in Figure 39. The survey ran from the ARGN station (AUS099) to the tide gauge benchmarks (AUS186 and NMV/S/4). Efforts were made to observe level connections to other survey marks along the route, namely D3 and D5, AUS303, the Met bench mark and additional stainless steel pin change points (SSPIN1, SSPIN2, SSPIN3) previously drilled into rock along the survey route. The levels determined for these survey marks are shown in Table 14 along with a description of the location and approximate WGS84 latitude and longitude coordinates (obtained from a handheld GPS receiver). These coordinates are simply to assist with locating survey marks on plans and in the field. Table 15 provides a comparison of the 2009 level survey results with levels obtained in previous surveys. It should be noted that all heights shown in Table 14 and 15 are based on the Davis 1983 MSL value for NMV/S/4 (Johnston, G. & Digney, P., 2001 AUSLIG Technical Report 5). After completing the level run in both directions, the final level misclosure was calculated as 0.0008m. Well within zero-order specifications.

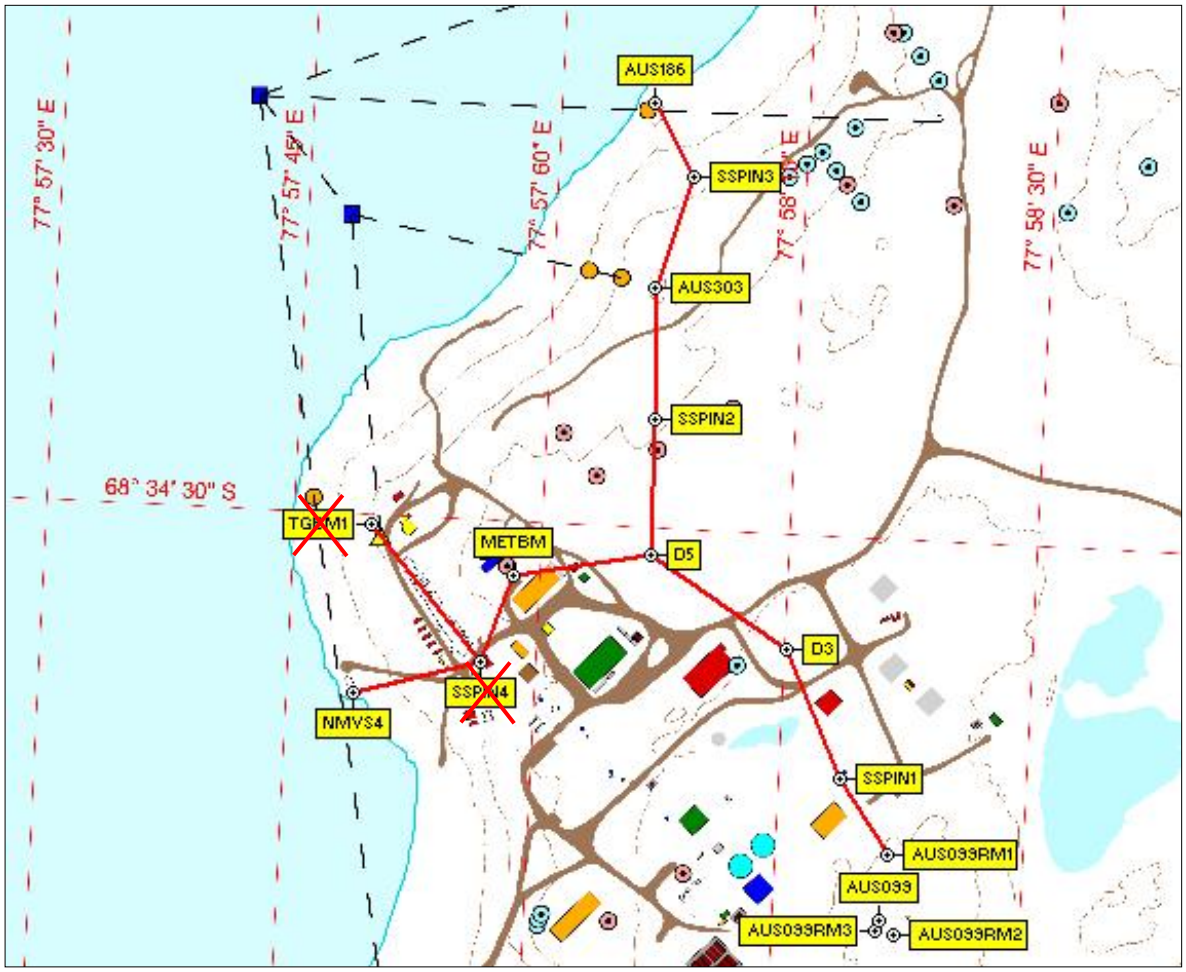


Figure 39: *Davis station levelling route and location of survey marks observed*

***Table 14**. Summary of survey marks connected to in 2009 levelling survey with a short location description, approximate WGS84 Latitude and Longitude coordinates (units are in DMS) and derived final Reduced Level (RL) with respect to NMV/S/4*

Station	Location description	Latitude	Longitude	RL (m)
AUS099	ARGN pillar	-68° 34' 38.3"	77° 58' 21.4"	27.8629
AUS099 RM1	Inside magnetic quiet zone	-68° 34' 36.9"	77° 58' 21.7"	25.5358
AUS099 RM2	Inside magnetic quiet zone	-68° 34' 38.7"	77° 58' 22.3"	27.4187
AUS099 RM3	Inside magnetic quiet zone	-68° 34' 38.6"	77° 58' 21.2"	26.9150
SSPIN1	Survey pin in rock b/w RM1 & D3	-68° 34' 35.3"	77° 58' 18.8"	22.4373
SSPIN2	Survey pin in rock b/w D5 & A303	-68° 34' 27.6"	77° 58' 07.1"	15.0095
SSPIN3	Survey pin in rock b/w A303 & A186	-68° 34' 22.3"	77° 58' 08.3"	8.4055
GRAV	New GRAV BM in EVS 200891.9911			22.2437
D2	Adjacent to paint test panels	-68° 34' 35.6"	77° 58' 11.1"	23.8177
D3	40m NE of Workshop	-68° 34' 32.5"	77° 58' 14.8"	23.0798
D4B	50 NE of new field store / boat shed	-68° 34' 29.3"	77° 58' 11.3"	18.5282
D5	50m NE of Science Building	-68° 34' 30.5"	77° 58' 06.9"	19.9154
AUS186	TGBM	-68° 34' 20.7"	77° 58' 05.5"	4.7145
AUS303	On top of rise near shore	-68° 34' 24.6"	77° 58' 06.1"	15.4943
AUS2006	Construction BM, next to SMQ (SE)			17.2861
CON18	Construction BM next to flag poles	-68° 34' 39.0"	77° 58' 00.7"	15.6272
METBM	On slab of tower at Met building	-68° 34' 31.1"	77° 57' 58.4"	18.3954
NMV/S4	Next to Beach House	-68° 34' 34.0"	77° 57' 49.6"	2.1790

Note: Misclosure of 0.0008m from AUS099 to the tide gauge bench marks and back.

***Table 15:** Comparison of Reduced Levels obtained for survey marks at Davis Station in 2009 with previous survey results. All heights in metres and relative to NMV/S/4*

Survey mark	1994/95	1996/97	1998/99	1999/2000	2000/01	2004/05	2006/07	2008/09
AUS099	27.8659	27.8690		27.8680	27.8686	27.8637	27.8628	27.8629
AUS099 RM1		25.5420			25.5415	25.5370	25.5363	25.5358
AUS099 RM2		27.4250			27.4245	27.4202	27.4191	27.4187
AUS099 RM3		26.9210			26.9206	26.9163	26.9155	26.9150
SSPIN1							22.4396	22.4373
SSPIN2							15.0104	15.0095
SSPIN3							8.4064	8.4055
D3		23.0880	23.1010	23.0870	23.0843	23.0810	23.0803	23.0798
D5		19.9220			19.9195	19.9161	19.9161	19.9154
AUS186	4.7140	4.7320	4.7200	4.7202	4.7202	4.7151	4.7155	4.7145
AUS303			15.5080	15.5000	15.4995	15.4953	15.4952	15.4943
METBM	18.4000	18.3994			18.4013	18.3957	18.3956	18.3954
NMV/S4	2.1790	2.1790	2.1790		2.1790	2.1790	2.1790	2.1790

Note: Surveys from 2000/01 onwards were performed using the EDM heighting technique

The misclosure of 0.0008m is very good. This is most likely due to an accumulation of random errors and indicates that no gross errors were made during the survey. It should be noted that there is very little difference between the recent surveys, with the discrepancy generally less than 1mm. It seems that SSPIN1 has shifted since 2007, with a drop of approximately 2mm. In 2007 it was noted that there was a consistent difference of approximately 5mm between the 2000/01 and 2004/05, 2006/07 surveys. This pattern was repeated in 2009 and supports that there may have been an error in the 2000/01 data reductions or that NMV/S/4 the datum for the survey has been disturbed. There were no visible signs of disturbance to NMV/S/4 at the time of survey.

Larsemann Hills

In the week from the 16th to 23rd of January 2009, a GNSS campaign and high precision level survey was conducted across the Eastern portion of Broknes Peninsula in the Larsemann Hills. Precise orthometric height differences were observed between survey marks to be used together with the GNSS derived ellipsoidal heights of survey marks, obtained over the last decade, to develop a model of the geoid/ellipsoid separation in the area that encompasses Law-Racovita Base, Progress II and Zhong Shan. A high precision levelling survey was conducted from the tide gauge benchmarks alongside Nella Fjord, to several marks around Law Base and onto a network of survey marks at Zhong Shan Station. Figure 40 shows the area surveyed and the position of survey marks.

The electronic distance measurement (EDM) heighting technique was used to measure changes in height between survey marks, as it was most suitable travelling between stations on Broknes Peninsula, as the area has a lot of topography with many changes in grade.

The levelling survey fell within zero-order specifications, with an achieved overall misclosure of approximately 4mm over the 4km distance from Law-Racovita to Zhong Shan. The observed changes in height are precise to 1mm.

Table 16 shows changes in orthometric height between survey marks on Broknes Peninsula in the Larsemann Hills. The primary tide gauge benchmark for the Nella Fjord tide gauge is AUS334. Unfortunately, an approximate MSL value for AUS334 is not available as a connection has not been made from the shore to the tide gauge data. Therefore, precise MSL values for each of the survey marks in the level survey cannot be quoted.

The orthometric height information obtained from the survey has been incorporated into the AAGN dataset. In addition, a model will be developed for the variation in the geoid/ellipsoid separation across the area, simply by comparing the GPS derived ellipsoidal height differences, with the observed orthometric height differences. The absolute geoid/ellipsoid separation value requires knowledge of the MSL of one of the survey marks.

Table 16: *Changes in orthometric height between survey marks on Broknes Peninsula in the Larsemann Hills. Changes in height are in units of metres.*

FROM	TO	CHANGE IN HEIGHT
N278	A350	-63.982
A350	A335	2.281
A350	NN16	1.008
NN16	A334	0.109
N278	ZS02	12.332
N278	C1	50.316
N278	RS09	-3.889
N278	RS00	-14.773
RS00	PEAK	2.853
PEAK	ORIG	-24.012
ORIG	LONG	-19.177
LONG	TGBM	-2.964
TGBM	WEPK	19.887
WEPK	NL42	-7.324
NL42	ZHON	1.205
NL42	GANG	-2.299
GANG	PEAK	35.889

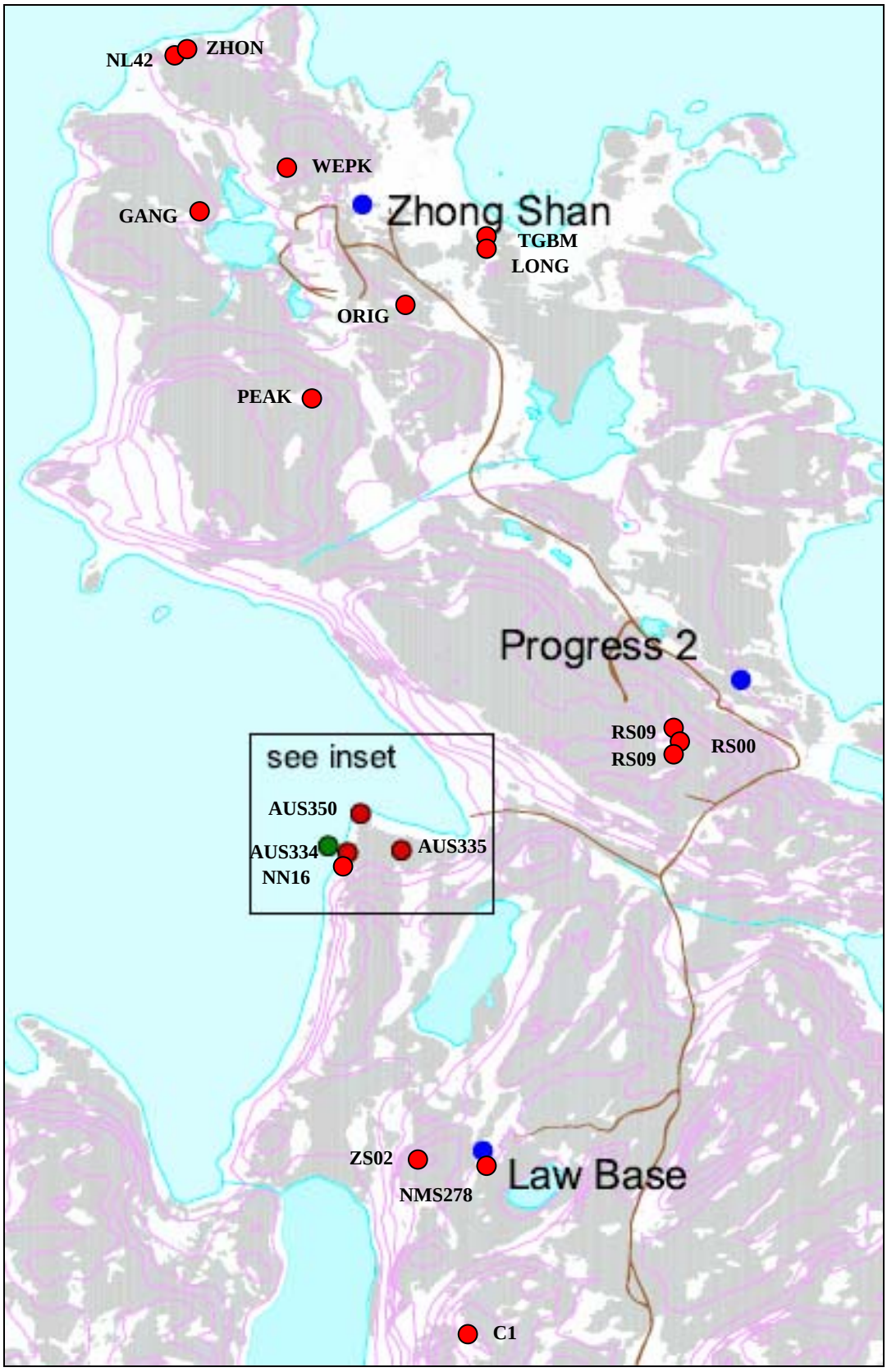


Figure 40: *Precise levelling survey network on East Broknes Peninsula in the Larsemann Hills.*

Macquarie Island

Precise orthometric height differences were observed from the tide gauges in Garden Cove (AQUATRAK and DRUCK) to the Macquarie Island ARGN station (AUS211) and its reference marks. The level run made direct connections to survey monuments observed in previous TGBM level surveys conducted on the island (Figure 41). The orthometric heights were derived with respect to the Macquarie Island mean sea level (MSL) height determined for benchmark AAE BM1 RM2 (2.598m). Each survey mark was observed at least twice as the level run went from the ARGN station (AUS211) down to the tide gauges and back up to AUS211. An analysis has not been made in this report to distinguish any absolute sea level rise or crustal movement.

The Macquarie Island station tide gauge levelling survey was conducted on the 21st of March 2009. The route taken for the levelling survey is shown in Figure 41. The survey ran from the ARGN station (AUS211) to the tide gauge benchmarks (AQUATRAK and DRUCK). Connections were made to other survey marks along the route, namely SPM10708 and SPM10709, AUS091, AUS092, AUS156, AUS228, AAE BM1 RM1 and AAE BM1 RM2 and a new GPS ground survey mark (GBAY) installed in Garden Cove in 2009. The GBAY survey monument is a stainless steel threaded spigot, which extends into rock approximately 100mm and is held into the rock with epoxy adhesive. The survey monument is designed to support direct GPS observation in tide gauge calibration surveys, as it allows a GPS antenna to be attached directly to the monument.

The mean sea levels determined for all the survey marks in the network are shown in Table 17 along with a description of the location. Table 18 provides a comparison of the 2009 level survey results with mean sea levels obtained in previous surveys. It should be noted that all heights shown in Table 17 and 18 are based on the Macquarie Island MSL value for AAE BM1 RM2 of 2.598m (installed in 1992). After completing the level run in both directions, the final level misclosure was calculated as 0.0005m, well within zero-order specifications.

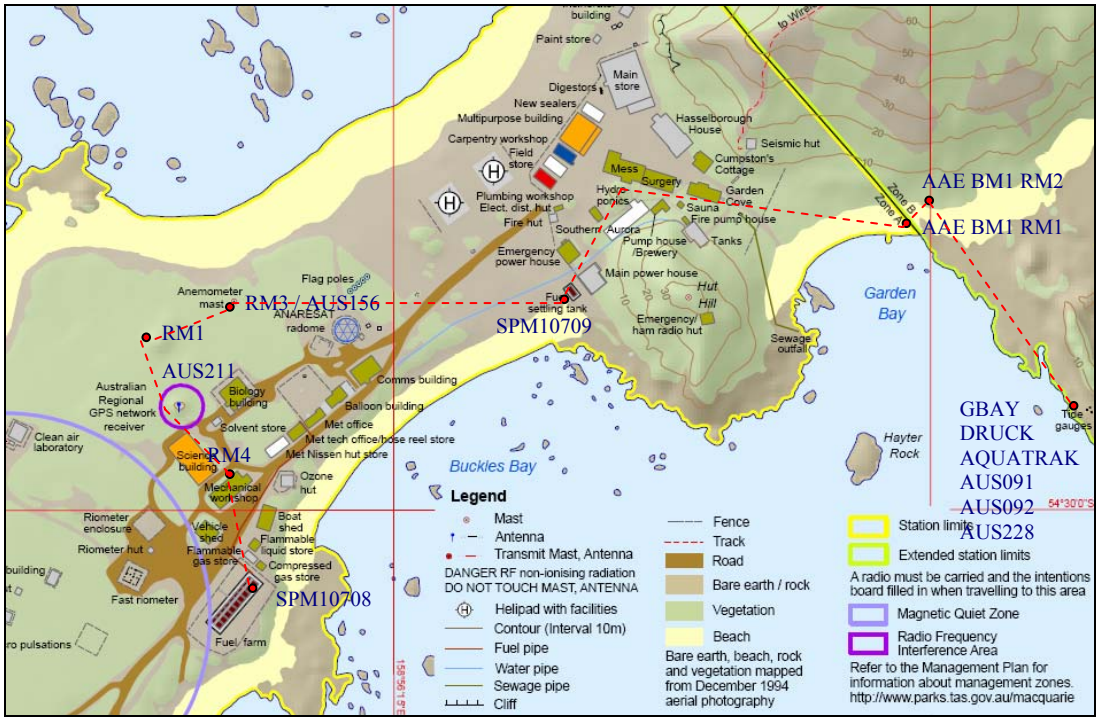


Figure 41: *Macquarie Island station levelling route and location of survey marks observed*

Table 17: *Summary of survey marks connected to in the 2009 levelling survey with a short location description and derived final mean sea level (MSL) with respect to AAE BM1 RM2*

Station Name	Location Description	MSL Height (m)
AUS211 A.R.P	Base of GPS antenna	12.9087
AUS211 Top	Top of AUS211 threaded spigot on top of ARGN pillar	12.8854
AUS211 Bottom	Bottom of AUS211 threaded spigot on top of ARGN pillar	12.8743
AUS211 HT RM1	Top of bolt on top of ARGN pillar	12.8810
AUS211 HT RM2	Top of bolt at base of ARGN pillar	11.6817
NM/X/1 RM1	Ground mark on mound north of ARGN pillar	9.1631
AUS211 RM4	Ground mark at Mechanical Workshop	5.8413
AUS211 RM3	Ground mark at Anenometer mast	5.5995
AUS156	Top of bolt at base of Anenometer mast	5.7231
SP10708	East Cnr of Fuel Farm	7.2141
SP10709	East Cnr of Fuel Settling Tank	4.9698
AAE BM1 RM1	On top of rock at east end of beach in Garden Bay	1.9031
AAE BM1 RM2	On rocky mound at east end of beach in Garden Bay	2.5980
AUS228	Near Tide Gauges	3.2956
AQUATRAK RM	Tide Gauge RM	3.2117
AQUATRAK RIM	Top of brass rim of Tide Gauge	3.2277
DRUCK RM	Tide Gauge RM	3.3342
DRUCK RIM	Top of brass rim of Tide Gauge	3.3509
AUS091	Near Tide Gauges	3.3307
AUS092	Near Tide Gauges	3.4940
GBAY	Base of threaded spigot near Tide Gauges	6.6011

Note: Misclosure of 0.0005m from AUS211 to the tide gauge bench marks and back.

Table 18: *Comparison of Reduced Levels obtained for survey marks at Macquarie Island Station in 2009 with previous survey results. All heights in metres and relative to AAE BM1 RM2 (except 2002 and 2006 surveys which are relative to AUS211 HT RM2)*

Survey mark	1994	1996	1996	1997/98	1999/00	2002	2006	2009
AUS211 A.R.P	-	-	-	-	-	-	12.9087	12.9087
AUS211 HT RM1	-	-	12.8830	-	-	-	12.8813	12.8810
AUS211 HT RM2	11.6810	11.6810	11.6810	11.6810	-	11.6810	11.6810	11.6817
NM/X/1 RM1	9.1620	9.1620	9.1610	9.1610	-	9.1620	9.1626	9.1631
AUS211 RM4	-	-	-	-	-	5.8400	5.8408	5.8413
AUS211 RM3	-	-	-	-	-	5.5980	5.5990	5.5995
AUS156	5.7220	5.7230	5.7230	5.7250	5.7230	-	-	5.7231
SP10708	-	-	-	-	-	-	7.2139	7.2141
SP10709	-	-	-	-	-	-	4.9694	4.9698
AAE BM1 RM1	1.9030	1.9030	1.9030	1.9030	1.9040	1.9040	1.9027	1.9031
AAE BM1 RM2	2.5980	2.5980	2.5980	2.5980	-	2.5990	2.5974	2.5980
AUS228	3.2970	3.2960	3.2970	3.2970	3.2970	-	3.2960	3.2956
AQUATRAK RM	3.2120	3.2120	3.2120	-	-	-	-	3.2117
AQUATRAK RIM	3.2280	3.2280	3.2280	3.2290	3.2290	3.2270	3.2281	3.2277
DRUCK RM	-	3.3350	3.3360	-	-	-	-	3.3342
DRUCK RIM	-	3.3510	3.3520	3.3520	3.3530	3.3500	3.3512	3.3509
AUS091	3.3320	3.3320	3.3320	3.3320	3.3320	3.3310	3.3313	3.3307
AUS092	3.4950	3.4950	3.4950	3.4950	3.495	3.4940	3.4945	3.4940
GBAY	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.6011

Note: Surveys from 2002 onwards were performed using the EDM heighting technique while all previous surveys were performed using precise spirit levelling. The EDM heighting technique was particularly beneficial in observing the ARGN pillar which is on an isolated, elevated rock.
The GBAY survey monument was installed on the 20th March 2009. The height relates to the base of the threaded spigot.

The overall levelling misclosure of 0.0005m is very good. This is most likely due to an accumulation of random errors and indicates that no gross errors were made during the survey. There is generally close agreement between the 2009 and past surveys. However, it should be noted that the 2002 and 2006 surveys did not adopt AAE BM1 RM2 as the fixed station and did not relate all MSL heights to this monument. The 2009 height values are approximately 0.5mm lower than the 2006 results for the survey marks around the tide gauges, while the 2009 heights of survey marks within Macquarie station are approximately 0.5mm higher than the 2006 results. This is attributed to the 2006 survey not adopting AAE BM1 RM2 as the fixed height station for the survey and there being a 1mm difference between the observed change in height from AAE BM1 RM2 and AUS228 between the 2006 and 2009 surveys.

There has been confusion as to the height reference mark of the Macquarie Island ARGN pillar monument. Height offsets from AUS211 HT RM2 were determined for all survey marks connected with the pillar and are detailed in Table 19.

Table 19: *Height offsets from AUS211 HT RM2 to each of the survey marks connected with the ARGN pillar. All units are in metres.*

		MSL
AUS211 HT RM2 to …	**Change in Height**	11.6817
AUS211 HT RM1	+1.1993	12.8810
AUS211 ARP	+1.2270	12.9087
AUS211 Top of threaded spigot	+1.2036	12.8854
AUS211 Base of threaded spigot	+1.1925	12.8743

Note: The AUS211 ARP was determined by observing the height at the top of the antenna choke ring and subtracting 0.102m (the value shown in the MAC1 log file antenna diagram).

Figure 42: *Macquarie Island ARGN pillar height reference points, plan and profile view.*

Support for the Australian National University

Similar to Geoscience Australia the Research School of Earth Sciences at the Australian National University manages remote GPS (Paul Tregoning) and Seismic (Anya Reading) sites in the Prince Charles Mountains and Amery Ice Shelf. Support was provided to these projects during the 2008/09 season with the removal of equipment at Beaver Lake (GPS), Dalton Corner (GPS), Landing Bluff (GPS) and Wilsons Bluff (Seismic).

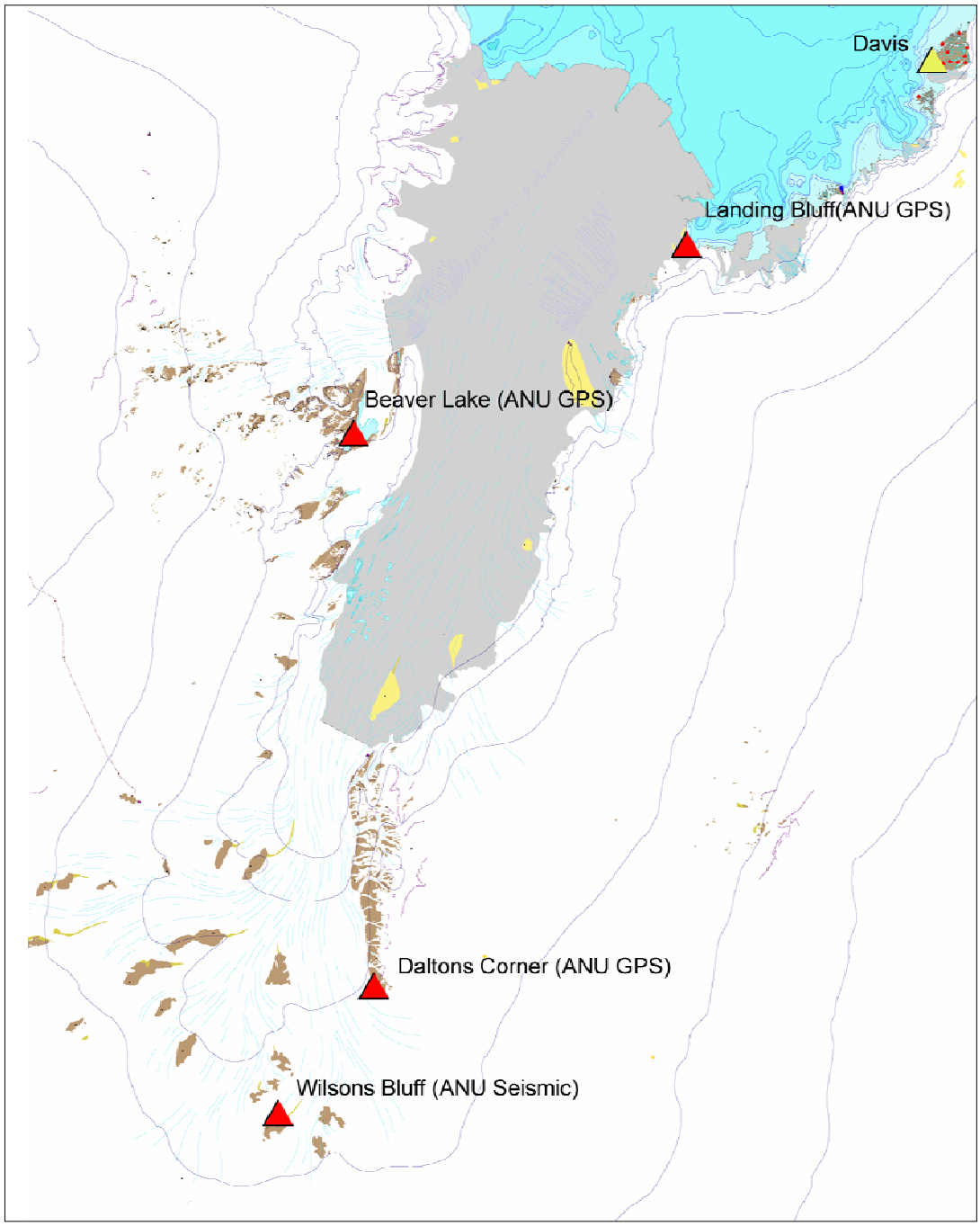
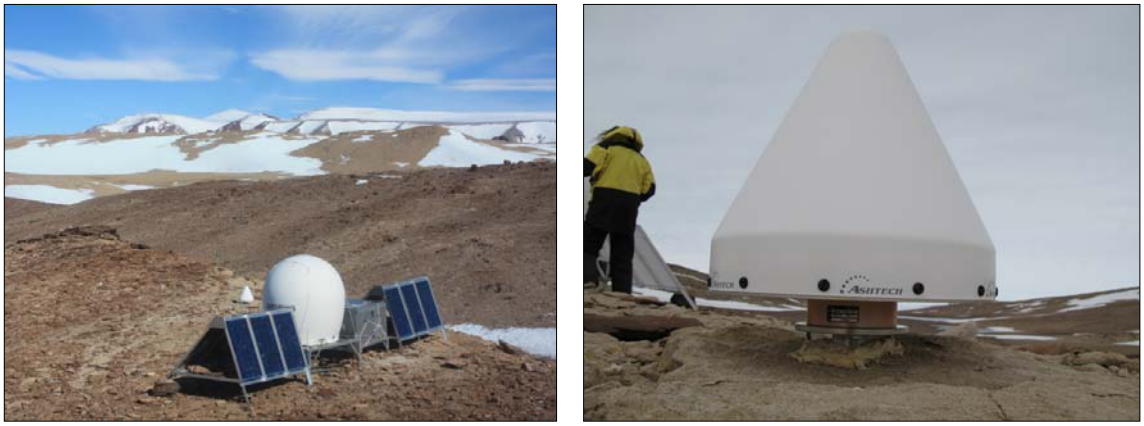


Figure 43: *Location map showing the Australian National University GPS and seismic sites visited during the 2008/09 season.*

BEAVER LAKE

Beaver Lake is located on the eastern side of the Northern Prince Charles Mountains. The ANU previously operated a CGPS station approximate 5 km from the Beaver Lake Apples. The site is situated on a sandstone rock outcrop in a valley, above some small lakes.

During January 2009 Simon Alexander (AAD) and Helicopter Resources staff visited the GPS site at Beaver Lake to remove the solar panel frame, communications dome and equipment box that were left in 2007, when Dan Zwartz (ANU) decommissioned the site. The GPS antenna was left in place, along with the antenna. The exposed end of the antenna cable was weatherproofed using amalgamation tape. All the equipment was slung by helicopter back to Davis for RTA on Voyage 4.



Figures 44: *Beaver Lake GPS prior to retrieval (left). GPS antenna and survey monument remaining at Beaver Lake (right).*

DALTON CORNER

Dalton Corner is located at the southern end of the Mawson Escarpment in the Southern Prince Charles Mountains. The GPS site is located approximately 2 km up hill from a campsite beside the Lambert Glacier.

Between the 2nd and 5th of January 2009, Ryan Ruddick (GA), Alex Woods (GA) and Mike Grimmer (AAD) visited Dalton Corner to withdraw the equipment from the CGPS site operated by the Australian National University. On arrival the GPS receiver was observed as having full memory. The GPS antenna was directly attached to the survey monument AUS306, a small plate drilled into bedrock with three stabilising screws. The GPS antenna was noted as loosely connected to the plate and was removed from the site. A 5/8" threaded nut was screwed onto the survey plate spigot to minimise any damage to the survey monument. All equipment was removed and flown back to Davis by CASA C212 for RTA on Voyage 4.

The GPS data was downloaded from both the receiver and PCMCIA card and backed up on DVD.

Table 20: Days of data retrieved from the GPS receiver and PCMCIA card at Daltons Corner.

SITE	2007	2008	2009
Ashtech UZ-12	327 - 365	001 - 024	-
PCMCIA card	017 – 115, 287 - 326	-	-

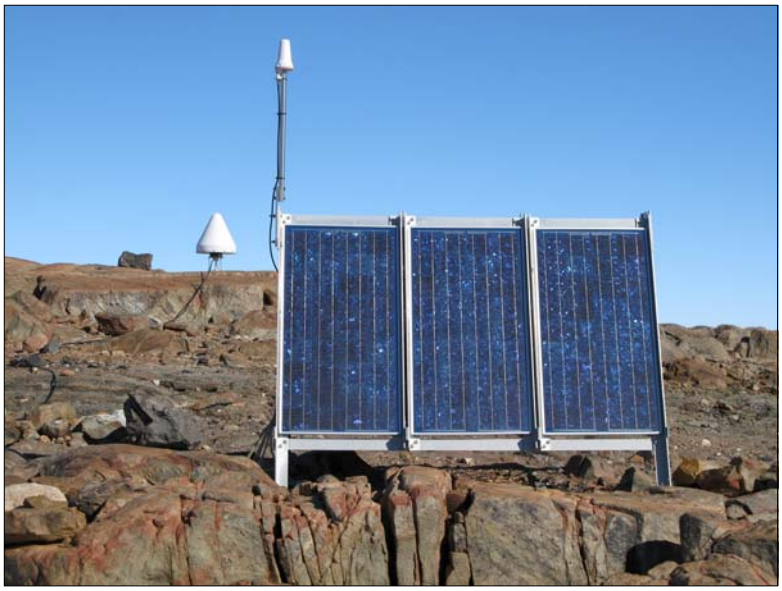


Figure 45: *Daltons Corner GPS prior to removal.*

Figure 46*: AUS306 survey monument remaining at site (left); Small rock cairn indicates the location of the Dalton Corner site (right).*

LANDING BLUFF

On the 11th of January 2009, Ryan Ruddick visited Landing Bluff on the eastern edge of the Amery Ice Shelf to withdraw the CGPS site managed by the Australian National University. On arrival the GPS receiver (*Ashtech* Z-XII) was observed to be off, this was attributed to a faulty power switch. As requested, all equipment was withdrawn, with the exception of the GPS antenna, which was inspected and left in place for future occupations. The N-type connector on the antenna was weatherproofed using amalgamation tape. All equipment was returned via helicopter to Davis for RTA on Voyage 4.

The GPS data was downloaded from both the receiver and PCMCIA card and backup up to DVD.

Table 21: Days of data retrieved from the GPS receiver and PCMCIA card at Landing Bluff.

SITE	2007	2008	2009
Ashtech Z-XII	-	-	-
PCMCIA card	001 – 025, 042 – 099, 357 - 365	002 - 099	-

Figure 47: *Landing Bluff GPS prior to retrieval (Ryan Ruddick).*

WILSONS BLUFF

Between the 27th of December 2008 and the 2nd of January 2009, Ryan Ruddick (GA), Alex Woods (GA) and Mike Grimmer (AAD) visited Wilsons Bluff at the southern end of the Lambert Glacier to upgrade the equipment at the Geoscience Australia CGPS site. During this visit the seismic station managed by Anya Reading (UTAS) was withdrawn. All the seismic station equipment was withdrawn, including the solar panel frame, equipment box and seismic sensor. Equipment was handled with care and returned to Davis by CASA C212 for RTA on Voyage 4.

Davis Absolute Gravity Mark Installation

On the 25th of February 2009 an absolute gravity benchmark was installed in the Emergency Vehicle Shelter (EVS) at Davis. The benchmark was placed in the EVS after discussion with the engineering supervisor and consideration of several locations around station. Building drawings for the EVS were unavailable, although the floor in the EVS is a floating slab on columns that extend to bedrock. The EVS was identified as the optimal location as the building is rarely used and has sufficient floor space for the FG5 absolute gravimeter. There is 1.5m of vacant floor space around the monument which is located on the slab, along the line between two wall columns, in the Eastern corner of the building (Figure 48). This area is usually allocated for storage of search and rescue equipment. In placing the monument a 12mm diameter hole was drilled approximately 100mm into the slab and the mark was fixed using *Ramset* Ultrafix Plus polyester anchoring adhesive. The monument is identified as 200891.9911. A precise level connection was made on 2 March 2009 from PSM D3 to the new BM, incorporating it into the Davis level network with a 1983 Davis MSL height of 22.2437m.

Figure 48: *EVS (top left); Absolute gravity benchmark (top right); Installed BM and rear wall and doorway (bottom left); Installed BM and SAR equipment (bottom right).*

Support for Other AAD Projects

During the summer spatial support was also provided to a number of other AAD projects, this included an infrastructure survey of Davis station, a new building detail survey at Davis, lake leve monitoring surveys in the Vestfold Hills, a detail survey of the Old Wallow near Davis station, and DEM creation of a Cyroconite plot on the Sorsdal Glacier. Details are provided below on projects that have geodetic significance.

Spatial Infrastructure Survey

There is a network of survey marks throughout Davis station. As part of a survey of new buildings on station, a precise survey traverse was observed between the survey marks around station. The survey was linked in with the reference mark monitoring survey conducted around the Davis continuous GNSS station. This supported the alignment of the survey to ITRF2000 @ 2000.0 with final coordinates provided to the AAD mapping group to upgrade records of station spatial infrastructure. An additional GPS survey was carried out on station; with several days of GPS data collected over three survey marks, being D5, D9 and AUS099 RM1. The derived ITRF coordinates for these points will be compared against the results of the terrestrial survey and possibly used to adjust the Davis survey network.

The survey mark traverse was conducted at Davis station on the 28th of February 2009 using a *Leica* TCA2003 total station and a set of *Leica* precision prims. Three sets of tripods were used to setup equipment over the survey marks. The total station was used to observe horizontal and vertical angles as well as slope distances between each of the survey marks. In addition, precise EDM heighting provided precise changes in height between survey marks. This levelling technique involved the use of a total station and a fixed stainless steel rod with bi-pole supports and a *Leica* precision prism.

All survey observations were run through initial pre-processing using in-house software developed by Geoscience Australia and then processed using the least squares survey network adjustment program (SNAP) to determine the final coordinates of survey marks, with estimates of their precision, and evaluate the quality of the observations. The network was fixed using the known ITRF2000 @ 2000.00 coordinates of AUS099 from the Antarctic Geodesy 2000/01 report (Johnston & Digney, 2001) and was aligned with an azimuth to AUS099 RM1 (derived using coordinates supplied in 2000/01 report). These coordinates were set upon the GRS80 reference ellipsoid.

Orthometric heights (MSL reduced levels) were derived for each of the survey marks relative to the 1983 MSL of NMV/S/4 (2.179m).

Survey Results

Table 22: *2008/09 Survey Latitude and Longitude, ellipsoidal height and Davis 1983 MSL height and associated standard errors for the Davis station survey marks. GRS80 ellipsoid and ITRF2000@2000.00 coordinates adopted for AUS099 (from 2000/01 survey). Standard deviations (SD) are in units of millimetres and heights are in units of metres.*

Mark	Latitude	SD	Longitude	SD	E. Height	MSL	SD
AUS099	-68° 34' 38.36207"	0.0	77° 58' 21.40903"	0.0	44.4160	27.8629	0.0
RM1	-68° 34' 36.94421"	0.3	77° 58' 21.69995"	0.0	42.0891	25.5358	0.1
RM2	-68° 34' 38.69743"	0.3	77° 58' 22.27437"	0.1	43.9720	27.4187	0.0
RM3	-68° 34' 38.63382"	0.2	77° 58' 21.17215"	0.0	43.4683	26.9150	0.0
D16	-68° 34' 34.59611"	0.7	77° 58' 24.26627"	0.5	40.0034	23.4501	0.2
D3	-68° 34' 32.54282"	1.3	77° 58' 15.07076"	0.8	39.6331	23.0798	0.3
D4B	-68° 34' 29.25151"	2.0	77° 58' 11.28110"	1.0	35.0815	18.5282	0.4
AUS303	-68° 34' 24.64743"	3.3	77° 58' 06.16749"	1.1	32.0475	15.4943	0.4
D5	-68° 34' 30.59139"	2.1	77° 58' 06.56102"	1.0	36.4687	19.9154	0.4
D9	-68° 34' 34.43692"	2.1	77° 57' 59.12868"	0.9	31.5934	15.0400	0.5
CON18	-68° 34' 38.95082"	1.9	77° 58' 00.74882"	1.1	32.1806	15.6272	0.4
D2	-68° 34' 35.56651"	1.1	77° 58' 11.06226"	0.7	40.3710	23.8177	0.3

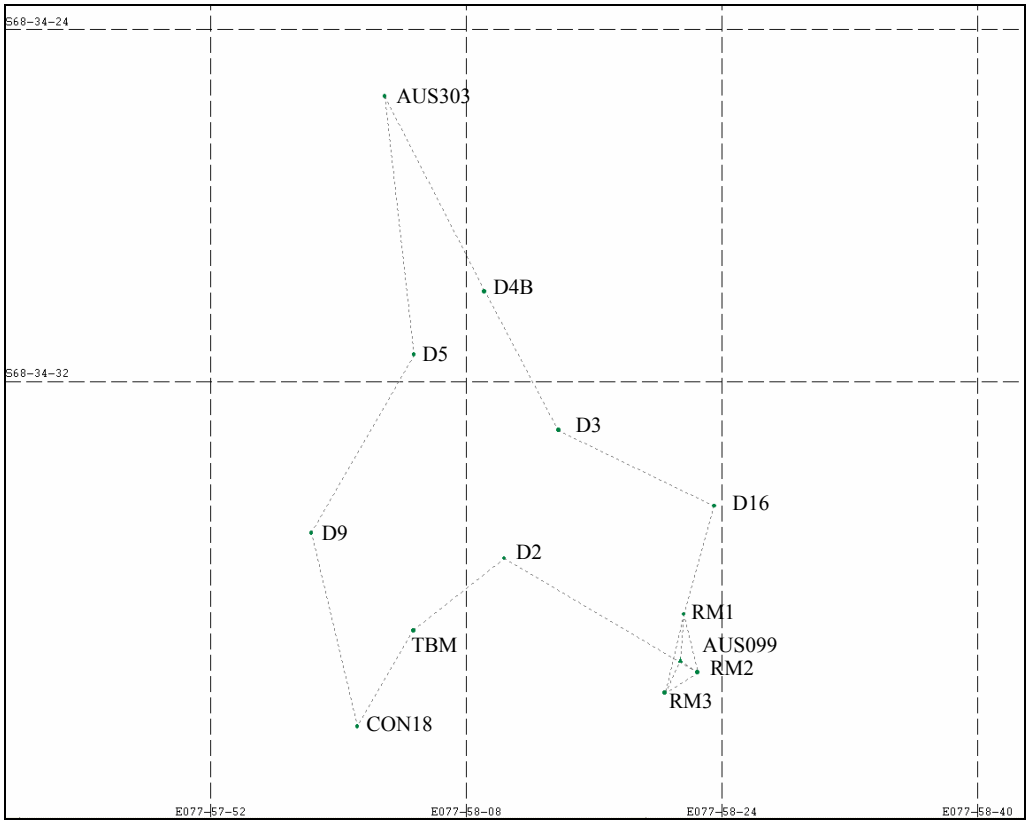


Figure 49: *Davis station survey infrastructure diagram*

VESTFOLD HILLS LAKE LEVELLING

At the end of the season, relative height differences were measured between lake benchmarks and lake water level, for 23 lakes in the Vestfold Hills. Height differences were observed using standard precise levelling techniques. A Topcon digital level and barcode staff were used to observe height differences from BMs to lake level. The lakes selected to be observed were specified by the AAD Mapping Group. Most of the lakes were visited on foot, working from huts within the hills. Helicopter support was also provided to access the more isolated lakes. The survey marks can be difficult to find, but are marked with large white painted crosses and usually have a small cairn alongside. All reduced levels were determined with respect to the quoted Davis 1983 MSL of benchmarks, provided by the AAD mapping group. During the survey, additional observations were made to permanent water level staffs in lakes. These observations are documented in Table 23 along with the observed change in height between survey benchmarks and lake water levels, and the reduced level determined for the surface of each of the lakes. Comparison is also made with the observations made in 2007 and has been added to a spreadsheet of lake levels surveyed in previous years, dating back to the 1980s (stored at Geoscience Australia and the AAD).

Table 23: *Vestfold Hills lake levelling results. All reduced levels are relative to the Davis 1983 MSL. All times of observation noted are with respect to UTC time. All units are in metres.*

BM NUMBER	LAKE NAME	RL	2009 ΔH	DATE	TIME	STAFF	2007 ΔH	DIFF
AUS/V/4	Pauk Lake	Unknown	-3.581	15/02/09	05:30		-3.746	+0.165
NMV/S/06	Lake Dingle	-9.453	-13.218	09/02/09	03:30		-13.093	-0.125
NMV/S/08	Deep Lake (NW end)	-50.760	-1.104	09/02/09	08:00	0.548	-0.925	-0.179
NMV/S/15	Lake Stinear (SW end)	-14.227	-16.881	09/02/09	05:30		-16.705	-0.176
NMV/S/20	Club Lake	-38.118	-3.813	10/02/09	03:00	0.128	-3.659	-0.154
NMV/S/21	Oval Lake	-29.050	-2.944	10/02/09	06:30		-2.756	-0.188
NMV/S/22	Lake Shield	5.625	-3.001	10/02/09	07:00		-2.865	-0.136
NMV/S/24	Ekho Lake	-1.789	-2.212	10/02/09	08:30		-2.035	-0.177
NMV/S/35	Watts Lake	-6.413	-10.808	17/02/09	09:30		-10.547	-0.261
NMV/S/36	Lake Lebed	-20.418	-3.627	17/02/09	11:00		-3.519	-0.108
NMV/S/40	Lake Abraxos	12.448	-4.522	03/02/09	07:30		-4.282	-0.240
NMV/S/43	Pendant Lake	3.155	-2.637	02/02/09	10:30		-2.689	+0.052
NMV/S/53	Organic Lake	1.919	-3.842	02/02/09	08:00		-3.928	+0.086
NMV/S/58	Clear Lake	-8.666	-3.828	15/02/09	04:00		-3.660	-0.168
NMV/S/59	Lake McCallum	-2.131	-3.795	15/02/09	04:30		-3.646	-0.149
NMV/S/63	Lake Zvezda	15.885	-1.265	15/02/09	06:00		-1.270	+0.005
NMV/S/66	Lake McNeill	26.124	-3.959	11/02/09	04:00		-3.546	-0.413
NMV/S/67	Lake Braunsteffer	34.210	-2.385	11/02/09	05:00		-2.229	-0.156
NMV/S/69	Lake Jabs	-37.192	-3.105	10/02/09	04:00		-3.087	-0.018
NMV/S/72	Lake Druzhby	8.159	-1.596	18/02/09	05:00		-1.814	+0.218
NMV/S/74	Oblong Lake	-3.551	-2.355	18/02/09	03:30		-2.313	-0.042
NMV/S/75	Ace Lake (East side)	9.033	-1.784	02/02/09	05:00		-1.719	-0.065
NMV/S/78	Anderson Lake	3.225	-2.853	17/02/09	09:00		-2.679	-0.174

Field book reference: Antarctica 2008/09.

(1) The height of the AUS/V/4 reference mark does not currently have a derived MSL height.

(2) The permanent staff at Club Lake is crooked, thus not a valid measure of lake level.

Many of the lakes (15) have shown a significant decrease in water level (greater than -100mm) between 2009 and 2007. Figure 50 and 51 show the shorelines of lakes which have dropped in the last two years, Ekho Lake (fell by 0.177m) and Lake McNeill (fell by 0.413m). In contrast, Lake Druhzby (+0.218m), Pauk Lake (+0.165m) and Lake Zvevda (+0.005m) have shown an increase in

lake level over the last two years. All of these lakes are closer to the plateau and are subject to inflow of ice melt. It would seem that while a greater amount of melt from the plateau has been increasing the level of these three lakes, the remaining lakes, isolated from plateau melt, have been subject to a greater amount of water evaporation, reducing their lake level. Between the 2009 and 2007 Antarctic seasons, the lakes were observed at near similar times of the year. In 2009 the lake levels were observed throughout the first half of February, whereas in 2007 the lake levels were observed in the first three days of March.

***Figure 50**: North East bank of Ekho Lake*

***Figure 51**: North West bank of Lake McNeil.*

The other two lakes to have shown an increase in level are Organic Lake (+0.086m) and Pendant Lake (+0.052m). Both these lakes are adjacent to Taynaya Bay, on the coast, in the north west of the Vestfolds. The reasons for their slight increase in level, which is against the trend of the other lakes is uncertain.

A full comparison of reduced levels from previous campaigns is stored at Geoscience Australia and with the AAD Mapping Group.

Appendix A

REFERENCE MARK SURVEY METHODOLOGY

Survey tripods were levelled and centred over the GNSS station reference marks (RMs) using a ZNL *Wild* optical plummet. The horizontal survey procedure involved the setup of a *Leica* TCA203 total station over each of the survey marks (GNSS Pillar, RM1, RM2, RM3). Five rounds of FL/FR observations were taken to each of the visible three survey marks. Each round of FL/FR observations involved recording horizontal and vertical angles as well as slope distances.

An EDM heighting levelling survey was conducted between the ARGN monument and the surrounding RMs. The level run went from the GNSS pillar to RM1 to RM2 to RM3 to the GNSS pillar and back again. For each instrument setup four rounds of FL/FR observations were made to each of the BS and FS, with readings of zenith angles and slope distances recorded.

All observed distances were corrected for the atmospheric effects by either entering temperature, pressure and humidity readings (obtained from the station bureau of met office) into the total station (done during levelling) or recorded and applied to the observations in data processing (horizontal survey).

All observations were run through initial pre-processing using in-house software developed by Geoscience Australia and then processed using the least squares survey network adjustment program (SNAP) to determine the final coordinates of survey marks, with estimates of their precision, and evaluate the quality of the observations. The network was fixed using the known ITRF2000@2000.00 coordinates of the ARGN pillar and previously observed azimuth to one of the reference marks.

Appendix B

GPS LOG SHEETS

All collected GPS data is backed up on the GA GPS data archive. Log sheets follow.

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMS153 **ID:** N153 **Number:**
Location: Filla Island, Antarctica **Location:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 48 36.0746	(WGS84)
Longitude:	E 77 48 09.3771	(WGS84)
Height:	102.7291 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		08:22	010/2009
Last day of occupation:		24:00	014/2009

Total number of days occupation: 5

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	ASHTECH UZ-12	UC2200515017	GA
Antenna	ASH701945E_M	CR6200538007	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of N153 on DoY 010/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMS153 **ID:** N153 **Number:**
Location: Filla Island, Antarctica **Location:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

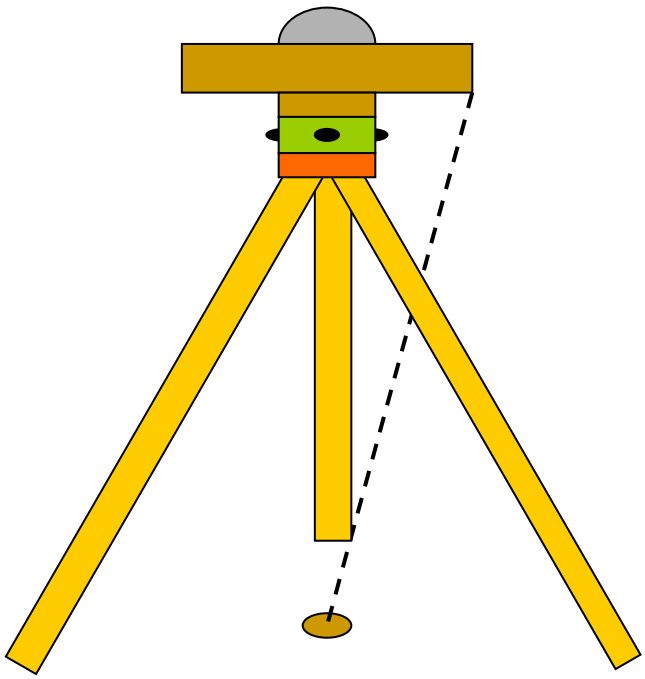
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.1977*
Top of Ground Plane			
Bottom of Ground Plane		1.2470	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMS153 **ID:** N153 **Number:**
Location: Filla Island, Antarctica **Location:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	08:22 010/2009	24:00 010/2009	UN153A09.010
2	00:00 011/2009	24:00 011/2009	UN153A09.011
3	00:00 012/2009	24:00 012/2009	UN153A09.012
4	00:00 013/2009	24:00 013/2009	UN153A09.013
5	00:00 014/2009	24:00 014/2009	UN153A09.014

GPS STATION OCCUPATION REPORT

SITE INFORMATION

Name: AUS186 **ID:** A186 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 20.5994	(WGS84)
Longitude:	E 77 58 05.6302	(WGS84)
Height:	21.363 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		11:23	010/2009
Last day of occupation:		24:00	015/2009

Total number of days occupation: 6

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of A186 on DoY 010/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: AUS186 **ID:** A186 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

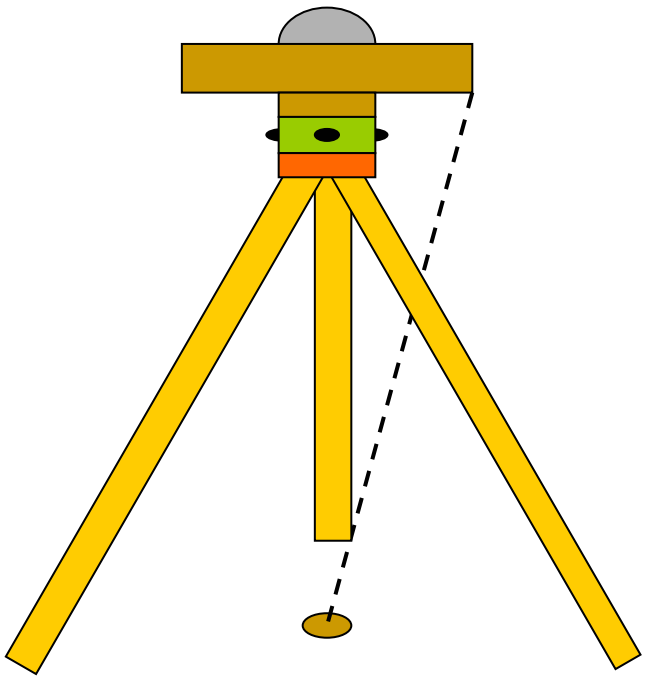
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.2118*
Top of Ground Plane			
Bottom of Ground Plane		1.2610	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: AUS186 **ID:** A186 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	11:23 010/2009	24:00 010/2009	A186010l.m21
2	00:00 011/2009	24:00 011/2009	A186011a.m00
3	00:00 012/2009	24:00 012/2009	A186012a.m00
4	00:00 013/2009	24:00 013/2009	A186013a.m00
5	00:00 014/2009	24:00 014/2009	A186014a.m00
6	00:00 015/2009	24:00 015/2009	A186015a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: AUS186 **ID:** A186 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 20.5994	(WGS84)
Longitude:	E 77 58 05.6302	(WGS84)
Height:	21.363 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		08:27	030/2009
Last day of occupation:		24:00	034/2009

Total number of days occupation: 5

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of A186 on DoY 030/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: AUS186 **ID:** A186 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

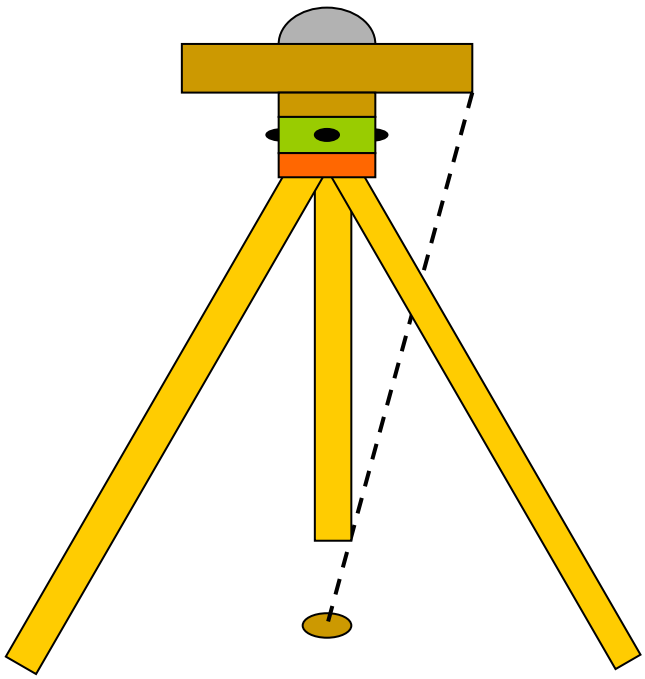
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.2220*
Top of Ground Plane			
Bottom of Ground Plane		1.2710	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: AUS186 **ID:** A186 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	08:27 030/2009	24:00 030/2009	A186030i.m15
2	00:00 031/2009	24:00 031/2009	A186031a.m00
3	00:00 032/2009	24:00 032/2009	A186032a.m00
4	00:00 033/2009	24:00 033/2009	A186033a.m00
5	00:00 034/2009	24:00 034/2009	A186034a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMV/S/4 **ID:** NMV4 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 33.9227	(WGS84)
Longitude:	E 77 57 48.9694	(WGS84)
Height:	1.1326 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		14:30	013/2009
Last day of occupation:		24:00	015/2009

Total number of days occupation: 3

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462980	GA
Antenna	ASH701945E_M	CR620024345	GA

Type of Setup: Static / Antenna on Spigot
Power: 12V battery with solar panel

SITE PHOTO

Photo of NMV4 on DoY 013/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMV/S/4 **ID:** NMV4 **Number:**
Location: Davis Station, Antarctica **Location:** AAD 1159

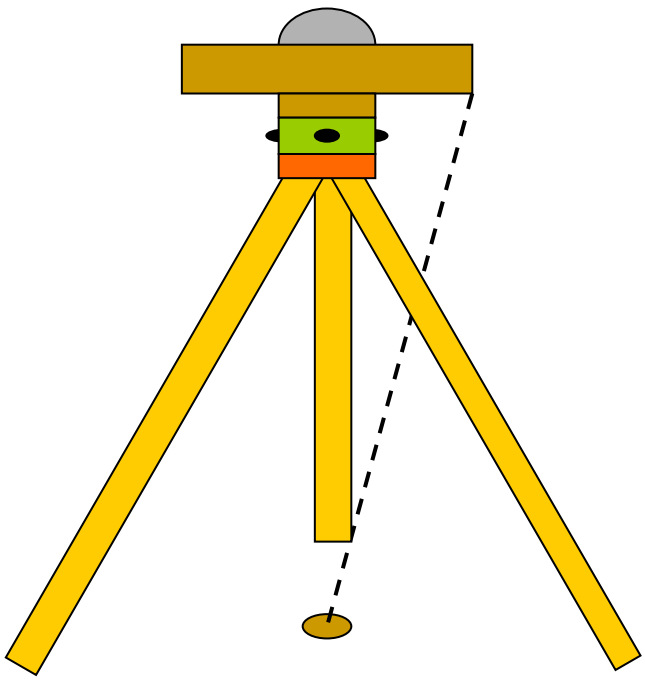
ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.3149*
Top of Ground Plane			
Bottom of Ground Plane		1.3630	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMV/S/4 **ID:** NMV4 **Number:**
Location: Davis Station, Antarctica **Location:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	14:30 013/2009	24:00 013/2009	
2	00:00 014/2009	24:00 014/2009	
3	00:00 015/2009	24:00 015/2009	

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMV/S/4 **ID:** NMV4 **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 33.9227	(WGS84)
Longitude:	E 77 57 48.9694	(WGS84)
Height:	1.1326 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		08:48	030/2009
Last day of occupation:		24:00	035/2009

Total number of days occupation: 6

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462980	GA
Antenna	ASH701945E_M	CR620024345	GA

Type of Setup: Static / Antenna on Spigot
Power: 12V battery with solar panel

SITE PHOTO

Photo of NMV4 on DoY 030/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMV/S/4 **ID:** NMV4 **Number:**
Location: Davis Station, Antarctica **Location:** AAD 1159

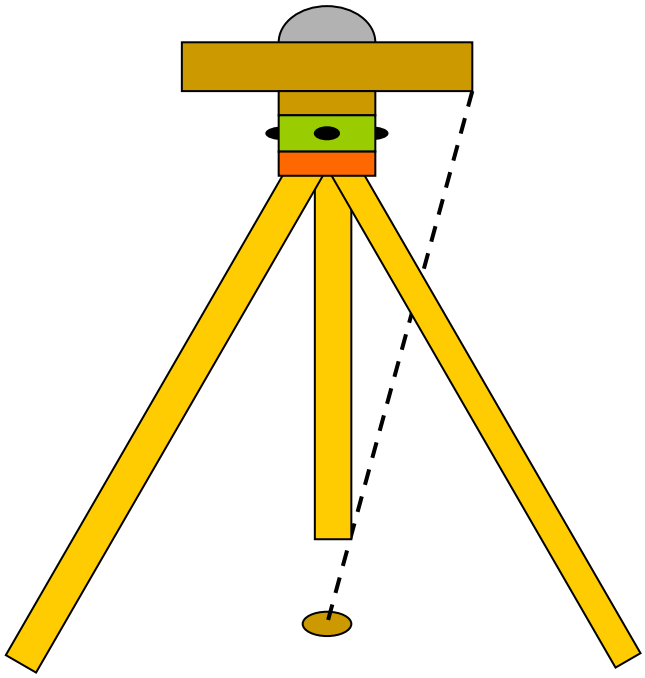
ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.2068*
Top of Ground Plane			
Bottom of Ground Plane		1.2560	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMV/S/4 **ID:** NMV4 **Number:**
Location: Davis Station, Antarctica **Location:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	08:48 030/2009	24:00 030/2009	NMS4030i.m48
2	00:00 031/2009	24:00 031/2009	NMS4031a.m00
3	00:00 032/2009	24:00 032/2009	NMS4032a.m00
4	00:00 033/2009	24:00 033/2009	NMS4033a.m00
5	00:00 034/2009	24:00 034/2009	NMS4034a.m00
6	00:00 035/2009	24:00 035/2009	NMS4035a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION

Name: DRM1 **Name:** DRM1 **Number:**

Location: Davis Station, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 36.94420	(WGS84)
Longitude:	E 77 58 21.69995	(WGS84)
Height:	42.0891m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		04:00	053/2009
Last day of occupation:		24:00	056/2009

Total number of days occupation: 4

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	ASHTECH UZ-12	UC2200515017	GA
Antenna	ASH701945E_M	CR6200538007	GA

Type of Setup: Static / Antenna on Tripod

Power: 12V battery with solar panel

SITE PHOTO

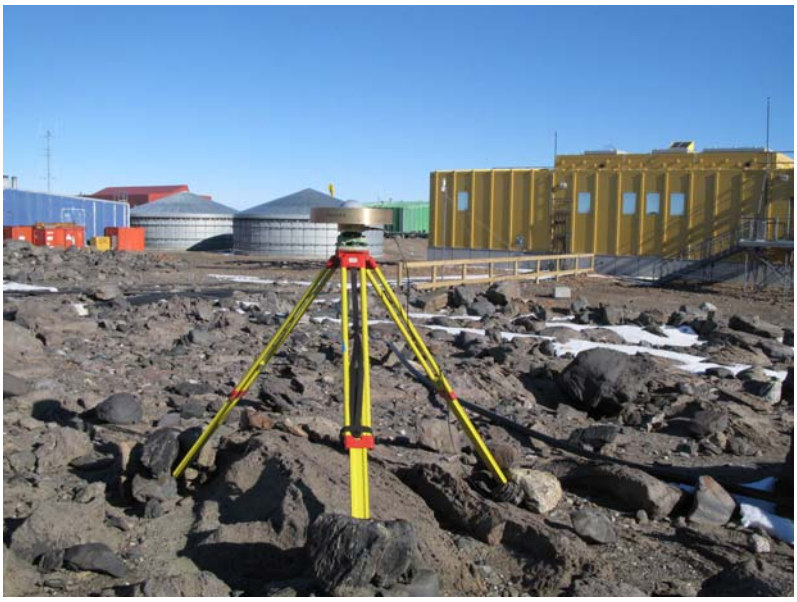


Photo of DRM1 on DoY 053/2009 facing (W)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: DRM1 **ID:** DRM1 **Number:**
Location: Davis Station, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

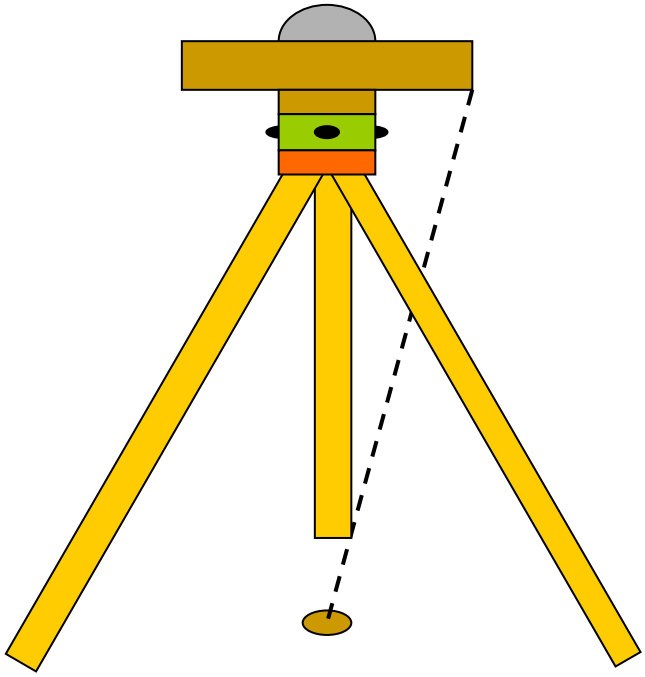
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.0802*
Top of Ground Plane			
Bottom of Ground Plane		1.1310	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: DRM1 **ID:** DRM1 **Number:**
Location: Davis Station, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	04:00 053/2009	24:00 053/2009	UDRM1A09.053
2	00:00 054/2009	24:00 054/2009	UDRM1A09.054
3	00:00 055/2009	24:00 055/2009	UDRM1A09.055
4	00:00 056/2009	24:00 056/2009	UDRM1A09.056

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: D5 **ID:** D5__ **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 30.59139	(WGS84)
Longitude:	E 77 58 06.56102	(WGS84)
Height:	36.4687 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		03:00	053/2009
Last day of occupation:		24:00	056/2009

Total number of days occupation: 4

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of D5__ on DoY 053/2009 facing (W)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: D5 **ID:** D5__ **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

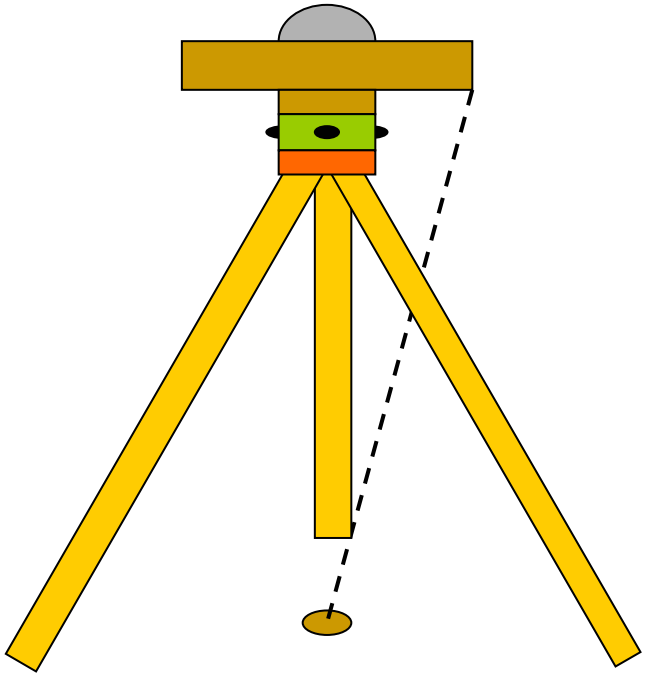
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.1075*
Top of Ground Plane			
Bottom of Ground Plane		1.1580	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: D5 **ID:** D5__ **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	03:00 053/2009	24:00 053/2009	D5__053c.m53
2	00:00 054/2009	24:00 054/2009	D5__054a.m00
3	00:00 055/2009	24:00 055/2009	D5_055a.m00
4	00:00 056/2009	24:00 056/2009	D5_056a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: D9 **ID:** D9__ **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 34.43692	(WGS84)
Longitude:	E 77 57 59.12868	(WGS84)
Height:	31.5934 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		02:47	053/2009
Last day of occupation:		24:00	056/2009

Total number of days occupation: 6

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462980	GA
Antenna	ASH701945E_M	CR620024345	GA

Type of Setup: Static / Antenna on Spigot
Power: 12V battery with solar panel

SITE PHOTO

Photo of D9__ on DoY 053/2009 facing (W)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: D9 **ID:** D9__ **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

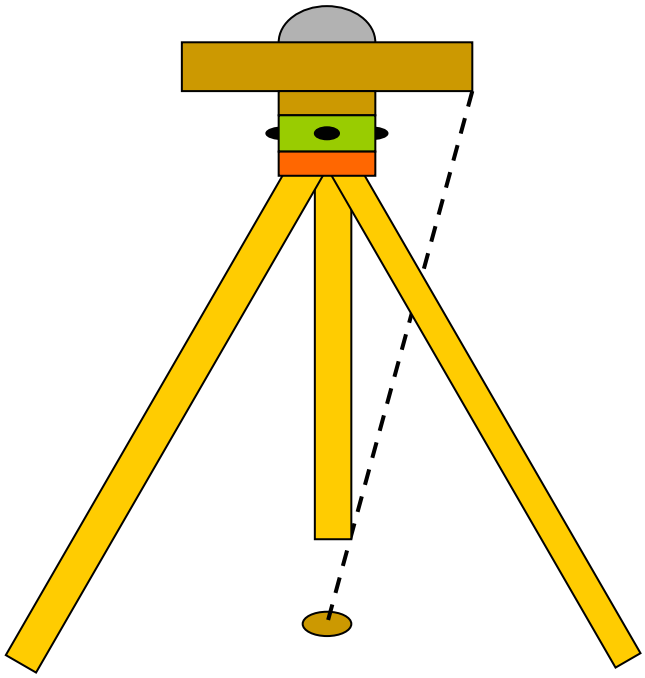
ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.1481*
Top of Ground Plane			
Bottom of Ground Plane		1.1980	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: D9 **ID:** D9__ **Number:** N/A
Location: Davis Station, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	02:47 053/2009	24:00 030/2009	D9__053c.m47
2	00:00 054/2009	24:00 031/2009	D9__054a.m00
3	00:00 055/2009	24:00 032/2009	D9_055a.m00
4	00:00 056/2009	24:00 033/2009	D9__056a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMV/S/8 **Name:** DEEP **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 33 22.94198	(WGS84)
Longitude:	E 78 11 16.29822	(WGS84)
Height:	-32.983	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		03:00	048/2009
Last day of occupation:		24:00	051/2009

Total number of days occupation: 4

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	ASHTECH UZ-12	UC2200515017	GA
Antenna	ASH701945E_M	CR6200538007	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of DEEP on DoY 048/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMV/S/8 **Name:** DEEP **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

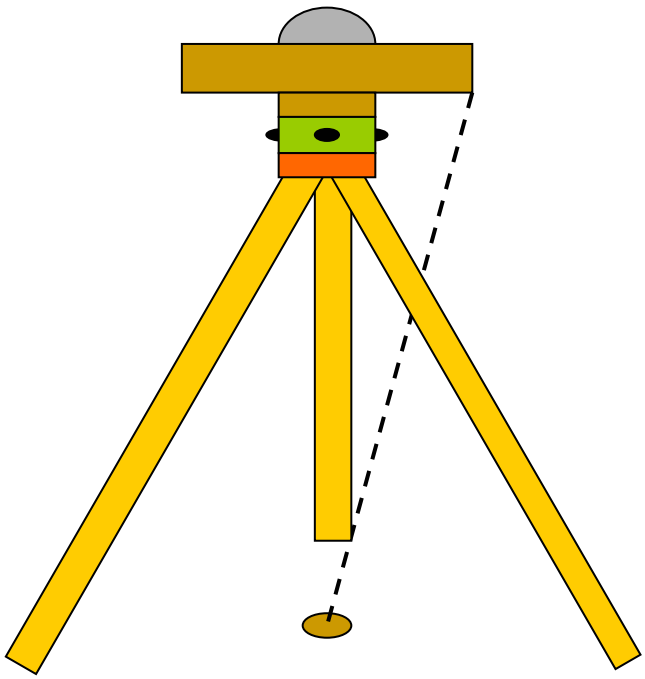
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.2493*
Top of Ground Plane			
Bottom of Ground Plane		1.2980	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMV/S/8 **Name:** DEEP **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	03:00 048/2009	24:00 048/2009	UDEEPA09.048
2	00:00 049/2009	24:00 049/2009	UDEEPA09.049
3	00:00 050/2009	24:00 050/2009	UDEEPA09.050
4	00:00 051/2009	24:00 051/2009	UDEEPA09.051

GPS STATION OCCUPATION REPORT

SITE INFORMATION

Name: NMS273 **ID:** N273 **Number:** N/A
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 38.5424	(WGS84)
Longitude:	E 78 11 54.7190	(WGS84)
Height:	140.930 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		07:15	044/2009
Last day of occupation:		24:00	048/2009

Total number of days occupation: 5

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of N273 on DoY 044/2009 facing (W)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMS273 **ID:** N273 **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

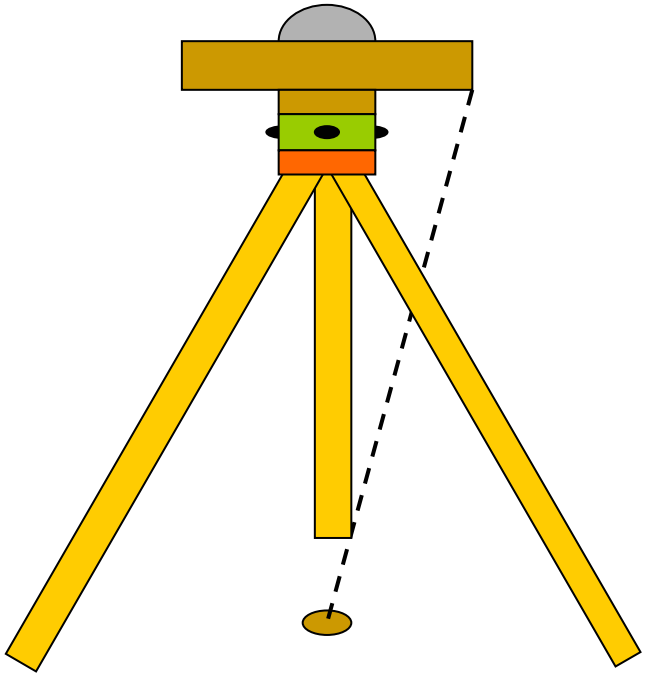
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.1248*
Top of Ground Plane			
Bottom of Ground Plane		1.1750	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMS273 **ID:** N273 **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	07:15 044/2009	24:00 044/2009	N273044b.m06
2	00:00 045/2009	24:00 045/2009	N273045a.m00
3	00:00 046/2009	24:00 046/2009	N273046a.m00
4	00:00 047/2009	24:00 047/2009	N273047a.m00
5	00:00 048/2009	24:00 048/2009	N273048a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMV/S/66 **ID:** NM66 **Number:** N/A
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 31 41	(WGS84)
Longitude:	E 78 21 00	(WGS84)
Height:	30.083 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		07:50	044/2009
Last day of occupation:		24:00	048/2009

Total number of days occupation: 5

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462980	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Spigot
Power: 12V battery with solar panel

SITE PHOTO

Photo of NM66 on DoY 044/2009 facing (W)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMV/S/66 **ID:** NM66 **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

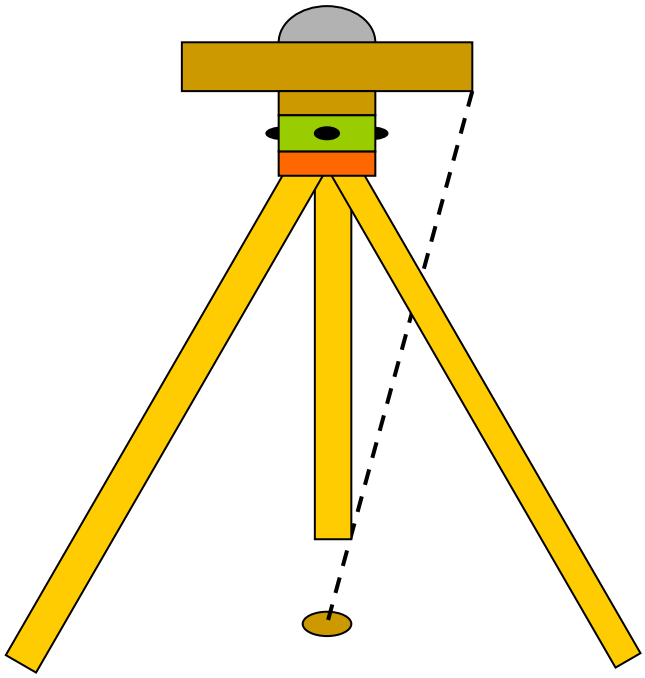
ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			0.9053*
Top of Ground Plane			
Bottom of Ground Plane		0.9590	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMV/S/66 **ID:** NM66 **Number:**
Location: Vestfold Hills, Antarctica **Location:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	07:00 044/2009	24:00 044/2009	NM66044b.m00
2	00:00 045/2009	24:00 045/2009	NM66045a.m00
3	00:00 046/2009	24:00 046/2009	NM66046a.m00
4	00:00 047/2009	24:00 047/2009	NM66047a.m00
5	00:00 048/2009	24:00 048/2009	NM66048a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMV/S/83 **ID:** NM83 **Number:** N/A
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 34 30	(WGS84)
Longitude:	E 78 23 35	(WGS84)
Height:	11.070 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		04:33	048/2009
Last day of occupation:		24:00	051/2009

Total number of days occupation: 4

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of NM83 on DoY 048/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMV/S/83 **ID:** NM83 **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

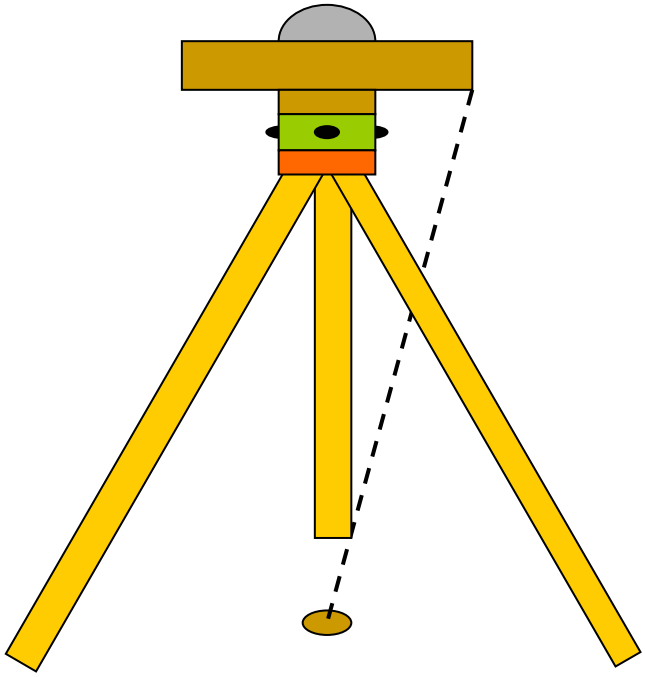
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.3028*
Top of Ground Plane			
Bottom of Ground Plane		1.3510	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMV/S/83 **ID:** NM83 **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	04:33 048/2009	24:00 048/2009	NM83048e.m19
2	00:00 049/2009	24:00 049/2009	NM83054a.m00
3	00:00 050/2009	24:00 050/2009	NM83055a.m00
4	00:00 051/2009	24:00 051/2009	NM83056a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMV/S/84 **ID:** NM84 **Number:** N/A
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 68 26 10	(WGS84)
Longitude:	E 78 17 50	(WGS84)
Height:	24.695 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		05:11	048/2009
Last day of occupation:		24:00	051/2009

Total number of days occupation: 4

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462980	GA
Antenna	ASH701945E_M	CR620024345	GA

Type of Setup: Static / Antenna on Spigot
Power: 12V battery with solar panel

SITE PHOTO

Photo of NM84 on DoY 048/2009 facing (W)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMV/S/84 **ID:** NM84 **Number:**
Location: Vestfold Hills, Antarctica **Project:** AAD 1159

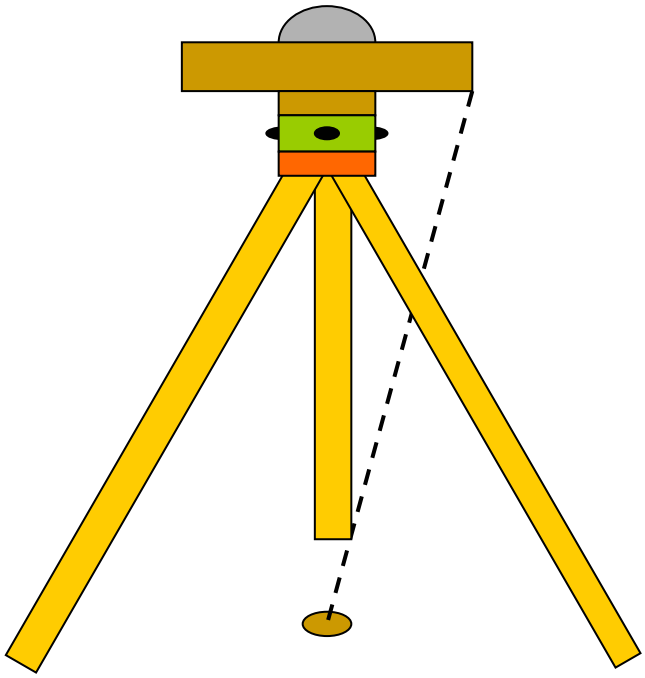
ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.0812*
Top of Ground Plane			
Bottom of Ground Plane		1.1320	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMV/S/84 **ID:** NM84 **Number:**
Location: Davis Station, Antarctica **Location:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	05:11 048/2009	24:00 048/2009	NM84048e.m55
2	00:00 049/2009	24:00 049/2009	NM84049a.m00
3	00:00 050/2009	24:00 050/2009	NM84050a.m00
4	00:00 051/2009	24:00 051/2009	NM84051a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: NMS278 **ID:** N278 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 69 23 21.1793	(WGS84)
Longitude:	E 76 22 50.7621	(WGS84)
Height:	63.5 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		13:59	016/2009
Last day of occupation:		24:00	023/2009

Total number of days occupation: 8

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462980	GA
Antenna	ASH701945E_M	CR6200538007	GA

Type of Setup: Static / Antenna on Spigot
Power: 12V battery with solar panel

SITE PHOTO

Photo of N278 on DoY 016/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: NMS278 **ID:** N278 **Number:**
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

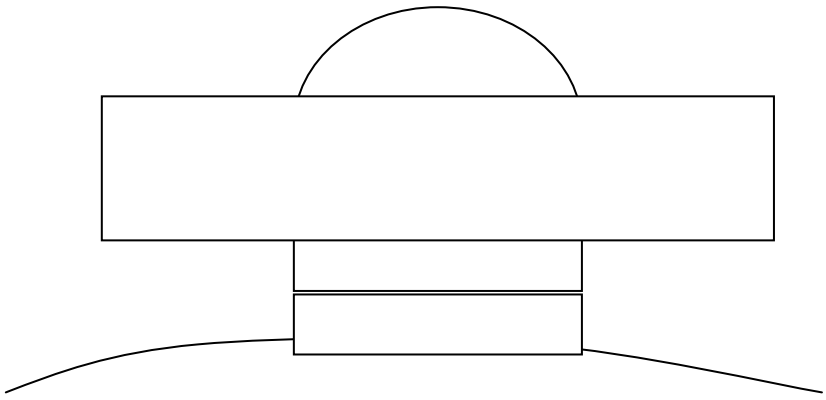
ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			0.0300 m
Top of Ground Plane			
Bottom of Ground Plane			
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: NMS278 **ID:** N278 **Number:**
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	13:59 016/2009	24:00 016/2009	N278016m.m59
2	00:00 017/2009	24:00 017/2009	N278017a.m00
3	00:00 018/2009	24:00 018/2009	N278018a.m00
4	00:00 019/2009	24:00 019/2009	N278019a.m00
5	00:00 020/2009	24:00 020/2009	N278020a.m00
6	00:00 021/2009	24:00 021/2009	N278021a.m00
7	00:00 022/2009	24:00 022/2009	N278022a.m00
8	00:00 023/2009	24:00 023/2009	N278023a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION

Name: ZS02 **ID:** ZS02 **Number:**

Location: Larsemann Hills, Antarctica **Location:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 69 23 20.3	(WGS84)
Longitude:	E 76 22 35.4	(WGS84)
Height:	75.0 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		14:20	016/2009
Last day of occupation:		24:00	019/2009

Total number of days occupation: 3

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	ASHTECH UZ-12	UC2200515017	GA
Antenna	ASH701945E_M	CR6200538007	GA

Type of Setup: Static / Antenna on Tripod

Power: 12V battery with solar panel

SITE PHOTO

Photo of ZS02 on DoY 016/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: ZS02 **ID:** ZS02 **Number:**
Location: Larsemann Hills, Antarctica **Location:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

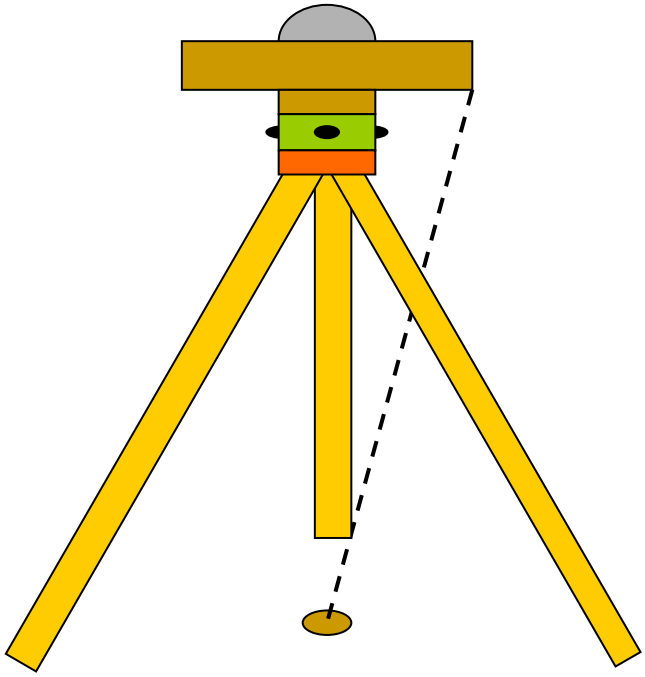
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.2007*
Top of Ground Plane			
Bottom of Ground Plane		1.2500	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: ZS02 **ID:** ZS02 **Number:**
Location: Larsemann Hills, Antarctica **Location:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	14:20 016/2009	24:00 016/2009	UZS02A09.016
2	00:00 017/2009	24:00 017/2009	UZS02A09.017
3	00:00 018/2009	24:00 018/2009	UZS02A09.018
4	00:00 019/2009	24:00 019/2009	UZS02A09.019

GPS STATION OCCUPATION REPORT

SITE INFORMATION

Name: C1 **ID:** C1__ **Number:** N/A

Location: Larsemann Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 69 23 31.2	(WGS84)
Longitude:	E 76 22 44.6	(WGS84)
Height:	113.816 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		02:00	020/2009
Last day of occupation:		24:00	023/2009

Total number of days occupation: 4

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	ASHTECH UZ-12	UC2200515017	GA
Antenna	ASH701945E_M	CR6200538007	GA

Type of Setup: Static / Antenna on Tripod

Power: 12V battery with solar panel

SITE PHOTO

Photo of C1__ on DoY 020/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: C1 **ID:** C1__ **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

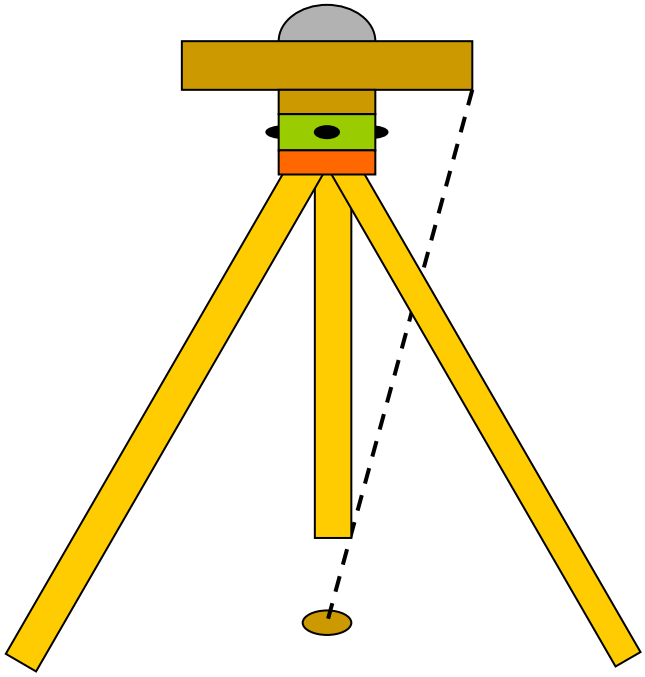
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.0731*
Top of Ground Plane			
Bottom of Ground Plane		1.1240	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: C1 **ID:** C1__ **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	02:00 020/2009	24:00 020/2009	UC1__A09.020
2	00:00 021/2009	24:00 021/2009	UC1__A09.021
3	00:00 022/2009	24:00 022/2009	UC1__A09.022
4	00:00 023/2009	24:00 023/2009	UC1__A09.023

GPS STATION OCCUPATION REPORT

SITE INFORMATION
Name: AUS334 **ID:** A334 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 69 22 58.8	(WGS84)
Longitude:	E 76 22 22.9	(WGS84)
Height:	2.0 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		09:00	016/2009
Last day of occupation:		24:00	019/2009

Total number of days occupation: 4

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

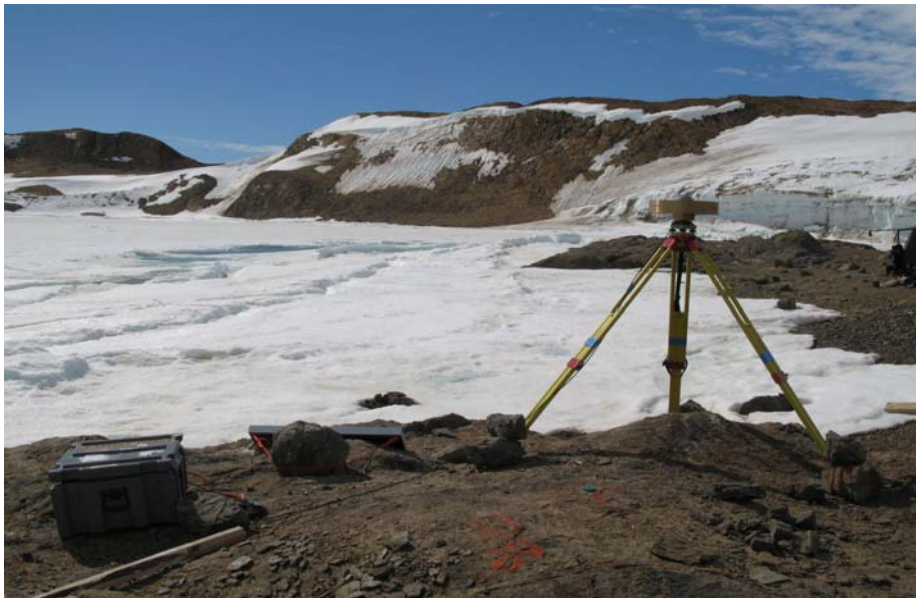


Photo of A334 on DoY 016/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: AUS334 **ID:** A334 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

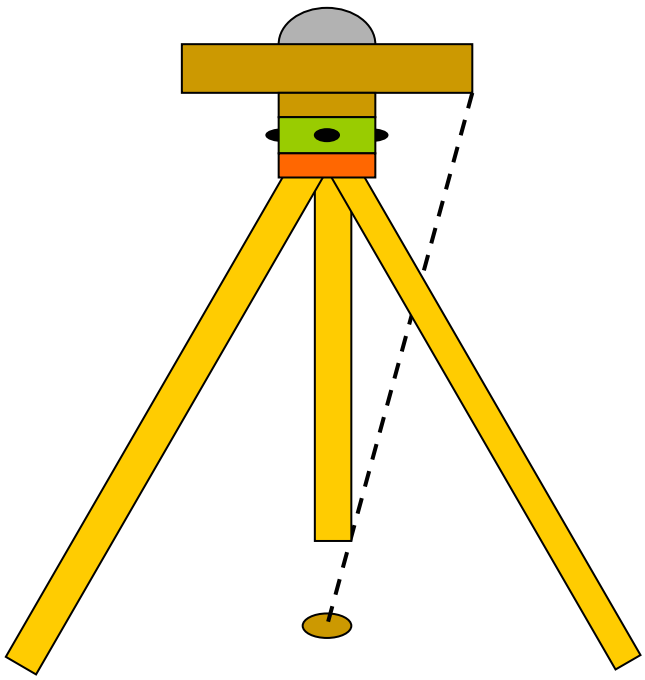
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.3096*
Top of Ground Plane			
Bottom of Ground Plane		1.0910	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: AUS334 **ID:** A334 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	13:15 016/2009	24:00 016/2009	A334016i.m33
2	00:00 017/2009	24:00 017/2009	A334017a.m00
3	00:00 018/2009	24:00 018/2009	A334018a.m00
4	00:00 019/2009	24:00 019/2009	A334019a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION

Name: AUS335 **ID:** A335 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 69 22 58.8	(WGS84)
Longitude:	E 76 22 22.9	(WGS84)
Height:	2.0 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		01:00	022/2009
Last day of occupation:		24:00	023/2009

Total number of days occupation: 2

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

Photo of A335 on DoY 022/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: AUS335 **ID:** A335 **Number:**
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

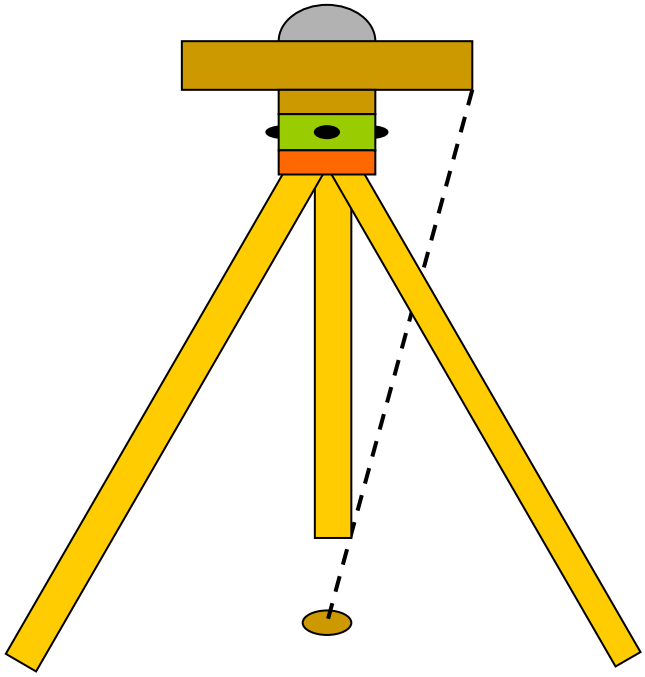
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.1653*
Top of Ground Plane			
Bottom of Ground Plane		1.2150	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: AUS335 **ID:** A335 **Number:**
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	01:00 022/2009	24:00 022/2009	A335022b.m37
2	00:00 023/2009	24:00 023/2009	A335023a.m00

GPS STATION OCCUPATION REPORT

SITE INFORMATION

Name: AUS350 **ID:** A350 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

APPROXIMATE COORDINATES

Latitude:	S 69 22 58.8	(WGS84)
Longitude:	E 76 22 22.9	(WGS84)
Height:	2.0 m	

OCCUPATION SUMMARY

	Local	UTC	Day of Year
First day of occupation:		00:40	020/2009
Last day of occupation:		24:00	021/2009

Total number of days occupation: 2

EQUIPMENT USED

	Model	Serial Number	Owned By
Receiver	Leica GRX1200	462888	GA
Antenna	ASH701945E_M	CR6200538020	GA

Type of Setup: Static / Antenna on Tripod
Power: 12V battery with solar panel

SITE PHOTO

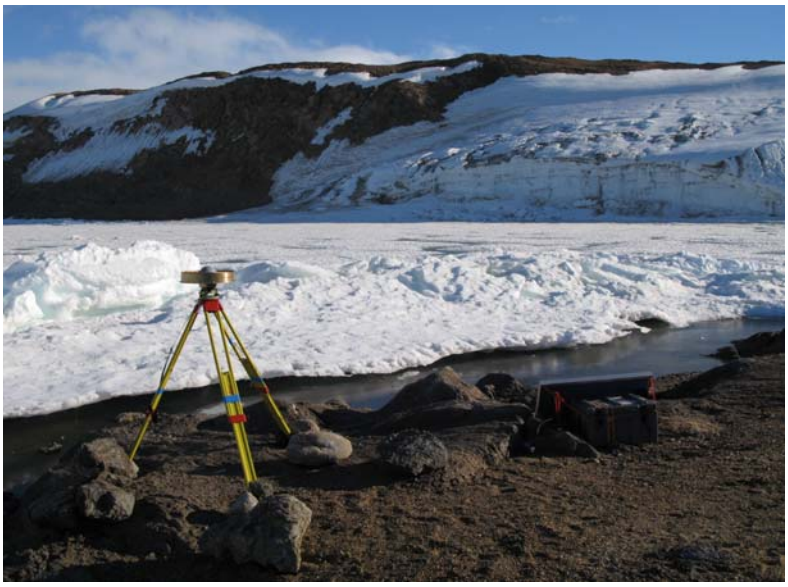


Photo of A350 on DoY 020/2009 facing (N)

ANTENNA SETUP INFORMATION

SITE INFORMATION
Name: AUS350 **ID:** A350 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

ANTENNA SETUP
Include a sketch of the antenna setup showing all mounting accessories (Tripod, pillar, tribrach etc …). Show all distances measured to ground marks or defined points. Indicate whether distances are slant or vertical.

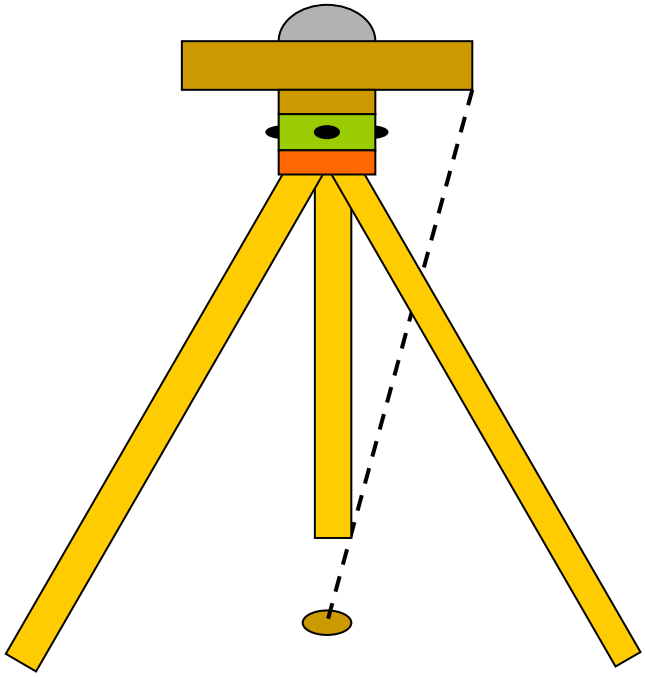
Antenna Height (metres)

Reference Point	Distance	Slant	Vertical
L1 Phase Centre			
L2 Phase Centre			
Base of Antenna (ARP)			1.2826*
Top of Ground Plane			
Bottom of Ground Plane		1.3310	
Bottom of Choke Ring			

Antenna IGS Code: ASH701945E_M

**Calculated Value*

ANTENNA SKETCH DIAGRAM



DAILY OBSERVATION LOG

SITE INFORMATION
Name: AUS350 **ID:** A350 **Number:** N/A
Location: Larsemann Hills, Antarctica **Project:** AAD 1159

PRIMARY OPERATOR CONTACT DETAILS
Agency: Geoscience Australia
Name: Ryan Ruddick
Address:
Phone: +61 2 6249 9426
Email: ryan.ruddick@ga.gov.au

LOGGING DETAILS

GPS/~~GLONASS/COMPASS/GALILEO~~

Elevation Mask: 0 Degrees
Orientation of Antenna: True North
Collection Interval: 30 Seconds

Archive Location: /

SESSION INFORMATION

Session	Start Time	End Time	Raw File
1	00:40 020/2009	24:00 020/2009	A350020a.m00
2	00:00 021/2009	24:00 021/2009	A335021a.m00