GOVERNMENT OF WESTERN AUSTRALIA

Landgate

Landgate Requirements for GNSS Geodetic Surveys

GSU-01 Version 5

Locate Value Secure

Survey Sept 2023 Version 5

Document control

Landgate requirements for GNSS geodetic surveys, Version 5 – September 2023

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Document version history

Date	Author	Version	Revision Notes
Sept 2023	B.Hellmund	5.0	Update to new style and refresh hyperlinks
	Survey	1.0	Initial

Table of contents

1. Overview

GNSS surveys for the establishment of Geodetic Standard Survey Marks (SSMs) are to be conducted in accordance with the Special Publication No 1 (SP1 v2.2). Minimum acceptable practice for surveying and data processing, should conform to SP1 v2.2 Guideline for Control Surveys by GNSS to achieve Positional Uncertainty < 30mm horizontal position. The following specifications cover procedure and requirements for observation of static GNSS baselines. If there is inconsistency between these specifications and SP1 v2.1, the requirements of these specifications will prevail.

2. Verify and Document Sites Occupied

2.1. Each occupied existing SSM must be checked for horizontal and vertical stability in the field using a minimum of two RM's. RM's should be selected ensuring good geometry for horizontal validation without ambiguity. Horizontal distance measurements and height differences between the SSM and its RM's are to be documented and included in the stability check. If disturbance of the main mark is suspected, angles are to be observed from the main mark to all Reference Marks (RMs). See Appendix C for an example of an annotated SSM summary.

2.2. Measure and provide the height difference from the SSM and RMs to ground level and where applicable from the hatch cover to ground level if these values don't exist in the GOLA report or are different from published values.

2.3. If the SSM is covered by a cairn or is not suitable for GNSS, occupy one of the existing RMs or establish a new RM and observe all distances, angles and height differences to the existing RMs. Also observe an azimuth and distance to the centre of the cairn or to the SSM. Do not remove the cairn. The RO for azimuth can be an inter-visible SSM or TCM with a GNSS baseline or VRS/RTK coordinate. If VRS or RTK is utilised a check shot on the SSM should be observed.

2.4. If a RM is used as a GNSS observation point, a difference in level between the RM and the main mark is required. If the main mark is covered by a large cairn, then an estimated difference should be provided. It is essential that an accurate azimuth and distance is either known or can be determined between an eccentric observation point and the main mark.

2.5. If an SSM is damaged or destroyed, notify the Landgate as soon as practicable. Landgate may issue instructions for its replacement and re-survey or suggest an alternative SSM to occupy or abandon the component of survey involving the SSM in question.

2.6. Repair or replace damaged or destroyed RMs, if it is found there are insufficient RMs remaining to validate the primary mark in 3 dimensions. Update access and location details

where necessary. Where only one RM remains to validate the mark, a geodetic azimuth must be observed from the main mark to the RM.

2.7. Levelling can be reduced on the Landgate excel spreadsheet *'levelling abstractV3.xlsm'*. Enable editing and macros if asked. The spreadsheet can populate data from to the geodetic database via SLIP (account required). Below is the link to Landgate Standards and Guidelines page containing the spreadsheet and instructions.

https://www.landgate.wa.gov.au/location-data-and-services/surveying/standards-and-guidelines/

3. Instrument and Observation Instructions

3.1. Placement of new geodetic marks must conform to the standards outlined by the Landgate Requirements for placement of Standard Survey Marks.

3.2. All survey equipment must have current calibration certificates, to be supplied to Landgate. GNSS receivers must be dual frequency geodetic quality with code and carrier phase tracking capabilities and equipped with IGS or NGS certified antennas. Details of the receiver and antenna type, model and serial number and processing software used must be provided. Check if your GNSS antenna is identified on the NGS Antenna code from Antenna Calibrations (noaa.gov).

3.3. Record and process data at a sampling interval of 15 seconds. Record data from all available GNSS constellations.

3.4. Sufficient data must be collected to ensure ambiguities are fixed in the baseline solution. The minimum baseline observation time must be 50 minutes plus 2 minutes per kilometre of baseline length. Rapid or quick static baselines will not be accepted. Longer observing sessions are required for sites with restricted sky visibility. At sites unsuitable for GNSS observations a nearby eccentric point, that meets the requirements in Section 2 should be occupied.

3.5. Set the minimum satellite elevation angle to 0 degrees.

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3.6. Antennas shall be aligned within +/- 5 degrees of true north. Where the antenna does not have a designated north point and the manufacturer documentation does not designate a north point, point the cable connector north. This will ensure that all like antennas are oriented the same. If in doubt, contact Landgate for advice. Where improvised north point is used, record details on log sheets and take images to document the orientation point of the antenna.

3.7. Incorrect antenna heights are the single most common errors in observing static GNSS baselines.

- All antenna heights are to be carefully measured and recorded on the log sheet along with four images
    - Station Summary for occupation identification.
    - Image of mark occupied (see Appendix D)
    - Image of the antenna height measurement. The measured value must be readable for confirmation of the antenna height (see Appendix E)
    - Setup of instrument in situ, showing the location and configuration of the setup (see Appendix F)
- Provide details for where on the antenna, the height component is measured.
- Provide a sketch showing the relationship between the Antenna Reference Point (ARP) and the point on the antenna to where the height has been measured.
- All details of the antenna type, model and serial number are required on the log sheets. Ensure the provided RINEX files contain the true vertical offset to the ARP.

3.8. GNSS observing details are to be recorded on supplied log sheets for all observed/occupied stations. Session numbers should be linked to a daily based schedule (preferably UT). Session times can be recorded on the log sheet in UT or Local time. If possible, record the raw data filename on the log sheet. See Appendix A for a sample log sheet.

4. Independent Baselines

For a given session with n receivers used there is $n-1$ independent baselines. Therefore, in a network observed with three receivers logging simultaneously, there are two independent baselines and one trivial baseline. Landgate does not accept trivial baselines in the geodetic network. Trivial baselines must be removed from the computations supplied to Landgate.

5. National GNSS Campaign Archive (NGCA)

These observations are used by Landgate and ICSM for the National GNSS Campaign Archive (NGCA) to improve national positioning and GDA modernisation. At least six hours of GNSS data needs to be collected at a single SSM that has been validated horizontally and vertically. Data collection does not require simultaneous GNSS observations.

6. Baseline Processing

6.1. All processed baselines must be ambiguity fixed solutions, irrespective of length of line.

6.2. The processed baselines must be scrutinised for poor quality. If data quality is insufficient the baseline must be excluded from the processing and re-observed.

6.3. When processing the baselines, the current Geocentric Datum of Australia (GDA2020) co-ordinates for all SSMs occupied must be used. The most accurate coordinates available from GOLA or that can be determined shall be used in processing. Navigation based, default coordinates are inaccurate and unacceptable.

6.4. Best practice requires that baselines are processed with the International GNSS Service (IGS) Final, Rapid or Ultra Rapid ephemerides. However, if this is not practical, baselines less than 30km may be processed with broadcast ephemeris.

6.5. Use IGS tested Absolute Antenna Models where possible. If IGS Absolute Antenna Models are not available, use NGS Absolute Models. Prior approval from Landgate is required if processing with NGS Relative Antenna Models.

6.6. The software default atmospheric models can be used for processing all baselines.

6.7. If the survey campaign is observed over multiple days, Landgate recommends processing daily observation sessions.

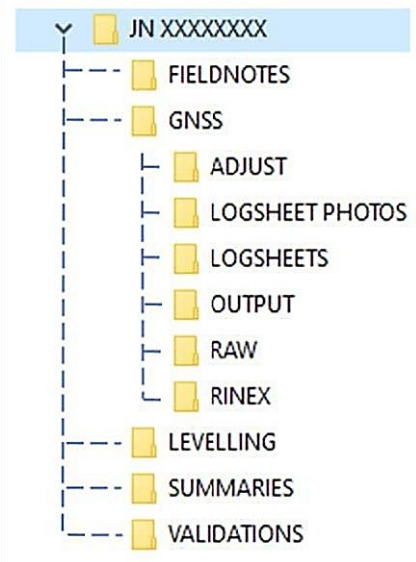
6.8. Document the name of processing software used, the version number and baseline processing software options used during processing.

7. Adjustment

7.1. Conduct a minimally constrained 3-dimensional least squares adjustment of each network observed to prove the quality of the observations. Refer to the SP1 v2.2 Guideline for Adjustment and Evaluation of Survey Control for the recommended procedure for evaluating the quality of the observations.

8. Digital Data

8.1. Folder structure



8.2. FIELDNOTES

Scans of any field notes, survey reports, Instrument downloads, etc that are not included in other directories.

8.3. GNSS / ADJUST

Provide reports and/or input and output files of minimally constrained and constrained least square adjustments.

8.4. GNSS / LOGSHEET PHOTOS

- Station Summary for occupation identification.
- Image of mark occupied (see Appendix D)
- Image of the antenna height measurement. The measured value must be readable for confirmation of the antenna height (see Appendix E)
- Setup of instrument in situ, showing the location and configuration of the setup (see Appendix F)

The photos requested on the log sheet and taken at the time of instrument setup. There is no need to rename images. The ‘Date taken’ property of the image file should be preserved so that they are in a logical order and correspond to the start of each RINEX file, if this date and time is unable to be preserved then rename of the photos will need to be undertaken.

8.5. GNSS / LOG SHEET

Provide scans of all field log sheets, each RINEX file should have a corresponding log sheet.

It should be possible to easily match log sheets to GNSS data. Log sheets should contain as a minimum, the following information:

- Full station name
- Station name as entered into the receiver
- Mark description
- Project name
- Antenna height as measured and reduced to ARP
- Images taken
- Date of observation and UT day of year
- UT or local start and finish times
- Epochs
- Session number
- Receiver make, model and serial number
- Antenna make, model, serial number and NGS antenna code
- Name of operator

Additional information on log sheet could include raw antenna height measurements and reductions, site map showing obstructions above 15 degrees.

8.6. GNSS / OUTPUT

Production software name and version as well as the final output files associated with baseline processing are required. Depending on the software output, the baseline processing report may contain the following details:

- Processing parameters
- Start and finish times (UT)
- Epoch interval
- Initial coordinates (indicate their origin, e.g. scaled, GESMAR)
- Antenna height (including where on the antenna height is observed to)
- Satellite information (which satellites used in solution?)
- Ambiguity resolution
- Final coordinates
- Delta X, Y, Z baseline
- Standard deviations of Delta X, Y, Z and Correlation or Covariance Matrix of same

Landgate uses the latest version of Trimble Business Center for baseline processing thus TBC Archived or VCE files are acceptable.

8.7. GNSS / RAW

Provide all raw data files as downloaded from receivers.

8.8. GNSS / RINEX

All observed GNSS data is to be supplied in RINEX format.

- Ensure the SSM name is correctly entered on the **MARKER NAME** line in the RINEX file.
- The antenna height entered in the RINEX file must be the vertical offset of the Antenna Reference Point (ARP) above the ground mark. The ARP is usually defined as the plane of the base of the standard 5/8 thread on the antenna. This information can usually be obtained from the GNSS equipment manufacturer or refer to the IGS/NGS Antenna Calibration website.
- The antenna make and model must be identified from the IGS RINEX antenna naming conventions and the antenna code entered on the RINEX file online ANT # / TYPE.

8.9. LEVELLING

Provide the levelling abstract.

8.10. SUMMARIES

Drawing files (DWG) of new or redrafted station summaries that have required amendments in accord with ***GSU-07 Disturbed Geodetic Marks guideline.***

8.11. VALIDATIONS

Annotated summaries as shown in Appendix C. Each mark visited should have an annotated summary with date and initials. Contains all terrestrial measurements including horizontal distances, angles, height differences and azimuths as observed to and between RMs.

9. Documentation

In addition to the Digital data described in section 8, other information to be submitted are:

- Project report outlining survey procedure and data processing steps.
- A summary of baselines observed, listed in day/session order.
- Station summaries for all new and existing marks where amendments are required original drawing files have been supplied. (Including Reference Mark (RM) measurement detail and updated access sketches).
- Any terrestrial observations.
- Observed network plan/s, not necessarily to scale.
- A geodetic survey check list (see Appendix B)

10. GNSS System Test

Landgate provides GNSS System Test facilities at Curtin University and recommends periodic checking of your GNSS system. For more information refer to Landgate instrument calibration website:
https://www.landgate.wa.gov.au/location-data-and-services/surveying/instrument-calibration/

11. Public Relations

The surveyor is to always maintain good public relations. It is the responsibility of the contractor to follow procedures and hold valid and relevant licences. Where entry onto private or leasehold land or vested reserves is required, contact must be made with the relevant owner, occupier, or authority prior to entry. Entry onto land is governed by the provisions in the Standard Survey Marks Act, 1924.

12. Appendix A – GNSS Log sheet

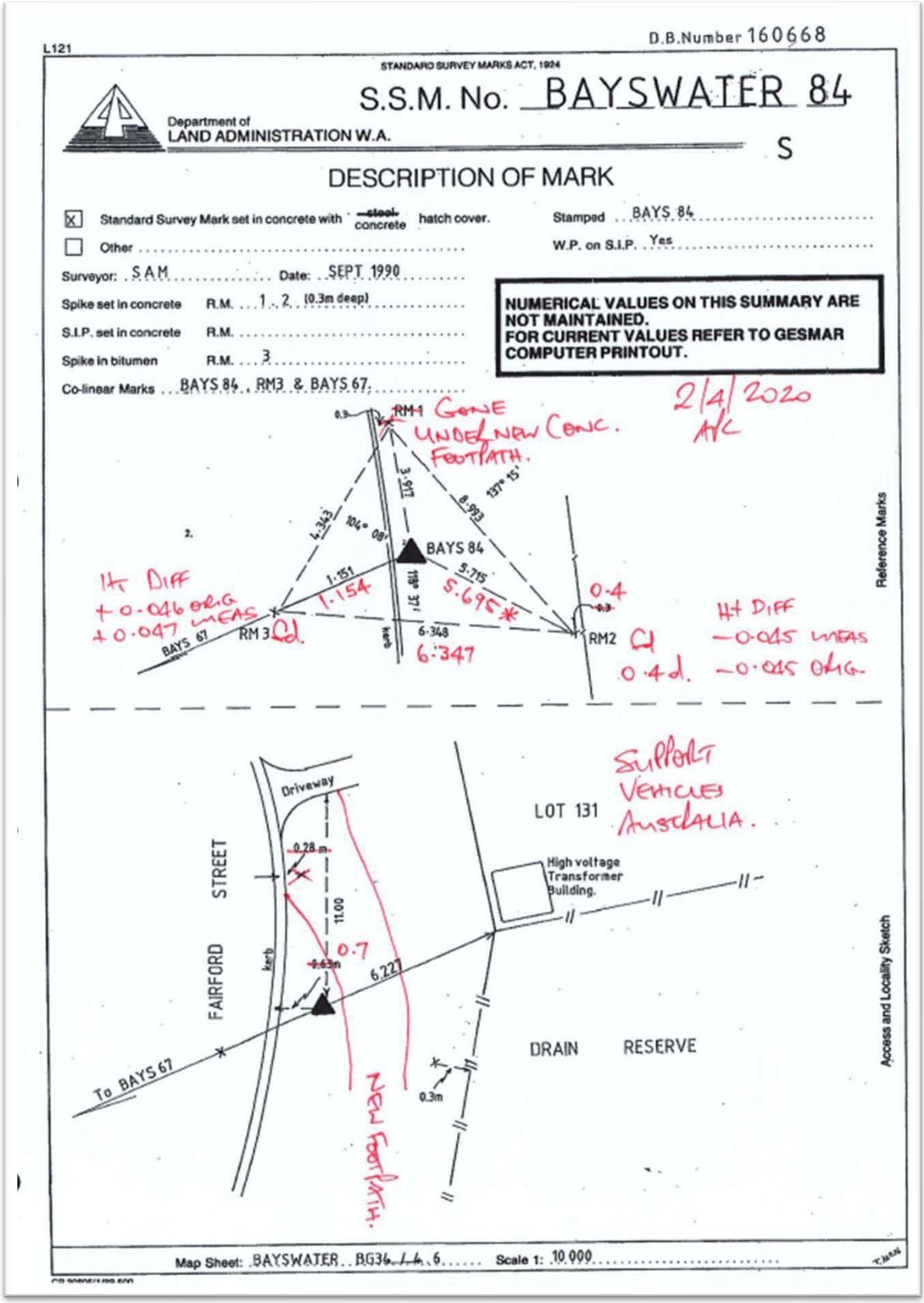
Job details				
Station Name :				
Entered in receiver as (As Above ☐)				
Mark Description (SSM☐) or			Survey Project :	
Measuring rods/offset tape				
Measurements (Slant) (1) m (2) m (3) m / ft				
Radius: m			Calculated Vertical Height: m	
Meas Check Height:		m	(Or) SKYHOOK Ht: m	
Offset Check Ht to ARP		m	Offset to A.R.P: m	
Check ARP Height		m	**ARP Height above Mark** m	
ARP Ht - Check ARP Ht		mm	ARP Ht Entered in Receiver:	Y / N
Images Taken Mark (☐) Setup (☐) Antenna Height Measurement (☐)				
Observation Time and Validations				
Day / Date:	UT Day:		Session/s:	
Start (Local/UT):	Finish (Local/ UT):		Length:	Minutes
Epochs set to: Sec (15 ☐)	Antenna orientated to North (☐)			
Mark Validated?	Horizontal (☐) Vertical (☐)		Operator Name:	
Equipment details				
	Make	Model	Serial #	Or Company ID
Receiver				
Antenna				
(Tick If) Antenna occupied main mark and site clear above 15 Deg. Show ray diagram with observing schedule and/ or site obstructions below or over page.	☐			

13. Appendix B – Geodetic Survey Checklist

Enter Y (Yes), N (No) or N/A (Not Applicable) plus the number of items if relevant in the appropriate boxes.

Geodetic Survey Job No:			
Digital Data Supplied			
GNSS Observed Data in RAW Format	[ ]		
GNSS Observed Data in RINEX Format	[ ]	Required File Name Convention	[ ]
GNSS Processed Baseline Report	[ ]		
GNSS Scanned Logsheets and Images	[ ]		
GNSS Adjustment Reports	[ ]		
GNSS Network Plan	[ ]		
GNSS Baseline Observation Schedule	[ ]		
Terrestrial Observation File	[ ]		
Levelling Files	[ ]		
Evidence Of Existing Mark Stability			
Horizontal Stability Provided	[ ]		
Vertical Stability Provided	[ ]		
Eccentric Observing Points			
Horizontal Connection to Main Mark Supplied	[ ]		
Vertical Connection to Mark Supplied	[ ]		
Other Data Supplies			
EDM Calibration Certificate	[ ]		
Staff Calibration Certificate	[ ]		
Scanned Field Books (Levelling/Others)	[ ]		
Levelling Abstract	[ ]		
Survey and Data Processing Report	[ ]		
Station Summaries Drafted/Amended	[ ]		
I …… have carried out the surveys according to the technical specifications and provided details in accordance with the requirements.			
Signed: ……		Date: ……	

14. Appendix C – Example of Annotated Summary



15. Appendix D – Example of Mark Image

16. Appendix E – Example of Antenna height Measurement Image

17. Appendix F – Example of Setup Image