

Landgate Guidelines for Dealing with Disturbed Geodetic Survey Marks

GSU-06



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Landgate Guidelines for Dealing with Disturbed Geodetic Survey Marks

Produced and published by: Location Services/Land Boundaries

Document version history

Date	Author	Version	Revision Notes
Sept 2025	Khandu	3.0	Major Revision
Sept 2023	Survey	2.0	Update to new style and refresh hyperlinks
	Survey	1.0	Initial

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1. Purpose

The purpose of this document is to provide a standard procedure for identifying, documenting, adjusting and reporting geodetic marks that are found disturbed or physically moved to ensure continuity and reliability of geodetic network in Western Australia.

As a Land Information Authority, Landgate manages the geodetic infrastructure to provide an accurate and a reliable geodetic system for all users in WA. Geodetic marks are regularly inspected and maintained after its establishment to ensure their accuracy, long-term stability, and usability.

The geodetic marks are categorised into Standard Survey Marks (SSM) or Benchmarks (BM) based on their use and horizontal and vertical positional accuracy requirements. As per the requirements provided in **GSU-01 – Landgate Requirements for Placement of Geodetic Survey Marks**, the SSMs and BMs are referenced by at least three and two physical marks set in the ground, respectively, which are called Reference Marks (RMs).

2. Definitions and abbreviations

Abbreviation	Definition
BM	Bench Mark
Geodetic Survey Mark	SSM or BM or RM
GESMAR	Geodetic Survey Mark Register
RM	Reference Mark
RTK	Real Time Kinematic
SSM	Standard Survey Mark
TCM	Temporary Control Mark
VRS	Virtual Reference Station

3. Identification

- 3.1.1 A Standard Survey Marks (SSM) or a Bench Marks (BM) must be validated from its Reference Marks (RMs) before commencing any geodetic survey. This validation process helps to determine whether the SSM or the BM is stable and suitable for use in geodetic surveys. **All the information on the Station Summary should be verified and annotated on the Station Summary or Redline Markup to ensure that the information is correct and up to date.**
- 3.1.2 A Primary Mark (i.e., SSM or a BM) is said to be disturbed, if it's found in good condition **but** its horizontal and/or vertical position has changed significantly due to physical ground movement. Such positional changes may arise from

- i) apparent movement of the Primary Mark, or
 - ii) apparent movement of one or more RMs affecting relative measurements, or
 - iii) apparent movements of all the marks (Primary Mark as well as the RMs) in different directions.
- 3.1.3 Where a Primary Mark or the RM(s) is suspected of physical movement, all existing RMs must be searched and located and their associated measurements including distances, angles and height differences observed.
- 3.1.4 Where RM(s) have moved, new azimuth(s) must be calculated based on the measured angle(s) and azimuth(s) to one or all of the stable RMs. If none of the RMs are found stable, new azimuths can be established based on **GSU-01 – Landgate Requirements for Placement of Standard Survey Marks**.
- 3.1.5 All new observations (e.g., distances, angles, and height differences) and calculated values (such as azimuths) should be abstracted in **GSU-3A – Abstract for Class C Levelling** (*Levelling abstractv3.xlsm*).
- 3.1.6 If the Primary Mark is found to be disturbed or physically moved up on validation, its entire history of previous observations and validations must be compiled and reviewed to re-establish its new position, if applicable.

4. Procedure for Reference Marks

4.1. Distance

- 4.1.1 If the observed distance to the RM is within 10 mm of the original value, it is deemed equal. No record of this new measurement will be updated in GESMAR unless other conditions are met.
- 4.1.2 If the observed distance to the RM differs by more than 10 mm but less than 21 mm to the original value, and it is conclusively proven that the RM has physically moved or shifted, the new distance is adopted. The original RM number is retained.
- 4.1.3 If the observed distance to the RM differs by more than 21 mm to the original value, and it is conclusively proven that the RM has physically moved or shifted, then a new RM number is assigned.
- 4.1.4 If the original distance is proven to be incorrect due to a gross error, the original RM number is retained, and the distance is amended to reflect the correct value, regardless of the magnitude of the change.

Note – The procedure for determining changes on disturbed or physically moved RMs are provided in **Figure 1**.

4.2. Azimuth

- 4.2.1 If a RM is identified as disturbed due to physical movements exceeding 10 mm, a new azimuth shall be observed or calculated. This can be done either using the observed angle from another RM that has not identified as disturbed or by using the method described in **Clause 3.1.5**.
- 4.2.2 However, if the combined vector shift of the RM is less than 14 mm, the original azimuth and/or the angle may be retained.
- 4.2.3 If the original azimuth or the angle between the RMs is proven to be incorrect due to a gross error, the new azimuth is amended to reflect the correct value, regardless of the magnitude of difference.

4.3. Height Difference

- 4.3.1 If the observed height difference to the RM is within 10 mm of the original value, it is deemed equal. No record of this new measurement will be updated in GESMAR unless other conditions are met.
- 4.3.2 If the observed height difference to the RM differs by more than 10 mm but less than 21 mm to the original value, and it is conclusively proven that the RM has physically moved or shifted, the new height difference is adopted. The original RM number is retained.
- 4.3.3 If the observed height difference to the RM differs by more than 21 mm to the original value, and it is conclusively proven that the RM has physically moved or shifted, then a new RM number is assigned.
- 4.3.4 If the original height difference is proven to be incorrect due to a gross error, the original RM number is retained, and the height difference is amended to reflect the correct value, regardless of the magnitude of the change.

Note – *The procedure for determining changes on disturbed or physically moved RMs are provided in **Figure 1**.*

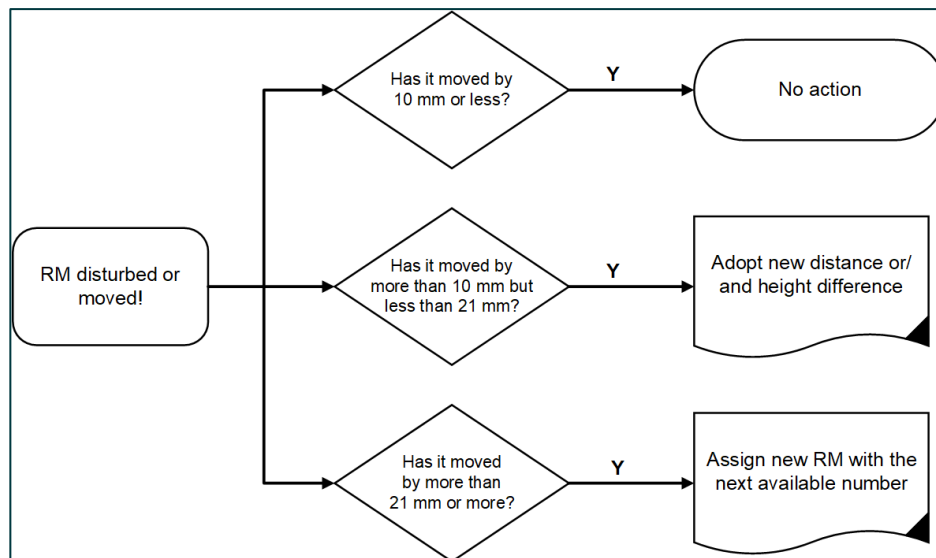


Figure 1 - RM adjustment flowchart

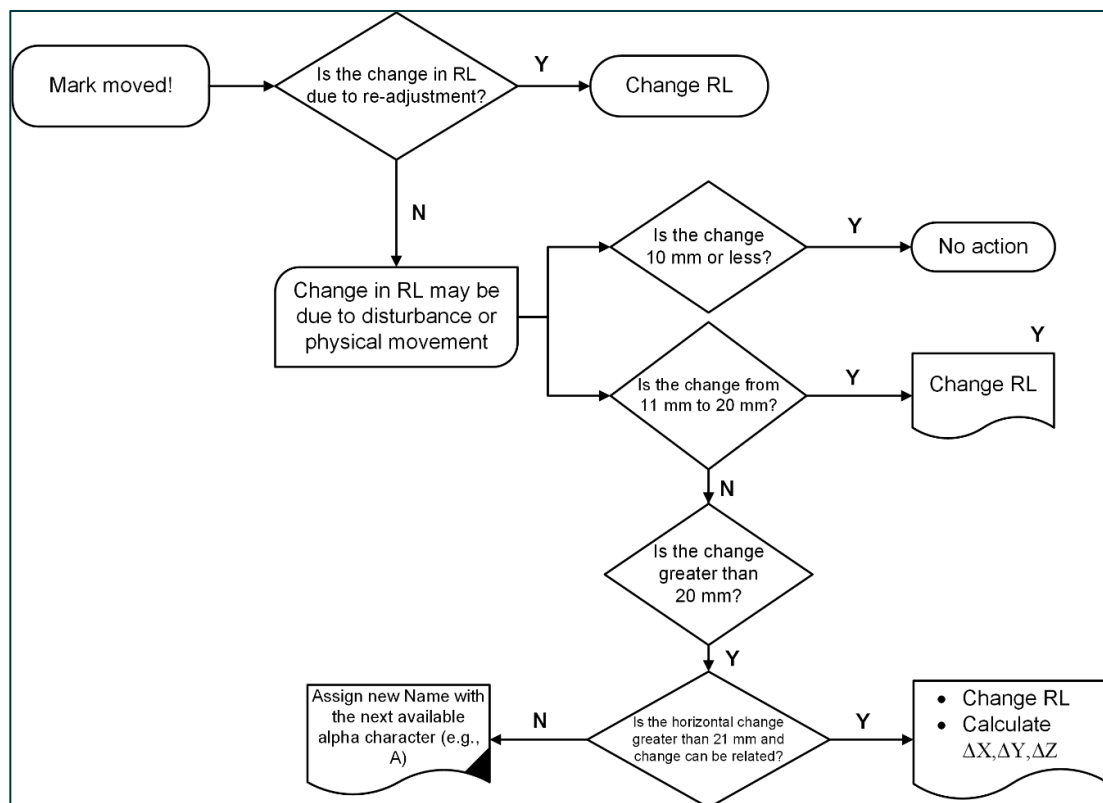


Figure 2: Flow chart for adjustment of vertical position

5. Procedure for Primary Marks

5.1.1 The horizontal and/or vertical position of a Primary Mark shall be re-adjusted to a new position when it is suspected or confirmed to be disturbed or physically moved by more than 10 mm. This can be determined either from:

- a. Distance and azimuth measurements or height difference measurements or combination of both measurements to all existing RMs and that the existing RMs are not disturbed.
- b. GNSS baseline observations or height difference measurements or combination of both measurements to at least two nearby Primary Marks and that these Primary Marks are not disturbed.

5.1.2 A Primary Mark subject to seasonal variations are typically identified through predictable changes in height difference. Users should check for special notes of possible warnings at the end of a Geodetic Mark Report, if the mark used is located on sites subject to seasonal ground fluctuations.

5.1.3 A Primary Mark re-adjusted for vertical position will retain their original name regardless of the magnitude of difference in the observed value unless condition in **Clause 4.3.4** is met. The flowchart in **Figure 2** describes the process for adjusting and updating changes resulting from vertical movements.

5.1.4 A Primary Mark re-adjusted for horizontal position will retain their original name regardless of the magnitude of difference in the observed value. However, it will become a new mark with a next available alpha character assigned to its original name, it has moved by more than 20 mm and no relativity can be established to its original position. The flowchart in **Figure 3** describes the process for adjusting and updating changes resulting from horizontal movements.

Note – Two examples are provided at the end of this document to show how the coordinates of physically moved marks are maintained in GESMAR.

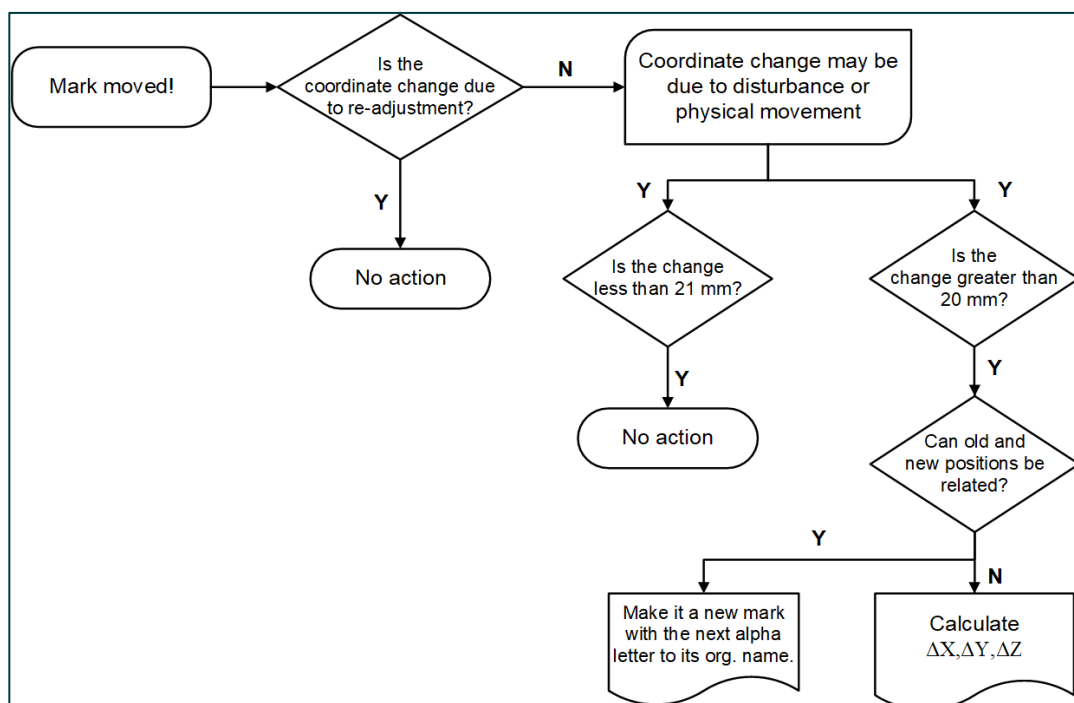


Figure 3: Flow chart for adjustment of horizontal position

6. Example 1 – Re-coordination of a SSM from RMs [Horizontal & vertical]

In this example, SSM GN 145 was found to have conclusively moved by more the 21 mm in April 2013 during a Survey Expedition (JN20182238) and its existing RMs were found to be stable. In the **Appendix**, the Redline Markup or mark validation is shown indicating the new observations inked in blue colour.

Using the existing and new observations to the RMs, GN 145 is re-coordinated, and a vector (pseudo-baseline) is calculated between the old position and the new position.

The new vector or the pseudo-baseline is loaded as a **special note** in GESMAR with the date of update, corresponding to when the new observation was carried out.

1. Prepare an input adjustment file in GeoLab format

- Use the following PADJ record to have dX dY dZ printed in the output
PADJ NO NO YES YES YES NO NO NO
- For convenience, a new name is assigned to record the new position of GN 145. It will be called GN 145A.
- GN 145 has also moved vertically by 0.073 m. This is recorded in the **abstractv3.xlsm**.
- The input adjustment file is shown below:

TITL 20182238 RE-COORDINATION OF GN 145									
ELIP	GRS 80	6378137.0000	6356752.3141	0.0	0.0	0.0			
PGE0	YES								
PADJ	NO	NO	YES	YES	YES	NO	NO	NO	
PMIS	NO	NO							
PSOL	NO	NO							
CONF	YES	YES	NO	YES	CON				
PLO	111	GN146	S 28 11 37.81149	E114 17 16.71614		2.930			
PLO	111	GN145	S 28 12 35.32585	E114 17 33.45675		-0.260			
PLO	001	GN145-RM1	S 28 12 35.15248	E114 17 33.40654		-0.260			
PLO	001	GN145-RM2	S 28 12 35.42689	E114 17 33.59529		-0.260			
PLO	001	GN145-RM3	S 28 12 35.45214	E114 17 33.32823		-0.260			
PLO	000	GN145A	S 28 12 35.32598	E114 17 33.45647		-0.187			
PLH	111	20182238/BS1	S 28 12 32.24415	E114 17 35.82415		-21.742			
*Geoid values are derived from AUSGeoid2020									
GFIL P:\ageoid20\binary\AG2020_WA.gsp									
*Original observations									
SIGM	dr	2.0			0.003		0.003		
DSET	dr								
DIR		GN145	GN146		00 00 00.00		7.40		
DIR		GN145	GN145-RM1		00 00 00.00		7.40		
DIR		GN145	GN145-RM2		143 01 30.00		7.40		
DIR		GN145	GN145-RM3		236 27 10.00		7.40		
DIST		GN145	GN145-RM1		5.507		0.005		
DIST		GN145	GN145-RM2		4.832		0.005		
DIST		GN145	GN145-RM3		5.225		0.005		
DIST		GN145-RM1	GN145-RM2		9.811		0.005		
DIST		GN145-RM2	GN145-RM3		7.330		0.005		
DIST		GN145-RM1	GN145-RM3		9.462		0.005		
*Current observations									
OHDF		GN145	GN145A		0.01		0.073		0.001
DSET									
DIR	dr	GN145A	20182238/BS1		00 00 00.00		7.40		
DIR		GN145A	GN145-RM1		311 26 30.00		7.40		
DIR		GN145A	GN145-RM2		94 16 09.00		7.40		
DIR		GN145A	GN145-RM3		187 44 39.00		7.40		
*SIGM dis									
DIST		GN145A	GN145-RM1		5.512		0.005		
DIST		GN145A	GN145-RM2		4.839		0.005		
DIST		GN145A	GN145-RM3		5.221		0.005		
DIST		GN145-RM1	GN145-RM2		9.815		0.005		
DIST		GN145-RM2	GN145-RM3		7.330		0.005		
DIST		GN145-RM1	GN145-RM3		9.466		0.005		

2. Adjust & Output

- The adjustment is done in DynAdjust, which produces the following output, including the cartesian coordinates (X, Y, Z).

Adjusted Coordinates													
Station	Const	Easting	Northing	Zone	Latitude	Longitude	H(Ortho)	h(Ellipse)	X	Y	Z	SD(e)	SD(n)
20182238/BS1	CCC	234329.9868	6876682.3868	50	-28.123224415	114.173582415	1.2809	-21.7420	-2314081.8007	5126725.1338	-2996921.3893	0.0000	0.0000
GN145	CCC	234266.5349	6876586.9551	50	-28.123532585	114.173345675	-0.2600	-23.2898	-2314003.9491	5126709.5775	-2997004.2570	0.0000	0.0000
GN145-RM1	FFC	234265.0414	6876591.3617	50	-28.123515251	114.173340637	-0.2600	-23.2897	-2314003.7346	5126712.4418	-2996999.5548	0.0006	0.0023
GN145-RM2	FFC	234270.3818	6876583.1242	50	-28.123542378	114.173359532	-0.2600	-23.2897	-2314006.8069	5126706.7242	-2997006.9138	0.0019	0.0016
GN145-RM3	FFC	234263.1217	6876582.0912	50	-28.123545205	114.173332843	-0.2600	-23.2901	-2314000.0041	5126709.3430	-2997007.6803	0.0017	0.0018
GN145A	FFF	234266.9262	6876586.9515	50	-28.123532598	114.173345643	-0.1870	-23.2168	-2314003.9669	5126709.6382	-2997004.2946	0.0002	0.0002
GN146	CCC	233778.2792	6878346.7636	50	-28.113781149	114.171671614	2.9300	-20.0694	-2313933.1797	5127662.6070	-2995445.4393	0.0000	0.0000

- The cartesian coordinates are then used to calculate the displacement vector (ΔX , ΔY , ΔZ) from old position (GN 145) to the new position (GN 145A).

Station	Const	Latitude	Longitude	H(Ortho)	h(Ellipse)	X	Y	Z	SD(e)	SD(n)	SD(up)
GN145	CCC	-28.123532582	114.173345657	-0.260	-23.2137	-2,314,003.9724	5,126,709.6410	-2,997,004.2922	0.0000	0.0000	0.0000
GN145A	FFF	-28.123532593	114.173345625	-0.187	-23.1407	-2,314,003.9902	5,126,709.7017	-2,997,004.3297	0.0002	0.0002	0.0010
						ΔX	ΔY	ΔZ			
						-0.0178	0.0607	-0.0375			

- Finally, the calculated vector or the discontinuity is placed as a [internal] special note in GESMAR with the date that of the new observation date or when the movement is detected (see Figure 4).

Select a Mark | Mark Details | Horizontal Coordinates | Reduced Levels | Reference Marks | Physical Status

Notes/History | GS Fieldbooks | Non-GS Fieldbooks | LinAdj Reference | Non UTM Coordinates

Special Notes and Mark History

Type of Mark: **SSM**
 Primary Name: **GERALDTON 145** Database Number: **144443**
 Alternate Names:

Note Type Filter: ☒ Show Special ☒ Show Historical
 View Type Filter: ☒ Show Public ☒ Show Internal

Type	Creation Date	View Type
* Special Note	10/04/2013	Internal
Special Note		Public

DISCONTINUITY ENU -0.0178,0.0607,-0.0375

Figure 4: Discontinuity note created in GESMAR.

7. Example 2 – Re-coordination of a SSM [Vertical]

In this example, SSM BBN 14 was re-established in the same horizontal position but at slightly lower height in June 1998 after it was found damaged.

The height difference between the old and new position was -0.145 m with no change in horizontal position.

The height difference of -0.145 is now the ΔZ component with 0, 0, in ΔE , ΔN . The vector (pseudo-baseline) will then become 0.000, 0.000, -0.145, which is placed as a **special note** in GESMAR with the date of when the repair/re-establishment was conducted as shown in **Figure 5**.

Select a Mark | Enquiry Results - Notes History

Special Notes and History

▲ **SSM BOORABBIN 14**
 Alternate Names:
 APREF:
 NGCA: 61WR

Show Note Types: ☒ Special Notes ☒ Historical Notes
 Show: ☒ Public Notes ☒ Internal Notes

Type	Creation Date	View Type
Historical Note	16/10/1998	Public
Special Note	25/06/1998	Public
Historical Note	2/08/2021 11:25:3	Internal
Historical Note	8/05/2025	Internal
Special Note	9/07/1998	Internal

DISCONTINUITY ENU 0.0,-0.145

Figure 5: Special note created in GESMAR indicating the vertical displacement of 0.145 m

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In line with Geoscience Australia's National Adjustment (NADJ) procedure, Landgate uses a term called "discontinuity" to describe the change in position of a geodetic mark due to physical movement and a clear relationship can be established between the old and the new position.

Previously, a pseudo-baseline was calculated and loaded to GESMAR as a normal baseline and the mark name is changed to the next available alpha character. This is no longer continued due to complexities of mark identification unless no clear relationship can be established.

Landgate's modified approach is as follows:

- a) Calculate the relationship between the old and the new position as a vector (ΔX , ΔY , ΔZ)
- b) Insert a **special note [internal]** in GESMAR with a creation date that of the new observation made or when the physical movement was detected. See the mark validation in the **Appendix**.
- c) The JDAJ (Jurisdictional Adjustment) performs the geodetic network adjustment for the whole of WA, and the coordinates are updated in GESMAR, including the changes in the moved mark.

8. Appendix – Redline Markup

