

# Landgate Requirements for Vertical Control Surveys by Differential Levelling

This guideline shall apply to all differential levelling for the geodetic network using digital levels and barcode staves in Western Australia.

Further information can be obtained by contacting the geodetic section of Survey Services at Landgate:

- Phone +61 (0)8 92737111.
- Email: [geodesy@landgate.wa.gov.au](mailto:geodesy@landgate.wa.gov.au)

## 1 Connection of Datum

Vertical control surveys shall commence from a verified geodetic survey mark. The SSM or BM used shall be validated using its reference marks (RMs) and the results recorded for each mark used. The validation should ensure mark stability before commencing the survey.

## 2 Differential Levelling Quality

Differential levelling run should start and finish on the same mark. Any misclose of forward and back level runs of a traverse, including individual bays, must not exceed maximum allowable value as defined by the following formula:

$$r = n \sqrt{k}$$

Where

$r$  = maximum allowable misclose in mm

$n$  = an empirical value describing the outcome (for majority of Landgate Geodetic work it is  $n = 12$  between existing geodetic marks)

$k$  = distance in km

It is expected that modern survey level instruments with calibrated staves can achieve better accuracy than  $12\sqrt{k}$  and if misclose values are consistently close to the limits, the survey methodology and instruments should be reviewed and checked.

See ICSM Guideline for Control Surveys by Differential Levelling section 5 for practical example.

## 3 Differential Levelling Equipment

For equipment requirements refer to ICSM Guideline for Control Surveys by Differential Levelling section 3.1.1.

## 4 Differential Levelling Observation Techniques

- Staff readings shall be recorded to at least 0.0001m in digital files.
- The length of any sight must not exceed 80 metres.
- Temperature, at the instrument, shall be recorded at the start of each levelling bay between geodetic marks. Generic Bureau of Meteorology provided values are not acceptable.
- The overall distance of levelling line must be recorded. The difference between the sum of the back sight distances and the sum of the fore sight distances should be less than 10m.
- As a general rule, two-way levelling is always required. One-way levelling is only to be used with the prior approval of Landgate.

For details of the differential levelling techniques refer to ICSM Guideline for Control Surveys by Differential Levelling section 3.1.2

## 5 Calibration of Instruments

- Instrument (level) collimation shall be checked at appropriate intervals and always before commencing a new survey.
- The Two Peg Test shall be applied, and results recorded. Collimation should be corrected where the error exceeds 0.0015m over a distance of 80m.

## 6 Calibration of Bar Coded Staves

- Bar coded staves shall be calibrated within 2 months prior to commencement of Landgate contract. Calibrated staves used in previous Landgate contracts can continue to be used without additional recalibration for 5 years so long as there is no noticeable wear or damage to the staff.
- The staves should be constructed of wood, fibreglass or invar. The use of aluminium staves is only via prior approval from Landgate.
- Staff bubbles shall be checked to ensure verticality and adjusted as necessary.
- Regular staff calibration should be performed at Landgate's Boya Site. Check [Booking and procedures for barcoded staff calibrations.](#)

## 7 Data Supplied to Landgate

- Levelling plan/sketch
- Raw digital level files
- ASCII file of digital level file.
- Completed Abstract of results. See [example abstract](#). Abstract template is available from [Levelling-abstract.xlsx](#)
- Job report.

- Additional notes if required
- Scan of amendments to summary sheets of existing marks, noting reference marks found and any changes to the summary sketch highlighted. These can be hand drawn. See 10 Example of amendments to summary sketch.

## 8 References

- [ICSM Standard for Australian Survey Control Network \(SP1 V2.1\)](#)
- [ICSM Guideline for Control Surveys by Differential Levelling \(SP1 V2.1\)](#)
- [ICSM Guideline for Adjustment and Evaluation of Survey Control \(SP1 V2.1\)](#)

## 9 Example Abstract of Results

Evaluating forward and backward misclose and adjustment

SURVEYOR				ABSTRACT OF CLASS C LEVELLING							Calculation File GS		
Level Book No. GS				Job No.							Computer		
Date of Survey				Staff No.			C Const = 1.000000 COE = 0.000010		Inst. No.		Date		
Temp	Distance km	From BM	To BM	Total Distance From	Difference in Elevation			Calibrated Mean	Adjustment Closure	Elevation Above AHD			Remarks
					Forward	Backward	Mean			Observed	BM	Adjusted	
		SSM A	SSM B	1.00	1.000	-1.000	1.000	1.000	0.003	101.000	SSM A	100.000	
23	1.00	SSM A	SSM B	1.00	1.000	-1.000	1.000	1.000	0.003	101.000	SSM B	101.003	
23	2.00	SSM B	SSM C	3.00	-3.000	3.000	-3.000	-3.000	0.010	98.000	SSM C	98.010	Allow= 0.021
											SSM B	101.003	From Above
23	1.00	SSM B	SSM D	1.00	1.000	-1.000	1.000	1.000		102.004	SSM D		
											SSM E	100.000	GS xxx/xxxx/xx
23	1.00	SSM E	SSM F	1.00	1.000	-1.000	1.000	1.000		101.000	SSM F		

SURVEYOR				ABSTRACT OF CLASS C LEVELLING							Calculation File GS		
Level Book No. GS				Job No.							Computer		
Date of Survey				Staff No.			C Const = 1.000000 COE = 0.000010		Inst. No.		Date		
Distance km	From BM	To RM	Total Distance From	Difference in Elevation			Calibrated Mean	Difference (Allow 0.010)	Elevation Above AHD			Remarks	
				Forward	Backward	Mean			Original Diff.	BM	Adjusted		
		SSM A	RM 1	-0.123	-0.125	-0.124		0.001	-0.125	RM 1			
			RM 2	-0.234	-0.236	-0.235		0.002	-0.237	RM 2			
			RM 3	-0.345	-0.343	-0.344		0.003	-0.347	RM 3			
		SSM B	RM 1	-0.123	-0.125	-0.124				RM 1			
			RM 2	-0.234	-0.236	-0.235				RM 2			
			RM 3	-0.345	-0.343	-0.344				RM 3			
		SSM C	RM 1	-0.123	-0.125	-0.124		0.001	-0.125	RM 1			
			RM 2	-0.254	-0.256	-0.255		-0.018	-0.237	RM 2		New HD Adopted	
			RM 3 4	-0.385	-0.383	-0.384		-0.037	-0.347	RM 3 4		RM Moved	

