



Spatial Services

Kirribilli Levelling AHD71

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Organisation:	DCS Spatial Services
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1. Purpose / Background

The purpose of this survey is to check and confirm the existing SCIMS AHD71 heights on **PM38358 (LB)**, **PM38357 (LB)**, **SS21705 (LB)** and **SS21704 (LB)**. Reports of significant disagreement and suspected mark movement have been made to DCS Spatial Services.

Initial inspection of these survey marks indicated the strong likelihood that these survey marks had moved since their initial survey. PM38358, located at Milson park, was placed on an embankment built up on landfill, while SS21705 and SS21704 are located on a kerb which exhibited signs of cracking and shifting due to tree root growth. PM38357 did not directly show any signs of disturbance, however, is placed on a footpath constructed on fill and therefore may have moved over time.

A Class LC levelling run has been performed to investigate the suspected survey marks. Standards and specifications adhere to Surveyor-General's Direction No.12 (SGD12) and associated documentation.

This report covers the 1D AHD71 adjustment of Kirribilli Levelling survey. It is intended to update SCIMS with AHD71 heights, Class and other relevant metadata. AHD Positional Uncertainty (AHD-PU) has not been calculated.

2. Fieldwork / Observations

Fieldwork was carried out over a period of 3 days between 24 – 26 March 2020 by DCS Spatial Services staff.

Two-way levelling was performed to Class LC standards as per SGD12 and the Technical Specifications for NSW Secondary Control Surveys (Tech Specs). The unsystematic method was used to level the instrument and a leap-frog system of progression was adopted. At the conclusion of each day, levelling was suspended on two stable permanent survey marks and resumed from those two points the following day.

3. Equipment

Table 1: Levelling equipment details.

Designation	Make	Model	Serial Number
Digital Level	Leica	LS15	xxxx xxxx

The level instrument was checked daily via a two-peg test with results attached. A barcoded fibreglass stave was used with the verticality checked prior to commencement of the survey using a total station.

4. Network Design and Control Strategy

The survey is designed as a small linear level run that predominantly follows the McDougall St and Clark Rd in a north – south direction. The level run picks up suspect survey marks PM38358 (LB), PM38357 (LB), SS21705 (LB) and SS21704 (LB) as well as any other survey mark along the way.

It was attempted to establish 3 x survey control marks at each end of the level run however this proved difficult due to disagreements in the local AHD datum. This meant that the level run had to be extended for a considerable distance until agreement was found.



Figure 1: Levelling run shown in black with survey control marks shown via the yellow pentagons.

A total of 5 survey control marks have been used to establish AHD datum for the survey – refer to **Figure 1** and **Section 8** for more details. Ideally a third survey control mark would have been connected into at the north end of the survey however this was considered out of scope. The network design is considered fit-for-purpose and meets the requirements of a Class LC level run.

5. Processing and Reduction Strategy

Software: NATOLEV
Version: v 1.6

In house reduction utility, NATOLEV v1.6, was used to reduce the forward and backward run measurements and produce an average height difference between two connected survey marks. In house utility, HTDIFF, was then used to check for gross errors and agreement between the forward and backward runs to ensure it complies with Class. All measurement residuals were checked at the processing stage and were deemed fit-for-purpose.

6. Adjustment Strategy and Options Used

Software: LEVADJ
Version: v 1.0

Table 2: Digital level observation weightings applied to overall adjustment.

Component	Constant	Centering To (m)	Centering From (m)
HDF	0.001 m	0.001	0.001

A 1D minimally constrained adjustment has been run to check the quality of the survey and determine Class. Applied observation weightings (input standard deviations) are listed in **Table 2**.

A 1D fully constrained adjustment has also been run to determine provisional AHD71 heights. Constraints have been fixed and AHD-PU has not been calculated.

7. Minimally Constrained Adjustment

The intent of this survey is to award a AHD71 **vertical Class LC**.

PM38353 (LB) has been fixed in AHD71 height as sourced from SCIMS. Individual measurements and residuals were checked in the processing / reduction stage with no changes proposed.

The heights of the minimally constrained adjustment were compared to SCIMS to check for agreement in survey control marks and observe any potential mark movement. Only survey marks with a levelled Class have been investigated (see **Figure 2**).

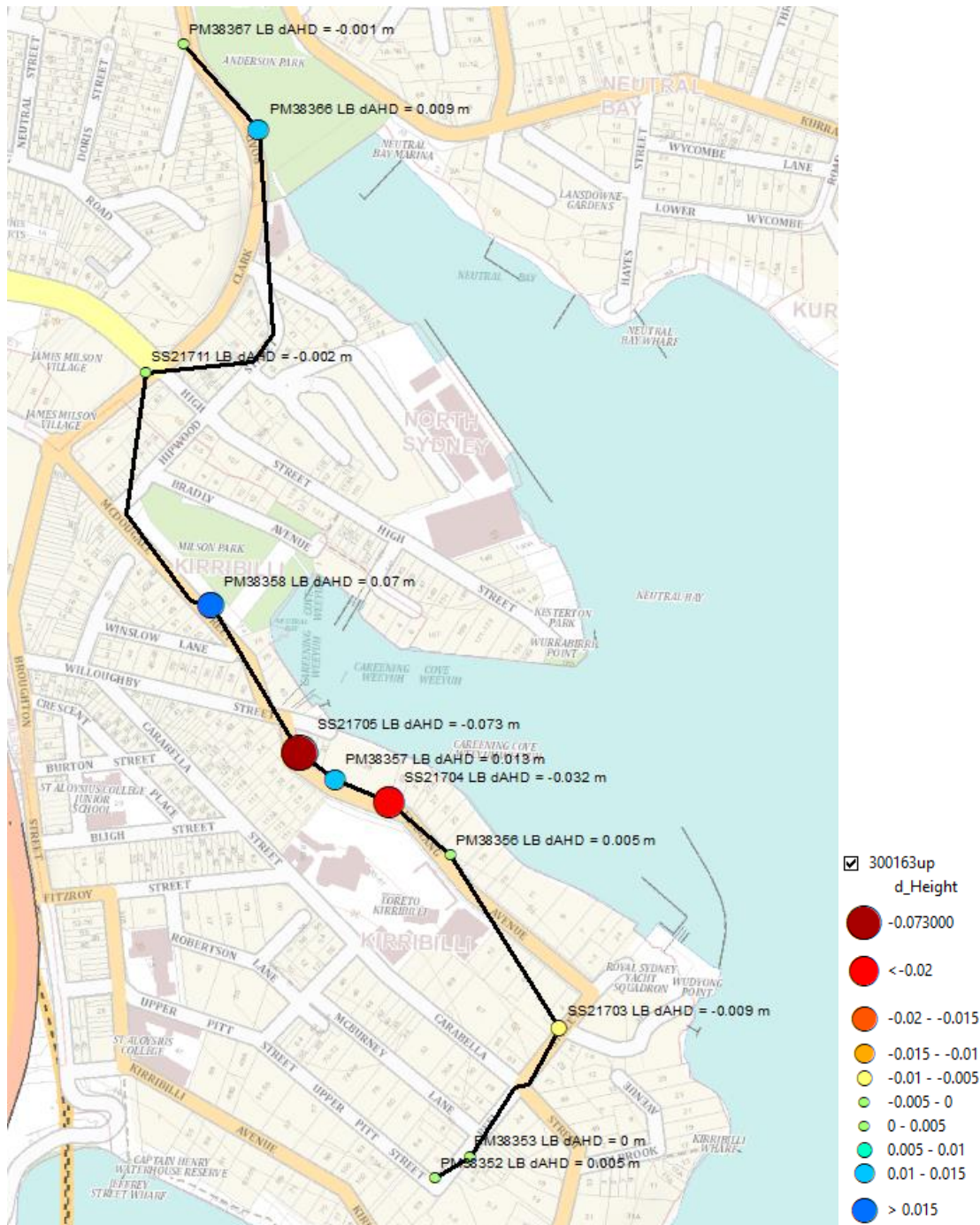


Figure 2: Comparison of minimally constrained adjusted heights to SCIMS (indicated by the dAHD). Only survey marks with a levelled Class have been considered.

The general shift on survey marks is within 5mm of the fixed survey mark PM38353 and this will constitute the assumed local ADH71 datum. SS21703 (LB, dAHD = -0.009m) and PM38366 (LB, dAHD = 0.009m) show marginally larger differences to the assumed datum and so will be tested to ensure they pass for Class.

The survey marks flagged for investigation PM38358 (LB dAHD = 0.070m), PM38357 (LB dAHD = 0.013m), SS21704 (LB dAHD = -0.032m) and SS21705 (LB dAHD = -0.073m) clearly exhibit larger differences to SCIMS with no clear pattern or consistent size. This confirms the suspected mark movement, and it is proposed to float and readjust these survey marks in height.

As per the requirements of SGD12, Class will be assessed statistically on:

- the misclose between the forward and return section of the level run between consecutive survey marks, and
- the misclose between the terminals of a level run.

The level run will also be checked for agreement between survey control marks to ensure it meets Class LC tolerances and verifies local AHD datum.

Referring to **Table 3**, the misclose between forward and backward runs between consecutive survey marks, and the distance, have been used to calculate a **c** value by rearranging the levelling Class formula ($r = c\sqrt{d}$). The calculated **c** value was then checked to see what Class it meets.

Table 3: Class assessment based on the misclose between consecutive survey marks.

From	To	Misclose (Forward – Backward Run) (m)	Distance (km)	c	Class
PM38352	PM38353	0.0000	0.05	0.0	L2A
PM38353	SS197206	0.0001	0.09	0.3	L2A
SS197206	SS197207	0.0001	0.02	0.7	L2A
SS197207	SS21703	0.0000	0.06	0.0	L2A
SS21703	PM38356	0.0003	0.25	0.6	L2A
PM38356	SS21704	0.0000	0.09	0.0	L2A
SS21704	PM38357	0.0001	0.06	0.4	L2A
PM38357	SS21705	-0.0001	0.04	0.5	L2A
SS21705	SS206366	-0.0001	0.04	0.5	L2A
SS206366	PM38358	-0.0009	0.13	2.5	LA
PM38358	SS58114	-0.0003	0.07	1.1	L2A
SS58114	SS105357	-0.0006	0.13	1.7	L2A
SS105357	SS21711	-0.0007	0.21	1.5	L2A
SS21711	PM38359	0.0005	0.14	1.3	L2A
PM38359	PM38360	-0.0001	0.05	0.5	L2A
PM38360	PM38366	0.0009	0.21	2.0	L2A
PM38366	PM38367	-0.0002	0.11	0.6	L2A

In addition, the accumulated misclose between the terminals of the level run have been tested for Class (see **Table 4**). All survey control marks highlighted in **Figure 2** that fit the assumed local datum have been checked including SS21703 and PM38366. The suspected survey marks that were confirmed to have moved have not been checked

Table 4: Class assessment based on the accumulated misclose between terminals of the level run.

From	To	Accumulated Misclose (Forward – Backward Run) (m)	Distance (km)	c	Class
PM38353	SS21703	0.0002	0.2	0.0	L2A
PM38353	PM38356	0.0005	0.5	0.7	L2A
PM38356	SS21711	-0.0026	0.8	3.0	LA
SS21711	PM38366	0.0013	0.4	2.1	LA
SS21711	PM38367	0.0011	0.5	1.5	L2A

Based on **Tables 3** and **4**, the level run predominately meets **Class L2A** in terms of internal quality based on a misclose analysis, far surpassing the intended **Class LC** allocation.

As a final confirmation of Class, the level run was checked to ensure there is sufficient agreement between survey control marks to verify and establish AHD71 datum.

Referring to **Table 5**, the allowable misclose between two survey control marks was calculated and compared to the actual misclose (i.e. dAHD). Only potential survey control marks were checked, and the suspected survey marks above were omitted as they were confirmed to have moved.

Table 5: Class assessment based on the agreement between survey control marks and verification of AHD71 datum.

From	To	Distance (m) (km)		dAHD (m)	Allowable Misclose (mm)	Pass / Fail for Class LC	Comment
PM38353	PM38352	40.1	0.040	0.005	0.0024	Fail	Ignore – marginal
PM38353	SS21703	160.1	0.160	0.009	0.0048	Fail	
PM38353	PM38356	361.4	0.361	0.005	0.0072	Pass	
PM38353	PM38357	57.7	0.058	0.013	0.0029	Fail	
PM38353	SS21711	269.5	0.270	0.002	0.0062	Pass	
PM38353	PM38366	269.5	0.270	0.009	0.0062	Fail	
PM38353	PM38367	269.5	0.270	0.001	0.0062	Pass	
SS21703	PM38356	201.4	0.201	0.014	0.0054	Fail	Float SS21703
PM38356	PM38357	138.6	0.139	0.008	0.0045	Fail	
PM38356	SS21711	621.5	0.622	0.007	0.0095	Pass	
PM38356	PM38366	964.5	0.965	0.004	0.0118	Pass	
PM38356	PM38367	1076.8	1.077	0.006	0.0125	Pass	
PM38357	SS21711	482.9	0.483	0.015	0.0083	Fail	Float PM38357
SS21711	PM38366	343.0	0.343	0.011	0.0070	Fail	
SS21711	PM38367	455.3	0.455	0.001	0.0081	Pass	
PM38366	PM38367	112.3	0.112	0.010	0.0040	Fail	Float PM38367

SS21703 and PM38366 don't fit the established datum despite only showing marginally larger disagreements in **Figure 2** (-0.009 and 0.009m respectively). It is possible that these survey marks have settled slightly over time since they were initially levelled which would explain the disagreement. It will be proposed to float and readjust these survey marks to ensure a homogeneous fit of local AHD71 survey control.

PM38352 only marginally fails for Class LC and is an important survey control mark to tie down the southern section of the level run. It is not thought to have moved.

PM38352 (LB), PM38353 (LB), PM38356 (LB), SS21711 (LB), and PM38367 (LB) all showed good agreement and pass for **Class LC**. These survey marks will be constrained to establish AHD71 datum throughout the survey.

Based on the results of the minimally constrained adjustment and the criteria for determining levelled Class, and factoring in network design, survey practices adopted, equipment used, and reduction techniques employed; the following recommendations are made:

- The level run is awarded a vertical **Class LC**.
- **PM38357, PM38358, PM38366, SS21703, SS21704 and SS21705** and are shown to have moved and are proposed for readjustment.

8. Adjustment Constraints

Based on the results of the minimally constrained adjustment, the following survey control marks will be used as adjustment constraints.

Table 5: AHD71 constraints applied in the fully constrained adjustment.

Mark	Class	AHD71	Source	Constrained
PM38352	LB	31.362	201345	Yes
PM38353	LB	28.664	201345	Yes
PM38356	LB	12.666	201345	Yes
PM38357	LB	6.41	201345	No
PM38358	LB	2.548	201345	No
PM38366	LB	2.415	201345	No
PM38367	LB	2.383	201345	Yes
SS21703	LB	18.984	201345	No
SS21704	LB	7.572	201345	No
SS21705	LB	5.466	201345	No
SS21711	LB	17.382	201345	Yes

9. Fully Constrained Adjustment

Fixing the adjustment constraints listed in **Table 5**, a fully constrained adjustment has been run to determine provisional AHD71 heights. These are listed in **Section 10 Table 6**.

AHD Positional Uncertainty has not been calculated.

10. Recommendation

It is recommended that SCIMS is updated with the survey marks listed in **Table 6** including AHD71 heights and Class.

Specifically, it is recommended that **PM38358**, **PM38357**, **SS21705**, **SS21704**, **SS21703** and **PM38366** are readjusted based on the results of this survey.

MARK	VFIX	VSOURCE	HEIGHT	VC
PM38352	F	201345	31.362	LB
PM38353	F	201345	28.664	LB
PM38356	F	201345	12.666	LB
PM38357			6.400	LC
PM38358			2.479	LC
PM38359			22.085	LC
PM38360			20.254	LC
PM38366			2.405	LC
PM38367	F	201345	2.383	LB
SS21703			18.995	LC
SS21704			7.608	LC
SS21705			5.542	LC
SS21711	F	201345	17.382	LB
SS58114			3.261	LC

SS105357			4.463	LC
SS197206			21.977	LC
SS197207			20.982	LC
SS206366			5.652	LC

11. Appendix

Indicate which appendices have been attached to this report and provide relevant file names.

Yes	N/A	Appendices
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix A: <i>SGD12 Survey Checklist.pdf</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix B: <i>Photos</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix C: <i>Field notes, log sheets, session diagrams</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix D: <i>Instrument calibration certificate(s)</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix E: <i>Native instrument raw data files</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix F: <i>Spatial Services format specific raw data file(s)</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix G: <i>Processing / reduction files</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix H: <i>Network diagrams, plans</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix I: <i>Least squares adjustment input file(s) – minimally + fully constrained</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix J: <i>Least squares adjustment output file(s) – minimally + fully constrained</i>
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Appendix K: <i>Provisional coordinates, heights, Class and Positional Uncertainty</i>

Outline any additional attachments:

Not applicable.

12. Submission Statement

I, **John Surveyor**, of **DCS Spatial Services**, present the survey outlined in this report as meeting the requirements of a vertical Class **LC** control survey as per *Surveyor-General's Direction No. 12*.

I understand that the inclusion of these results in SCIMS and their final Class and uncertainty classification is at the sole discretion of DCS Spatial Services.

A signed checklist, as per the requirements of *Surveyor-General's Direction No. 12* is attached (Appendix A).

Signed: *Include signature here*

Dated: *Include date of signature here*

End of Report

DCS Spatial Services use only

Analysis by DCS Spatial Services:

Comments by DCS Spatial Services Senior Surveyor or nominated representative:

Approved for SCIMS update:

Transaction Number:

SCIMS Updated: