NSW Department of Lands

Control Surveys and SCIMS

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Control Surveys and SCIMS
Version 1.0 Public Release 21/12/2007

Department of Lands

DOCUMENT CONTROL SHEET

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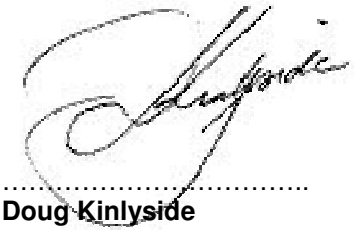

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1 Scope

This document provides a “plain english” policy as to what the NSW Department of Lands (Lands) requires before it will place coordinates and heights on **public record** in the Survey Control Information Management System (SCIMS). Issues covered include, marking, positioning technologies, survey practice, processing, least squares adjustment and reporting.

Other documents such as the Surveying Regulations, the Surveyor General’s Directions and ICSM’s publication “Standards and Practices for Control Surveys” (SP1) are referred to by this policy where appropriate.

The survey control requirements listed in this document apply to coordinate values to be placed on public record in SCIMS at horizontal class C and vertical class B & LD or better.

Details of Lands full requirements and the interpretation of this document **must be discussed with a Lands’ Senior Surveyor prior to commencement of surveys**.

2 Overview of SCIMS Accuracy - Class

Accuracy class is dependant on mark type, observation techniques, measurement standards, the results of rigorous least square adjustments and analysis of error ellipses. To handle the emergence of new positioning technologies, Lands also uses the following criteria to assign class:

- What is the intent of the survey?
- How does the survey fit within the existing control network?
- Is there sufficient redundancy?
- Are the observation and processing techniques appropriate?
- Can the results be easily interpreted and analysed?

Therefore typically:

2.1 Class & GDA94 Coordinates

Class U is assigned for coordinates with unknown or approximate accuracy, derived from locality sketches, scaled from a map or captured with hand-held GPS. (SCIMS delivers these coordinates rounded off to the nearest metre).

Class E is assigned where a "survey" was undertaken and the results are intended for applications such as mapping/imagery control, rural DCDB upgrade and similar sub-metre accuracies. These surveys require differential GPS, either real-time or post processing. (SCIMS delivers these coordinates rounded off to the nearest 0.1 metre).

Class D is assigned where the survey methodology has delivered accurate coordinates (a few centimetres or better), however may involve unchecked radiations, only single occupations with GPS and similar surveys where there is insufficient redundancy. Coordinates are suitable for urban DCDB upgrade, asset management, high resolution imagery rectification and other lower order surveys. (SCIMS delivers these coordinates rounded off to the nearest 0.01 metre).

Class C is assigned where the coordinates are "**established**", allowing use under the Surveying Regulations for cadastral surveys. The surveys in this case

must have sufficient redundancy and checks to guarantee the accuracy of the coordinates. Therefore closed figures when traversing, multiple occupations and well configured connections to existing established control are required.
In locations where there is no established control, GNSS techniques such as AUSPOS may be used – see further discussion below. (SCIMS delivers these coordinates to the mm).

Class B, A & AA are assigned to rigorous control and geodetic surveys where high accuracy is required for engineering/construction, National or State-wide infrastructure applications. ICSM's SP1 comes into play here.

2.2 Class & AHD Heights

Class U is assigned for heights with unknown or approximate accuracy, usually derived from the nearest map contour. (SCIMS delivers these heights rounded off to the nearest metre).

Class E is assigned where the results are intended for mapping/imagery control and similar sub-metre applications. (SCIMS delivers these heights rounded off to the nearest 0.1 metre).

Class D is assigned where the survey methodology has delivered heights accurate to a few centimetres or better, however may involve unchecked radiations, only single occupations with GPS and similar surveys where there is insufficient redundancy. Heights are suitable for image rectification and other lower order surveys. (SCIMS delivers these heights rounded off to the nearest 0.01 metre).

Class C is assigned where the heights are derived from surveys with sufficient redundancy and checks, however may be some distance from reliable height control and relying solely on a geoid model. Heights are suitable for such applications as high resolution image rectification, but should be used with caution. (SCIMS delivers these heights to the mm).

Class B is assigned where the heights are "**accurate**", in terms of the survey regulations. As a guide, the accuracy of the height is considered similar to that of traditional 3rd order levelling. Surveys in this case must have sufficient redundancy and checks to guarantee the accuracy of the heights. Therefore closed figures, multiple occupations and well configured connections to existing accurate height control are required. (SCIMS delivers these heights to the mm).

Class A & AA are assigned to rigorous control and geodetic surveys where high accuracy is required for engineering/construction, National or State-wide infrastructure applications. ICSM's SP1 comes into play here.

Levelled classes **LB** or **LC** etc. are assigned to height values depending on how the survey conforms to specifications in SP1 under differential levelling (sec 2.4). Note. Lands assigns levelled class to spirit levelling only.

3 Mark Placement

Survey marks must be **stable**. Refer to Surveyor General's Direction No.1 which details the different types of "Approved Permanent Marks" and their construction.

Marks are to be placed with special consideration for Occupational Health and Safety (**OH&S**) issues, particularly with respect to high speed road carriageways.

Where possible, **access** to the mark should not be restricted (railway corridors, private property etc.) and the locations selected should be "**satellite friendly**".

Locality sketch plans are required for all marks, as described in Surveyor General's Direction No.2. These sketch plans must contain measurements to physical features and not just cadastral connections from deposited plans.

Lands will not approve a survey and update SCIMS unless:

- *OH&S risks are minimised (as determined by Lands).*
- *All marks are placed to the approved standard.*
- *A satisfactory locality sketch plan is received for each mark placed.*

4 Network Design

Survey network design is determined by the task being undertaken, however a fundamental requirement is to establish datum - both horizontal and vertical. To this end, **connection to existing local control** in and adjacent to the survey must be part of the design.

Where possible, connections to accurate height control should include an **overlap** to additional marks to check datum. An extension of the existing height control network may be required, rather than relying solely on the accuracy of a geoid separation model.

Good survey control practice is to work from the whole to the part by observing a **primary network** to establish the datum, then in-fill other control as necessary. The primary and in-fill networks may be submitted to Lands as separate adjustments.

The overall network geometry must be "fit-for-purpose". This implies redundancy, closed figures and no **radiations**. Lands policy is that multiple observations to the same setup over a mark is a radiation and that redundancy is only achieved by a new setup (new occupation) - preferably observed to from a different mark.

As described in section 2 above, established horizontal coordinates (class C or better) or accurate height (class B, LD or better) will not be assigned for values derived from radiations.

Lands will not approve a survey and update SCIMS unless:

- *Proper connection is made to existing local control in and adjacent to the survey, therefore establishing datum.*
- *Network design is appropriate (as determined by Lands).*

5 GNSS Techniques

Global Navigation Satellite Systems (GNSS) offer very effective methods to establish survey control, however basic survey principles with regard to network design and establishing datum as described above still apply.

A "**static**" observation technique based on the local datum is currently the normal practice for survey control networks.

Field notes or log sheets are an invaluable record of what is actually surveyed and must include the following details:

- Date & start/stop times.
- Mark labels (full mark type & number should be entered in the field).
- Receiver filenames.
- Equipment details, including models, serial numbers and antenna types.
- Details of antenna height measurement and method used. It must be obvious whether the antenna reference point (ARP) or phase centre is used for the antenna height - a simple sketch is easy and clear.

A useful independent **check for antenna heights** is to take a second measurement using imperial units (inches).

A session-by-session **observation diagram** allows for easy analysis of network design and in particular redundancy.

Although final coordinates and reduced observations are included in the least squares adjustment, Lands requires the following data to be submitted:

- Raw observations in "**RINEX**" format for all static and base station occupations.
- Processed baseline vector data in an "**ASCII**" data exchange format as exported from proprietary software. Variance / covariance information is to be included.

Lands will not approve a GNSS survey and update SCIMS unless:

- *Appropriate field notes or log sheets are submitted.*
- *Antenna height measurement is unambiguous.*
- *Observation data in RINEX format is submitted*
- *Processed baseline vectors are submitted.*

A generic logsheet can be found at:

http://www.lands.nsw.gov.au/survey_maps/surveying/survey_information

5.1 RTK

Although Real Time Kinematic (RTK) is an efficient method to capture position, its use for control surveys is limited. Given the technology employed and equipment used (bi-pods etc), Lands maintains that **RTK accuracy** is at the centimetre level horizontally and 3-5 cm in the vertical.

RTK produces radiations, therefore careful network design and redundancy - **multiple occupations** are essential to achieve an acceptable control survey outcome.

Given these limitations, Lands may update SCIMS with RTK derived coordinates at an established accuracy (class C only), if observations to the mark have been made from **three independent occupations** using at least two separate base stations set on existing established SCIMS marks or surveyed in as part of the primary network.

5.2 AUSPOS

AUSPOS is an example of "**absolute**" positioning whereby coordinates are derived independent to the local datum. Further, heights are derived from ellipsoid values with geoid separation applied; therefore they are not strictly AHD. **Accuracy of the technique** is dependent on observation length, the antenna model and the satellite orbit data adopted for processing.

Lands uses coordinates from precisely determined AUSPOS sites for quality assurance of the existing survey control network, and the data will be included in future re-adjustments of the datum.

Lands archives AUSPOS **raw observation data** (RINEX files) and intends to store the results in SCIMS with absolute coordinates and ellipsoid heights (not to be published at this point in time). Lands is therefore keen to receive raw observations (RINEX) for long occupations (in excess of four hours) of any survey control mark.

The major issue with AUSPOS surveys is their **proximity to existing control**. In some areas of the State, the difference between absolute and locally derived GDA and AHD is significant.

Lands may update SCIMS with established coordinate values derived from AUSPOS, under the following conditions:

- Occupations are at least four hours long.
- Log sheets are complete.
- Antenna model type and height measurements are unambiguous.
- IGS final orbit type ephemeris is used for the on-line computation.
- Internal AUSPOS quality indicators are satisfactory.
- There is redundancy with multiple occupations or coordinates are verified by ground survey.
- There is no conflict with existing local control.

Accuracy class for AUSPOS observations is assigned at the discretion of Lands. Factors to be considered include:

- Session length.
- Redundancy.
- Proximity to existing control.
- Homogeneity with existing control (local datum distortions etc).

Horizontal accuracy up to and including class 2A may be assigned.
AHD accuracy will not exceed class E.

5.3 SydNET & CORS

SydNET is the initial phase of a proposed Continuously Operating Reference Station (CORS) network across NSW. The discussion below therefore applies equally to both SydNET and CORS networks.

Various observation techniques are used in conjunction with CORS networks:

- **Post processing**, where static-type observations are made in the field and baseline vectors from the reference stations are computed later using processing software.

- **Single-base RTK**, where via a communication link, the roving receiver computes the baseline vector from the reference station.

- **Network RTK**, where the roving receiver computes its position based on baseline vectors from multiple reference stations.

The benefits of CORS networks are obvious; however fundamental surveying principles, accuracy and the issues related to control surveys must still apply. With regard to network design, these observations are **radiations** and are treated accordingly.

Although Lands operated reference stations are assigned local GDA94 and AHD71 values, the coordinates derived from CORS networks are “absolute” in terms of adjacent existing marks.

Therefore as with AUSPOS, the **proximity of the survey to existing local control** must be taken into consideration. Some form of site calibration - localisation technique may overcome this issue.

Accuracy class is assigned at the discretion of Lands. Factors to be considered include:

- Session length.
- Redundancy.
- Proximity to existing control.
- Homogeneity with existing control.

For SydNET, horizontal accuracy up to and including class C may be assigned as per section 5.1 (RTK) above, however AHD vertical accuracy will not exceed class D.

6 Computation / Adjustment

Aside from proper computation of coordinate values, the intent here is that all data submitted is suitable to be archived away for use in later re-calculations or combined adjustments. Therefore;

The computation software and technique must be approved by Lands prior to submission of the survey. Adjustment by a **least squares** method is essential.

All observation data must be submitted in an **organised and unambiguous digital format**. To this end, it is preferred that adjustments use reduced sets of observations rather than individual pointings which swamp the statistics and make analysis difficult.

Fundamental to the adjustment are the standard deviations (weighting) applied to observations. These values must be clearly stated.

Explanation and justification is required where any of the following options are used in the adjustment:

- Re-weighting or rejection of observations
- Scaling of observations
- Solving for rotation/orientation or scale parameters
- Standard deviations applied to constraints
- Scaling of error ellipses

Lands will not approve a survey and update SCIMS unless:

- *An approved adjustment method is used.*
- *Observation data is suitably organised in digital format.*
- *All adjustment options employed are acceptable.*

7 Survey Report

A survey report containing a description of the following is required in digital format:

- The overall job including background and intent.
- Fieldwork - equipment, observation techniques, software etc.
- Data processing.
- Network geometry.
- Adjustment software, options, analysis and results.
- Recommendations for Class and Order.
- Data archive, presentation and formats.

To accompany the report, digital diagrams/plans of the complete survey are necessary to show the geometry of the network, connections to existing control and other relevant information as required. Ideally these should be in Arc Shape, DWG or similar formats which include attribute information such as mark labels, coordinates and observation types.

Other useful information includes the status of existing control and digital photographs of trig stations and other marks.

A template for the survey report can be found at:

http://www.lands.nsw.gov.au/survey_maps/surveying/survey_information

Lands will not approve a survey and update SCIMS unless a satisfactory survey report and associated information is submitted in a timely manner.