

ASSOCIATION OF  
PUBLIC AUTHORITY SURVEYORS  
presents

# Challenging Our Hot Zone



**16th ANNUAL CONFERENCE**  
**6th - 7th April 2011**

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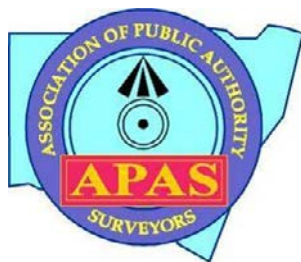
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**16th Annual Conference, Association of Public Authority Surveyors (NSW) Inc**  
(incorporating 86th Annual Conference, NSW Staff Surveyors Association Inc)

**Citigate Conference Centre, Mount Panorama, Bathurst, NSW**

## **Challenging Our Horizons**

**6 - 7 April 2011**

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# WASTE MANAGEMENT TRANSFER STATION

## KATOOMBA

### Graeme Paterson

Senior Surveyor  
Blue Mountains City Council

#### Background

*Waste Management is a major issue for most Local Government, particularly in urban areas where suitable areas for landfill are extremely scarce. Blue Mountains City Council has put a high priority in recent years into Waste Management and Recycling.*

*Up to the early 1990's the Mountains had 4 Waste Fill areas. Two sites (Blackheath and Lawson) were closed in the 80s and 90's and have been undergoing substantial remediation works during the last several years. Katoomba and Blaxland Waste Fill areas have continued operating. In the last 10 years Council has developed Blaxland to be the major land fill site for the region.*

*Katoomba has been operating as an open land fill site until this year. As it was reaching its planned capacity, and an extension of the fill area would have met sustained opposition from the community and environmental groups, it was decided to close the land fill operations and transfer all waste to Blaxland. To facilitate this and maintain cost-effective services, a Waste Transfer Station was to be constructed on the site. Waste would be delivered to the site; be sorted into recyclables and waste; and the waste would be compacted and baled and transported by truck to the Blaxland Waste land fill.*

*Concept Plans and some detailed design was undertaken by external consultants (GHD). These plans were used to submit the Development Approval with Council.*

*Subsequent to DA Approval it was decided that the Design and Survey Section of the Council would:*

- Refine the existing civil concept designs where it was identified that improvements for proposed works, or cost savings, could be identified, eg retaining walls, internal roads and produce final construction drawings*
- Undertake new civil design works as required eg the car park areas, wash down bay and access road from Woodlands Road; and produce final construction drawings*
- Assist GHD in their structural design of buildings and the major retaining wall in the Waste Drop-off Area by providing updated data, both survey and civil design amendments*
- Install further survey control on site suitable for construction and carry out the site surveys for further design work and construction were to be carried*
- Undertake all construction set-out works and construction checks, ending with a full work-as-executed plan of the site*
- Undertake all cadastral survey work required. This included boundary set-outs in areas for construction and service connections and the Plan of Survey for the Substation installed on site.*

## **Initial earthworks and Clearing**

The allowable construction footprint was clearly defined in the DA approval, and was the subject of community discussion, particularly by environmentally-focused groups. We marked out the defined development area and negotiated an extra 20 metre buffer and working area for woodchip stockpiles. This was necessary to avoid double handling of these stockpiles during construction. All vegetation removed on site for the development was chipped and stockpiled for final landscaping purposes.

Most of the topsoil removed for construction was contaminated by previous landfill works and was deposited in the existing landfill. Clean topsoil was stockpiled in the buffer zone for re-use in final landscaping of the site.





## **Detail Survey and Site Control**

The survey model of the site was obtained from Thiess, the previous landfill contractor. This was checked for currency of data and some extra detail survey was undertaken and merged into the survey model.

Initial survey control was of a low density as it was required only for normal landfill operations and reporting of volumes. This survey control was checked by survey as some of the marks were subject to movement as landfill settled over time.

This control was then used as a framework to set-out new control across the site in both strategic areas for use throughout the construction period (control marks to be protected) and close to areas of major construction for short term use (control marks were dispensable).

## **Detail Design**

The concept designs had been completed by GHD and had obtained DA Approval. There was a substantial list of conditions set by Council through the DA Approval which needed to be incorporated in the final designs. BMCC undertook final construction design in civil areas (Roads, drainage, sediment and retardation basin, pathways, wash-down bay and major car park).

**Internal Roads** – final designs of the internal roads were amended a couple of times to take into account changes in other construction areas, particularly in the refinement of final levels.

**External Roads** – the intersection of Woodlands Road and access to the car park were re-designed for safe and functional access to the site.

**Drainage** – all water off the site was accepted to be of a non-pristine nature and would carry high levels of sediment. As such, all storm water on this part of the site was directed through Interceptor Pits, a retardation and sedimentation basin and then through further filtration before release in the natural bush. The site, however, was considered to be separate to the existing land fill area with its contaminated leachates etc. The drainage and filtration ponds for this area continue to be maintained independently.

**Sediment and Retardation Basin** – was designed along rural dam-style configuration with a clay-impregnated fabric core in the wall. The dam was one of the first structures to be constructed and was a key element in control of sediment during the construction phase.

**Car Park** – was designed (and redesigned) four times as construction progressed as the available area varied with changing constraints, levels and gradients as construction proceeded – the car park needed to fit between the existing landfill (and its impervious membranes which needed to remain intact and maintain a specific depth of cover), and the new Waste Drop-off Area, as well as comply with accepted gradients and depth of cover over existing and new services and other infrastructure already installed. Being the last structure designed and built, everything else constructed on site impacted on the car park.







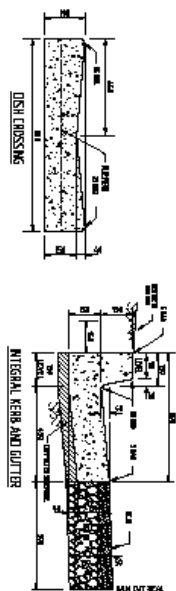
50  
SHEPHERD  
PER



PLAN  
SCALE 1:200

4. Severed of Turf on either side of Footpath where the Platford Surface is Droved or is Specified in the Plan.

## TYPICAL SECTIONS

[illegible]





**Wash Down Bay** – was relocated twice during construction to fit with changing onsite conditions. Its original location was moved for a more preferable location but then struck problems with the location of existing land fill and the protective membranes which had not been mapped correctly.

**Services** – Location of new Services were aligned originally to existing service and known site conditions. However some services and drainage had to be relocated due to the uncertain boundary of the existing land fill. In addition, subsoil drainage was upgraded as groundwater was infiltrating into the service trenches, particularly the underground power and telecom.

**Retaining Walls** – the concept design showed a substantial retaining wall between the Upper and Lower levels of the site and allied to the waste drop-off Area – this was up to 7 metre high. Due to redesigned levels of other site areas (primarily the access road to the drop-off area and the car park), this retaining wall was eliminated and a natural slope to a 1 metre high rock wall was attained. This had a huge improvement on the budget (approximately \$500,000 saving) and streetscape, with the wall replaced by a landscaped and tree planted bank. A further \$200,000 was saved in another location near the Baling and Waste Transfer building through replacing the engineered solution of retaining walls with soft landscaping features of a rock wall with landscaped banks behind. In the end, all retaining walls originally proposed were drastically reduced or eliminated, by varying the levels of the adjoining areas or by changing the footprint of the adjoining area to enable a soft-landscaping design.

### Set-out survey

Set-out surveys were carried out as required throughout construction and took up a considerable period of time throughout the project. More complex set-outs included:

**Retaining Walls** – Most of retaining walls were fairly straight forward and only involved set-out marks on the footings. However, the concrete retaining wall at the Waste Drop-off Area (which was up to 3 metres high) presented particular difficulty, as the wall was to be built with the holding-down bolts for large steel shelters to be connected to the steel reinforcing in the wall and concreted insitu. These steel frames were pre-made and the tolerance for the holding-down bolts was minimal. The initial set-outs for the wall formwork were undertaken and the bolts then had to be set-out in space up to 3m high above the footing. The set-outs were done by placing 4 offset nails in the formwork cladding for the wall so that the centre of each of the set of 4 holding-down bolts could be established in space by direct stringing between marks. Templates for the set of holding-down bolts were then made and this was set-over the centre mark and fixed in place. Checks were made while the concrete was being poured to ensure that there was no movement on the bolts.



**Baling and Waste Transfer Building** – This was the major building constructed in the project and was designed around a 5 metre grid system to which all building design dimensions were related. These grids were marked on site and regularly checked for stability and accuracy. Most building set-outs were undertaken from the grid marks excepting, in particular, the holding-down bolts for the major structural columns. These were also poured insitu in the footings (again a quoted minimal tolerance) and were done in a similar fashion to the retaining wall using offset marks and templates. These were also accurately leveled so the column base plates were all set to the correct design level when placed over the bolts by crane. All the columns were placed by BBC method.

A particular problem was noted in the pouring of the major concrete slabs in the buildings and in the erection of the major steel beams. Construction happened to occur in winter and zero temperatures presented challenges with the pouring of the major concrete slabs and with the contraction of the major structural beams – it was bit cooler than where the beams were constructed in Sydney. The steel contractors managed it all in their stride.

The set-out for the major equipment which crushed the garbage and baled it into blocks, also needed great care. It had to be set-out precisely (again) to ensure that it fitted snugly over the holding bolts and was welded to preset steel plates in the concrete slab foundations.



**Precast Panels** – The exterior of the building was clad in precast panels. Because of the size of the panels, the expense of casting them off-site and trucking up the highway was prohibitive. These were poured on-site in moulds which were set out by survey and continually checked to ensure that the panels were being constructed to specification.

**Re-Use Building** – This was to house recycled goods where residents could browse unwanted goods and take home. Unfortunately some of the dimensions were vague or not defined and design changes, such as for prefabricated stairs would not fit the available space. We were then involved in design reviews of the buildings and dealing with architects to make some of

the elements of the building fit. Funnily enough once these stairs were sorted out and the retaining structural wall was built to the new dimensions, the stairs were then dropped in a subsequent on-site design change.

**Roads, Wash Down bays and Drainage** – Roads, was-down bays and drainage structures were set-out in the normal manner and constructed with little difficulty.

### **Problems with Building**

Late in construction, or after completion and occupation, some major construction issues became apparent.

**Northern Roofline** – a major sag became visually apparent and needed to be analysed and repaired. Check surveys were undertaken to determine the nature of the problem – a roof beam was deforming, translating this deformation through to the external roof and guttering. The contractor eventually accepted liability and fixed the problem.

**Western Awning** – this awning also sagged after construction through inadequate bracing. This was also resurveyed to determine the size of the deformation, and the contractor accepted liability for this as well.

**Disabled Ramp** – access to the external ramp to the training room and offices in the building did not comply with the standards for disabled access. This needed some re-engineering including removal of part of the existing slab and re laying to different levels.





## **Work as Ex Survey**

Two works-as-Ex Plans were prepared:

- A plan for the civil works on site such as roads, kerbs, car park, pathways, drainage and drainage ponds
- A plan for the buildings in major internal dimensions, compliance with standards, such as disabled access and all Services on-site.

During construction, the location and depths of all service trenches were surveyed as they were dug. After completion all surface works were surveyed. All data was merged into one model and the WAX drawings produced.



## **Cadastral Works**

The site is a series of old Crown Portions and the base Title Surveys are old Crown Plans. Survey marks in this area were strictly limited. All plans in the area were either quite old, or compiled (before the guidelines were made and enforced).

**Site boundaries along Road** – As part of construction and location of services, the road boundaries were pegged. This was mainly fixed through adoption of marks a considerable distance up Woodlands Road, adoption of old posts and occupations across the road, and then checking for sufficient dimensions to properties along the access road to the west.

**Plan of Survey for Sub Station** – The development required the installation of a new Padmount Substation. This requires a Plan of Survey for the creation of the necessary easements to the guidelines required by the Electrical Authority. The Plan of Survey is underway. Even though the Easement for the substation is only 20 m<sup>2</sup> and the area of the site is 15ha and the Plan will involve a large area of residue by deduction, survey will be quite extensive due to the paucity of existing survey marks in the location.

## **Conclusion**

This was a major project for Council which had many different facets for us. We were integrally involved in all survey works and civil design.

The project was successfully completed and the site is fully operational.

The only outstanding works is the Plan of Survey for the Padmount Substation.





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## HYDRO - THE LRSS WAY: HYDROGRAPHIC SURVEYING IN THE AUSTRALIAN ARMY



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Jane Hayward and Tony Baker

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*Hydrographic surveying within the Australian Defence Force (ADF) has primarily been seen as the Royal Australian Navy's (RAN) domain and for almost all chart related work, this is certainly the case. The Littoral and Riverine Survey Squadron (LRSS) is the Australian Army's sole hydrographic survey unit and works closely with the RAN when assisting with inshore surveys and other chart related activities.*

*Increases in capability through the acquisition of new equipment and improved procedures have recently seen the squadron deploy in support of, Army Aboriginal Community Assistance Program (AACAP) activities in Western Australia, ADF exercises in Papua New Guinea, and with wreck detection in Jervis Bay.*

*This paper summarises the squadron's role and position within the ADF hydrographic community and the methods used to achieve this, and outlines a series of recent activities undertaken by the squadron.*

### INTRODUCTION

The Littoral and Riverine Survey Squadron (LRSS) is the Australian Army's hydrographic survey unit and conducts surveys and provides engineer advice in the littoral and riverine environment to support point of entry (POE) and logistics over the shore (LOTS) operations. This is achieved by gathering, analysing and interpreting geospatial data related to the coastal and riverine environment and producing detailed plans, maps / charts and reports in the field.

This ability enables LRSS to provide a specialist deployable Hydrographic survey capability in order to support the Australian Defence Force (ADF) on operations.

### ADF HYDROGRAPHIC COMMUNITY

The hydrographic community within the ADF consists of two quite distinct parts. The first is a very large part consisting of the Australian Hydrographic Office (AHO) in Wollongong and the RAN assets based in Cairns. The AHO task these assets according to Hydroscheme, the chart maintenance program. At present these assets consist of the Laser Airborne Depth Sounder (LADS) aircraft, two hydrographic survey (HS) ships and four survey motor launches (SML). Full time staff within this part totals approximately 350.

LRSS completes the community with two 7.5m Inshore Survey Vessels (ISV) (see figure 1) and 30 part time staff (Army Reserve).



**Figure 1:** Inshore Survey Vessel

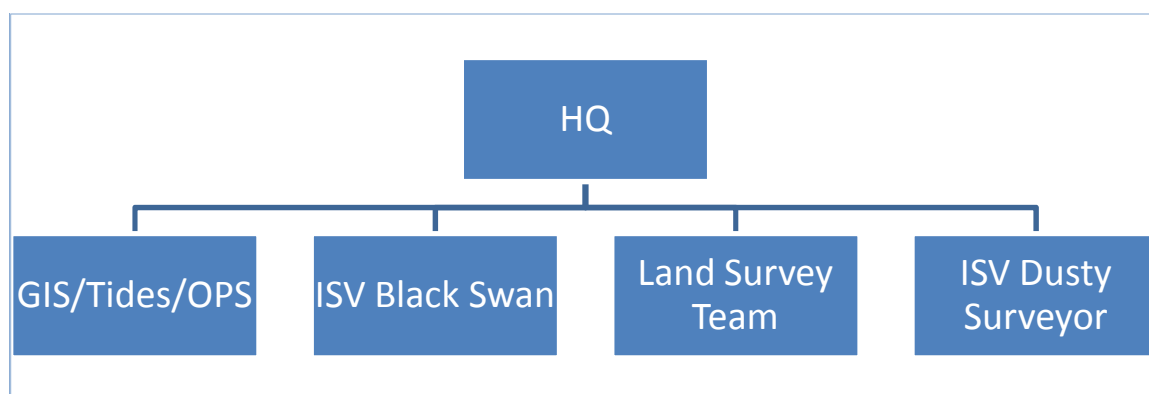
## **THE SQUADRON**

### **Squadron Origins**

LRSS owes its origins to the 45<sup>th</sup> Port Maintenance Squadron which was raised as a Supplementary Reserve unit in 1955. The squadron was reorganised into a series of port construction and repair teams (5, 6, 7 & 8) in 1961 with these teams operating for almost 10 years when they were amalgamated into the 1<sup>st</sup> Port Construction & Repair Group in 1971. In 1994 the group was integrated into the 19<sup>th</sup> Chief Engineer Works at Randwick as a Works Section which undertook planning and a Hydrographic Survey Detachment. December 2006 saw the members transferred to the 21<sup>st</sup> Construction Regiment (Royal Australian Engineers) at Holsworthy to man the newly created Littoral and Riverine Survey Squadron (LRSS). The Australian Army's Survey Corps was amalgamated with the Corps of Engineers in 1989.

### **Present Structure**

The majority of the squadron's key professional technical personnel are employed by government departments or corporations with only a small number in private practice. A task / location based structure (see figure 2) is used within the squadron with team selection based on the individual skills and experience contributed by each member. These attributes and personal qualities need not be gained through employment with the ADF.



**Figure 2:** LRSS Organisation Chart

Squadron members hold qualifications ranging from certificate to masters level in a wide variety of fields including engineering, environmental science, surveying, GIS, and maritime operations. The squadron's relationship with the RAN was strengthened with 2008 seeing the first army member successfully complete the H2 course at the RAN School of Hydrographic Surveying.

### Equipment

The key equipment (see table 1) utilised by the squadron allows each survey team to operate independently when required. Data collection is undertaken in the field by each team according to their task specifications and analysed and post processed at the conclusion of each phase. Final report production and product generation are finalised on site with output available to colour A3.

**Table 1:** Equipment Summary

Category	Item
Vessels	Inshore Survey Vessels (ISV's), Inflatable water craft (Zodiacs)
RTK Positioning	Trimble R8 base station with repeater R8 rovers
Single Beam E/S	ODOM MKIII Echo Sounders
Side Scan Sonar	C-Max Side Scan Sonar (loan from RAN)
Tide Gauges	RBR TGR1050P tide gauges
Sound Velocity Probes	Digibar Pro 1200's Probes
Total Station	Trimble S6
Software	Hypack TGO ARCGIS

## RECENT SQUADRON ACTIVITIES

### LRSS in the Kimberleys: AACAP 2008

The Australian Army has assisted aboriginal communities for many years through the Army Aboriginal Community Assistance Program (AACAP) and in 2008 the squadron was asked to participate by conducting a survey within Napier Broome Bay in Western Australia. The purpose of the survey was to determine the suitability of a series of alternate landing sites in the vicinity of Kalumburu in the East Kimberley.

For the AACAP project to be completed, 1200 tonnes of construction stores had to be off-loaded from HMAS Manoora utilising a combination of landing barges (LCH and LCM8). As a result of the tidal windows and steaming times, two separate beach landing sites were required with each needing an approach 400 metres wide and 4.5 km long.

150 km of depth soundings were acquired by the three survey teams who worked in searing heat for up to 12 hours per day continuously for 12 days.



**Figure 3:** LRSS – Napier Broome Bay

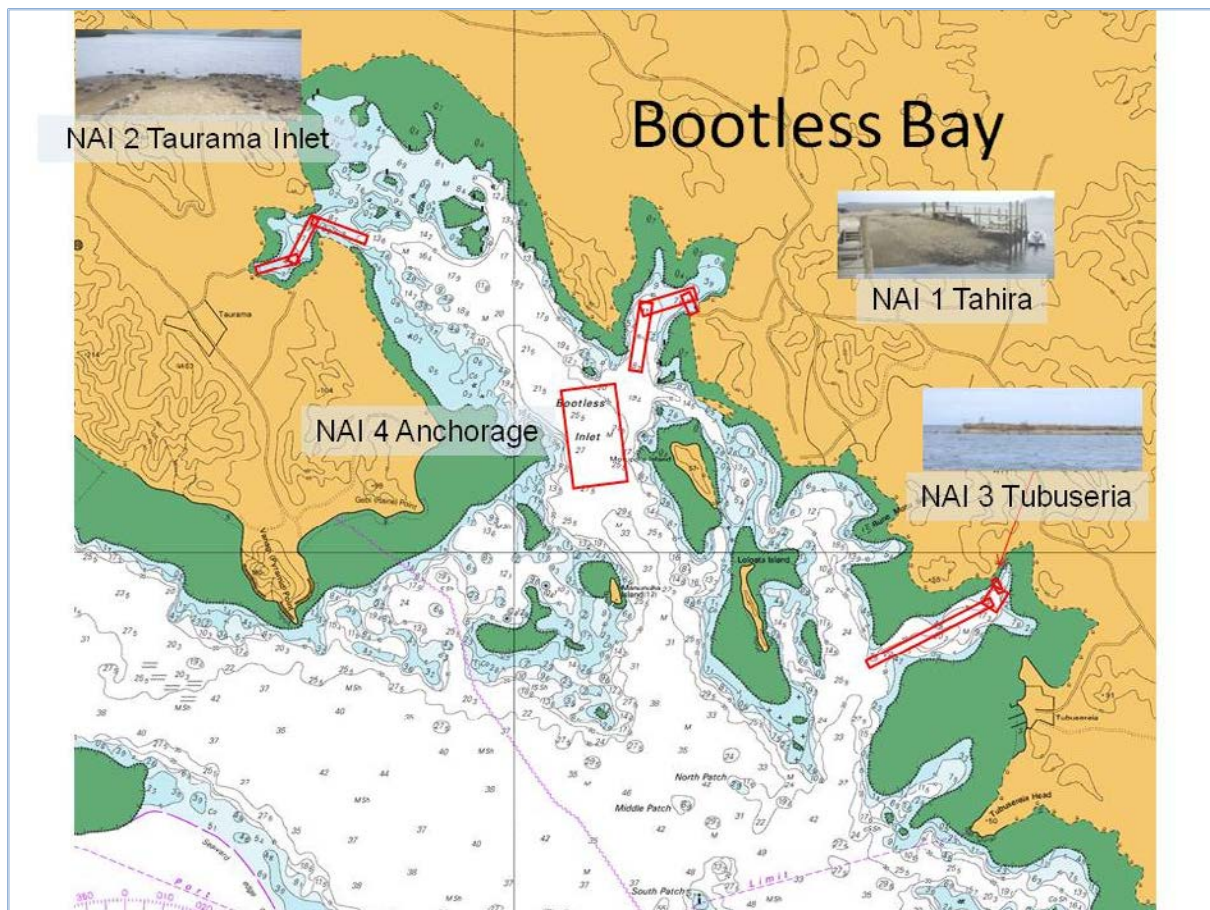
Final products included

- Charts of landing sites,
- Beach surveys,
- Road survey from landing site to main supply routes, and
- Engineer report to assist in future construction tasks.

### Exercise Olgetta Warrior: PNG 2009

In 2009 the ADF conducted a joint exercise with the PNGDF in the vicinity of Bootless Bay which is about 25km east of Port Moresby. LRSS was tasked with producing a series of planning products over Bootless Bay in support of the exercise's amphibious operations. The survey teams conducted initial surveys (see figure 4) to determine the most suitable landing site for the purposes of the exercise.





**Figure 4:** Survey Areas in Bootless Bay

A more detailed survey was conducted after the final landing site was chosen.

### Wreck Hunting in Jervis Bay

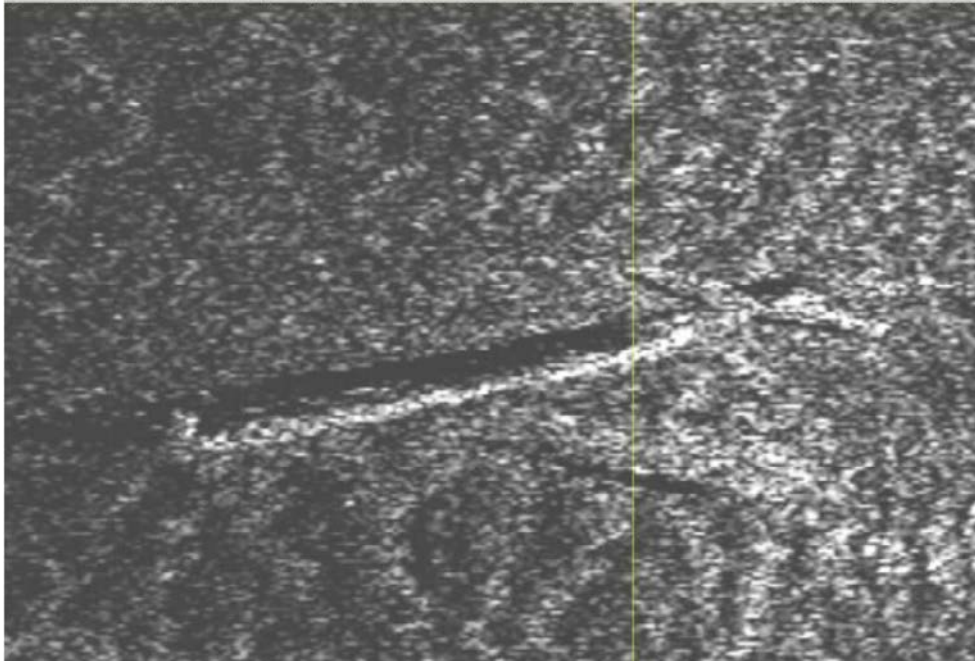
In late 2010, LRSS was contacted by the AHO and asked to confirm the position of a wreck in the northern section of Jervis Bay. Investigations revealed that the wreck was actually an aircraft, the RAN Fairey Firefly VX381 (a similar aircraft is shown in figure 5).



**Figure 5:** RAN Fairey Firefly



The plane was on a routine training flight in November 1956 with several other aircraft when a mid air collision resulted in the loss of two aircraft. VX381 crashed into the middle of Hare Bay and now sits on a sandy bottom in about 12 metres of water. The aircraft's position has been long known to the local dive community after being originally discovered in the early 1980's.

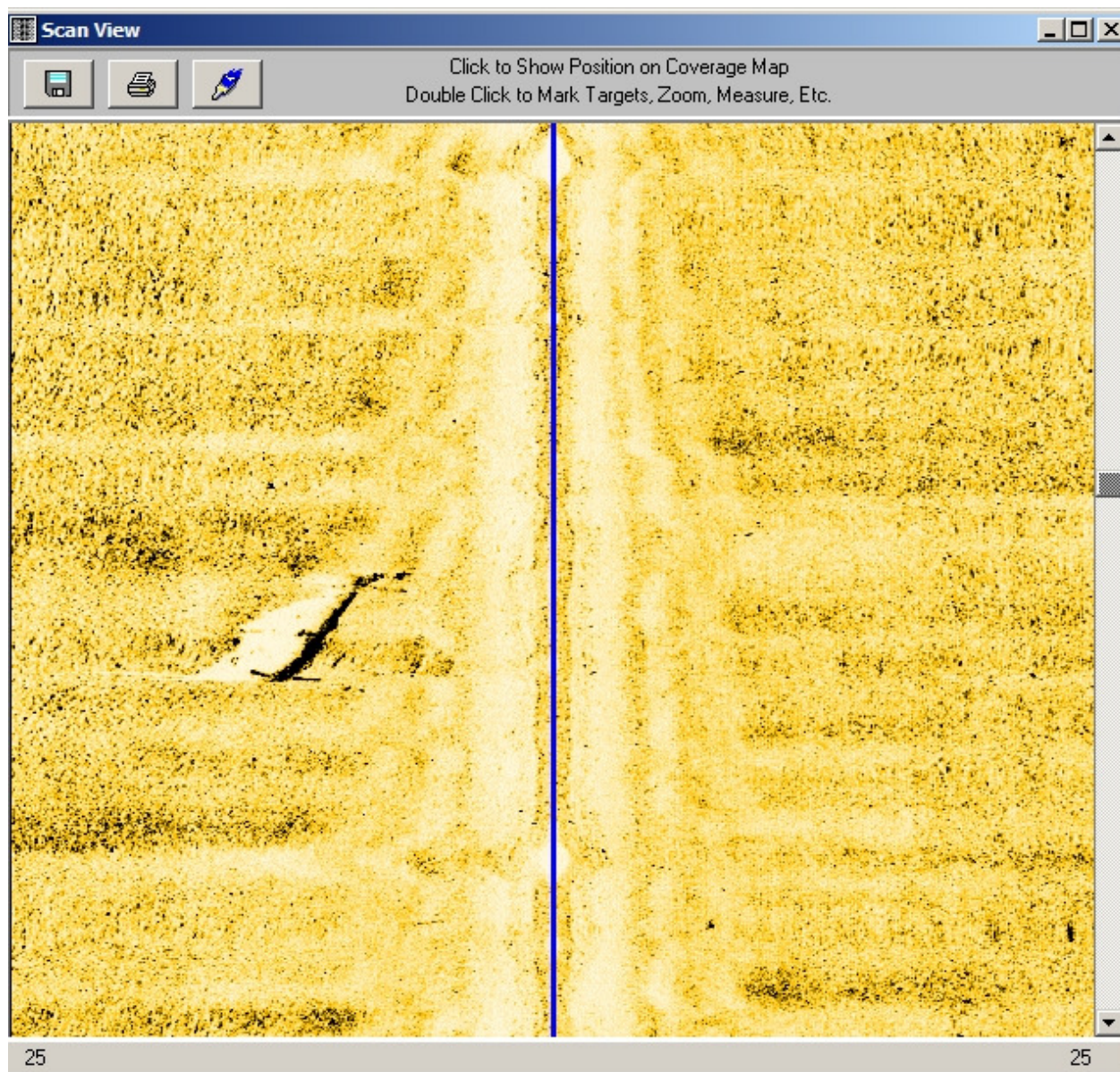


**Figure 6:** Side Looking Sonar Image of VX381

The aircraft's position was confirmed in November 2010 using the following key processes:

- RTK base station and repeater established at HMAS Creswell,
- Search grid established in the vicinity of the aircraft,
- Depth profile determined using single beam echo sounder,
- Imagery obtained using side-looking sonar.

Additional information regarding the aircraft's location and orientation (see figure 7) was obtained in March 2011 using a c-max side scan sonar loaned from the RAN.

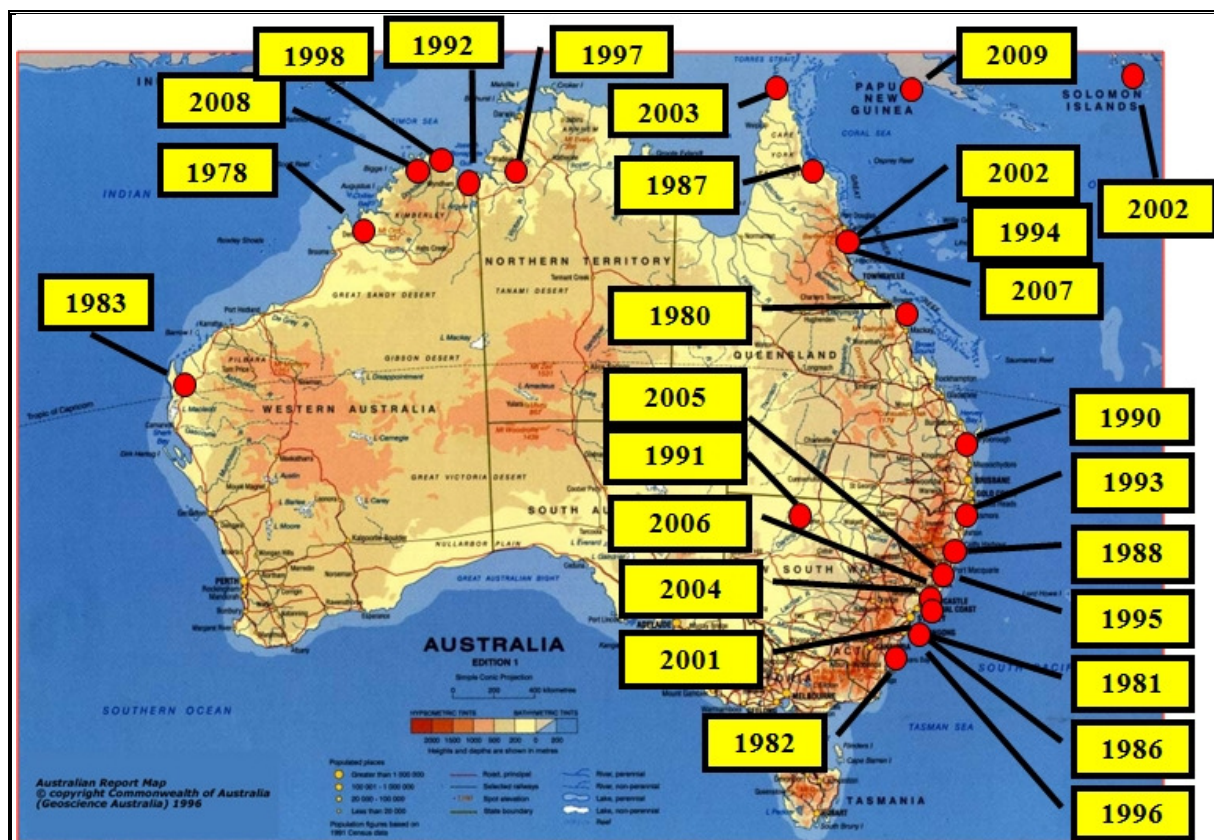


**Figure 7:** Cmax side scan sonar image of VX381

### **CONCLUDING COMMENTS**

In the thirty years to 2009, the squadron had undertaken surveys in East Timor, Tonga and Samoa, conducted riverine surveys in NSW, QLD, WA and the NT, supported ADF exercises in Australia and in PNG, and taken the lead survey role on four AACAP exercises (see figure 8).





**Figure 8: LRSS Survey Operations 1978 - 2009**

This experience coupled with the appropriate range of skill sets enables LRSS to be uniquely placed within the ADF whilst continuing to fulfil it's primarily role of providing a specialist deployable Hydrographic survey capability.

## Enquiries

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# Performance of AUSGeoid09 in NSW



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## **Abstract**

*In March 2011 Geoscience Australia released AUSGeoid09, an improved geoid model for Australia to relate GNSS-derived ellipsoidal heights to the Australian Height Datum (AHD71) and vice versa. This paper briefly reviews the theory of GNSS-based height determination and illustrates that the absolute accuracy of  $N$  values is increasingly important for users of Global Navigation Satellite System (GNSS) Continuously Operating Reference Station (CORS) networks. In order to quantify the expected improvement of replacing the current geoid model, AUSGeoid98, with AUSGeoid09 in New South Wales (NSW), four tests were performed. These tests investigated how well the two geoid models fit known AHD71 heights, based on (1) about 500 AUSPOS solutions, (2) 38 CORSnet-NSW sites, (3) several GNSS-based adjustments, and (4) numerous height control points from these adjustments. It was found that AUSGeoid09 provides a considerably improved fit to AHD71 for GNSS-based height transfer in NSW. In most cases the AUSGeoid09-derived height results fall within the expected  $\pm 0.05$  m accuracy stated by Geoscience Australia. It is also shown that the magnitude of  $N$  values in NSW will change by up to 0.5 m when AUSGeoid09 is introduced in order to provide a better fit to AHD71. The NSW Land and Property Management Authority (LPMA) has adopted AUSGeoid09 for all operations and urges all spatial professionals to do the same.*

## **Introduction**

A vertical datum defines a reference for elevation comparisons and is essential for a wide range of applications such as road and drainage design, floodplain management, agricultural management and surveying in general. Australia, like most countries, uses an approximation of the orthometric height system referenced to the geoid. The geoid is defined as the equipotential surface that best approximates mean sea level (MSL). A detailed treatment of height systems and vertical datums in the Australian context can be found in Featherstone and Kuhn (2006).

The Australian Height Datum (AHD71) was realised in 1971 by setting the observed MSL to zero at 32 tide gauges situated around the coast of Australia and adjusting about 195,000 km of spirit levelling across the country (Roelse et al., 1971). However, 40 years later we know that shortcomings in the AHD71 realisation resulted in MSL not being coincident with the geoid at the 32 tide gauges involved. These shortcomings included not considering dynamic ocean effects (e.g. winds, currents, atmospheric pressure, temperature and salinity), a lack of long-term tide gauge data, and the omission of observed gravity. This has introduced

considerable distortions of up to about 1.5 m into AHD71 across Australia. Nevertheless, AHD71 continues to be a practical height datum, providing a sufficient approximation of the geoid for many applications.

Positions obtained by a Global Navigation Satellite System (GNSS) such as GPS, GLONASS or the planned Galileo include height information referred to a reference ellipsoid. These heights are based purely on the geometry of the ellipsoid and therefore have no physical meaning. In most practice, however, heights are generally required that correctly reflect the flow of water and must therefore be referenced to the geoid. GNSS-derived ellipsoidal heights ( $h$ ) can easily be converted to orthometric AHD71 heights ( $H$ ) if the appropriate geoid undulations ( $N$ ), also known as geoid-ellipsoid separations or  $N$  values, are available (e.g. Featherstone and Kuhn, 2006; Janssen, 2009):

$$H = h - N \quad (1)$$

Figure 1 illustrates the important role  $N$  values play in the conversion of heights. On the one hand,  $N$  values are required to convert (non-GNSS) geodetic control information (i.e. orthometric heights) into a mathematically equivalent reference system to which GNSS results refer (i.e. ellipsoidal heights). On the other hand,  $N$  values are necessary to obtain orthometric heights (i.e. physical meaning) from GNSS-derived ellipsoidal heights (i.e. geometrical meaning) (Rizos, 1997).

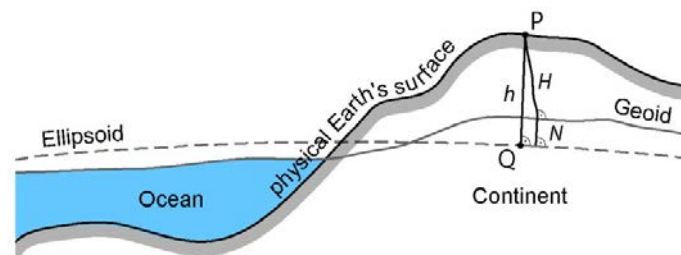


Figure 1: Relationship between ellipsoidal height ( $h$ ), orthometric height ( $H$ ) and geoid undulation ( $N$ ), courtesy of M. Kuhn, Curtin University of Technology.

In practice, a geoid model is used to provide these  $N$  values necessary for GNSS-based height determination. This paper highlights the increased importance of  $N$  values for users of Continuously Operating Reference Station (CORS) networks and shows that the new AUSGeoid09 geoid model substantially improves GNSS-based access to AHD71 in New South Wales.

### ***Considerations for CORS Users***

The use of CORS networks, such as CORSnet-NSW (Janssen et al., 2010), for GNSS real-time and post-processing applications has grown significantly over the last few years. This development has substantially increased the importance of accurate  $N$  values in regards to GNSS-based height determination.

In the traditional base-rover field scenario, the published, local AHD71 height of a temporary GNSS reference station is converted to an ellipsoidal height according to equation 1. The ellipsoidal height of the rover is then determined via Real Time Kinematic (RTK) or post-processing techniques and converted back to AHD71 using the same equation. The entire process is based on the calculated ellipsoidal height of the reference station.



In the CORS scenario, the height conversion is only applied once (at the rover end) and is based on an observed ellipsoidal height. The ellipsoidal height of most CORS in Australia (those following CORS Best Practice Guidelines) is determined via Regulation 13 certification. Geoscience Australia determines these site coordinates in a global (or, more precisely, regional) context based on a week of GNSS data and highly traceable, standardised, scientific processing. This process provides a direct and consistent connection to the Australian Fiducial Network (AFN) and its successor, the Australian Regional GPS Network (ARGN), exclusively via GNSS observations. The resulting coordinates (latitude, longitude and ellipsoidal height) are stated on Regulation 13 certificates which are valid for five years and provide a Recognised Value Standard for positioning infrastructure with respect to the Geocentric Datum of Australia (GDA94).

As illustrated by Figure 2, in the traditional base-rover scenario most of the error in the absolute N values cancels due to the conversion being applied twice (from AHD71 to ellipsoidal height and back again). The absolute N values involved may have relatively large errors ( $e$ ) but by starting and ending the process with AHD71, the height of the rover is only contaminated by the small difference of these errors (ignoring any observational errors). However, in the CORS scenario, the height conversion is only applied once (from ellipsoidal height to AHD71) and any error ( $e$ ) in the absolute N value will therefore fully propagate into the AHD71 height of the rover. Consequently, the absolute accuracy of N values is now more important than ever for AHD71 height determination using CORS techniques.

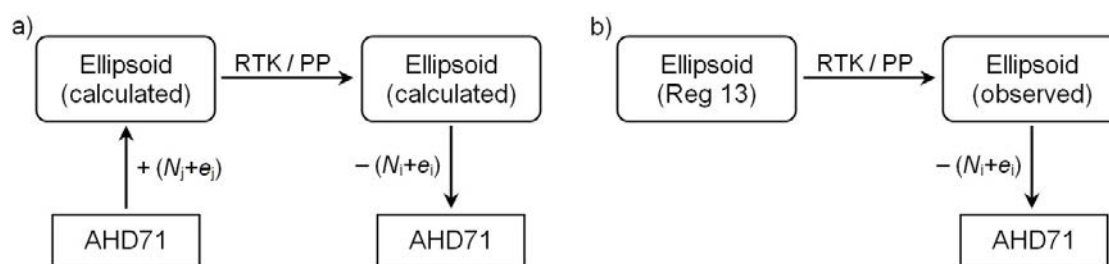


Figure 2: GNSS height transfer methodology using RTK or post processing (PP) in the past (a) and using CORS (b).

## AUSGeoid09

In March 2011 Geoscience Australia released AUSGeoid09, a new Australia-wide gravimetric geoid model that has been a-posteriori fitted to the Australian Height Datum. AUSGeoid09 provides an improved means to relate GNSS-derived ellipsoidal heights to AHD71 and vice versa. It is expected to convert GNSS heights to AHD71 heights to within  $\pm 0.05$  m across most of Australia, although the accuracy can exceed a decimetre in some areas due to errors in the aging levelling network, land subsidence, geoid anomalies, GNSS observational errors or simply a lack of data in some remote locations (Brown, 2010). In comparison, its predecessor AUSGeoid98 only provided an estimated accuracy of better than  $\pm 0.4$  m in absolute terms (Featherstone and Guo, 2001).

AUSGeoid09 covers the same area as AUSGeoid98 (between 108°E and 160°E longitude and 8°S and 46°S latitude) and also refers to the GRS80 ellipsoid. However, it is given on a 1' by 1' grid (about 1.8 by 1.8 km), making it four times denser than its predecessor (Featherstone et al., 2011). In contrast to previous versions of AUSGeoid, the new AUSGeoid09 combines an improved version of the standard “gravimetric geoid” model with a new additional “geometric” component, colloquially referred to as the “sliver” by its makers.

The first component of AUSGeoid09 is the latest gravimetric geoid model produced by the Western Australian Centre for Geodesy at Curtin University (Featherstone et al., 2011). It provides the gridded height offset between the GRS80 ellipsoid and the geoid surface. It is a product far better than the one used in AUSGeoid98.

The second, and new, component of AUSGeoid09 is the gridded geometric offset between the gravimetric geoid and AHD71, the “sliver”, calculated by empirical testing. This offset is mainly caused by AHD71 not taking into account sea surface topography, which includes the differential heating of the oceans. The warmer or less dense water off the coast of northern Australia is about 1 metre higher than the cooler or denser water off the coast of southern Australia. Therefore, AHD71 is about 0.5 m above the geoid in northern Australia and roughly 0.5 m below the geoid in southern Australia (Brown et al., 2010). The introduction of the geometric “sliver” component largely takes care of this 1-metre trend across Australia (0.6-metre trend across NSW), thereby providing a better overall fit to AHD71 (Figure 3).

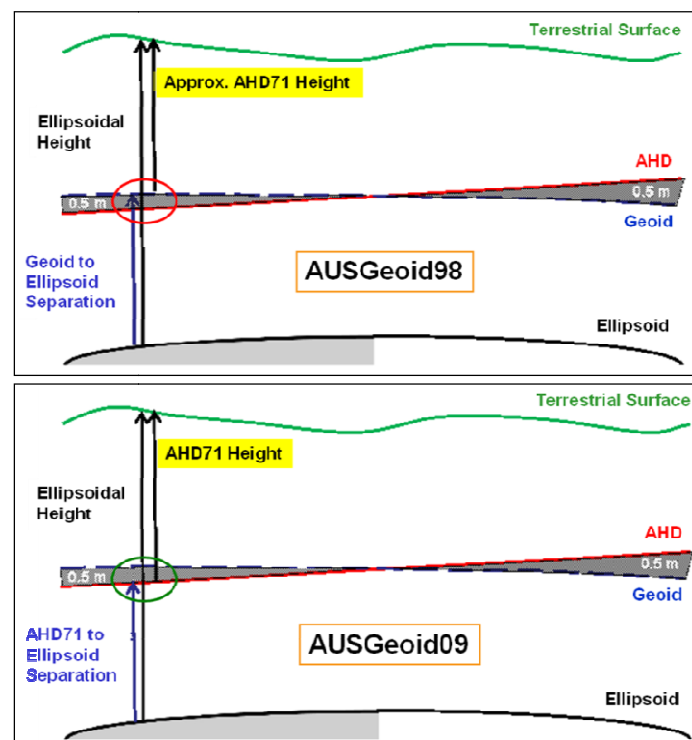


Figure 3: AUSGeoid09 provides improved access to AHD71 due to the introduction of the geometric “sliver” component (adapted from Brown et al., 2010).

## Performance of AUSGeoid09

In order to quantify the expected improvement of replacing AUSGeoid98 with AUSGeoid09 in New South Wales (NSW), we carried out four tests. These tests utilised beta version 0.7 of AUSGeoid09 which is identical to the final product in NSW. Firstly, we used more than 500 AUSPOS solutions to investigate how well the two geoid models fit known AHD71 heights across the State. Secondly, we performed a similar analysis based on 38 CORSnet-NSW sites. Thirdly, we studied the overall fit of several GNSS-based adjustments, incorporating different adjustment area sizes and various ranges in elevation. Lastly, we analysed the residuals of the height observations stemming from these adjustments. This section summarises the tests performed and presents the results obtained. For a more detailed analysis the reader is referred to Janssen and Watson (2010).

## Test 1: AUSPOS Solutions

The first test investigated 513 AUSPOS solutions (GA, 2009) collected by the NSW Land and Property Management Authority (LPMA) on established marks with accurate AHD71 heights (C3 or better, including 45% of levelled marks with LCL3 or better). Detailed definitions of the terms class and order can be found in ICSM (2007). The AUSPOS solutions were based on between 3 and 94 hours of GNSS data. It should be noted that about 100 of these AUSPOS solutions were used in the determination of the geometric component of AUSGeoid09.

AUSGeoid09 and AUSGeoid98 N values were interpolated for each solution to determine the agreement with published AHD71 heights. Since the differences to the known AHD71 values will sometimes be positive and sometimes be negative, the root mean square (RMS) is used to quantify the average agreement. The RMS of  $n$  residuals ( $x_1$  to  $x_n$ ) is calculated by the square root of the mean of the sum of the squared residuals:

$$RMS = \sqrt{\frac{\sum_{i=1}^n x_i^2}{n}} \quad (2)$$

Applying AUSGeoid09 to GDA94 ellipsoidal heights rather than AUSGeoid98 resulted in an improvement by a factor of 2.7, with the RMS dropping from 0.185 m to 0.069 m. The achieved overall accuracy is therefore only slightly worse than the expected accuracy of  $\pm 0.05$  m stated by Brown (2010). It should be noted that no correlation was evident between the length of the GNSS observation span and the level of agreement with the AHD71 values. The magnitude of N values in NSW will change by up to 0.5 m when AUSGeoid09 is introduced (Figure 4), thereby providing a much better fit to AHD71 across NSW. The North Coast area is known to exhibit a large offset in relation to the national datum (up to about 0.3 m horizontally and 0.5 m vertically) caused by a large, sparse survey control network. It clearly stands out as a block with positive differences while the remainder of the state shows negative values.

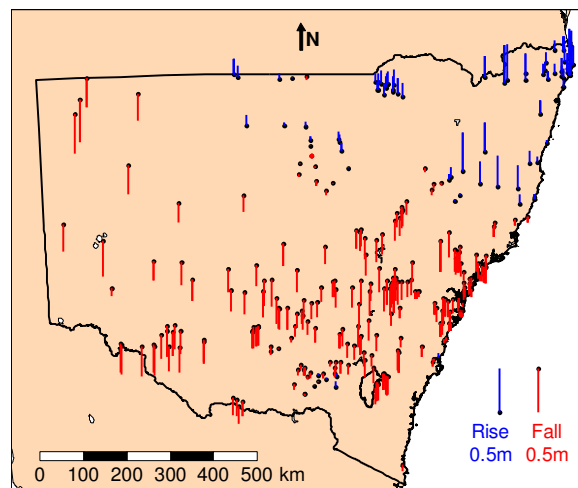


Figure 4: Difference in N values (AUSGeoid09 minus AUSGeoid98) for AUSPOS solutions across NSW.

## Test 2: CORSnet-NSW Sites

CORSnet-NSW is a rapidly growing GNSS CORS network providing fundamental positioning infrastructure for New South Wales (Janssen et al., 2010). 38 CORSnet-NSW

sites with Regulation 13 certified GDA94 coordinates and accurate AHD71 heights (mainly A1 obtained by LPMA through a GNSS-based local tie survey) were used to perform a similar test. Using AUSGeoid09 resulted in an improvement by a factor of 4.1 in the agreement to AHD71 with the RMS dropping from 0.176 m to 0.043 m, thus falling within the expected accuracy of  $\pm 0.05$  m stated by Brown (2010). The test confirmed that the magnitude of N values in NSW will change by up to 0.5 m when AUSGeoid09 is introduced (Figure 5). While this dataset contains only a limited amount of data in the north-eastern part of NSW, this area is again identified as a block of positive differences in contrast to the rest of the State.

The higher accuracy achieved in comparison to Test 1 is due to improved processing methods (Regulation 13 vs. AUSPOS) and the much more consistent quality of the input data (7-day vs. 6-hour or so datasets). The Regulation 13 certification and LPMA's local tie survey process are highly traceable and standardised, while the AUSPOS dataset was collected over many years with differing processing parameters. Both tests show that AUSGeoid09 provides an improved fit to AHD71 across NSW when compared to AUSGeoid98.

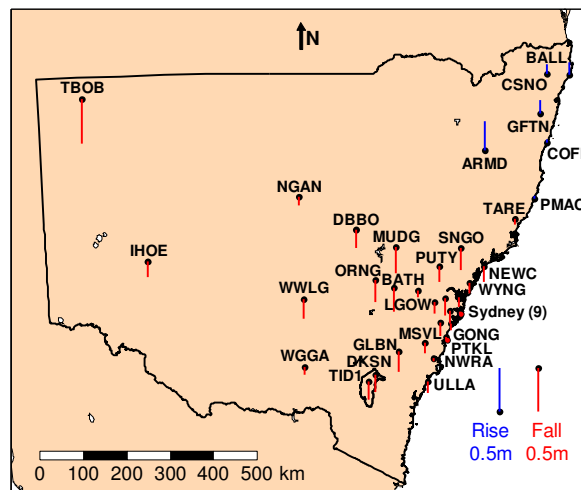


Figure 5: Difference in N values (AUSGeoid09 minus AUSGeoid98) for selected CORSnet-NSW sites.

### Test 3: Constrained 3D Network Adjustment Fit

To investigate the performance of the new geoid model in practice with regards to GNSS-based adjustments in NSW, seven 3-dimensional network adjustments were run using AUSGeoid98 and AUSGeoid09. All height control points were tightly constrained in the adjustment to their accurate (LCL3 or B2, or better), predominantly optically levelled AHD71 heights. Therefore, the adjustment was highly constrained in height. The resulting variance factor and flagged residuals were inspected to get an indication of the overall fit of each adjustment to AHD71.

The seven adjustments were chosen carefully to incorporate different adjustment area sizes, ranging from small (20 by 20 km) to state-wide (1,000 by 800 km) with average baseline lengths varying between 2 and 130 km. The datasets included various ranges in elevation: small (290 m), moderate (380 m to 620 m) and large (1,000 m to 2,200 m). The number of sites included in each adjustment varied from 18 to 155 sites, incorporating between 33 and 567 baselines (each baseline component being represented as a separate observation). Table 1 summarises relevant information about these adjustments, while Figure 6 illustrates their location and extent in NSW.



Table 1: Summary of GNSS-based adjustment datasets used in this study.

Adjustment	Extent (km)	Height Range (m)	Number of Sites	Number of Obs	Baseline Length (km)	Average Bsl Length (km)
1: South Coast	21 x 18	7 – 296	18	159	0.4 – 12	5
2: Oxley Hwy	53 x 35	116 – 1,208	13	108	0.03 – 53	16
3: Singleton	33 x 42	30 – 442	87	631	0.6 – 30	5
4: Bellingen	40 x 27	2 – 1,041	107	565	0.3 – 23	2
5: Bland	212 x 162	167 – 544	155	1,075	0.1 – 67	12
6: SW NSW	633 x 553	20 – 645	34	752	8 – 270	128
7: NSW	1,000 x 800	2 – 2,229	89	1,721	3 – 393	130

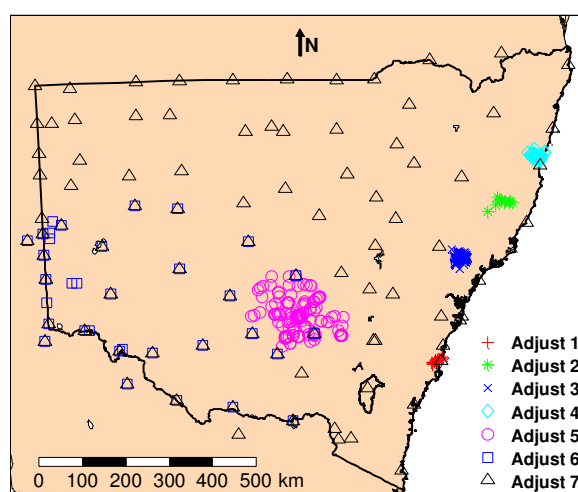


Figure 6: Location and extent of the seven GNSS-based adjustment datasets investigated.

In general, AUSGeoid09 improved the variance factor, indicating a better adjustment result in comparison to AUSGeoid98 (Table 2). The number of flagged residuals was also reduced in most cases. The smaller adjustments (1 and 2) showed a large improvement in the overall fit. Here the variance factor improved by factors of 2.3 and 4.6, while the number of flagged residuals was significantly reduced from 13 to 2 and from 7 to 0 respectively. The improvement is more prominent for adjustment 2 which displays a much larger variation in height across the area. Owing to the higher density of AUSGeoid09, this could be expected.

The overall fit of the larger adjustments also increased but only showed slight improvements in the variance factor and the number of flagged residuals. Adjustments 6 and 7, covering very large areas with baseline lengths reaching up to 390 km, showed minimal improvements in the variance factor, while the number of flagged residuals was reduced slightly to 0 and 1 respectively. It can be expected that distance-dependent error sources mask the improvement achieved by using AUSGeoid09 to some degree in these cases. In summary, the seven adjustments give further evidence that AUSGeoid09 considerably improves access to AHD71 across NSW compared to AUSGeoid98.

Table 2: Variance factors obtained for the adjustments investigated.

Adjustment	AUSGeoid98	AUSGeoid09	Improvement Factor
1: South Coast	2.68	1.19	2.3
2: Oxley Hwy	2.50	0.54	4.6
3: Singleton	1.11	1.05	1.1
4: Bellingen	1.19	1.12	1.1
5: Bland	1.00	1.00	1.0
6: SW NSW	0.28	0.24	1.2
7: NSW	0.63	0.63	1.0

#### Test 4: Minimally Constrained 3D Network Adjustment Fit

The final test was based on the same seven GNSS-based adjustment datasets. In this analysis, only one observed AHD71 height was held fixed (located in the centre of each adjustment area), while the others were introduced as observations and allowed to float. Therefore, the adjustment was minimally constrained in height. For those marks that had accurately known AHD71 heights, the adjusted heights (obtained by applying AUSGeoid98 or AUSGeoid09) were compared against their known AHD71 values by analysing the residuals of the height observations after the adjustment. The values of these residuals indicate how well the geoid model fits the AHD71 heights in practice.

The use of AUSGeoid09 considerably improved the residuals, with RMS improvement factors generally larger than 1.5 (Table 3). By far the largest improvement is evident for adjustment 2 with an improvement factor of 4.6 for the RMS, although it should be remembered that the sample size is very small for this adjustment.

Table 3: Results of the height observation residual analysis.

Adjustment	Parameter	AUSGeoid98	AUSGeoid09	Improvement Factor
1: South Coast (11 marks)	<b>RMS (m)</b>	0.061	0.024	2.6
	<b>Range (m)</b>	0.166	0.070	2.4
2: Oxley Hwy (5 marks)	<b>RMS (m)</b>	0.157	0.034	4.6
	<b>Range (m)</b>	0.299	0.050	6.0
3: Singleton (53 marks)	<b>RMS (m)</b>	0.039	0.029	1.3
	<b>Range (m)</b>	0.159	0.104	1.5
4: Bellingen (60 marks)	<b>RMS (m)</b>	0.081	0.053	1.5
	<b>Range (m)</b>	0.477	0.340	1.4
5: Bland (68 marks)	<b>RMS (m)</b>	0.077	0.049	1.6
	<b>Range (m)</b>	0.321	0.281	1.1
6: SW NSW (24 marks)	<b>RMS (m)</b>	0.150	0.087	1.7
	<b>Range (m)</b>	0.389	0.408	1.0
7: NSW (9 marks)	<b>RMS (m)</b>	0.190	0.144	1.3
	<b>Range (m)</b>	0.308	0.411	0.7

In most cases the accuracy of the AUSGeoid09 results falls within the expected accuracy of  $\pm 0.05$  m. Only adjustments 6 and 7 show larger values, reaching 0.09 m and 0.14 m respectively. This was expected because these two adjustments cover large areas and contain relatively long average baseline lengths of 130 km. These baselines were processed with 1990's-era commercial GNSS software having limited modelling options, and distortions in AHD71 are more prominent over longer distances.

It needs to be emphasised that the RMS values stated in Table 3 should be interpreted as the average accuracy achievable in these adjustments. As the range of the obtained height residuals illustrates, the residuals continue to show considerable variations, although the improvement of using AUSGeoid09 is obvious.

It should also be remembered that errors in the AHD71 and GNSS heights at the analysed points contribute cumulatively to the overall error in the residual comparison of these adjustments. This may be compensated by errors present in AUSGeoid98, giving a falsely accurate answer for AUSGeoid98 residuals and leading to a seemingly smaller accuracy gain when AUSGeoid09 is used. Nevertheless, the overall indication is that AUSGeoid09 improves considerably upon AUSGeoid98.

In summary, all four tests have shown that AUSGeoid09 will substantially improve the access to AHD71 for GNSS-based height determination in NSW.

### ***Concluding Remarks***

In March 2011 Geoscience Australia released AUSGeoid09, an improved geoid model for Australia. This paper has briefly reviewed the theory of GNSS-based height determination and illustrated that the absolute accuracy of N values is increasingly important in the era of expanding CORS networks.

Tests based on more than 500 AUSPOS solutions across the State, 38 CORSnet-NSW sites and seven carefully selected adjustment datasets have shown that AUSGeoid09 substantially improves access to AHD71 for GNSS-based height determination in NSW when compared to its predecessor, AUSGeoid98. This improvement is due to the larger and higher-quality input dataset, improved modelling and the increased density of AUSGeoid09, as well as the inclusion of a geometric component. This allows a more direct determination of AHD71 heights from GNSS observations. In most cases the AUSGeoid09 results fall within the expected accuracy of  $\pm 0.05$  m stated by Geoscience Australia.

It is important to understand that AUSGeoid09 provides a correction surface between the GRS80 ellipsoid and AHD71, not the geoid. AHD71 continues to be a practical but less than ideal height datum, and a strategy to update it needs to be discussed at the national level. In the meantime, LPMA has adopted AUSGeoid09 for all operations (including CORSnet-NSW) and urges all spatial professionals to do the same.

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# SIX-SCIMS Project

## An Integrated Delivery System for Survey Control for NSW



Author: John Kelaher

### **Introduction**

*It has been a over a decade since the development and release of the current GDA version of the SCIMS Online product, and 17 years since the first external access to SCIMS data was made available*

*The previous versions are/were focused on the delivery of the geodetic spatial data and because of technology or lack of it the navigation to and selection of marks was limited. The development of the Spatial Information Exchange (SIX) Viewer product, now allows for the graphical display of survey marks on a state wide basis. This product has established the environment to integrate all spatial/metadata and imagery relating to control survey marks.*

*This presentation will be more a demonstration of the new Generation SCIMS Online product than discussion of the philosophy and technology behind its development.*

*I must apologise to organisers as the development team had intended to launch SIX-SCIMS today, however technology has not been kind with the untimely death of our development server at the final hurdle. As it is I hopefully will deliver a live demonstration of this new LPMA product. If this live demonstration fails I will revert to a PowerPoint presentation.*

# **SIX-SCIMS Project**

## **SIX-SCIMS Key Points**

SIX-SCIMS will have SIX Viewer frontend, based on the Survey Mark Channel.

Improved navigation tools to define area of interest.

Map toolbar tailored to survey industry needs

Allow for the graphical selection of survey marks using rectangle, radial and polygon search types as well as the option to enter a list of marks required.

Will provide access to SCIMS spatial data, metadata and Locality Sketch Plans in one website.

Options to download data will include:

- Pdf: standard Acrobat Reader file format this file can include all SCIMS spatial data , any metadata, an image of the search area and all locality sketch plan images of the marks selected

- CSV: standard comma separated variable file format for download to survey application

- Moss: standard file format for download into Compunet software.

An integrated e-commerce system has been developed and will allow payment for searches by credit card or monthly account. Monthly invoices will be fully itemized and delivered directly from the LPMA accounts system

It is comforting to know that many of the new functions developed for the SIX-SCIMS project will be used in new SIX products now under development.

## **Special Note**

SIX-SCIMS will only be accessed through the SIX- Survey Services Portal.

Remember the Survey Portal is an individual access. Any surveyor, field assistant or office staff who requires access to SCIMS will need a Survey Portal access.

## **Special Thanks**

I would like to thank the SIX-SCIMS development team of Belinda Mead, Simon Reynolds, Kelvin Cooke and Daniel Miller for their enormous contribution and patience with this project.

Also Project Team Member Glenn Jones and Sponsor Doug Kinlyside for his support.

UAT Test Team Paul Neale, Paul Vong, James O’Kane, Rachael Tribe and John Waldon

# CORSnet-NSW Network RTK: Same Look and Feel... Only Better



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## ***Abstract***

*CORSnet-NSW is a rapidly growing network of Global Navigation Satellite System (GNSS) Continuously Operating Reference Stations (CORS) providing fundamental positioning infrastructure for New South Wales that is accurate, reliable and easy to use. This positioning infrastructure supports a wide range of GNSS applications in areas such as surveying, agriculture, mining and construction. This paper presents the current status of CORSnet-NSW and briefly outlines the difference between the traditional, single-base Real Time Kinematic (RTK) and the Network RTK (NRTK) approaches. Initial results from some of the extensive testing of NRTK performance undertaken by LPI across eastern NSW are then presented. These tests have shown that while NRTK has the same 'look and feel' as single-base RTK, it produces superior coordinate results in regards to both precision (i.e. repeatability) and accuracy (i.e. agreement with the State's survey ground control network). The benefit of averaging observations over a 1-minute window and re-occupying points 20-40 minutes later is illustrated. It is also shown that coordinate quality (CQ) indicators provided by the GNSS rover equipment are often overly optimistic, even under favourable satellite visibility and multipath conditions, and should therefore be used with caution.*

## ***Introduction***

Global Navigation Satellite System (GNSS) Continuously Operating Reference Stations (CORS) networks are being introduced across Australia and internationally to provide improved access to positioning infrastructure for a wide range of GNSS applications in areas such as surveying, agriculture, mining and construction. Benefits include the rationalisation of infrastructure, establishment of multi-user systems, positioning services that are similar across the network, consistent and reliable connectivity to the national datum, and the ability to provide a degree of legal traceability for satellite-based positioning.

CORSnet-NSW is a rapidly growing network of GNSS CORS providing fundamental positioning infrastructure for New South Wales that is accurate, reliable and easy to use (Janssen et al., 2010). The network aims to support the spatial community and provide stimulus for innovative spatial applications and research using satellite positioning technology. It is built, owned and operated by Land and Property Information (LPI), a division of the NSW Land and Property Management Authority (LPMA). CORSnet-NSW aims to ensure that the best possible positioning infrastructure is available to NSW, while maintaining national and international standards and best practice (e.g. ICSM, 2002; 2007;

Lands, 2006) to accommodate established and developing positioning and navigation applications.

LPI's first CORS was installed in 1992 in Bathurst to support internal survey and aerial photography operations (Kinlyside and Yan, 2005). In 2004 a network of seven CORS was installed in the Sydney metropolitan area and made available to the public one year later under the name SydNET (Roberts et al., 2007). A renewed effort of expansion to extend the coverage of CORS throughout NSW commenced in 2009 and corresponded with the rebranding of the network as CORSnet-NSW (LPMA, 2011a). Currently consisting of about 60 permanent stations tracking multiple satellite constellations, CORSnet-NSW will expand to over 110 stations within the next two years. While SydNET has been operated in tandem with CORSnet-NSW over the last 18 months, all SydNET services will cease on 2 May 2011.

This paper presents the current status of CORSnet-NSW and briefly outlines the difference between the traditional, single-base Real Time Kinematic (RTK) and the Network RTK (NRTK) approaches. Initial results from some of the extensive testing of NRTK performance undertaken by LPI across eastern NSW are then presented.

### ***Current Network Status and Rollout***

The network currently (March 2011) consists of 59 CORS, mainly located in the highly populated coastal region and the eastern part of the State. Figure 1 illustrates the coverage of CORSnet-NSW, showing stations that are operational (indicated by small triangles) as well as planned stations (indicated by small circles). A 150 km radius around active stations is shown in order to illustrate sub-metre Differential GPS (DGPS) coverage, while a 50 km radius indicates the coverage area for single-base Real Time Kinematic (RTK) operation at the 2-cm level. Network RTK (NRTK) coverage at the 2-cm level (horizontally) is shown as a pink polygon. Initially only covering the Sydney metropolitan area, NRTK services have now been extend into the Illawarra, Central Coast and Lower Hunter regions.

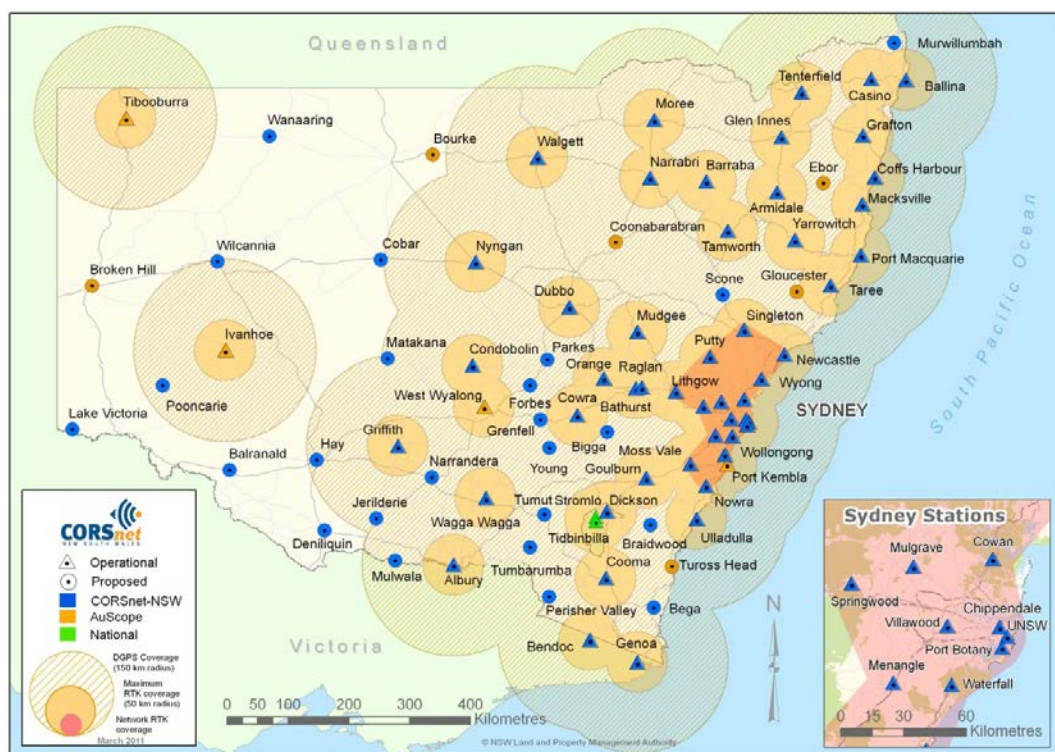


Figure 1: Current coverage of CORSnet-NSW (March 2011).



Currently more than three quarters (78%) of the area of NSW is covered by the DGPS service, while single-base RTK is available to one third (31%) of NSW. It should be noted that the latter percentage is not expected to reach 100% state-wide coverage since vast areas of western NSW are very sparsely populated and dense CORS coverage is therefore not justified. In the vicinity of CORSnet-NSW stations, the network is well-suited to support efforts to improve cadastral infrastructure in rural areas with RTK GNSS techniques (Janssen et al., 2011).

All CORSnet-NSW reference stations currently in operation are equipped with the most recent dual or triple constellation GNSS hardware (e.g. GPS, GLONASS and Galileo), purposely mixing GNSS equipment from different manufacturers. In order to provide a legally traceable survey monument that allows the GNSS antenna to be oriented to True North without the need to introduce an antenna height, a new CORS antenna mount, the CORSnet-NSW Adjustable Antenna Mount (CAAM), was developed in-house and a patent submission has been accepted. LPI has invested nearly one million Australian dollars in software over the last 18 months, being the second institution in the world to install Trimble Navigation's VRS<sup>3</sup>Net CORS network management software.

CORSnet-NSW is operated and managed by an expert team consisting of seven staff in the technical group and three staff in the customer support group. The network is fully funded by LPI. A number of CORS-net NSW stations have been built to geodetic specifications with support from federal sources, allowing their participation in the scientific, national AusCORS network managed by Geoscience Australia (Janssen, 2009b). Additionally, a large number of CORSnet-NSW stations are hosted by local councils, and in the near future several sites will be hosted by private industry. LPI collaborates with the ACT Planning and Land Authority to provide CORS services across the Australian Capital Territory. LPI also collaborates with the VIC Department of Sustainability and Environment, which operates Victoria's GPSnet (DSE, 2011), in order to ensure consistent positioning services in the border region between the two states. Currently 80% of CORSnet-NSW stations are hosted by our partners, and this percentage is expected to rise. As LPI progresses with the rollout of CORS, more users will have services available to them and the level of service may also improve from its current levels.

### ***Single-Base RTK versus Network RTK***

The traditional single-base RTK approach uses the GNSS data of a single reference station or CORS to model the distance dependent errors (i.e. the ionospheric and tropospheric delays and orbit errors) and provide corrections to the user. Since the corrections that model the offset between observed and corrected user position are based on the location of a single CORS, positioning quality decreases with increasing distance from the CORS. NRTK, on the other hand, enables reliable modelling of the distance dependent errors across the network and allows the correction data provided to a user to be optimised based on their location within the network, thereby providing a modelled offset that represents the actual conditions much better (Figure 2).

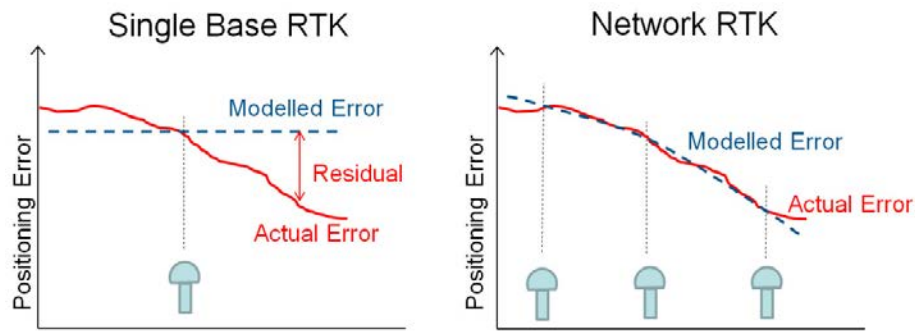


Figure 2: RTK vs. NRTK modelling of the distance dependent errors.

High-accuracy single-base RTK solutions are generally limited to a distance of 20 km (Zhang et al., 2006), although tests conducted by LPI have shown that acceptable results can be achieved over up to 50 km (McElroy, 2007). Providing high-accuracy GNSS solutions state-wide using single-base RTK would require many hundreds of CORS and is not feasible due to the extreme cost involved. The NRTK solution is generally based on between three and six of the closest reference stations with respect to the user and allows much greater inter-CORS distances (up to 70-90 km) while maintaining the same level of accuracy (Figure 3). CORSnet-NSW provides users with NRTK correction data according to both the Virtual Reference Station (VRS) approach and the Master-Auxiliary Concept (MAC). For a comparison of these two techniques the reader is referred to Janssen (2009a).

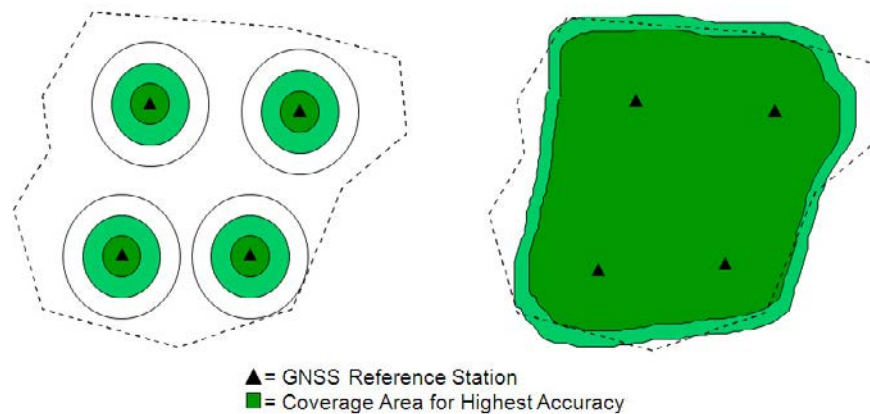


Figure 3: RTK vs. NRTK coverage.

A recent international study compared the performance of NRTK across the United Kingdom in order to quantify the achievable accuracy with VRS and MAC, and to provide a basis for NRTK best practice guidelines (Edwards et al., 2008; 2010). It was found that the two commercial NRTK systems investigated provided similar levels of overall accuracy, i.e. 10-20 mm in the horizontal component and 15-35 mm in the vertical component at the one-sigma level (68%). However, users were urged to pay close attention to coordinate quality (CQ) indicators provided by the GNSS rover equipment and to be aware that overly optimistic CQ values (by a factor of 3-5) can be obtained under limited satellite visibility and multipath conditions. The adoption of the mean of two 3-minute averaged observation windows separated by 20-45 minutes was shown to reduce errors by about 5 mm, particularly in the vertical component. The use of averaging (or windowing) techniques was also recommended if the height difference between the user and the nearest reference station(s) exceeds 250 m.

Wang et al. (2010) assessed the performance of NRTK in Australia when longer than recommended inter-CORS distances are utilised. It was found that it may be possible to offer

NRTK services to regional areas using larger than recommended inter-CORS distances. However, CORS operators and users need to be aware that the risk of incorrectly resolving integer ambiguities increases substantially when larger NRTK cell sizes are used. For some applications, these errors may be identified by multiple occupations. The authors also demonstrated that CQ values tend to be overly optimistic, especially under challenging conditions, and do not function well in regards to identifying incorrectly fixed integer ambiguities.

### ***CORSnet-NSW Network RTK Performance Testing***

Extensive tests were carried out at several locations in eastern NSW to investigate the performance of the CORSnet-NSW NRTK service outside the Sydney metropolitan area, and with larger inter-CORS distances than those found in Sydney (25 km on average). This paper presents initial results obtained from a selected sample of the data, collected in NRTK cells within the recommended size. Comparisons are made between NRTK and single-base RTK operation to illustrate the performance of NRTK in the study areas. The achievable precision was investigated during a 3-day test, while the achievable accuracy was determined by comparison to established marks contained in the Survey Control Information Management System (SCIMS) database (LPMA, 2011b).

#### ***Test 1: Long-Term Precision***

##### **Test 1: Methodology**

The long-term precision (i.e. repeatability) of NRTK and single-base RTK solutions was investigated by collecting three days of real-time GNSS data at multiple locations within eastern NSW. The results presented here are from the roof of a building at Macquarie University, collected on 4-6 January 2011. Figure 4 shows the study area including the surrounding CORSnet-NSW sites. The average inter-CORS spacing around the perimeter of the four closest CORS was 29 km (with a maximum of 33 km), i.e. well within the recommended maximum. Six Leica Viva GNSS receivers were set up next to each other, observing in NRTK mode (VRS and MAC) utilising data from the surrounding CORSnet-NSW sites, in single-base RTK mode connected to three different CORS (CHIP, MGRV and the more distant WFAL), and in DGPS mode. All receivers collected real-time data at a 1-second interval. Due to the very close proximity of the receivers (using equipment of the same type), it can be assumed that all datasets were exposed to the same conditions. This paper focuses on the results obtained by NRTK (utilising the VRS concept) and single-base RTK connected to CHIP (the closest CORSnet-NSW site, 15 km away).

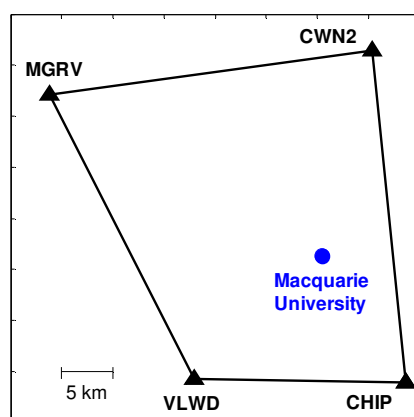


Figure 4: Location of the Macquarie University study area and surrounding CORSnet-NSW stations.

## Test 1: Results

A real-time coordinate solution (Easting, Northing, and Ellipsoidal Height) was determined for each second over this 3-day observation period. In order to simulate a situation generally encountered in practice, a coordinate quality indicator that can be set in the GNSS rover equipment was applied to the collected data. In the Leica software, this indicator is referred to as CQ. It is calculated at the rover as the root mean square (RMS) of coordinate errors, based on ambiguity-fixed double-differenced observations, and indicates how much the computed position is likely to deviate from the ‘true’ value (Leica Geosystems, 2009). In other words, the lower the reported CQ, the higher the estimated quality of the coordinates.

Our analysis only considers data within a CQ value of 50 mm for position & height, i.e. the default value recommended by the manufacturer. This resulted in a small amount of data being discarded due to insufficient quality (as determined by the GNSS rover software). Table 1 lists the percentage of the 3-day dataset that was within specifications as well as the resulting RMS relative to the mean of the remaining data for both NRTK and single-base RTK. It should be emphasised that all remaining figures and tables in this paper represent data that has passed this ‘CQ filter’.

Table 1: Statistics of the 3-day dataset at Macquarie University.

	<b>NRTK (VRS)</b>	<b>RTK (CHIP)</b>
<b>Data within specifications (%)</b>	99.6	99.8
<b>Horizontal RMS (mm)</b>	12.3	15.4
<b>Vertical RMS (mm)</b>	21.2	30.8

It is evident that a slightly larger amount of data was found to be of insufficient quality in the case of NRTK. The RMS provides a measure of the precision achieved over the 3-day test. NRTK performs better in both the horizontal component (i.e. distance from mean coordinate) and the vertical component, reaching about 12 mm and 21 mm respectively. Figure 5 illustrates the higher precision of NRTK in regards to horizontal position compared to single-base RTK. The histograms along the coordinate axes indicate the number of points involved in each millimetre bin from the mean. It should be noted that the figure does not show the small number of outliers that passed the CQ filter but still deviated by more than 50 mm from the mean value (see Table 2). There were 18 such outliers out of 264,524 observations for NRTK, and 451 outliers out of 267,423 observations for single-base RTK.

The cumulative distribution of the analysed data allows us to quantify the precision achieved by a given proportion of the data. Table 2 compares the number of observations that were outside specified quality bins of up to 500 mm. It is clearly evident that performs better than single-base RTK, showing significantly fewer observations outside each quality bin. Note in particular the large difference between the two methods for observations outside 50 mm from the mean, both in horizontal position and the height component. While it is recognised that the initial CQ filter may have been more effective in eliminating outlier observations for NRTK than for single-base RTK, this only accounts for about 0.2% of the difference between the two methods (cf. Table 1).



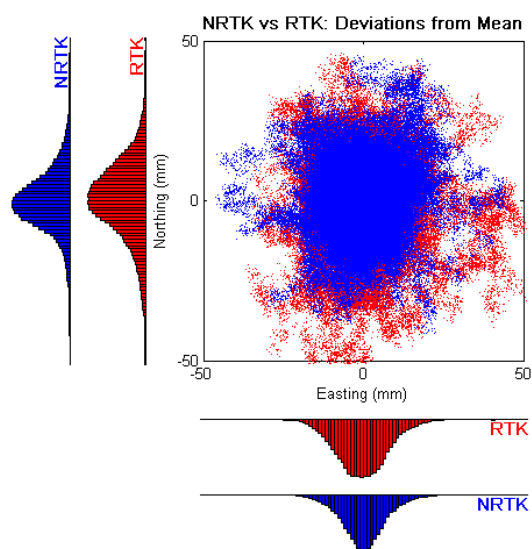


Figure 5: Horizontal precision of NRTK (blue) vs. RTK (red).

Table 2: Selected quality bins for NRTK and single-base RTK.

Quality Bin	NRTK (VRS)				RTK (CHIP)			
	Distance		Height		Distance		Height	
# > 500 mm	0	0.00%	18	0.01%	0	0.00%	0	0.00%
# > 200 mm	0	0.00%	18	0.01%	39	0.02%	28	0.01%
# > 100 mm	18	0.01%	449	0.17%	49	0.02%	2,051	0.77%
# > 50 mm	<b>18</b>	<b>0.01%</b>	<b>4,954</b>	<b>1.87%</b>	<b>451</b>	<b>0.17%</b>	<b>25,291</b>	<b>9.46%</b>
# > 40 mm	998	0.38%	11,987	4.53%	3,800	1.42%	42,484	15.89%
# > 30 mm	5,696	2.15%	32,543	12.30%	12,485	4.67%	69,630	26.04%
# > 20 mm	23,226	8.78%	77,312	29.23%	41,553	15.54%	116,755	43.66%
# > 10 mm	105,270	39.80%	153,580	58.06%	144,835	54.16%	183,800	68.73%
# > 0 mm	264,524	100.00%	264,524	100.00%	267,423	100.00%	267,423	100.00%

Figure 6 visualises the cumulative distribution in regards to the horizontal position (i.e. distance from mean position) and height for NRTK and single-base RTK. For instance, it can be seen that, for NRTK, 95% of the horizontal positions are within 25 mm of the horizontal mean and within 40 mm of the vertical mean. For single-base RTK, 95% of the positions are within about 30 mm and 60 mm of the mean, respectively. This again shows that NRTK performs better. It should be noted that the figure does not display all of the outliers that have slipped through the CQ filter (cf. >50 mm bin in Table 2). The cumulative distribution does however take these outliers into account.

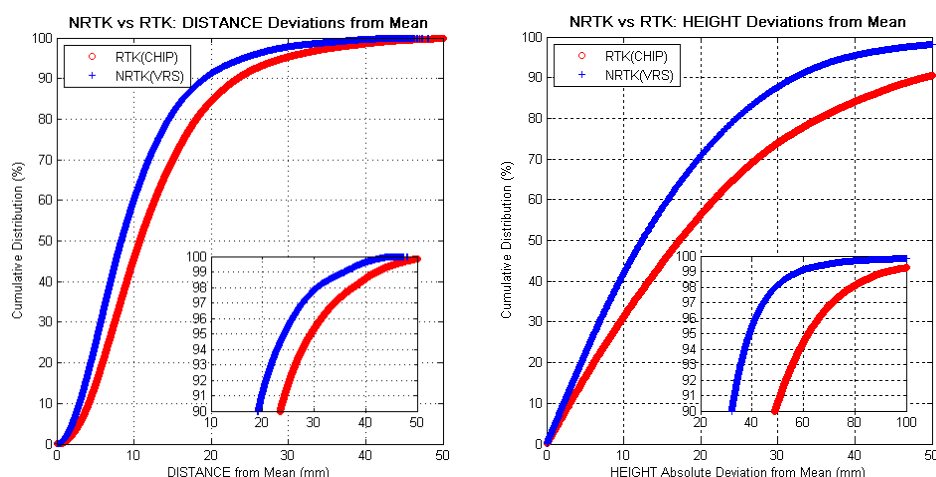


Figure 6: Cumulative distribution in horizontal position (left) and height (right) for NRTK and single-base RTK.

The NRTK time series showing the epoch-by-epoch difference from the mean in horizontal position and height for the first day is depicted in Figure 7. The following days produced similar figures. In addition to the original single-epoch (1 second) data, a smoothed time series obtained by applying a moving average of 5 minutes (i.e. 300 epochs) is also shown, to indicate the effects of windowing. Windowing is achieved by determining the average of several epochs observed at a point and is a method commonly employed in the field. It increases the reliability of an observed position by eliminating extreme fluctuations. Obviously, a larger window will produce a smoother time series, but the resulting coordinates still follow the main trend of the time series. This emphasises the importance of re-occupying a point (i.e. double occupation) for high-accuracy applications, even when the windowing technique is employed. Visual inspection of the time series indicates that a small window (i.e. an observation period of several seconds) may produce results that are still significantly offset from the mean, while a larger window increases the time in the field but further reduces the effect of outlier observations.

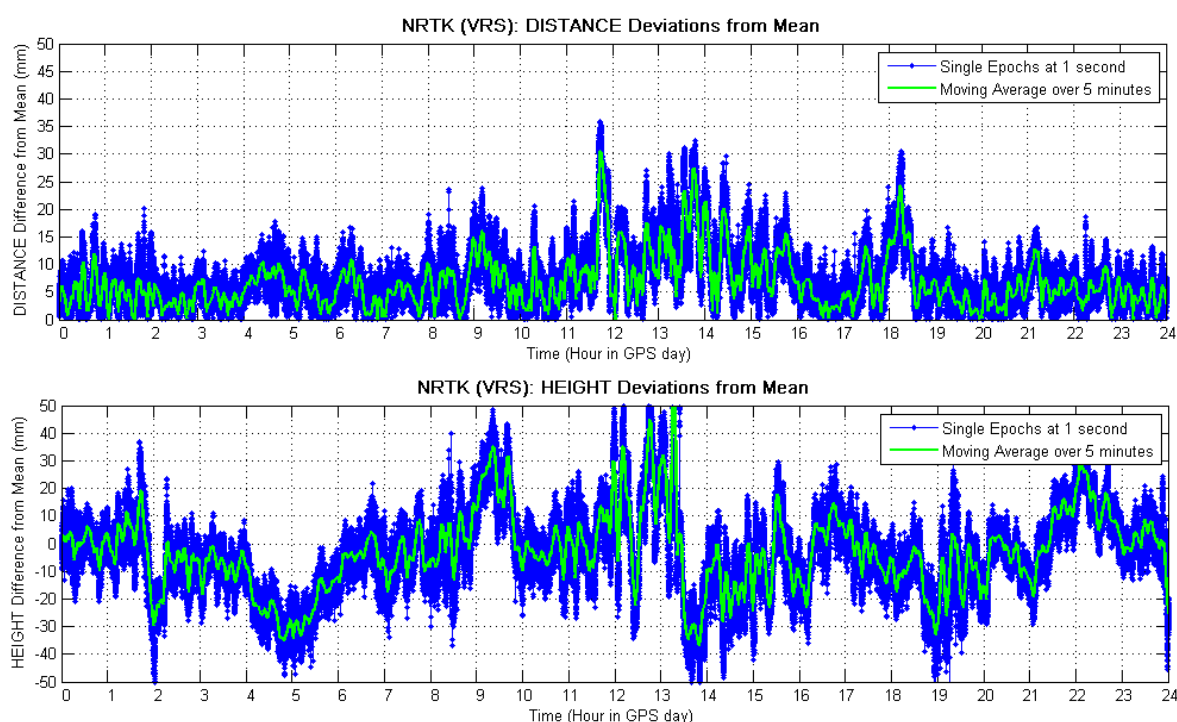


Figure 7: NRTK precision time series of the horizontal component (top) and vertical component (bottom) on 4 January 2011.

How long should a user spend on a mark in order to benefit from windowing without sacrificing productivity? We investigated the present 3-day dataset in regards to the RMS and the range of the difference from the mean for both coordinate components, utilising observation windows of varying length. While windowing provides a relatively small improvement in the RMS, it significantly reduces the range of the differences from the mean (Figure 8). This reduces the risk of obtaining a coordinate result that disagrees with the mean by a large amount. The results reveal that a 1-minute window substantially reduces the effects of individual coordinate solution variations and removes potential outliers as much as possible in a short time frame. While one minute may seem like an eternity for some users in the field, it is generally feasible for most applications, considering that the time can be spent filling out the field book, taking site photos, and looking up the next point to be occupied. For applications requiring the GNSS rover to be in motion, more sophisticated techniques would need to be employed. It is important to note that a huge improvement is achieved between

observing for 1 second, 30 seconds and 60 seconds, while observing for longer than 1 minute does generally not provide any significant improvement.

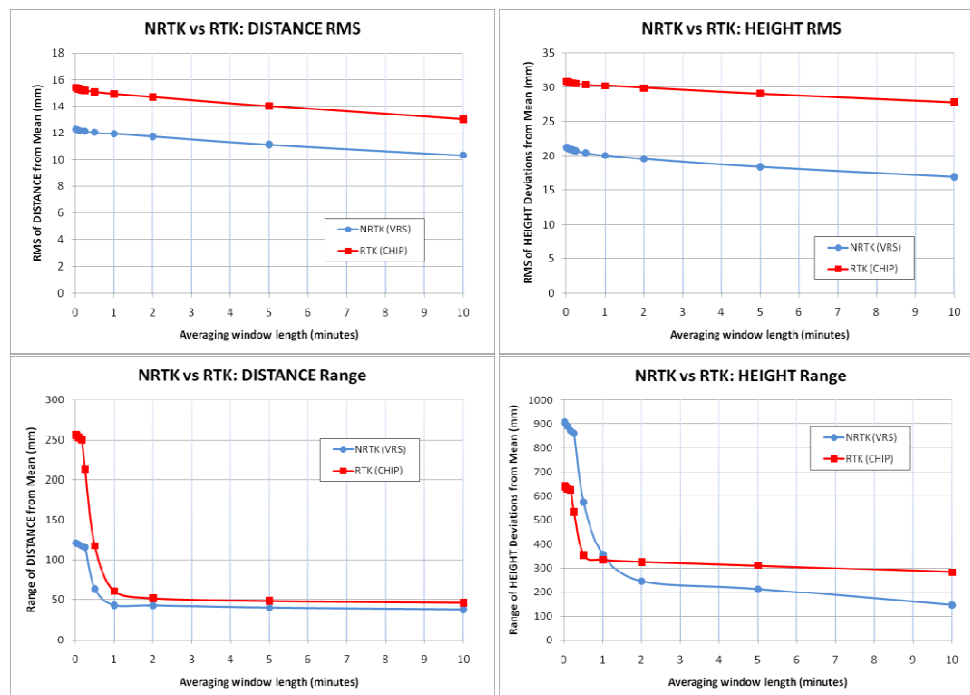


Figure 8: RMS and range of differences from the mean for horizontal position (left) and height (right). NRTK (blue) and single-base RTK (red) results are shown.

How long should a user wait until re-observing with the assumption that both occupations are sufficiently independent? In order to answer this question, the difference in horizontal position (and separately in height) was determined between every pair of epochs in the 3-day dataset that were a specified time apart. For example, comparing all epochs that are 300 seconds apart represents on average the effect of re-occupying the point after 5 minutes. This was repeated for every possible time separation up to 2 hours. Figure 9 illustrates the RMS of the resulting horizontal distance and height difference between two occupations undertaken a specified time apart. Our dataset indicates that two occupations can be assumed sufficiently independent from each other if they are taken 20-40 minutes apart, while waiting longer to re-observe is not likely, on average, to improve positioning results any further. While these findings agree very well with the recommendations made by Edwards et al. (2010), pending analysis of the remaining two long-term datasets collected by LPI will contribute to a more detailed answer.

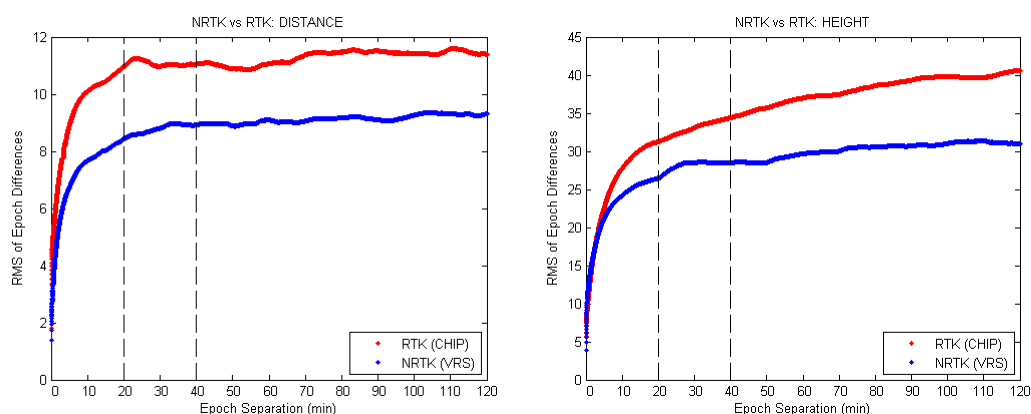


Figure 9: RMS of horizontal position (left) and height (right) for increasing observation windows. NRTK (blue) and single-base RTK (red) results are shown.

Recent studies have shown that users should be aware of overly optimistic CQ values, especially under limited satellite visibility and poor multipath conditions (Edwards et al., 2010; Wang et al., 2010). The present dataset is well suited to investigate the agreement between the CQ values calculated at the GNSS rover and the actual precision achieved over the 3-day period. Figure 10 visualises this relationship in regards to the horizontal position for NRTK and single-base RTK, and Figure 11 displays the same data for the NRTK solution, as the distance and height from the mean, coloured according to the CQ value. In addition to the already mentioned smaller spread of the NRTK solutions, NRTK also exhibits smaller CQ values (not shown), suggesting a better quality of the position solutions. It is important to note that for both NRTK and RTK there are instances where a low CQ value is reported, indicating a high-quality solution, even though the coordinate solution is significantly different from the mean. Obviously this is of more concern to the user than the reverse scenario, also shown, where a high CQ value is reported for an epoch with good agreement with the mean.

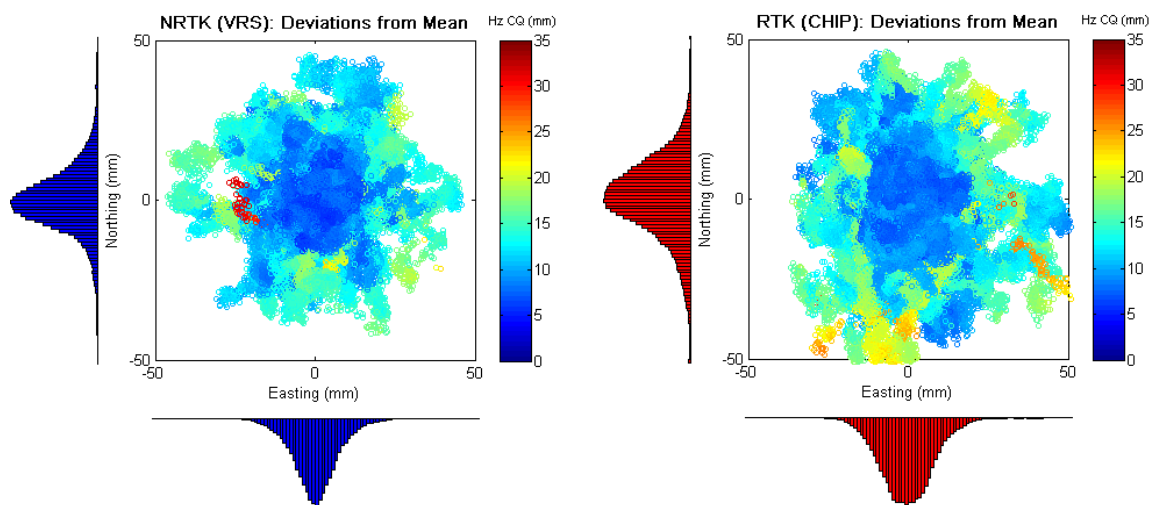


Figure 10: Horizontal precision vs. CQ value for NRTK (left) and RTK (right).  
Deviations larger than 50 mm are not shown.

Figure 11 clearly shows that a specified CQ value does not necessarily represent the actual precision of the coordinate solution, both in the horizontal and vertical component. In fact, the actual precision is often a lot lower than indicated by the CQ, by up to a factor of 5 in the horizontal component and a factor of 7 in vertical component, *even under the favourable satellite visibility and multipath conditions encountered during this test*. It should be remembered that a CQ filter of 50 mm was applied to the data, so higher CQ values are not shown. It can be seen that CQ values have a minimum value of 5 mm in the horizontal component and 8 mm in the vertical component in this case. It is also evident that a small number of large outliers (the same 18 NRTK epochs in both the horizontal and vertical components) are presumably caused by incorrect ambiguity resolution and cannot be detected by the CQ filter. These findings show that CQ values are prone to be overly optimistic and should be used with caution, confirming results by Edwards et al. (2010) and Wang et al. (2010).



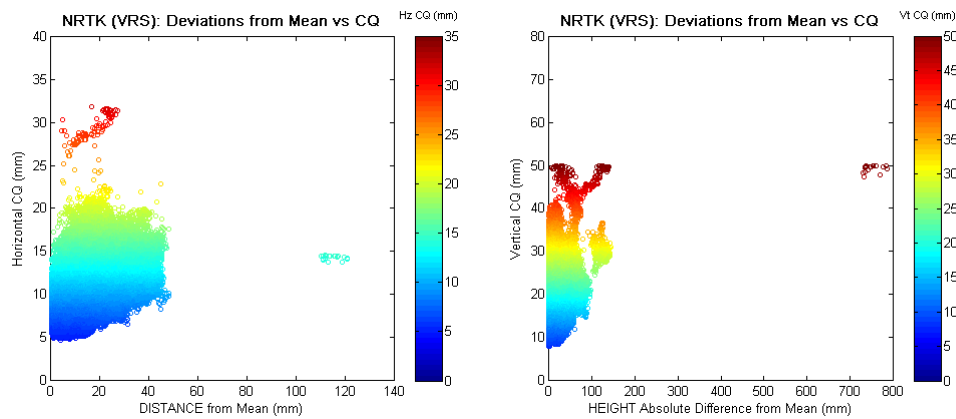


Figure 11: NRTK precision vs. CQ value for the horizontal component (left) and vertical component (right).

## ***Test 2: NRTK Performance in Practice***

### **Test 2: Methodology**

In order to investigate the achievable real-time agreement with SCIMS in a practical scenario, NRTK and single-base RTK solutions on a number of established marks were compared to their official SCIMS values. This test was performed at seven study sites throughout eastern NSW. All observations were performed with a tripod for stability, using Leica Viva GNSS receivers.

As CORSnet-NSW operates in the GDA94(2010) realisation of the national datum, a site calibration (also known as localisation or local transformation) is required to relate surveys utilising CORSnet-NSW to the local survey control network (Janssen and McElroy, 2010). The site calibration points were chosen to be of the highest class and order possible, i.e. A1 horizontal and LCL3 vertical, or better. Detailed definitions of the terms class and order can be found in ICSM (2007). In order to ensure that the site calibration does not contaminate the test results, it was decided to observe for 5 minutes at each site calibration point. This is far beyond recommended best practice but ensured that a reliable, high-quality local transformation between the CORSnet-NSW reference frame, i.e. GDA94(2010), and the local ground control network, i.e. GDA94(1997), could be determined. One site calibration was performed using NRTK, another using single-base RTK to the closest CORSnet-NSW site. Absolute antenna modelling was applied to the GNSS rovers involved in all tests (Janssen and Haasdyk, 2011). It should be noted that the site calibration used a direct 3-dimensional, 7-parameter transformation without the use of a geoid model, i.e. the geoid-ellipsoid separation was considered as part of the similarity transformation parameters between GDA94(2010) and GDA94(1997). This procedure is acceptable for research purposes only. The threshold for acceptance of the site calibration was set to 20 mm in Easting and Northing, and 50 mm in Height.

Within the area surrounded by the site calibration points, a number of high-quality established marks (B2 hz. and LCL3 vt., or B2 hz. and B2 vt. if not optically levelled, or better) were selected as test points. The test points were chosen to exhibit ‘typical’ conditions accepted for GNSS surveys, i.e. a good skyview with low to moderate obstructions. Test points were observed for 1 minute using NRTK (applying the NRTK-derived site calibration) and, following immediately after re-initialisation (without re-setting the tripod), using single-base RTK relative to the closest CORSnet-NSW site (applying the site calibration derived by single-base RTK). After all test points were occupied once, the procedure was repeated to obtain 10 rounds of observations on each test point at different times of day over several days.

While the extensive testing conducted by LPI involved seven test areas across eastern NSW, this paper presents results obtained in two study areas, Albion Park in the Illawarra (Figure 12) and Cessnock in the Lower Hunter region (Figure 13). The figures illustrate the location of the test points, surrounded by the site calibration points and the closest CORSnet-NSW sites. The average inter-CORS distance around the perimeter of the four closest CORS was 37 km (with a maximum of 52 km) for Albion Park and 66 km (with a maximum of 80 km) for Cessnock, i.e. within the recommended maximum for inter-CORS distances of 70-90 km. Single-base RTK operation utilised the closest CORSnet-NSW site, i.e. Port Kembla (PTKL) in Albion Park (16 km away) and Singleton (SNGO) in Cessnock (34 km away). The fieldwork was conducted over several days in January and February 2011.

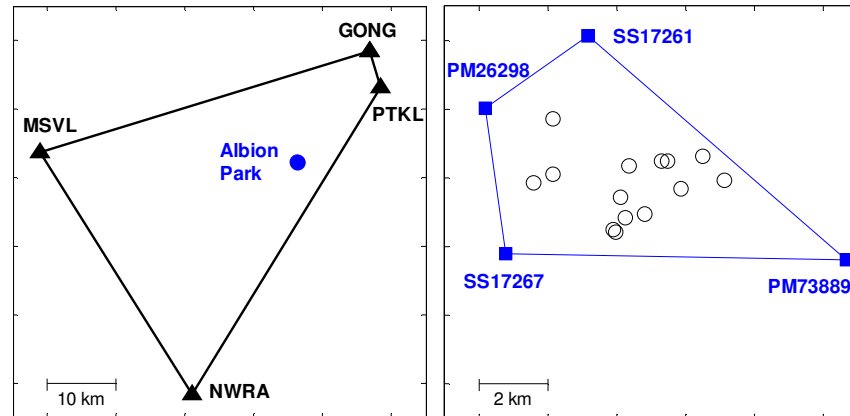


Figure 12: Location of the Albion Park test area and surrounding CORSnet-NSW stations. Site calibration points are shown as blue squares, and test points as black circles.

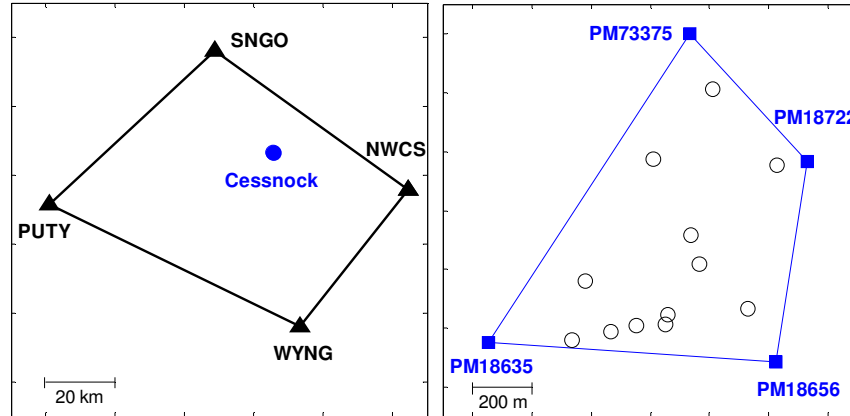


Figure 13: Location of the Cessnock test area and surrounding CORSnet-NSW stations. Site calibration points are shown as blue squares, and test points as black circles.

## Test 2: Results

In order to quantify the achievable accuracy of NRTK and single-base RTK, real-time observations on established marks in two study areas were compared against their published SCIMS coordinates. The resulting deviations from SCIMS in the horizontal and vertical component are shown in Figure 14 (Albion Park) and Figure 15 (Cessnock). For every test point surveyed, each 1-minute occupation is represented individually. It is evident that NRTK generally produces a better agreement with SCIMS (after a site calibration) with a smaller spread among re-occupations. This is particularly clear in the Cessnock test area, showing that NRTK provides a substantial improvement on single-base RTK in larger cells.

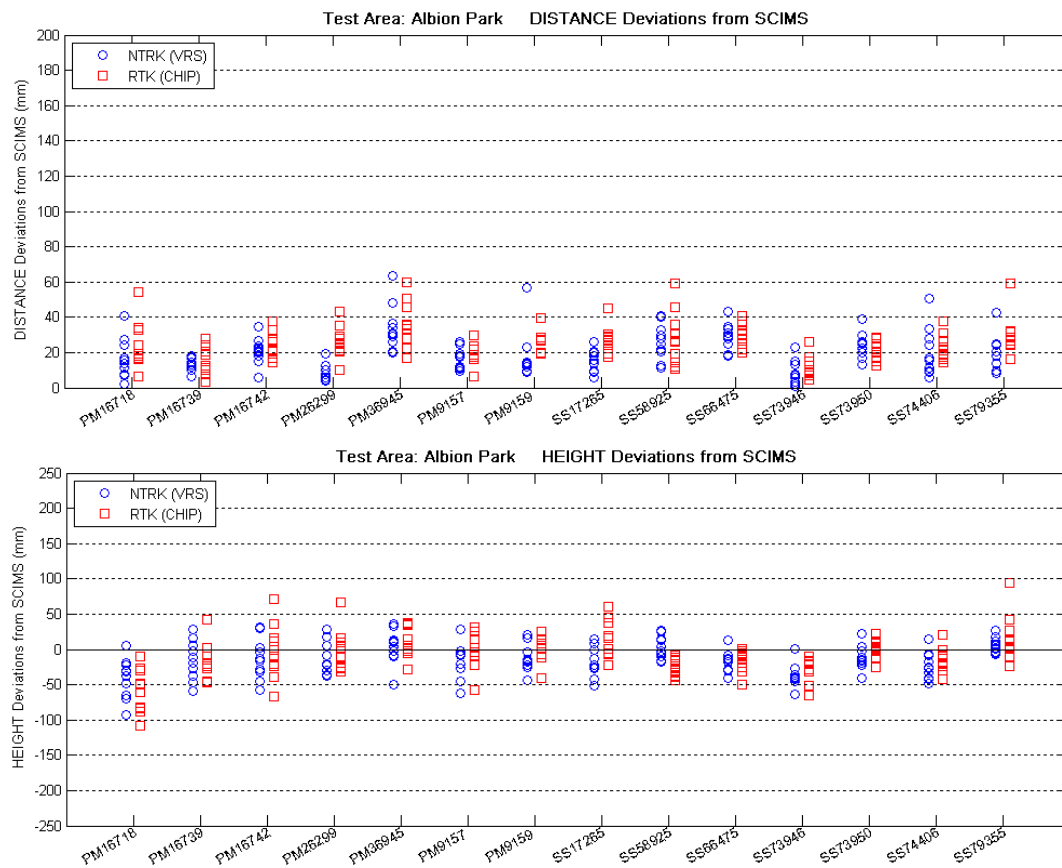


Figure 14: Horizontal and vertical accuracy vs. SCIMS in Albion Park.  
NRTK (blue) and single-base RTK (red) results are shown.

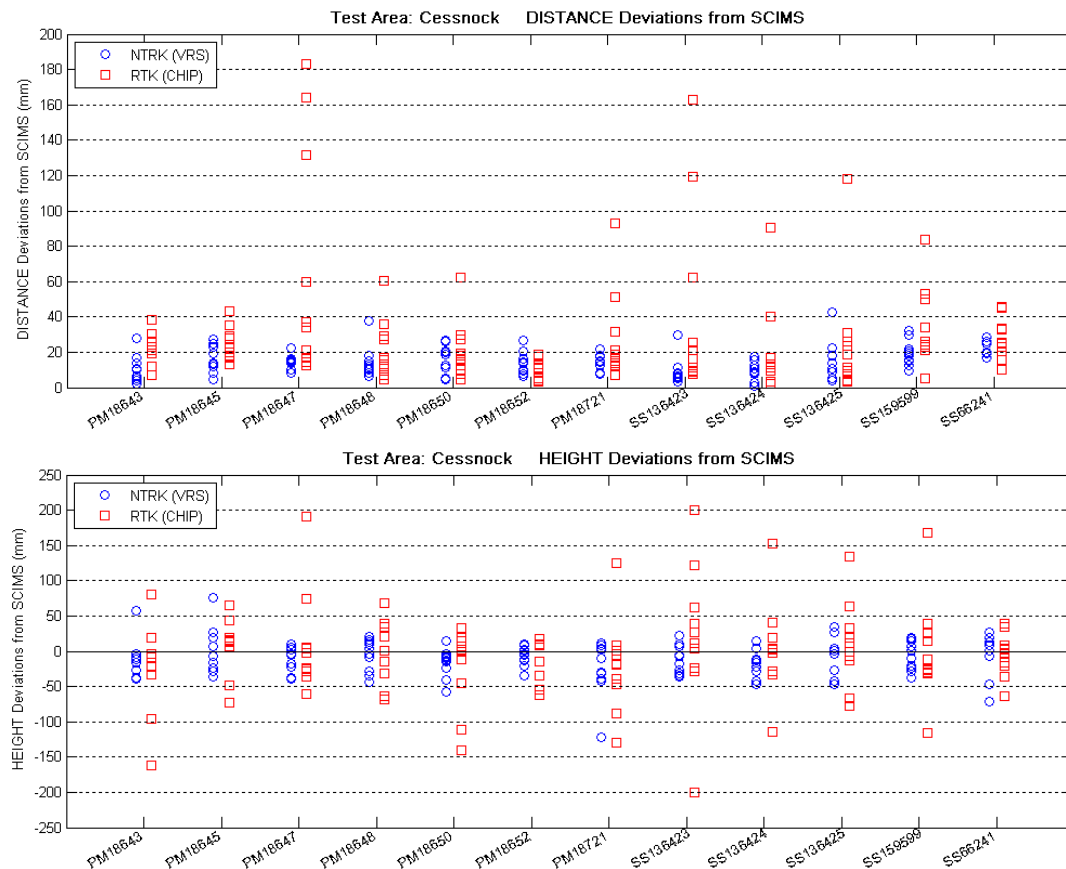


Figure 15: Horizontal and vertical accuracy vs. SCIMS in Cessnock.  
NRTK (blue) and single-base RTK (red) results are shown.

In order to quantify the overall agreement with SCIMS in each test area, the RMS in the horizontal and vertical component was calculated across all occupations on all test points (Figure 16). Clearly, NRTK produced better results, especially if compared to single-base RTK over a longer distance. In Cessnock, the RMS obtained with NRTK improves on single-base RTK by a factor of 2.6 in the horizontal component and 2.3 in the vertical component.

In both test areas NRTK produces comparable agreement with SCIMS (RMS at  $1\sigma$ ) of about 20 mm in the horizontal and better than 30 mm in the vertical component, while single-base RTK accuracy degrades significantly with increasing baseline length, as expected. While pending analysis of the remaining five test areas will enable us to investigate NRTK performance in more detail, the presented results agree very well with findings presented by Edwards et al. (2010).

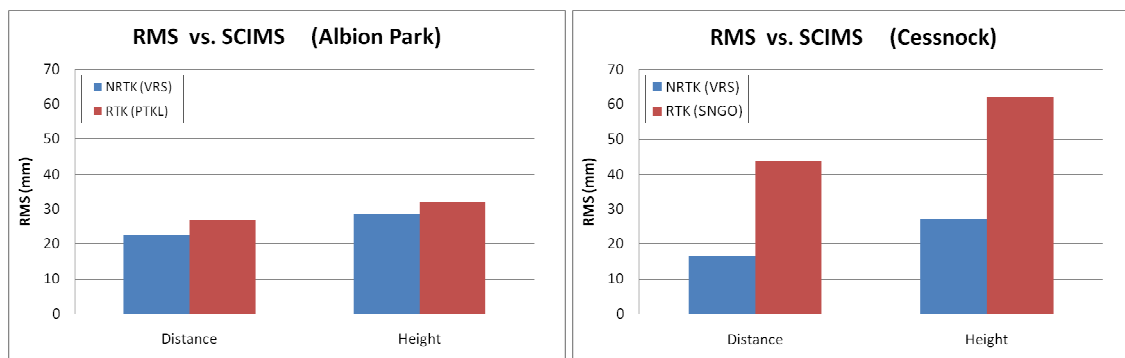


Figure 16: RMS of NRTK (blue) and single-base RTK (red) positioning vs. SCIMS. Single-base RTK was observed over distances of about 16 km (PTKL) and 34 km (SNGO) respectively.

## Concluding Remarks

This paper has outlined the current status of CORSnet-NSW and briefly described the fundamental differences between the single-base RTK and NRTK concepts. In order to investigate the performance of the NRTK service outside the Sydney metropolitan area with larger inter-CORS distances, extensive tests have been carried out at several locations in eastern NSW. The achievable precision (i.e. repeatability) was investigated during 3-day tests, while the achievable accuracy was investigated by comparison to established marks contained in the SCIMS database.

We have presented promising results obtained from the analysis of a subset of the data collected. Further analysis of the extensive data collected by LPI will provide more insight into the performance of NRTK in NSW. At this stage we recommend the following in regards to NRTK observations utilising CORSnet-NSW for high-accuracy applications:

- Observe for 60 seconds to obtain an averaged position. This averaging (windowing) technique will reduce the effects of individual coordinate solution outliers.
- Averaging for 60 seconds rather than 15 seconds delivers a huge improvement in positioning quality, while averaging for longer than one minute is generally not expected to provide substantial further improvement.
- Re-observe each point after waiting 20-40 minutes. Waiting any longer is not likely to provide any further benefits other than perhaps logistic convenience.
- Be aware that coordinate quality (CQ) indicators provided by the GNSS rover equipment are often overly optimistic, even under favourable satellite visibility and multipath conditions.



- NRTK has the same ‘look and feel’ as single-base RTK but provides better precision and agreement with SCIMS, especially in larger NRTK cells that would require longer single-base RTK baselines but are still within the recommended limit for inter-CORS distances.
- NRTK can deliver precisions of about 12 mm in the horizontal component and about 21 mm in the vertical component (RMS at  $1\sigma$ ) when inter-CORS distances are approximately 30 km.
- In the two test areas investigated so far, consistent accuracies (against SCIMS) of about 20 mm in the horizontal and better than 30 mm in the vertical component (RMS at  $1\sigma$ ) can be achieved with NRTK, while single-base RTK accuracy degrades significantly with increasing baseline length.
- The findings of our NRTK testing will form the basis of future updates of regulations, Surveyor General’s directions, standards and best practice guidelines.

## Acknowledgements

This study would not have been possible without the invaluable help from all LPI offices across the State, supplying GNSS equipment and staff to perform the extensive fieldwork involved. In regards to the datasets presented in this paper, special thanks are due to Wayne Fenwick, Andrew Holt, Matt Hopson, Michael London, Mark Morrison and Peter O’Kane. Macquarie University is thankfully acknowledged for giving permission to conduct Test 1 on university grounds.

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# Pegless Road Boundary Surveys



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## ABSTRACT

*It's back to the Kosciuszko National Park - where it all began (referring to Mark Gordon's presentation on the Kosciuszko Ko-Ordinated Kadaastre and the State Forests presentations)! This time, the Snowy Mountains Highway road boundary definition is given the treatment.*

*The highway is the main access road between Tumut and Cooma and provides access to the Mt Selwyn snowfields. The investigation spans from the eastern boundary of the National Park near Providence Portal to just west of Talbingo. Of the total distance of around 100 kms, 70 kms was found to have a lost or confused boundary requiring definition. This fact has been known to the DMR/RTA Survey Managers and documented since the 1970's, though with added notations: that it was a low priority or, resources were not available! Project kick off occurred in 2005 with a 'low priority (but keep it going)' timeframe and is now reaching the Deposited Plan lodgement stage.*

*The following paper has been scribed by John Gillies, a 'semi-retired' member of the team. John has the intimate knowledge of the project and his paper is a fascinating read. The paper was first published in volume 40, No 1 of the Main Roads Surveyors Association Newsletter (Dec 2010) and is presented with his permission.*

*This project displays the cooperation between government instrumentalities for mutual benefit. It highlights innovation and the practical application of technology to reduce costs to society and the reduction of greenhouse gases to the world.*

# THE MAN FROM SNOWY MOUNTAINS (HIGHWAY)

**: So how did I get to here?**

For those faithful MRSA readers breathlessly awaiting a follow-on story from my Kings Highway exploits — wait no more — we've moved on to Highway No. 4: The Snowy Mountains Highway. And now we're back with more tall tales and true about the creation of a new road reserve through Kosciuszko National Park from Talbingo to West Denison (no I'd never heard of it either — a largely "paper" town near Providence Portal to the west of Adaminaby).

You may remember my earlier tale about the "State Forests Project" and the creation of new road reserves through National Parks without the requirement for; and expense of; a conventional cadastral survey. Well; based on the successful pioneering of this method of road reserve creation, Dennis Clark, in 2005 the Property Manager for Southern Region in Wollongong, saw the potential for resolving a long-standing problem in his region of "rationalising" the road reserve for HW4 for the 70 or so kilometres where it passes through Kosciuszko National Park from Talbingo to West Denison.



Photo 1: The RTA's 2008 "Photo Frenzy" winner. Alex Gillies' photo of Lake Blowering from the top of Big Talbingo Mountain (plus RTA 278, of course).

But first, a bit of history! A road across the Snowy Mountains between Tumut and Cooma has been in existence from at least the mid-1800s servicing the miners at Kiandra, Yarrangobilly and elsewhere as well as the 'high-country' graziers. As it became formalised as a road for motor vehicles it was originally called the Monaro Highway, but later was renamed the Snowy Mountains Highway; and the Snowy Mountains Highway it remains today. The first of the many road surveys started in



the late 1800s with a survey for a road up Talbingo Mountain in 1891 and an 1889 survey for a one-chain road reserve from Cooma to Kiandra. Elsewhere, there was sporadic survey activity to carve out Portions where there was a demand for grazing lands and in many of these areas there was no road survey, as such, but the “evolution” of a road reserve by abuttal to the surveyed Portions. Kosciusko State Park, as the forerunner of Kosciuszko National Park, was gazetted on 2 June 1944 (*...just a month after my birthday as it happens – so I’m exactly one month older than KNP!*). Kosciuszko National Park was gazetted in 1967 — and it is around this period that the problems of 2010 had their genesis. The photo below almost tells the story.



Photo 2: It's a bit hard to read (and in fact was replaced just recently – now with RTA logo, of course!), but essentially, and at a time when the Snowy Mountains Hydro Electric Scheme construction was nearing completion, it tells the “almost inspirational” tale of the reconstruction of the Snowy Mountains Highway between Kiandra and Inspiration Point (the top of the climb up Talbingo Mountain) during the 6-year period between 1968 and 1974 at a total cost of \$7m (...and that'd be in 1974 dollars – it would probably be more like \$700m in today's dollars!).

Prior to the start of this reconstruction in 1968, DMR surveyors had been active on some lengths of the highway. Brian Keogh surveyed a new road reserve through the village of Yarrangobilly in 1957 and then through part of Kiandra in 1962. Peter Cooper completed a long section of new road reserve between Adaminaby and West Denison in 1957-58, as well as a section of the highway through Kiandra. Fortunately, Keogh's Yarrangobilly survey and Cooper's Adaminaby surveys made it to plan drawing, registration and gazettal, but for reasons unknown (*... but which I suspect were related to the 1967 gazettal of KNP*), the surveys through Kiandra never got to plan drawing and remained as a couple of fully-surveyed and marked surveys destined to go no further than the beautifully drawn “final notes” in their respective DMR field books. For anyone who's driven through Kiandra in recent years, Peter Cooper's fieldbook of his 1958 survey through the village of Kiandra is a

real eye opener. Firstly, there were buildings everywhere (where none exist today). There was a Post Office, the 'Bushcraft Ski Hostel', and at least ten cottages, not to mention on page 9 of the field book the "*Concrete Foundations of Proposed Ski Lift*" (I kid you not; and if one looks hard today it's still there!). Secondly, and even more amazing, was the road layout portrayed in the field book. The highway with side streets and small lanes and, of course, because this was an "urban" area there was a splay at each intersection and the reference marks are concrete blocks, rather than the easier to transport and place RMGIPs! Standing on site today, with the few remaining buildings (the Court House, currently being restored, and one weatherboard cottage (Mathew's Cottage)) it's almost surreal to imagine it as Peter Cooper surveyed it in 1958!!



Photo 3: And here's the Ski Lift foundations (in 2007) with Court House and current RTA snow-plough depot in the background:

Fast forward to 1984, and the most recent DMR survey activity on HW4 was a new road reserve survey by John Farrell (... remember him??) for a new bridge and approaches for a crossing of the Yarrangobilly River in Yarrangobilly. Fortunately this one did get to a registered DP stage; but even it didn't get to the follow-up gazettal of the acquired lots as public road!

So, back to the 1968-72 reconstruction and the status of HW4's road reserve. I have no idea what negotiations may have taken place between the then DMR and NPWS and its predecessors about what survey action would take place to create a new road reserve to follow the highway in its re-constructed position. What I do know is that nothing came to fruition to create that new road reserve, and I suspect it was always

a job in the bottom of the Wagga Wagga and Wollongong (Survey & Property Manager's) in-tray which, at each succession into the job, was always described as *"this is a job that needs to be done – but it has a low priority and I haven't got around to it yet – good luck!"*

There was a brief flurry of activity on Wollongong's side of the regional border in 1976 (the northern section of HW4, as far as about Yarrangobilly Caves, is in Wagga's area, and the south-eastern section is now in Wollongong's area and before that in Bega Division), when the unstoppable John Dansie was sent out with Survey Instruction SC1070 to survey the highway between Kiandra and Rules Point and prepare a compiled survey road reserve utilising the old Regulation 46 of the Survey Practice Regs. In what seems to have become a bit of a theme for HW4 surveys, John completed his survey, drew up a survey foil, and there's where it stopped. A 1990 memo from the Divisional Engineer in Bega to Head Office notes: ... *"The Survey was completed in accordance with Reg.46 of the Survey Practice Regulations which regulation has now been cancelled. A standard real property survey to define the Highway is now necessary"* (with a handwritten note on the side of the memo saying ...*"no urgency"* ... and another note saying ...*"resources not available for at least 15 years"* !!!) John Dansie also completed a similar exercise compiling a road reserve plan for the highway from the end of Peter Cooper's survey at West Denison to Kiandra, but more of that later.

## **2: The Project Brief starts to come together**

As mentioned above, by early 2005 the 'State Forests' project methodology was fairly well sorted and Dennis Clark could see the application of this same methodology providing a solution to the HW4 road reserve problem which had so bedevilled his predecessors from the 1960s onwards.

Recapping briefly, the essential elements developed for the 'State Forest' methodology were:

- An established control survey network with permanent survey marks placed at regular intervals along the road
- Survey-accurate compiled road reserve boundaries based on the coordinated road formation centreline derived from GIPSICAM mapping but with regular connections made between the calculated boundaries and the coordinated control marks
- An exemption from marking the boundaries obtained from LPMA ( the nature of the road/national park interface being one which would rarely, if ever, need to be fenced )
- Preparation of a standard Deposited Plan which can, upon registration, be used to effect the necessary gazettals of road reserve and national park estate

And so it came to be that in June 2005, with the State Forests project in full swing, Dennis came up to Parramatta from Wollongong one day with a car boot full of old plans, old search, bits and pieces of correspondence and reports and a Project Brief which went something like: *"When you've got a bit of spare time between State Forest jobs — have a look at all this stuff and let's see if we can't establish a new road reserve for the Snowy Mountains Highway"*. And so for me began an almost 6 year, part-time dalliance with the Snowy Mountains Highway through Kosciuszko



National Park! Now, in November 2010, as the project approaches finalisation, it's almost with a touch of sadness that I can see the end of this close relationship I've had with, what is after all, just a length of road.

### 3: Getting Started

As a first step there was the sorting through and organising all the material that Dennis had supplied to arrive at the current status of the HW4 road reserve. This sorted itself out fairly logically into sections, as follows:

**Northern park boundary to Talbingo** (abt. 24 km): a fully-surveyed road reserve completed during the years 1962–70 mainly by then DMR Surveyor Ron MacKenzie (1969-70) as well as Surveyor Cronan (WC&IC – 1962) and a contract survey at the Talbingo end by Surveyor Simms (1968).

**Eastern park boundary to West Denison** (abt. 6.5 km): again, a fully-surveyed road reserve by DMR Surveyor Peter Cooper (1958).

**Talbingo to West Denison** (abt. 70 km): this length of highway thus became the “real” project as, essentially, except for a small (abt. 2 km) section of survey at Yarrangobilly by Brian Keogh (1957) and John Farrell (1984), there was no surveyed road reserve. For the most part the Parish Maps and the DCDB just showed the highway as a curvilinear road reserve with the location probably extracted from topographical mapping. In some sections, as described earlier, there was no surveyed road reserve; simply that which was defined as road by abuttal to the adjoining Portions.

Then the search for existing survey control. Surprise No.1: a SCIMS search of the whole 110 km project length revealed the existence of 3 ( *yes that's right, 3!!!*) control marks. So clearly, we were almost starting from scratch in the provision of survey control for the project. In fact, in my longish association with DMR/RTA control surveys throughout NSW I couldn't recall a single highway — even out west — which had such a long length of road with nary a control mark in existence! (*as it happened, we did find a couple of marks in the field – but they weren't in SCIMS*).

### 4. The Control Survey

In some respects, the lack of any existing control made our task a simpler one because what we were really faced with was a “greenfields” site without the constraints of fitting in with existing control. The obverse of this, of course, was how far would we have to go to extend our network to bring in sufficient control to achieve our objective of a B/2 (Class/Order) control survey in SCIMS, and what were going to be the difficulties of achieving this?

As an example, here is a photo of the Trig Station Gooandra (TS2248) within Kosciuszko National Park north-west of Kiandra. Not only was it well and truly obstructed by trees (which, of course, can't be cleared in a national park!) but it has no witness marks — simply the original ground mark under the cairn).





Photo 4: So here's the Gooandra trig cairn as we found it:



Photo 5: And ultimately, here's what the "Demolition Team" (Alex Gillies and Pete Radley) had to do for us to be able to use it!



Through late 2005, as time and resources were available, the reconnaissance and mark placement continued until by January 2006 the major network was sorted out and the first of the GPS field surveys commenced. By that time we had placed around 55 new permanent survey marks (PM/SSMs) over the length of the job and had selected existing control to connect into ranging from: in the north-east, Wereboldera Trig near Tumut, to marks in Batlow; Talbingo Trig on Big Talbingo Mountain; Gooandra Trig (above); a SMHEA trig near Lake Eucumbene, and other marks nearly to Adaminaby at the far south-eastern end of the job.

As was to become something of a pattern with this job, the availability of Survey Graduates and/or students, working through their summer break meant that this was an opportunity to muster sufficient personnel to do this “part-time” project. Many of our recent students and grads (Sam Byrne, Alexandra Lyle, Ryan Fifield and Matt Behling to name a few) were able to “cut their teeth” on a real-live GPS geodetic control survey the size of which they’re unlikely to see again during their career. And not everyone gets to work in such a stunning environment!! (*...excluding the sudden summer alpine electrical storms, of course*).



Photo 6: “Big Pete” Radley loving the weather on Talbingo Mountain (photo taken by an equally wet Ray Gilmour). There’s nowhere to park the vehicle nearby, of course, so it’s parked about 800m away — no chance of shelter there!

By December 2007 (remember this was a “part-time” job!) the control survey network adjustment by Stewart Amery was complete and the Control Survey Diagram was ‘signed-off’. By mid-2008 we had all our new PSMs in SCIMS having achieved the aimed-for B/2 classification.

## 5. Matters Cadastral

### Some preliminary skirmishes:

For those lengths of the highway with an already surveyed road reserve (at the northern and south-eastern ends of the park) the first task on Dennis's list was to ascertain whether the existing road formation was within the road reserve (not as silly as you might think – remember that elsewhere, whole lengths of the highway had been relocated and reconstructed without the niceties of an accompanying boundary survey!).

So, essentially, this task was just a repeat of the 'State Forests' methodology: compile a cadastral model based on MGA coordinates and overlay the road formation centreline derived from GIPSICAM. A simple-enough task – given that we'd become "old hands" at it doing the many 'State Forests' jobs. But – there's always a but – there's always a complication — or two!

The first was that the NPWS, for whatever reason, had removed almost all the fencing which used to delineate the road reserve throughout the National Park — so this made it just that much more difficult to find a "starting point" to start looking for survey marks. Fortunately, in just a few places, they had removed the fencing alright, but had done so by chain-sawing off the fence posts just above ground level leaving the stumps — and in this way we were able to locate our first survey marks. Of course, once you've found one mark you can find two and the job's almost in the bag – right? Well, no actually — not when the next complication is a missing 20 metres! At this point I've come south from the northern park boundary near Blowering towards Talbingo with enough marks found and coordinated (by GPS) to give quite reasonable comparisons – certainly good enough to construct the cadastral model required. I've also come north from Talbingo in the same way. But there's this 20m misclose between the two! Of course, I tell myself, it's all in how I've entered the PO data from the various plans — and somewhere I've missed a one chain road reserve (I mean a 20.115m road reserve width, when you're looking for about a 20m misclose, it's obvious isn't it?).

Now, it didn't seem to matter how many times I would enter and re-enter the boundary lines from the DPs, or how many times I would close the parcels — they would always close — no missing 20m there. So what to do? Thanks to the regard with which field books were held and stored in DMR days, and with a fairly good carry over of this practice into the RTA (despite the many re-structures!) I was fortunate in being able to obtain the original field books for the particular survey in question (a DMR survey, as it happened, but don't worry Ron, your secret's safe with me!). With the field book I was then able to "re-create" the boundaries from the original traverse and lay-in data to compare it with the DP. And guess what? A simple blunder in calculating the boundary lines from the field data produced a very neat 20m error in the calculated distance — which was what ended up in the drawing, and registered, DP. Of course, because it was a calculation error in one line on one side of the road reserve, and it was a constant width road reserve with the opposite side calculated from the first — it all closed perfectly on paper! But at this point all I had was a hypothesis — and I would need field survey to prove or disprove same. Eventually, in another summer vacation period with plenty of students in tow, we were able to traverse the now thickly overgrown roadsides (... did I ever mention how well blackberries seem to grow along the shores of Lake



Blowering?) to survey the marks in question and indeed confirm that that there was nothing wrong with the field survey and marking — it was all down to a simple calculation error in calculating the new road reserve boundaries (and, for the record, the DP in question has now been amended). Oh, and by the way, that oh-so-obvious “red herring” of the missing one-chain road reserve was just that — a “red herring” ( a logical conclusion – but the wrong conclusion!!).

Similarly, at the south-eastern end of the park, an initial struggle to find the first mark and then, in time, enough marks found to complete the cadastral model. Mind you, it wasn't the removal of fences by NPWS that was the problem this time — it was the removal of fences by bushfires that did the trick — fortunately, the fencing wire and the remains of a couple of burnt out corner posts remained as evidence of the originally fenced boundaries and led us to the first of the survey marks found.



**Photo 7: Burnt-out corner post and RMGIP from Peter Cooper's 1957 survey at West Denison**

So with the odd complication overcome, I had my cadastral model of the two surveyed road reserves and the GIPSI-CAM centreline overlaid — and all was in order — the road formation was indeed within the road reserve and that part of the project was complete.



### **And now for the remainder (all 70 kms of it!)**

To recap, in terms of the existing cadastre, we had a surveyed road reserve at the start of the Talbingo Mountain ascent as our northern 'terminal'. Similarly, a surveyed road reserve at West Denison as the south-eastern 'terminal' and a short length of survey through Yarrangobilly Village. In between these locations the Snowy Mountains Highway exists: (1) as a road reserve existing in law (by virtue of the 1967 gazettal of Kosciuszko National Park); it exists: (2) as linework on the Parish maps and; it exists: (3) physically as a road formation. The problem now was how to reconcile these three 'versions' of the highway and come up with a final product consisting of the physical highway formation (cuts, fills, structures, drainage & a nominal 'clearance' for maintenance purposes) contained within a surveyed road reserve.

In many ways tying in to the existing cadastre at each terminal (and the bit in the middle) was the most straightforward of tasks, and with Registered Surveyor Ray Gilmour behind the Leica the survey marks from those surveys were found and coordinated and the fixation of the existing road reserve boundaries at those locations was completed.



Photo 8: Ray "Teflon" Gilmour pressing buttons at Gang Gang Creek near West Denison — the south-eastern terminal of the "new" road reserve.

## 6: The “all-singing, all-dancing”, GIPSICAM and ROADFLIX

At the very heart of this project was Steve Greening’s GIPSICAM and the output of sufficiently accurate ( $\pm 1\text{--}1.5\text{m}$ ) MGA coordinates of the road formation centreline. Without this primary data there was no way we could have compiled nearly 70 km of road reserve boundaries to accurately contain the road formation. Also invaluable as an “office” tool for this project was the GIPSICAM derivative of ROADFLIX. With ROADFLIX it was possible to “drive” and “re-drive” the road — in both directions at any place and at any time, it could be used in the planning stages of the project to identify suitable roadside locations for placing control marks, it could be used to identify the locations of cuts and fills — in so many ways the use made of ROADFLIX in this project were almost endless. It’s a great legacy you’ve left us Steve!

## 7: Sorting out the proposed road reserve widths

Now, the existing road reserve width of the Snowy Mountains Highway, where it exists as surveyed sections at the northern and south-eastern ends of the park, is 3 chains, or 60.35m wide. Dennis Clark, using this as a precedent, decided that a 60m road reserve width would be our ‘ambit claim’ in our negotiations with NPWS. Dennis’ call was consistent with the previously surveyed sections and it simplified the issue of ensuring that all the road formation, including cuts and fills, would be contained within the road reserve. 60m, being a fairly generous road reserve width, should have easily contained almost all of the road formation — except for a short section of major construction with large cuts and fills near Rules Point. Of course, from the point of view of a simplified process in compiling a new road reserve, the wider, the easier. The narrower the ‘nominal’ road reserve, the closer the examination of the existing road formation needs to be, to ensure all the cuts and fills are contained within the road reserve.

In terms of the width of the 70 odd kms of ‘non-surveyed’ road reserve, an investigation was completed by then RTA Searcher, John Miller, in 1996 to confirm the status of HW4’s road reserve. His conclusion, *inter alia*, was that the Snowy Mountain Highway existed as a public road with a road reserve width of 20.115m wide, “... *unless a dedicated width in excess of 20.115m is shown “public road \_ \_ wide” ...*”. And in fact, there were some lengths of the highway shown 300 [links] wide on some of the parish maps. So for those sections of the highway where it was only shown diagrammatically in the parish maps, we could assume an existing ‘default’ road reserve width of 20.115m. The implications of this for our project was, of course, that any road reserve width in excess of 20.115m would have to be by way of acquisition of land from Kosciuszko National Park — and this would be when the fun would really start!

By February, 2008 we were ready for an initial meeting with the Estates Branch staff of NPWS in Hurstville and Dennis and I duly went along with our plots of the proposed 60m road reserve all beautifully coloured up showing the ‘new’ road reserve and what would be surplus road for return to KNP. This all seemed to go well and the discussions concluded with a few closing remarks from NPWS staff that, of course, “... they’d need to pass the proposal by their Regional Office at Tumut just to get a sign-off” ( ... *and this, Dear Readers, could form the basis of a whole new article!*) — but I digress.

Suffice to say that the issue of the proposed new road reserve widths for HW4 became an ongoing one and subject to negotiations with NPWS that continue still. Part way through this process there was a change of Property Manager in Wollongong and Dennis passed the Snowy Mountains baton on to Steve Waugh. One of Steve's successful 'negotiating tools' was to use the RTA's GIS resources – in the person of Greg Nagy - for production of an orthophoto of each section of the highway with my cadastral model of the road reserve overlaid on it, all with appropriate annotation. This turned out to be a very effective way to convey the extent of the proposal to those working in non-survey areas of both the RTA and NPWS. People invariably relate to a pictorial representation where they fail to comprehend a line plot of the same proposal – no matter how well it's presented.

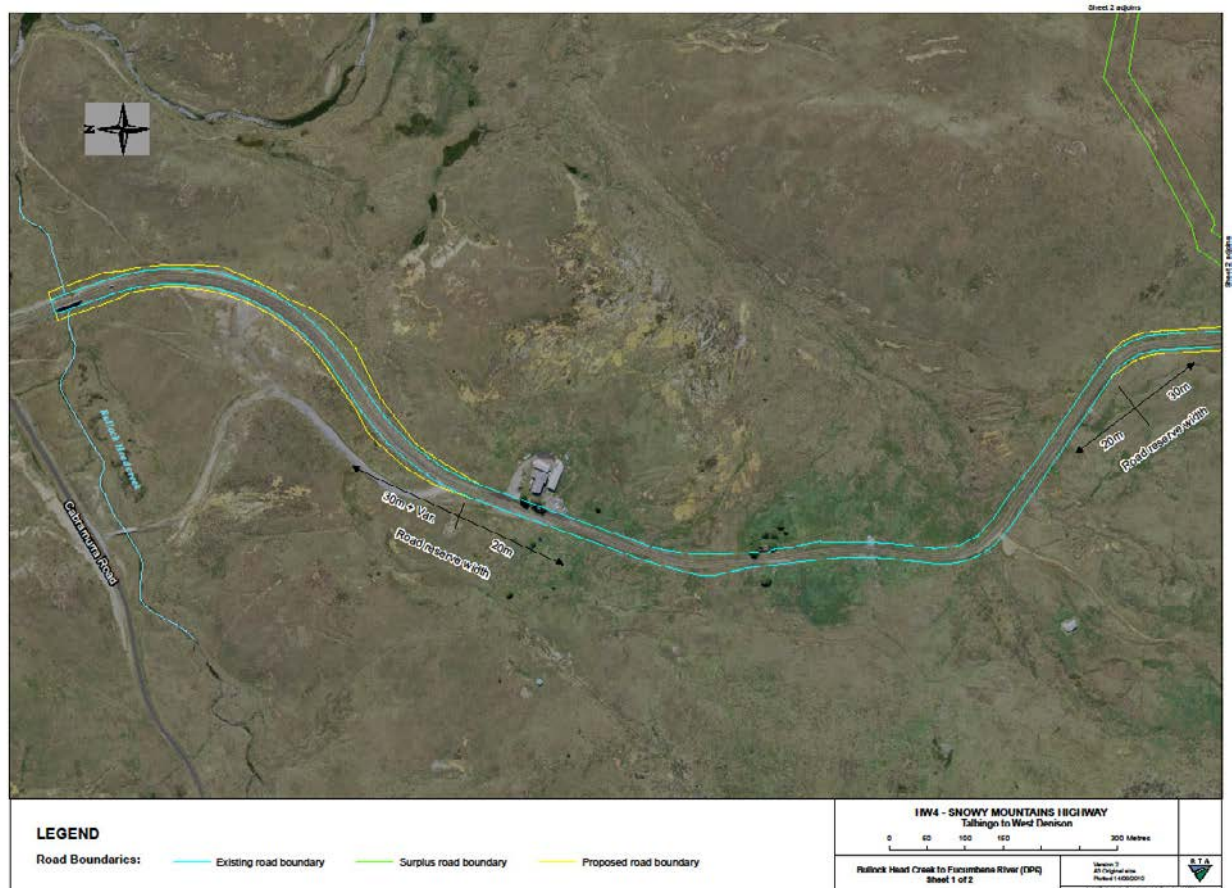


Photo 9: This is one sheet of the orthophotos covering the Kiandra area – in the top right can be seen a former location of the road reserve (it's at a very small scale, of course, but if you look really hard you can see evidence of the old road formation)

As I've alluded to above, the narrower the proposed road reserve width, the more investigation that is required to guarantee the road formation is contained within the new road reserve. From aerial photography and from ROADFLIX and from an increased familiarity with the road as the years on this project passed by, it was pretty easy to identify those areas which would require field investigation to determine those cuts and fills which were going to exceed a particular road reserve width (which at this stage we'd more or less settled on being 40m). Again, as



resources could be found, there were further field trips to 'measure-up' these large cut/fill areas.

The technique used for 'detailing' these large cuts and fills was one developed previously with the 'State Forests' project. This used a combination of Real-Time GPS to position a temporary survey station by the side of the road (to an expected accuracy of abt.  $\pm 1-2\text{m}$ ) and then using a hand-held reflectorless distance meter (a Contour XLRic) to measure the horizontal distance square to the road to the top of cut or bottom of fill. Back in the office, the position of the survey station is overlaid on the MGA Liscad model of the proposed road reserve and the position of the top/bottom of the cut/fill is plotted by distance square to the road centreline. This method also provides a check – of sorts. By placing the temporary survey station a fixed distance from the physical road centreline - the GPS position of the station relative to the GIPSICAM derived centreline provides an independent check of the GIPSICAM centreline (within the expected tolerance of around  $\pm 1-1.5\text{m}$ ).



Photo 10: Here's the intrepid student survey team of Alexandra Lyle and Ryan Fifield about to start detailing some cuts near the Yarrangobilly River. (Note R/T GPS & Contour XLRic)





Photo 11: And here's a typically large cut on the section of highway between Yarrangobilly Village and Yarrangobilly Caves:

## **8: Let the Deposited Plans begin!**

Commencing from the northern end of the new road reserve project at Talbingo, preparations commenced to break-up the total 70 km length of the job into logical sections for the DPs. For a start the existing road reserve DP at Yarrangobilly was an obvious terminal for a DP. Then it was a case of looking at where we had placed our control marks such that we could terminate each DP with a pair of control marks. Finally, there was the matter of the variation in Scale Factor over the length of a DP. Because sections of the highway had a large change in elevation in a relatively short distance, the impact that this had on the CSF became a critical factor. For example, the climb up Talbingo Mountain from Talbingo to Inspiration Point is a climb of more than 500m in elevation over a distance of about 5 kms with a commensurately large change in CSF. Under the Surveyor General's Directions the accuracy requirement for length measurements meant we couldn't exceed an distance accuracy of 30ppm over the length of a DP so, ultimately, we had to take the unusual approach of dividing this DP into two sections in so far as the control schedules were concerned — one CSF for the first half of the DP — and a second CSF for the second half. This change of CSF also affected the section of the highway descending from Kiandra to West Denison. Fortunately, in this case, the scale factor issue was easily overcome by splitting the originally planned one DP into two.

Ultimately, by July 2010, there was general agreement from NPWS that a 40m road reserve be adopted through the park, except where localised widening was required to accommodate the road formation, and with the exception of a few special areas, for example, through the historic precinct of Kiandra, where a minimal road reserve

width was to be adopted. Finally, with the road reserve widths settled, the finalisation of Deposited Plans could begin in earnest!

### **“Defining” the existing road reserve**

With agreement reached on the road reserve widths to be adopted, the compilation of the proposed new road reserve boundaries became a fairly straightforward computational task. But now the issue of how to define the existing road reserve on the new DPs becomes a bit tricky. Bearing in mind, that the only reason for having to “define” the existing road reserve, where it is outside the proposed road reserve is that: ultimately these lot-numbered parcels of unnecessary road will be gazetted as national park; the new road reserve will be gazetted as public road; and the DCDB will then be adjusted accordingly. Also, in defining the surplus lots, the areas of land available to become park becomes a negotiating point with NPWS in balancing the area of park which is proposed to be acquired for road. A net area of 83.2 ha of land to be acquired for road from KNP looks a whole lot better than a gross area of 142 ha in a submission to the Minister for a revocation of a part of KNP.

Clearly, given that this whole exercise in ‘rationalising’ the HW4 road reserve through KNP is one in which the aim is to achieve an up-to-date and enhanced cadastre (survey-wise and in the DCDB), but without the expense - in time and resources – of a conventional boundary survey, then a way had to be found to achieve this “definition” of the existing road reserve with a minimum of field survey.

Firstly, for those lengths of the highway where there was no surveyed road reserve – and the road is just shown diagrammatically in the relevant parish maps – then, the decision was made to simply show the existing road reserve as a 20.115m wide corridor centred on the existing road formation (derived from GIPSICAM) centreline. The proposed road reserve thus becomes a 40m wide road reserve centred on the same centreline and the land to be acquired from KNP becomes the two strips either side of the existing road reserve. In a way, this is a very similar process to way the RTA currently goes about defining a road reserve through a Travelling Stock Route (TSR), so we’re not really talking about anything new here.

Elsewhere, mainly to the east and west of Yarrangobilly village, the existing road reserve is shown on the parish maps, but as explained previously, there is no road survey as such – just the road defined by the abutments of the adjoining portions. Again, given that this is just an exercise in delineating – in as simple a way as possible - the land parcels of surplus road for transfer to KNP, then the decision was made to find identifiable common points in both the DCDB and the new road reserve boundaries and simply transform the former (DCDB) boundaries onto the latter. All with an appropriate note on the face of the DP, of course. Now, although this probably is an unusual approach to take, it’s not completely new, and we ended up doing a similar thing with one of the ‘State Forests’ project DPs where an un-surveyed boundary which existed in a parish map needed to be “defined” in our DP (and that was one the LTO did accept).

And now the long-awaited return to John Dansie and his 1977(?) “Regulation 46” survey from Kiandra to West Denison, foreshadowed earlier in this piece!

You may recall from earlier on, that the original route of the road from Cooma to Kiandra had been surveyed in 1889 and can be found depicted in road plan R.3727-1603. Over time, the road formation had been re-aligned and re-constructed in many locations as well as two major deviations constructed — immediately east of Kiandra and around Sawyers Hill. All without any subsequent survey action to define the new alignment, needless to say! What John did was to traverse (using sun obs for azimuth – *on ya John!*) the centreline of the C.1977 Snowy Mountains Highway from Peter Cooper’s survey at West Denison to connect to Brian Keogh’s survey at Eucumbene River, a few kms east of Kiandra. More importantly, as far as I was concerned, he connected into survey marks from which he was able to re-define the whole of the original road plan (R.3727) between Kiandra and West Denison. Now John placed some marks and connected into other marks and I was able to find enough of these marks to re-establish John’s survey – and thus I was able to “re-define” the original road survey via John’s survey. And just in case you think there’s an element of “near-enough is good-enough” in all this, in my comparison with John’s survey over a distance of 9180m I got a difference of 0.062m — yes folks, that’s a distance comparison of 1 part in 148,000!!

This put the last piece of the puzzle of how to “define” the existing road reserve into place. A compiled, but survey-accurate, definition of the road boundaries from R.3727.

## **9. Ready for Lodgement**

And now it’s November 2010, and all eight Deposited Plans have been meticulously drawn by Steve Nicholls (in Wollongong Property Section), and checked and they are now but a hairbreadth away from being lodged with LTO. Stay tuned for my next article when I can relate the (hopefully straightforward) path to registration — but don’t hold your breath!!!!

## About the Author:

John Gillies, B.Surveying (NSW), Dip. Urban Studies (Macq), MIS (NSW), Emeritus Surveyor (NSW), Lieutenant Commander RANR (Ret'd), has spent almost all of his surveying career with the Department of Main Roads and then the Roads and Traffic Authority of NSW, with some time spent escaping to sea as an Hydrographer during a 25 year stint in the Royal Australian Navy Reserve. As a "failed retiree" (his wife, Roslyn's description), he returned to the RTA in 2004 on a short-term contract to work on the "Highly Commended" (ISNSW Excellence in Surveying awards - 2008) 'State Forests' project which he duly guided through to completion at the end of 2007. Concurrently, in 2005, he commenced working as the Project Surveyor - HW4 Road Reserve Project, the subject of this article. John has received many DFWS Awards over the years, but the one closest to his heart is his 2008 'Grand Master' achievement award for "guiding another crops of kids into the RTA way of things", which was mainly to do with mentoring and team work associated with the HW4 project. John's partner in crime, over many years, has been Ray Gilmour - both on the 'State Forests' project and - of course - on the HW4 project (and for a few years before that as well!). Ray, as the Registered Surveyor half of the team gets to take as all the cadastral glory and all of the cadastral responsibility for the project. When the Board of Surveyors and Spatial Information eventually catch up with Ray - as they surely must - I expect to be holidaying in the Bahamas.

For those of you who vaguely recall the name but can't remember what he looks like — here's a self-portrait of the author:



**A photo taken beside one of the old huts in Kiandra.**



# Supervision and Work Health & Safety



Mark Gordon

Principal Surveyor

Roads and Traffic Authority of New South Wales

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## ***Abstract***

*Mark Gordon is the Principal Surveyor of the NSW Roads & Traffic Authority.*

*Through his involvement with the NSW Board of Surveying & Spatial Information and as convenor of its investigation committee, Mark has developed an interest in the level of supervision being provided by surveyors, particularly in respect to occupational health and safety of personnel in the field. Mark also has had the experience of being phoned by WorkCover on a Friday afternoon after their discovery of safety breaches by one of his field surveyors and being told “Thanks for your explanation – I’ll let you know on Monday whether I’m going to fine you or not”.*

*Mark’s presentation today is on the topic of Supervision and Work Health & Safety.*

## SUPERVISION AND WORK HEALTH & SAFETY

The responsibility of surveyors for work health and safety extends beyond the confines of the office to the field situation, even when the supervising surveyor is not on site at the time.

In July 2010, the NSW Board of Surveying and Spatial Information (BOSSI) issued its **Determination on the Supervision of Persons by Registered Surveyors** which stated, in part:

*“The supervising surveyor is responsible for ensuring that the supervised person is aware of the importance of the surveyor’s role in ... ensuring that work is undertaken in a safe and responsible manner (OHS) and in accordance with other relevant legislation”*

and

*“A supervising surveyor ... is responsible for the health and safety at work of the supervised person. This is particularly relevant with respect to a supervised person in the field, even if the supervising surveyor is not present in the field with the supervised person (vide Section 8, Occupational Health & safety act 2000).”*

BOSSI then emphasised this advice in its December 2010 release of the **Guide for Professional Conduct by Registered Surveyors**, which stated in part:

*“Surveyors shall .... exercise care in the performance of their duties, including adherence to Occupational Health and Safety obligations and responsibilities”*

and

*“A surveyor shall exercise the required level of professional supervision in accordance with the BOSSI Determination on Supervision.”*

If a serious accident occurs at work, it must be reported to WorkCover. This organisation will examine the circumstances behind the accident and determine if a breach of the Occupational Health and Safety Act 2000 or the associated Regulation has occurred. This could lead to prosecution and personal fines of \$55,000 for a first offence and \$82,500 or 2 years imprisonment for a repeat offender. If an accident results in a workplace death, a personal fine of \$165,000 or 5 years imprisonment, or both, could result.

To mitigate the risks of the occurrence of serious accidents, the supervising surveyor must put measures in place to ensure compliance with occupational health and safety procedures implemented by the organisation. In addition, the organisation needs to ensure itself that “safety first – work second” is being implemented across all facets of work. In particular:

- Supply adequate resources to mitigate OHS issues, such as Personal Protective Equipment.
- Provide appropriate training to staff and ensure staff possess the mandatory OHS General Induction (white) card as a minimum.
- Implement an OHS Management System, including policies and procedures, regular staff meetings, site inductions, Safe Work Method Statements (including annual review), field audits and the recording & monitoring of OHS failures and near misses.
- Encourage Staff to speak up and intervene when they see an act which they personally regard as unsafe and to report & document OHS system failures.

- Properly plan work and provide resources to minimise the risk of survey parties being placed in the position of making a ‘crunch’ decision at a worksite eg *“Do we delay the job to get the proper equipment/ resources or just go ahead with the additional risk?”*.
- Put measures in place to verify that field staff are complying with procedures (eg field audits).
- Personally comply with OHS rules and procedures: lead by example.
- Actively encourage staff to raise safety issues, including those relating to your own behaviour.

The presentation at today’s APAS conference details two occurrences which resulted in a failure of the OHS system to prevent injury to employees. The first demonstrates how minor breaches of the system can cascade into a catastrophic failure and emphasises that just because an OHS management system is in place does not mean that everyone is using it. The second occurrence details an accident that happened to a surveyor on site which led to prosecution by WorkCover and the implementation of more stringent OHS/WHs procedures by the employer.

**Safety is everyone’s responsibility.**





# Remake of Surveying and Spatial Information Regulation 2011



Land & Property  
Management Authority

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## *Introduction*

*Under the Subordinate Legislation Act 1989 all statutory rules (including regulations, by-laws, rules and ordinances) are remade every 5 years to ensure they remain relevant to government, community and industry needs. During 2011 the Surveying & Spatial Information Regulation (S&SI) 2006 will be remade. The following discussion briefly addresses the main issues identified since the Surveying Regulation commenced in September 2006 and emerging technology and community needs of surveying and spatial information.*

## **Main Issues for the Remake**

The following points outline the main issues and changes identified from monitoring of the S&SI Regulation since 2006 and survey industry consultation during 2010-11 for the Remake of the Surveying & Spatial Information Regulation. The responses to some questions presented to the industry are shown in some instances. The main issues and changes identified to date are summarized below;

- Proposed new Definitions
  - Benchmarks – New definition.
  - Candidates – Refer to a Board of Surveying and Spatial Information (BOSSI) Determination for a person to be eligible to become a registered surveyor.
  - Coordinate and Projections. This is the “Surveying & **Spatial Information** Regulation” and reliance is placed upon external sources to define a point of truth for coordinate and projections parameters.
  - Candidate practical experience – should be BOSSI Determination.
  - Refer to the Survey Control Information Management System (SCIMS) as the point of truth for information relating to the State control survey.
- Supervision
  - Amendments in December 2009 to Section 36k of the Surveying & Spatial Information Act 2002 enabled provisions to be made in the Surveying & Spatial Information Regulation regarding supervision.

*“(k) prescribing what constitutes immediate supervision or general supervision for the purposes of all or any of the provisions of this Act (including authorising a person or body to determine what constitutes such supervision).”*

The Board of Surveying and Spatial Information (BOSSI) in July 2010 published “Determination – Supervision of Persons by Registered Surveyors”. As the Board has published this Determination, the need to specify an outcome for “supervision” in the Remake of the Regulation is no longer required. Therefore it will not be included in the remake of the Regulation.

- Basis of Datum Line.
  - ALL surveys will **not** be based upon MGA? (*no change there*)
  - Urban Survey will use Class “2A” to “C” when adopting MGA (*no change here*)
  - Rural surveys will use Class “2A” to “D” when adopting MGA? (*change here*)
  - Will use Mark Status **and** Class recorded in SCIMS to define the datum line. Will only require survey marks with mark status or “Null” (*assumed OK*), “F” (*Found*) or “N” (*Not Found*) to be used to define the datum line of a survey. The following Mark Status will be excluded; “D” (*Destroyed*), “S” (*Subsided*), “R” (*Restricted*) or “U” (*Uncertain*).
  - Small easements (i.e. easements shorter than 200metres) will connect from established survey marks if the established marks are located within 300 metres of the land in a urban survey or 1000 metres of the land in a rural survey. If there are no marks available, then new permanent survey marks are not required to be placed.
- Bench Marks.
  - New Schedule outlining all different forms and styles of Bench Marks.
  - Bench Marks will be identified by MGA coordinates to an accuracy equal to or better than hand held GNSS to describe their location.
- Area of Easements.
  - The area of all easements created under Clause 18 must be shown.
- Accuracy of Angle and Distances
  - The angular misclose must not exceed 10 seconds plus  $10\sqrt{n}$  (where “n” is the number of traverse stations (it is currently 20” +  $10\sqrt{n}$ )).
  - All lengths must achieve an accuracy of 6mm + 50 parts per million or better at a confidence interval of 95% (it is currently 10mm + 15ppm @ 67%).
  - The Misclose tolerance will remain at 15mm + 100ppm.
  - Many surveyors have expressed a need to specify the accuracy of each position if using GNSS. However, specifying the outcome is very difficult. At this stage no accuracy of position has been defined. The accuracy of each length shown on a plan must satisfy 6mm + 50ppm.
- Residue Lots.
  - All Lots must be described by Bearings and Distances (where available).
  - The accuracy of the misclose of the residue Lot(s) must be better than four times (4x) the original misclose tolerance, otherwise the survey must resolve the discrepancy by further measurements or outline the problem in a comprehensive report.

- Line Types
  - The method of determining the line will **not** be disclosed. i.e. measured, computed, traversed, derived, deduced, etc. This issue was canvassed during industry consultation. If each boundary line or measurement satisfies the accuracy requirement, then the benefits from specifying additional attributes of each line may be limited.
  - The need to define different types of lines, i.e. road frontage, boundary line, connection line, occupation, easement, administration line, etc will not be prescribed, however, this will be an attribute within a LandXML file.
- Survey marking
  - Roads – Exclude Footpaths from road definition for marking requirements.
  - Place Reference Marks in rural surveys at every extremity fronting a road
  - RM's every side boundary of large river frontage – i.e. stream frontage  $\geq 500$ metres.
  - RM placed if total length of boundaries > 2400 metres.
  - RM at either end of cut off corners at road intersections or at intersection,
  - Mark boundaries at safe distance for stream bank if bank liable to erosion.
  - Place PM's & RM's in position to preserve the mark.
- Traceability of AHD on stratum surveys
  - New bench marks must show an AHD value with an accuracy equal to or better than "LD" or "B".
- Connection to survey control network for small easements
  - Small easements (i.e. <200 metres) will adopt MGA if established marks are within 300m (urban)/1000m (rural).
  - Small easements (i.e. <200 metres) will connect from 2 Permanent Survey Marks if they are available within 500 metres. No placement of Permanent Survey Marks.
  - Only show connection from one terminal of the easement to Permanent Survey Mark.
- MHWB & Banks
  - MHWB should be approved by Minister if not previously approved.
  - Landward boundaries of stipulated fronting streams previously not surveyed need not be marked with boundary marks. RM every 1000 metres is required.
- Spatial Information
  - The street address for each Lot must be shown. The format and content of the street address shall be in the form "as approved". i.e. a new schedule.
  - Library and symbol to standardise plan preparation – Surveyor General's Direction.
  - Showing occupations.
  - Complete dimensions of each parcel.
- Reporting.
  - If a surveyor discloses a difference of 40mm + 200ppm or greater, then the surveyor must report the difference or difficulty in a comprehensive report.

- Survey Marks
  - New PM for CORS marks
  - New BM specifications
  - Refinement of a few reference marks.
- 3D Cadastre & Strata Surveys
  - Many Emergency Services and the modern community require accurate spatial description and street addressing of all parcels. Current practices for Strata Plans do not support an accurate description of land owner interests. i.e. the thick line describing walls shown on the strata plan have limited spatial integrity. The vertical arrangement of strata title interests are poorly described on survey plans and in spatial data sets. The Digital Cadastral Data Base (DCDB) operated by the Land & Property Management Authority is a 2 Dimensional representation of land interests. Only land titles/interests at “Ground Level” are shown and maintained in the DCDB. If systems supporting the management and visualisation land interests were 3 Dimensional, then there would be a compelling argument for all surveys to show heights or depths if they are so limited by measurements or by a structure (i.e. a building in a strata plan). To enable the complete description of strata titles, the position of the walls, floors and ceilings are be required. The accuracy of measurements used to describe walls and floors need clarification. Industry consultation for the remake of the S&SI Regulation addressed this issued and most sectors indicated that surveyors not willing to provide AHD floor levels or accurate descriptions of walls in Strata Plans.
  - There will be **no** AHD Floor Levels shown in Strata plans.

The draft Surveying & Spatial Information Regulation 2011 with a Regulatory Impact Statement that assesses the cost, benefit and alternatives to the proposal will be circulated throughout the community and surveying industry requesting comments and submissions. Following consideration of comments and submissions, a proposal of final amendments will be forwarded to BOSSI for final approval prior to the formal submission by the Minister to the Governor to remake the Surveying & Spatial Information Regulation 2011. The Remake of the Surveying & Spatial Information Regulation 2011 must be made before 1 September 2011.



## **State Property Authority** *(...or whose building is it anyway?)*

**Warren Thomas**  
**Manager Property Transactions**  
**State Property Authority**  
Email: [warren.thomas@lpma.nsw.gov.au](mailto:warren.thomas@lpma.nsw.gov.au)

### **Abstract:**

*Since 2006, the State Property Authority (SPA) has implemented significant changes in government property legislation and policy. SPA's vesting program has seen a large proportion of government generic property transferred to SPA ownership for management by SPA, providing the catalyst for better asset management practices. SPA's aim is to generate significant economic, social and environmental benefits while providing more efficient management of property and helping agencies focus on their core service delivery functions. Some agencies are now seeking additional services to help them manage their property portfolio. SPA is attempting to explore these additional service requests and develop the necessary delivery models and/or seek the necessary legislative or policy reviews and approvals to implement even better management of agency property portfolios.*

*So how did SPA come about? What is its operational mandate? How does SPA acquire and hold land and interests in land? How do agencies occupy the land or the generic accommodation? And where does SPA see itself moving into the future? This paper attempts to answer these questions.*

## **Part 1- Introduction**

The State Property Authority (SPA) was established under the State Property Authority Act (SPA Act) which was assented to on 8 June 2006 and commenced on 1 September 2006. SPA was established to improve operational efficiencies in the use of government properties to better support the service delivery functions of government agencies by adopting a strategic approach to maintaining, acquiring, disposing and developing government property.

Staff from the former Department of Commerce's State Property Branch and those staff managing the Police Property Portfolio from the Ministry for Police were transferred to the new Authority on 1 September 2006 to commence the task of implementing the government's new property principles as outlined in the Act.

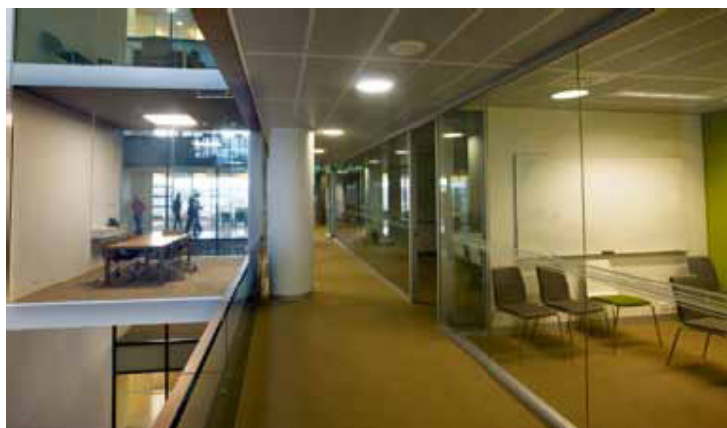
SPA's initial role was to manage the NSW Treasury's Crown Property Portfolio which was a collection of owned and leased government office buildings and other miscellaneous properties. Transfer of these properties to SPA was carried out by publication of the State Property Authority Order 2007 (Government Gazette 2.2.2007). This Order was the forerunner of some 12 further Orders vesting well over one thousand government land titles and lease interests under the State Property Authority Act for management by SPA.

Following a period of procedural development and consultations with agencies and the NSW Treasury the government released Premier's Memorandum 2008-06, a new property policy framework, particularly aimed at generic properties, to assist the State Property Authority achieve its legislated objectives. The framework outlines the relationship between agencies and the State Property Authority in the acquisition, management, maintenance and disposal of property.

SPA's work then commenced in earnest with agency consultation and agreements firstly being negotiated with agencies holding large owned or leased generic property portfolios, to vest (ie transfer by statute) properties to SPA for ongoing management.

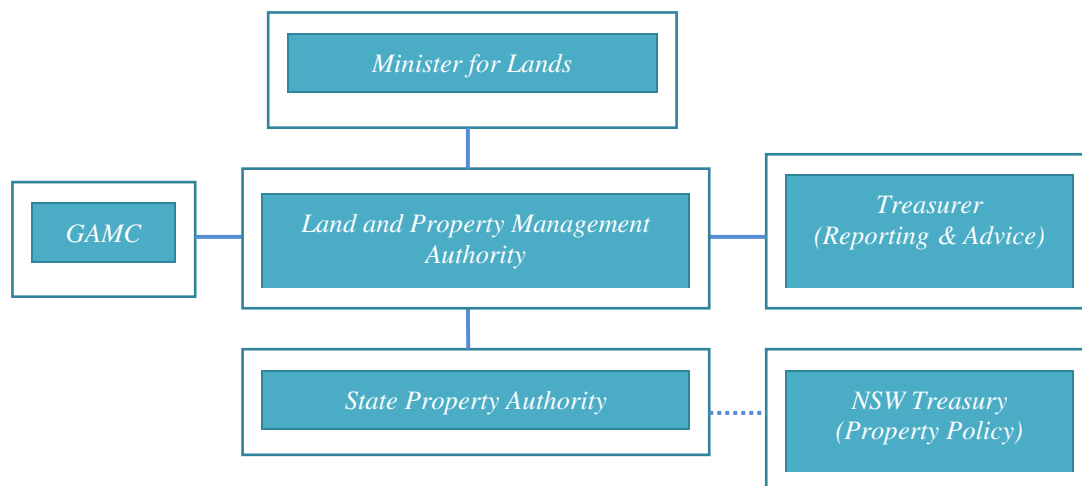
SPA is achieving accelerated outcomes in the government office accommodation sector by now having direct control over both owned and leased office accommodation previously managed by agencies. Gains are realised through the economies of scale from managing a larger portfolio (maintenance and day to day property management), more experienced and professional resources and capacity to coordinate the rationalisation of underutilised accommodation.

On 1 July 2009 as part of the administrative changes to create 13 new super Departments, the State Property Authority was amalgamated into the Land and Property Management Authority (LPMA) and continues its work under the State Property Authority Act as a Division of LPMA.



*Meeting rooms at the Parramatta Justice Precinct use natural ventilation and other methods to reduce energy usage.*

## Part 2 - Organisational Structure



The CEO of SPA is appointed under the SPA Act and is currently Warwick Watkins AM who also holds the position of Chief Executive of LPMA. The General Manager of SPA, Barry Douse, reports to the CEO. Together with a small corporate management team, the State Property Authority comprises three Groups which between them carry out the property functions under the SPA Act and Premier's Memorandum 2008-06. The Groups are:

- Portfolio Management Group
- Planning and Strategy Group
- Divestment Acquisition and Developments Group

The **Portfolio Management Group** is responsible for the efficient and cost effective management and maintenance of government-owned and leased property, including capital works, lease negotiation and management, portfolio services, engineering and facility management and contract administration.

The work performed by this Group includes:

- Vesting and integration of the management of government-owned and leased properties
- Negotiating government office accommodation leasing matters
- Coordinating a minor capital works program of upgrades, refurbishments and sustainability initiatives throughout the government property portfolio.

The **Planning and Strategy Group** identifies opportunities and develops strategies to improve the use of and management of government properties. The Group provides whole-of-government advice and advice and support to agencies on office accommodation and generic property asset management.

The work performed by this Group includes:

- Analysis of portfolio property asset performance
- Review of agency property holdings against service delivery needs
- Analysis of Government's regional property holdings to assess appropriateness for future service delivery
- Total asset management planning for the Government property portfolio.

The Group's Clients include the Government Asset Management Committee (GAMC), NSW Treasury and other government agencies. The Group's Stakeholders include the Minister for Lands, the Treasurer, NSW Treasury, GAMC, government agencies and the people of NSW.

Through its **Divestments Acquisitions and Development Group**, SPA provides strategic advice, research and analysis on property transactions. SPA is the NSW Government's preferred acquisition and disposal agency.

The Group undertakes a range of property transactions and development activities on behalf of government agencies, with a particular focus on multi agency capital works. It implements strategies to dispose of surplus property and acquires land and properties for the construction of facilities and infrastructure to support the delivery of government services.

The work performed by this Group includes:

- providing expert advice to government agencies on property acquisitions and sales
- acquiring land and property to support improvements to government services
- preparing for and disposing of surplus government properties
- lead all multi-agency property development proposals linked by timing, location or use.

### ***Part 3 - Government Property Principles***

On 10 April 2008 the NSW Premier, Morris Iemma, issued Premier's Memorandum 2008-06 titled "State Property Authority and Government Property Principles".

The requirements outlined in the Memorandum and the attached Government Property Principles applied immediately to all General Government Sector agencies and Public Trading Enterprises (excluding State Owned Corporations). Shareholding Ministers and Boards of State Owned Corporations were to note the establishment of the SPA and where their organisations did not have the necessary in-house expertise, they were encouraged to use the services of SPA.

The SPA's objectives as stated in the *State Property Authority Act 2006* are to:

- improve operational efficiencies in the use of properties of government agencies, particularly generic properties (such as offices, warehouses, depots and car parks);
- manage properties of government agencies in a way that supports the service delivery functions of those agencies;
- provide advice and support within government on property matters; and
- operate at least as efficiently as any comparable business, consistently with the principles of ecologically sustainable development and social responsibility for the community (including the indigenous community).

The Memorandum states that SPA is the Government's real estate services provider and is responsible for acquiring and managing Government's generic assets (and, by agreement, other property assets) and at the appropriate time will then arrange for the disposal of surplus assets.

To assist SPA to achieve its legislated objectives, the Government approved a new property policy framework. The framework outlines the relationship between agencies and the State Property Authority in the acquisition, management, maintenance and disposal of property.

The key initiatives of the framework are:

- the vesting (from 1 July 2008) to SPA of the ownership of all government owned office accommodation;



- the implementation of a commercial rental charge for all office accommodation vested in the SPA;
- the transfer to the SPA of management responsibility of all government leased office accommodation;
- the extension of the Government Leasing Service within SPA to include all lease renewals and new and existing lease negotiations for generic property in the Greater Sydney Metropolitan Area (as defined by the Department of Planning);
- regular and ongoing reviews by SPA of agency property portfolios to identify efficiencies to improve service delivery which will be monitored by the GAMC and reported to Government;
- the provision of information by all agencies for the generic property database, including the participation in surveys;
- review and endorsement of all proposed property acquisitions and disposals by the GAMC;
- SPA is Government's preferred acquisition and disposal agency;
- SPA will be the lead agency for all multi-faceted property proposals that are interlinked by timing, location or use; and
- the Department of Premier and Cabinet, SPA and NSW Treasury will work cooperatively with Government agencies and relevant unions to address any staffing and funding implications which may arise from implementation of the policy framework.

Attached to Premier's Memorandum 2008-06 are a number of Operating and Guiding Property Principles outlining the details of the property policy framework as well as other considerations relating to property title, preferred office locations, provision of car parking, lease pre-commitments, sale and lease back proposals and fitout amortisation.

Of particular interest to those involved in government property transactions will be the following summarised Principles. A full list of Operating and Guiding Property Principles can be found in the copy of Premier's Memorandum 2008-06 at Appendix A to this paper.

- Operating Principle 1 – All owned office buildings will be vested in SPA. Agencies will not be compensated for the vesting of assets in SPA, but will receive budget funding for net rental payments.
- Operating Principle 2 – Agencies may vest in SPA any or all of their non-generic assets subject to agreement with the Authority.
- Operating Principle 3 – SPA will assume management responsibility for all leased office space and other leased property assets.
- Operating Principle 4 – SPA will conduct all lease negotiations for property assets required by government Agencies, except where GAMC determines otherwise.
- Operating Principle 7 - All proposed property acquisitions must be referred to the GAMC to consider the proposed acquisition strategy and determine the appropriate agency to complete the transaction.
- Guiding Principle 2 - The title for all new property acquisitions where the responsible Minister does not have the legislative power to deal in property transactions is to be placed in the name of the State Property Authority. All property related leases (including office accommodation) will also be in the name of the State Property Authority.
- Guiding Principle 5 - The preferred location for agencies in the Sydney CBD is in the southern sector or other sector where equivalent terms can be negotiated. No agency, however, will be provided with accommodation in the Sydney CBD Core unless approval has been obtained from the GAMC.

## **Part 4 - What Property and Assets are transferred to SPA?**

The types of property being transferred to SPA are governed by the SPA Act and Premier's Memorandum 2008-06. Property is only transferred to SPA with the written certification and approval of the owner Agency.

One of the principle functions of SPA, amongst others, is "to hold, manage, maintain, acquire or dispose of **property** for the government and **government agencies**".

So what are the definitions of "property" and "government agency" under the Act?

**"property"** of a government agency means:

- (a) land that is vested in the government agency, or land that is vested in the Crown or Her Majesty and that is controlled and used by the government agency, or
- (b) an interest in land, being an interest that is vested in or held by the government agency.

**government agency** means any of the following:

- (a) a public authority constituted by or under an Act,
  - (b) a statutory body representing the Crown,
  - (c) a Department of the Public Service,
- but does not include a State owned corporation, a local authority or any person or body exempted by the regulations from this definition.

Property is categorised into two types – generic and non-generic (or specialised).

### **Generic Property**



*Dept of Justice and Attorney General,  
Parramatta Justice Precinct*

Generic property can be broadly defined as those properties that, with only minor redevelopment or refit could be utilised by any number of Government Agencies at any given time or over time. Assets such as offices, depots, warehouses and car parking areas are generally taken to be examples of generic property.

To date the majority of property transferred or vested in SPA has been generic in nature and SPA's concentration to date has centred on government office accommodation. At the present time the majority of office accommodation for government agencies as defined is now owned or leased by SPA.

Initially in 2007 the NSW Treasury's Crown Property Portfolio consisting of multi-tenanted government office accommodation was the first to be vested in SPA for ongoing management. Examples are the Governor Macquarie Tower leased accommodation and the Regional Government Office Blocks across NSW.

Since that initial vesting 168 owned assets have been vested for an estate in fee simple to SPA and 893 leased and licensed assets have been transferred to SPA.

## Non-generic (or Specialised) Property



Sydney Fish Markets

Premier's Memorandum 2008-06 focuses the government's property principles on generic assets. Operating Principle 2 however does provide that "Agencies may vest in the Authority any or all of their non-generic owned property assets subject to agreement with the Authority and Treasury on resource and funding transfers associated with those properties. In some instances Government may direct that certain properties or agency portfolios be vested in the Authority."

Examples of non-generic (or specialised) properties would be laboratories, gaols, hospitals and sites for utility infrastructure.

## Holding Title

Most agencies that have large land holdings have statutory power to hold land in their own right. For example the Minister for Disability Services when acquiring land or buildings for Group Homes can specifically hold that land under the Community Welfare Act 1987, viz,

### ***13A Acquisition and disposal of land***

- (1) *The Minister may, for the purposes of the community welfare legislation, acquire land (including an interest in land) by agreement or by compulsory process in accordance with the [Land Acquisition \(Just Terms Compensation\) Act 1991](#).*

Several agencies, however, with large land "holdings" are not empowered under any Act to acquire or hold land and their land parcels are held in a variety of names on Title with most either being in the name of the former Minister for Public Works, the Crown (Her Most Gracious Majesty Queen Elizabeth II) or the State of NSW as reserved or dedicated Crown land under the Crown Lands Act, sometimes with a Reserve Trust appointed. Bar the first mentioned category all others can provide some administrative challenges when proposed for disposal, being potentially subject to claims under the Aboriginal Land Rights Act.

Examples of agencies unable to hold land in their own right are NSW Police, Attorney General's, Corrective Services and Juvenile Justice.

Premier's Memorandum 2008-06, Guiding Principle 2 provides that "The title for all new property acquisitions where the responsible Minister does not have the legislative power to deal in property transactions is to be placed in the name of the State Property Authority....". This principle is underpinned by the SPA Act which provides,

### ***12 Agreements for management of property by Authority***

- (1) *A government agency may enter into an agreement with the Authority for the Authority:*
- (a) *to hold property for the agency or to manage, maintain or dispose of property of the agency, or*
  - (b) *.....*
  - (c) *to acquire any property on behalf of, or for the purposes of, the agency.....*

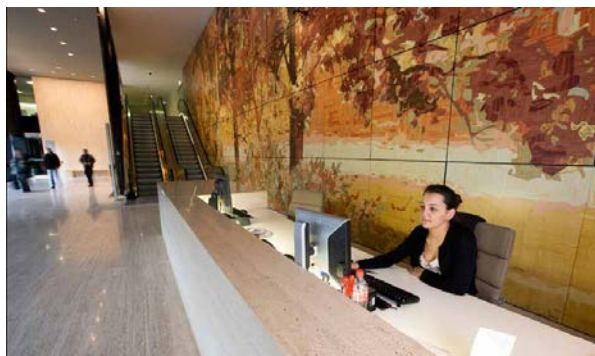
While SPA is mandated to hold all land and leases for generic property assets, under Sec 12 SPA Act, SPA has now entered into Memorandums of Understanding to acquire, hold title for and (when appropriate) to dispose of land for non-generic assets with several agencies that are unable to hold land in their own right. Current agencies with executed MOUs to acquire and hold non-generic assets are NSW Police, Attorney General's and Corrective Services. Title to the land is placed in the name of the "State Property Authority" with the agency having all operational responsibility and retaining all associated risk for the property asset.

## ***Part 5 - Agency Occupation of SPA Generic Assets***

### **Administration of current assets**

Once State Property Authority becomes the owner of the generic office accommodation (either by outright land ownership or as lessor of a lease from the private sector) then SPA enters into several agreements with agencies to occupy the premises.

- A Memorandum of Understanding is signed to provide a high level understanding of the business relationship between the SPA as the provider and manager of the agencies office accommodation.
- An Occupation Agreement is negotiated which authorises the agency's occupation of SPA premises for its office accommodation or other generic purposes.
- A Service Level Agreement is negotiated which outlines the day to day responsibilities of both parties as owner and occupier of the premises.
- The agency is encouraged to enter into direct debit arrangements for payment of rent to SPA together with a management fee on leased assets only of 2% (CBD) and 2.5%



*A central service desk in Parramatta Justice Precinct office is a welcome entry for the public who use government services.*



*The rooftop garden at the NSW Government Office, Penrith, is a popular breakout space.*

*(elsewhere).*

### **Review for future asset needs**

By being owner and manager of all of government's generic property assets SPA is in a position to advise government on its property needs now and into the future. SPA develops strategies which look at the whole of government property needs and identifies opportunities to improve efficiencies in property management.

SPA, through its Planning and Strategy Group will research agency service delivery needs, property market trends and demographics to advise government on property risks and risk management strategies. These reviews help SPA to develop an overall strategy for government's future property needs.



*Agency Property Portfolio Reviews* are a key government initiative to improve service delivery and identify inefficient property use. The reviews look at an agency's current assets as well as future property needs state-wide. They often reveal unused or surplus properties which might be sold to help fund the agency's core service delivery activities. The reviews also identify opportunities for agencies to improve service delivery through better building design.

*Centre Studies* focus on regions and review all the agencies within a regional centre to determine whether their existing properties and facilities are adequate to meet the needs of government and the community. The studies involve multiple agencies and examine government assets, service delivery requirements, funding priorities, demographics and the government's future property needs. In 2009-10, SPA completed centre studies for Liverpool/Campbelltown, Newcastle and Parramatta. Work also continued on the implementation of the Sydney CBD Asset Strategy and development of the Far West Strategy for the delivery of human services.



*Newcastle has been the focus of a Centre Study to review the office accommodation needs of all agencies within a regional centre.*

## ***Part 6 - Dealings in Land under the State Property Authority Act***

As a statutory corporation SPA has power to deal in property to exercise its functions by virtue of S50(1)(d) Interpretation Act, viz,

### ***50 Statutory corporations***

*(1) A statutory corporation:*

*(a)...*

*(b)...*

*(c)...*

*(d) may, for the purpose of enabling it to exercise its functions, purchase, exchange, take on lease, hold, dispose of and otherwise deal with property,*

SPA may also deal in land by direct provision in the State Property Authority Act 2006, viz,

### ***13 Land dealings***

*(1) The Authority may, with the consent of the Minister, sell, lease, exchange or otherwise dispose of or deal with any land vested in the Authority and grant easements or rights-of-way over such land or any part of it.*

More specific provisions for acquisition of land by SPA are also included in the SPA Act by:

- S.15 Acquisition of property by gift devise or bequest,
- S.18 Transfer of property described in Schedule 1 to Authority, and
- S.19 Transfer of additional property to the Authority – amendment of Schedule 1

## **Gift Devise or Bequest**

SPA is provided with a power to acquire under Sec. 15, viz,

### ***15 Acquisition of property by gift, devise or bequest***

- (1) The Authority may acquire by gift, devise or bequest any property for the purposes of this Act and may agree to carry out the conditions of any such gift, devise or bequest.*

A “gift” could be described as bestowing something voluntarily and without compensation. To “Devise” would be to transmit or give (real property) by will. Similarly “Bequest” is the act of giving, leaving by will, or passing on to another.

Clearly, the power to acquire by gift, devise or bequest was not intended to be the primary mechanism for SPA to acquire property.

## **Transfer by Vesting**

By far the most used method to date by which SPA has acquired land has been by transfer or vesting of the land or the interest in land (such as a lease) under Sec. 18 and Sec 19. State Property Authority Act 2006. All land (or interests on land) included in Schedule 1 State Property Authority Act are vested in SPA for an estate in fee simple (or such other interest as is specified in the Schedule).

### ***18 Transfer of property described in Schedule 1 to Authority***

- (1) On the transfer date relating to property described in Schedule 1, the property vests in the Authority for an estate in fee simple (or such other interest as is specified in the Schedule):*
- (a) without the need for any further conveyance, transfer, assignment or assurance, and*
  - (b) subject to any trusts, estates, interests, dedications, conditions, restrictions and covenants to which the land was subject immediately before the transfer date.*

Section 19 of the Act provides further that additional property may be added to Schedule 1 and thereby vested in SPA for an estate in fee simple.

### ***19 Transfer of additional property to Authority—amendment of Schedule 1***

- (1) The Governor may, by order published on the NSW legislation website, amend Schedule 1 by inserting the description of any property.*
- (2) Property is authorised to be included in Schedule 1 by order under this section only if it is property of a government agency (including vacant Crown land). Subject to section 18 (1) (b), this section does not prevent land, the fee simple in which is vested in Her Majesty, the Crown or a government agency, from being transferred by order under this section even if the land is subject to other interests.*

- (3) *Property is not authorised to be included in Schedule 1 by order under this section if it comprises, wholly or in part, any of the following:*
- (a) *land that is reserved under the [National Parks and Wildlife Act 1974](#) as a national park, historic site, state conservation area, regional park, nature reserve or karst conservation reserve or land that is acquired under Part 11 of the [National Parks and Wildlife Act 1974](#),*
  - (b) *any area that is declared as a marine park under the [Marine Parks Act 1997](#),*
  - (c) *any land that is reserved or dedicated under an Act for any purpose, being a reservation or dedication that can only be revoked by an Act,*
  - (d) *land reserved under Part 5 of the [Crown Lands Act 1989](#) unless the Minister for Lands has given concurrence to the transfer of the particular land identified by the Minister administering this Act.*

When the Act commenced there was **no** property included in Schedule 1. All property now shown in Schedule 1 has arrived there by virtue of the transfer process outlined in Sec. 19 i.e. by order of the Governor. To date over 1000 parcels of land and interests in land (leases, licences and easements) have been vested from government agencies to SPA.

## Process of Vesting

The statutory process of transfer by vesting under Sec 18 and 19 SPA Act is as follows:

- **Developing a schedule of land and/or interests in land to be vested.**

This process involves consultations and agreements with agencies, title search and due diligence investigations, loading data into SPA's databases, check that transfer is not barred under Sec 19(3) SPA Act and apply where necessary for the Minister for Lands approval to vest under Sec 19(3)(d) SPA Act.

- **Drafting a new State Property Authority Amendment Order.**

This process includes preparing a draft State Property Authority Amendment Order which details all land and interests in land to be transfer by vesting into the State Property Authority. The draft is reviewed by the Parliamentary Counsel and an Opinion is obtained that the Order may be legally made.

- **Gaining the approval of the Governor.**

A Ministerial Briefing Note and Executive Council Minute are prepared to accompany the draft State Property Authority Amendment Order seeking approval of the CEO, the Minister and the Governor to the publication of the Order.

- **Publication of the State Property Authority Amendment Order.**

On receipt of the Governor's approval the Parliamentary Counsel is requested to notify the approved Order on the NSW Legislation Website at which date the land or interest in land transfers to SPA (or on such later date as specified in the Order). NB: the Legislation Website has replaced notifications in the Government Gazette in many cases.



*The front cover of a State Property Authority Order signed by the Governor authorising the transfer of land or interests to SPA.*

- **Recording the new Registered Proprietor.**

AN “APPLICATION TO RECORD NEW REGISTERED PROPRIETOR” IS PREPARED AND LODGED AT LAND AND PROPERTY INFORMATION NSW TO RECORD SPA AS NEW OWNER OF THE INTEREST AND TO OBTAIN NEW CERTIFICATES OF TITLE WHERE LAND HAS BEEN TRANSFERRED.

## ***Part 7 - Land and Asset Information Management***

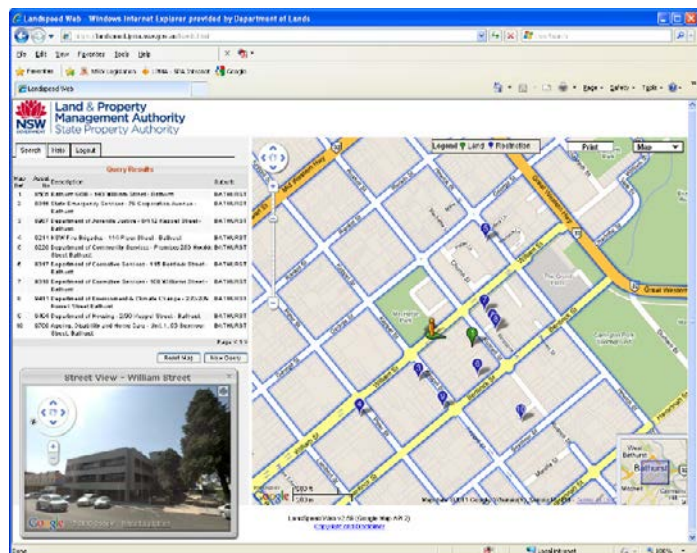
SPA has two core database systems – *LandSpeed*, a multi parcel transaction management tool and MRI, a commercial property management software tool. *LandSpeed* can be compared to bookends around MRI. LandSpeed acquires and disposes of the land or interest in land (e.g. lease) while MRI manages the property asset on the land or interest while held.

## LandSpeed

*LandSpeed* is an application developed in-house specifically for land information management and the management of transactional processes for land and interests in land. *LandSpeed* was developed by the former Department of Commerce and won the Sir Thomas Mitchell Award at the 2001 Excellence in Surveying and Spatial Information Awards. The *LandSpeed* application transferred to SPA in 2006 and development proceeded to suit the business needs of SPA. *LandSpeed* is written in OpenInsight, a windows-based application development tool, which contains a post-relational or [MultiValue database](#).

*LandSpeed* was developed as a project management aid for controlling transactional processes for projects and portfolios. That remains its primary function but by virtue of the sum of all settled or completed transactions *LandSpeed* also becomes a land database satisfying the requirements under the SPA Act for SPA to “establish and maintain a register of all land that is, from time to time, vested in or managed by the Authority”.

All land and interests in land transferred to SPA by vesting tranches under S.19 SPA Act are managed and controlled within the *LandSpeed* database. *LandSpeed* is not only suitable for single transactions but for multiple transactions that settle concurrently - the largest so far being over 300 land and leases that transferred in the one transaction. *LandSpeed* starts with LPI and other data and coordinates that data on a project or portfolio basis for use throughout the transaction processes. In building up an acquisition or vesting project there's a lot of land information and documentation collected and stored in the database which is then used in generating and completing letters, forms and reports.



*A LandSpeed Web screen shot centred on the Bathurst Government Office Building showing owned assets by green marker and leased assets by blue marker.*



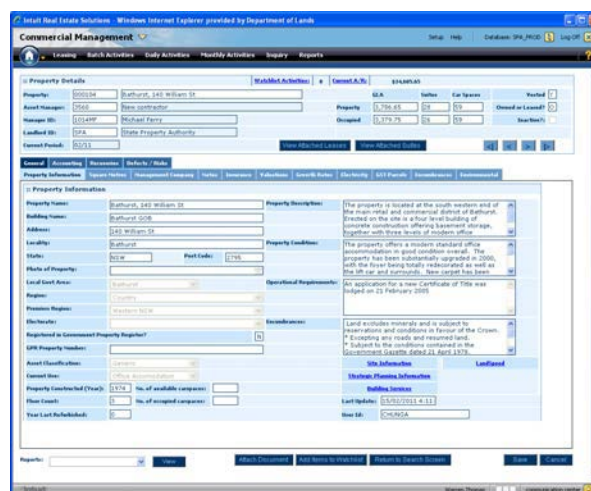
*LandSpeed Web* provides a web interface for secure remote access by staff to asset, portfolio and project land data and related documents held in the *LandSpeed* database with map and aerial photo links to land parcels via Google Maps (including Google Street View).

## MRI

MRI is a standalone financial and property management real estate solution which is modular in design and fully customisable. MRI provides a web-based solution to allow remote access to real estate data anywhere, anytime. Amongst others, SPA utilises the following MRI modules:

- Commercial Management
- LeaseFlow
- General Ledger
- Accounts Payable
- JobCost
- Purchase Order

MRI has a direct asset link from its Commercial Management module via *LandSpeed Web* to view GoogleMaps, Google Street View and the relevant land related data held in the *LandSpeed* database.



An screen shot of an MRI Commercial Management module asset screen. This screen includes a link to *LandSpeed Web* to spatially reference the asset.

## Part 8 – Where to from here?

SPA has now largely completed the transfers of generic government property accommodation and is looking to explore better ways to manage the properties and projects entrusted to its care. Many clients have indicated that they would be receptive to SPA providing additional property services or building upon existing services to help improve government performance and provide a commercial profit to government. While implementation of new services will depend on outcomes from the 2011 review of the SPA Act and associated policy, some of the improvements and new services being considered by SPA are described below.

## Data Exchange

SPA is currently exploring the opportunities for data exchange that have arisen through amalgamation into the Land and Property Management Authority. The potential is being explored for SPA to access titling and other spatial data by direct data transfer into its MRI and *LandSpeed* databases utilising the “source of truth” of the particular data set required. In return LPI is exploring the possibilities for direct data transfer from SPA of real time transaction settlement data that could lead to an interim notation being placed on affected Titles indicating that the Title is subject of a statutory transfer under a SPA Order (pending lodgement of a “Change of Registered Proprietor” Form). The Government Property Register is also exploring the transfer of data from SPA to source authoritative information on agencies that occupy government property assets owned by SPA.

## **Car Parks**

SPA currently manages the Domain Car Park on behalf of the Royal Botanic Gardens and Domain Trust and has a long term ground lease for the Opera House Car Park. SPA has discussed with some larger government agencies the potential to vest, develop and centralise ownership and management of car parks. This would meet a growing need identified by agencies themselves and could also provide a commercial opportunity to government, delivering more cost efficiencies and community facilities.

## **Depots and Warehouse**

Currently, some generic government properties such as depots and warehouses are owned and managed by agencies. SPA's experience from the vesting of government offices demonstrates that if these other generic properties were vested and managed by SPA then potential exists to improve the efficient use of that property, for example, by consolidating multiple government warehouse facilities in a region to a single warehouse or depot. SPA would also be in a position to better identify agency warehouse or depot needs and sell or redevelop surplus assets.

## **Consolidating Government Facilities**

Many NSW Government agencies manage their own specialist facilities such as training facilities, data centres, serviced offices and dispute centres. There are opportunities to provide shared government services by centralising management of these facilities in SPA. This could drive more efficiencies and savings to government and ensure better utilisation of these assets.

## **Fitouts**

Currently SPA owns and manages base buildings and agencies own their office fitouts, similar to a commercial leasing model. However, unlike commercial arrangements, government has an interest in the efficient and effective use of all tenancies and this presents opportunities to generate greater cost efficiencies and sustainable outcomes.

## **Part 9 – Conclusion**

So...who's building is it anyway? Well maybe there's a hint in the NSW Government's *Strategic Management Framework* which states that "Ministers and agencies are accountable to the citizens of NSW for the planning and delivery of government services". Maybe that says it all. At the end of the day it's the citizens of NSW that "own" the assets no matter which government agency's name appears on the Certificate of Title.

\*\*\*\*\*

## **APPENDIX A**

### **M2008-06 STATE PROPERTY AUTHORITY AND GOVERNMENT PROPERTY PRINCIPLES**

#### **Status: current**

The State Property Authority has been established by the NSW Government as a corporation with functions relating to the acquisition, management and disposal of Government owned property.

The requirements outlined in this Memorandum and the attached Government Property Principles apply immediately to all General Government Sector agencies and Public Trading Enterprises (excluding State Owned Corporations). Shareholding Ministers and Boards of State Owned Corporations are to note the establishment of the Authority and where their organisations do not have the necessary in house expertise, they are encouraged to use the services of the Authority.

The Authority's objectives as stated in the *State Property Authority Act 2006* are to:

- improve operational efficiencies in the use of properties of government agencies, particularly generic properties (such as offices, warehouses, depots and car parks);
- manage properties of government agencies in a way that supports the service delivery functions of those agencies;
- provide advice and support within government on property matters; and
- operate at least as efficiently as any comparable business, consistently with the principles of ecologically sustainable development and social responsibility for the community (including the indigenous community).

The Authority is the Government's real estate services provider and is responsible for acquiring and managing Government's generic and, by agreement, other property assets.

To assist the State Property Authority to achieve its legislated objectives, the Government has approved a new property policy framework. The framework outlines the relationship between agencies and the State Property Authority in the acquisition, management, maintenance and disposal of property.

The key initiatives of the framework are:

- the immediate vesting (from 1 July 2008) to the State Property Authority of the ownership of all government owned office accommodation;
- the implementation of a commercial rental charge for all office accommodation vested in the State Property Authority;
- the transfer to the State Property Authority of management responsibility of all government leased office accommodation;
- the extension of the Government Leasing Service within the State Property Authority to include all lease renewals and new and existing lease negotiations for generic property in the Greater Sydney Metropolitan Area (as defined by the Department of Planning);
- regular and ongoing reviews by the State Property Authority of agency property portfolios to identify efficiencies to improve service delivery which will be monitored by the Government Asset Management Committee and reported to Government;

- the provision of information by all agencies for the generic property database, including the participation in surveys;
- review and endorsement of all proposed property acquisitions and disposals by the Government Asset Management Committee;
- the State Property Authority is Government's preferred acquisition and disposal agency;
- the State Property Authority will be the lead agency for all multi-faceted property proposals that are interlinked by timing, location or use; and
- the Department of Premier and Cabinet, State Property Authority and NSW Treasury will work cooperatively with Government agencies and relevant unions to address any staffing and funding implications which may arise from implementation of the policy framework.

The attached Government Property Principles outline details of the property policy framework as well as other considerations relating to property title, preferred office locations, provision of car parking, lease precommitments, sale and lease back proposals and fitout amortisation.

This Memorandum supersedes [Premier's Memorandum 2008-02](#).

Morris Iemma  
Premier

Issued: Property Policy Implementation  
Lindsay Haraldson  
General Manager, Planning and Strategy  
State Property Authority  
(02) 9338 7084

Property Policy Framework  
Budget and Financial Implications  
Colin Campbell  
Principal Adviser, Property  
NSW Treasury  
(02) 9228 4115

Date: 10 April 2008

## **OPERATING PRINCIPLES**

### **Principle 1**

All owned office buildings will be vested in the State Property Authority and lease arrangements will be entered into with tenant agencies through a Memorandum of Understanding. Agencies will not be compensated for the vesting of assets, but will receive budget funding for net rental payments. Normal operating costs will be funded by agencies from existing resources. The vesting of all owned office buildings will occur from 1 July 2008.

### **Principle 2**

Agencies may vest in the Authority any or all of their non-generic owned property assets subject to agreement with the Authority and Treasury on resource and funding transfers associated with those properties. In some instances Government may direct that certain properties or agency portfolios be vested in the Authority.

### **Principle 3**

The Authority will assume management responsibility for all leased office space and other leased property assets and sublease arrangements will be entered into with tenant agencies through a Memorandum of Understanding. Agencies will pay a management fee to the Authority in addition to the rent payable under the head lease.

A program will be established to transfer management of existing head lease responsibilities to the Authority.



**Principle 4**

The State Property Authority will conduct all lease negotiations (new leases, renewals and rent reviews) for property assets required by government agencies except where the Government Asset Management Committee determines otherwise.

**Principle 5**

Consistent with Operating Principle 4, negotiations for all proposed lease pre-commitments must be conducted by the Authority and in accordance with existing approval processes. All pre-commitments to acquire property or office space must be assessed and approved in accordance with the Working with Government Policy and Guidelines.

**Principle 6**

Any request to the Authority to acquire new property assets must be consistent with the agency's Asset Strategy, supported by a business case and certification of funding availability for acquisition, rental and fitout, as appropriate. Where an office accommodation requirement exceeds 1,000m<sup>2</sup>, agencies must provide the Authority with a facility plan for approval before the Authority can approach the market.

**Principle 7**

All proposed property acquisitions must be referred to the Government Asset Management Committee to consider the proposed acquisition strategy and determine the appropriate agency to complete the transaction. Normal Treasury requirements for acquisitions continue to apply. All proposed property disposals will continue to be referred to the Government Asset Management Committee for approval.

**Principle 8**

No General Government Sector agency will approach the market to acquire property assets, either by lease or ownership, other than through the State Property Authority, unless the Government Asset Management Committee determines otherwise.

**Principle 9**

All proposals that involve either sale and leaseback arrangements or amortisation of fitouts as part of lease arrangements must be referred to the Authority and will require Treasury's specific approval.

**Principle 10**

All government agencies must immediately advise the Authority of any vacant, underutilised or no longer required office space or other property.

**Principle 11**

Car parking spaces that incur a cost to an agency should only be provided for official Government vehicles including vehicles supplied under salary sacrifice arrangements used for official business. There are circumstances where approval has been given by CEOs for the parking of private motor vehicles in official car spaces. These approvals have been given on the basis of the particular needs of the agencies concerned. Pending finalisation of a sector-wide policy in respect to these motor vehicles, existing approvals are to remain in force.

**Principle 12**

All agencies will enter into an agreed Memorandum of Understanding with the Authority for office space or other property assets it provides. If an agency fails to execute a Memorandum within a reasonable time, the Authority, subject to Treasury approval, may deem its execution and the terms of the Memorandum will be binding on the agency. For leased premises the term is to be consistent with the head lease. For government owned accommodation the term may be negotiated between the parties, but subject to a certain minimum term.

**Principle 13**

The Authority will enter into Service Level Agreements with agencies in relation to the provision and maintenance of owned or leased non-generic property assets that meet their service delivery requirements and deliver best value for Government.

**Principle 14**

Agencies are responsible for the provision of fitout, changes to existing fitouts and the makegood of premises provided by the Authority and no fitout, makegood or other alterations are to be undertaken without the Authority's prior approval.

**Principle 15**

The Authority will conduct regular and ongoing reviews of agencies' property portfolios, working with agencies to identify efficiencies to improve service delivery. The outcome of these reviews will be reported to the Government Asset Management Committee, which will monitor implementation.

**GUIDING PRINCIPLES****Principle 1**

The Government Asset Management Committee remains Government's peak Chief Executive body for considering all strategic asset management issues. The Committee's terms of reference are broadened to include all assets including assets other than real property.

**Principle 2**

The title for all new property acquisitions where the responsible Minister does not have the legislative power to deal in property transactions is to be placed in the name of the State Property Authority. All property related leases (including office accommodation) will also be in the name of the State Property Authority.

**Principle 3**

Government agencies are to achieve the office space use targets determined by Government. Currently these are an average of 17m<sup>2</sup> per person across an agency's office portfolio and 15m<sup>2</sup> per person for all new office space.

**Principle 4**

Government agencies are to actively pursue opportunities to share common resources or services consistent with Government policy or directives.

**Principle 5**

The preferred location for agencies in the Sydney CBD is in the southern sector or other sector where equivalent terms can be negotiated. No agency, however, will be provided with accommodation in the Sydney CBD Core unless approval has been obtained from the Government Asset Management Committee. Subject to individual agency service delivery requirements, the preferred locations for government agencies in the Sydney Metropolitan Area are those centres consistent with the Department of Planning's Sydney Metropolitan Strategy.

Government agencies will ensure that decisions on the location and fitout of office accommodation are consistent with planning for active living principles and sustainable travel options as referred to in the Premier's 'Why Active Living' Statement, including the necessary infrastructure such as showers, lockers and secure bicycle parking.

**Principle 6**

All government agencies are to ensure that office accommodation complies with Government policy in relation to sustainability and energy conservation. The current policy is outlined in Premier's Memorandum 2004/04.

# Cadastral Problems 2010



**David Job**

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Manager Old System/Primary Applications

Cadastral Integrity  
Land and Property Information

## **Abstract**

*A prime corporate objective of LPI is the provision of an accurate, prompt and cost effective service for the registration of plans and the subsequent creation of State guaranteed folios of the Torrens Title Register.*

*Cadastral Integrity's objective is to monitor the standard of survey practice to ensure the correct definition of title boundaries.*

*Examination Surveys are undertaken to resolve conflict in boundary definition, boundary disputes and problems with registered plans.*

*This paper highlights some of the day to day problems the Investigating Surveyors in Cadastral Integrity encounter on a frequent basis. The errors made usually, can be overcome by applying the main principles applicable to boundary definition.*

## **Boundary Definition**

In the relocation of title boundaries, it is often said that a surveyor employs a mixture of fact and law. Added to these are experience and commonsense.

There are certain basic principles associated with title boundary location which are constantly referred to and applied by surveyors. The courts have established precedents granting priorities of weight where any two or more of the following boundary features present conflicting evidence in the hearing of a dispute. These are in order of priority:

- (1) Natural features
- (2) Original crown markings of grant boundaries
- (3) Monuments
- (4) Original undisturbed markings of private surveys
- (5) Occupations, and
- (6) Measurements.

The ranking order is not rigidly applied and special circumstances may lead the court at times to give greater weight than normal to a feature of lower rank.

Every endeavour should be made to relocate the boundaries in the same positions as they are shown in the base plan from marks or monuments of that survey if possible.

Although a plan has been accepted by Land and Property Information, this has been done on the basis of the information shown, together with the usual office investigation. If a resurvey shows that some information in the plan was erroneous or that the investigation was incorrectly carried out then the base plan should not be followed where it is incorrect, merely because it is an accepted plan. However, sufficient verification should be made before deciding to discard any part of the base information.

## **Starting Point**

In many surveys insufficient thought or care is exercised in the choice or adoption of a starting point. If at all possible the starting point should be marks placed or shown in the base plan and not those of some later accepted plan in the vicinity. Errors in boundary location are often caused through the adoption of marks of some recent survey or even marks of a peg out, when those marks are in no way related or connected to the base plan.

## **Rear Boundaries**

Where lots facing parallel roads have a common rear boundary, and no supporting evidence is available to fix that boundary, the surveyor will have to refix both roads to verify the existence of any excess or shortage over the original dimensions. This enables the line of the rear boundaries to be re-established from end to end, avoiding the creation of "steps" in the rear line of adjacent lots.

Depths of lots can be affected by a change in the position of the road by either acceptance of a different definition upon resurvey or by alignment of the road after the original subdivision. Original depths should not be adopted from a road without verifying that the position of the road is the same as shown in the original plan.



## **Occupations**

In the absence of satisfactory original markings, probably the best evidence of the true position of a boundary will be obtained by reference to occupations either on the subject boundary or nearby boundaries or both. The present day surveyor is faced with the problem of defining boundaries from occupations only. As a result the chances are that the surveyor is not defining the boundary in the exact position in which it was originally laid out, but is, in fact, locating a boundary in a position which is acceptable as an equitable definition of the original.

In these situations all occupations should be measured along the road frontage and as many as possible along the rear lot boundaries and comparisons made with the original dimensions of the lots before a decision can be made. If this method is used to refix the boundaries the age and nature of the occupations must always be added to the plan. Greater weight can usually be given to older occupations.

While long and undisturbed occupation provides strong evidence that the occupations are erected on the boundary as originally laid, it is not indisputable. Further supporting evidence should be sought.

Clause 34(2) of the Surveying & Spatial Information Regulation 2006 states that “in the absence of monuments defining the land, the surveyor must indicate on the survey plan whether there is sufficient land available to permit the adoption of the measurement referred to in subclause (1) without causing any encroachment on any road or any adjoining parcel of land.

## **Resolving Excess Or Shortage In Measurement Disclosed By Survey**

If excesses and shortages in dimension are disclosed in a new survey every effort must be made to ensure that adjoining and other properties within the base subdivision have sufficient land to satisfy their entitlement. Careful consideration must be given to the intent of the original subdivision. For example, if parcels show equal frontage, every effort should be made to retain this relationship. However, the final decision on the boundary fixation will also be affected by:

- the position and age of occupations
- the relationship of monuments
- the standards of measurement applied over the years.

It requires substantial evidence to justify the inclusion of an excess in a title if doing so will re-locate the boundaries outside the existing occupations. However, it should be noted that the continued adoption of original title dimensions for each lot will have the unsatisfactory effect of moving the excess through the subdivision until it eventually becomes located in the last remaining lot.

## **Aligned streets**

A common source of error in redefinition of title boundaries is that caused by ignoring the effect of the alignment of streets subsequent to the original plan of subdivision. Alignments nearly always seem to have altered the original positions of streets to some extent, although it is sometimes difficult to prove.

In re-determining the alignment of a street where reference marks and alignment marks are not available, a surveyor needs to analyse all occupations on both sides together with the occupied depth of the section, assessing the age of various occupations and their relativity. Careful examination needs to be made of all available plans to assist in determining the age of fencing and the reliability of any redefinition based thereon. Fences can be useful monuments but the reliability of any particular fence needs to be assessed against the relevant facts.

Where streets have been aligned long after a subdivision was made and occupied, the positions of the streets as fixed by alignment obviously cannot be accepted as starting points to determine internal boundaries unless there is evidence that the alignments are in fact in the positions in which the streets were laid out in the subdivision. Useful evidence on this point can frequently be obtained from the field books of the alignment survey. The alignment plans do not show detailed measurements between occupations on frontages, but these may be obtained by calculations from the field books. Also it is not usual to show on alignment plans marks found which enable the alignment to be related directly to the subdivision. If the position of a street is altered by alignment the loss or gain will usually be borne by or accrue to the owner of the land immediately affected. There are, however, so many variations that a general rule applicable to all cases is impossible. Each case must be dealt with in the light of available evidence and its own facts.

## **Old System Land**

It is just as important to correctly define the boundaries of Old System land as it is to locate those of land held under Torrens title.

It is quite evident that this practice is not universally followed. Some surveyors appear to have the impression that fencing or other occupations, particularly if they are more than 12 years old, provide a satisfactory definition of Old System boundaries. This, of course, is quite incorrect. The same methods should be employed and the same care exercised in locating the boundaries of an Old System deed as would be employed in defining the boundaries of a certificate of title.

Where occupations, regardless of their age, are inconsistent with the deed boundaries that fact should be noted on any plan prepared and should be reported by the Surveyor with any information he may have been able to gather concerning the age of the occupations and the circumstances under which they were erected.

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# **INTERNATIONAL FELLOWSHIP: A STUDY OF CADASTRAL MANAGEMENT AROUND THE WORLD**

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## ***Abstract***

*The New South Wales Surveyor General generously grants an annual International Fellowship award to up to two university graduates annually from Surveying and Spatial Information Systems. The successful applicants of this Fellowship are provided with the opportunity to travel internationally to broaden and develop their personal and professional perspective. The purpose is to investigate international processes by exchanging knowledge and engaging in discussion on the specific topics proposed by the applicant.*

*In 2009, I was lucky enough to receive this award. I proposed to carry out my research on the use and significance of Geographical Information Systems (GIS) in two different topic areas:*

- 1. Cadastral Management*
- 2. Sustainability*

*My reasoning for choosing cadastral management was my belief that the cadastre is the fundamental backbone to all survey and GIS work.*

*I will be focusing on Cadastral Management in this paper. The purpose of the paper is to provide an informative summary by taking a 'compare and contrast' approach to understand the extensive differences in systems and processes in Germany, United States of America, England and the Netherlands.*

## **Introduction**

The Land and Property Management Authority (LPMA) defines cadastral as “records of a cadastre, concerned with keeping a cadastre, an official register of property”. Cadastre is defined in the Surveying and Spatial Information Act 2002 No 83 (2010) as “an inventory that records boundaries, dimensions and measurements on, above or below the Earth’s surface for the purpose of defining rights, interests, restrictions and responsibilities within the jurisdiction of New South Wales.” (LPMA, 2009). The management of cadastral data has evolved over the years especially with the introduction of the Geographical Information Systems (GIS) industry. Cadastral data can now be described in simple terms as a digital, spatial representation of property and its corresponding details such as ownership, address, land use and land taxes.

The need to have a current, well maintained cadastral database is becoming more and more vital and depended upon for a city, state or even country's planning and development. Advanced technology now makes it possible to have high accuracy data. The recording of ownership has always been important for land administration but the process greatly varies around the world.

## **History**

The first, and perhaps most important, difference that needs to be understood is the contrast in history of land administration of each country. History can be considered an explanation to the way in which each system and process is now carried out.

The need to prove ownership has always been a vital part of the British system. However, the system of registration underwent many changes before the current Land Registration Act 2002 was implemented. England's registration history dates back as far as when the Romans introduced a form of land registration to England and Wales. Many Land Registration Acts were introduced but were unsuccessful systems including the Land Registry Act 1862 where the first Chief Land Registrar, Brent Spencer Follett, was appointed. This system was replaced by 1875 Land Transfer Act which remained until compulsory registration was introduced. It was not until the mid 1800s that the registration of title was introduced but was not compulsory in the whole of England and Wales until 1990. Although registration is now compulsory, its history is the reason for the current 25% unregistered titles and therefore missing spatial data. Her Majesty's (HM) Land Registry is working to reduce this figure and now have some 20 million titles registered. (Mayer, Pemberton, 2000).

On the other hand the system in the Netherlands differs greatly from the English system, both in the past and present. In fact, England looked to Holland in the seventeenth century since they had introduced land registration in 1529 and were considered the most successful country in Europe of the day (Mayer, Pemberton, 2000). In England and Australia there is the state title system where the title is guaranteed. It is a legal transaction and registration with the state title office is required. In the Netherlands, the state does not guarantee the title, but merely facilitates the compulsory recording of documents. The key words to understand the difference is 'registration' and 'recording'. The historic reasoning for this is that Holland has adopted the French system which embraces the belief that it is a right of the citizens not the nobility. Therefore property rights and land market are a matter sorted by the citizens, not the state.

The United States of America is a whole other story compared to the two countries just mentioned. Like Holland, the state does not guarantee title but nor is it a right of the citizens. America has what is known as title insurance. This is a private entity which, as the name states, insures your title against any defects or issues. In other words, a title against a property is registered with the state but since it is not guaranteed a big business opportunity began in America to have private insurance on your title like you would your house or car. Each state has its own processes, systems and standards which may or may not be similar to other states. Therefore, there is no one national secure title system. Interestingly, a handful of the states adopted the Torrens Title system as is done in Australia.

## **United States of America**

As stated above, land administration in the United States employ a title insurance system. The state does not guarantee title and nor is a survey plan considered a legal document. It is important to remember that every state has its own system, laws, procedures and even variation in the levels of governmental structure hence the following step by step process may vary and is merely a generalised explanation of USA's land administration.



Surveyors carry out a field survey and prepare a survey plan. The map itself needs to conform to the universal survey requirement that a property's boundaries must have a small and acceptable misclose. However, the property 'illustration' on a survey plan in the USA does not require measurements to the millimetre, or more accurately to the inch. I specifically use the term illustration to highlight that, other than a misclose there are no strict mapping standards for the submission of the plan, unlike in NSW.

The key aspect of a survey plan in the USA is the written legal description which describes the property. According to C. Lodge (2009) these can be one of three descriptions and they are:

1. Metes and Bounds: Describes a parcel of land with direction and distance measurements and establishes its boundaries using markers such as monuments or natural objects.
2. Government Survey: It also describes a parcel of land by establishing boundaries however the description is not as specific as the direction and distance measurements on a metes and bounds description. The basis begins with a reference of section, township and range.  
(Metes and bounds and Government Survey can be categorised as unplatted land which is property defined by survey measurements rather than a lot and block identification.)
3. Platting: When an area is subdivided, a survey plan is recorded at the county which identifies each lot within a block with a unique identification number. The legal description of any further survey plan on platted land is simply a reference to the lot and block number along with the volume and page of the recorded plat.

The legal description from a plan is recorded at the county level. This written description is the most important section of a survey plan, also known as a survey map, as far as the county is concerned. A basic check of the survey measurements is often carried out and any major changes, such as consolidation or division of lots, will be updated to the spatial data using a simple coordinate geometry (COGO) method. Taxation, including property tax, is also collected at this level.

Following the legal recording at the county, the plan is passed on to the municipality, most commonly known as city level. At this stage each department has their own accuracy standards dependent on a number of contributing factors such as revenue, intended usage and resource. The city's separate cadastral database is updated accordingly.

Environmental Systems Research Institute, known simply as ESRI, provides the most commonly used advanced GIS software package worldwide known as ArcGIS. I was fortunate enough to visit ESRI's head office in Redlands, California. In the latest version of the software, ArcGIS version 10, ESRI's intention in terms of cadastral editing was to improve and make readily accessible a previously existing editing tool. The parcel editor, originally known as cadastral editor, aims to break down the barriers between the departments and various levels of land administration. The product has also been further developed in order to embrace the requirements of tax mapping in USA. It aims to encourage the upkeep of a spatially accurate cadastral database by providing simple, efficient, user friendly tools.

The counties are interested in legal description and attribute information. The cities are interested in accurate GIS mapping. It seems there is a future possibility for a merge to a single database. For this to be option, obviously there are many factors that need to be

considered but ESRI products will be a starting platform to consistency in software, data, methods and standards.

## England

England's system or even United Kingdom in general, is fairly unique. It was quite a contrast in research compared with cadastral administration and spatial information systems in the United States and also Europe.

Ordnance Survey (OS) is Great Britain's (England, Scotland and Wales) national mapping agency. The key aspect of their work is managing the nation's topographic data and mapping. In terms of cadastral management, OS does not map the legal boundaries of property nor does it handle deeds, titles, registration or other such legal operations. Ordnance Survey's topographic mapping is used by Her Majesty's (HM) Land Registry for land administration therefore can be considered a support of cadastre. HM Land Registry is responsible for registration of title and recording dealings of registered land in England and Wales.

As previously mentioned land registration in England has quite a colourful history. The fact that registration was not compulsory until 1990 is an explanation to the 25% of unregistered titles and therefore absent sections of national spatial cadastre. Over the years this figure is gradually diminishing.

In the past England had a 'fixed' boundary system but later adopted what is known as "general boundaries". This was due to the decision to use OS topographic data as a base for their cadastral work since they already possessed full mapping coverage of all of UK. The term "general boundaries" was implemented to allow a buffer for the fact that OS data does not capture legal property boundaries.

For the cadastral database itself HM Land Registry uses OS MasterMap among other in-house systems such as Land Registry Property Gate (LRPG). OS MasterMap is a continually updated database containing data and a unique reference (TOID) for every feature on the British landscape. This information is available through OS MasterMap products and online services provided by Ordnance Survey.

It is difficult to know the level of accuracy of the cadastre due to the use of general boundaries but it seems that high accuracy is not vital in this case. The accuracy of OS data however is said to be:

- 1:1250 Map accuracy = +/-1m for every 100m
- 1:2500 Map accuracy = +/-2m for every 100m

Ordnance Survey has built a national network of continuously operating reference stations (CORS) across Great Britain called OSNet. CORS networks such as this continuously collect data from satellites which creates a solid survey framework for the area covered. Real time information can be downloaded to receive positioning to centimetre level accuracy in most areas of Great Britain. Without the OSNet system GPS signals alone can only produce horizontal positional accuracy to approximately 5–10m. There are approximately 90 stations collecting GPS (American system) signals and has the potential to work with Galileo signals (Europe system) in the future.

England clearly has a very different approach to land administration and is heavily based on the data of the national mapping agency. It is quite unlike the processes and systems used in Europe, America or even Australia.

## The Netherlands

The Netherlands, also commonly referred to as Holland, is made up of twelve provinces and some 400 municipalities. Historically each province maintained separate databases for the cadastre. Errors along the boundaries of each province soon highlighted the fault of having divided systems. A great deal of time, money and effort was committed to repairing the alignment issues once the technology was available. This also called for the development of a centralised database which is now managed at the Dutch Kadaster: Land Registry and Mapping Agency which politically stands under the Minister of Environment, Spatial Planning and Housing although they are more correctly known as an independent public body.

Prior to this, over the years, nationwide cadastral maps were produced to a scale of 1:1000 as well as separate 1:1000 topographic maps. The formation of seamless cadastral data across Holland uncovered the fact that the cadastral and topographic maps did not match, often by substantial differences. This became a further necessary extension to the original project as Holland always had a reputation for “accurate data”.

Ten years later in 2007, a seamless, nationwide cadastral and topographic fabric was available.

Many may question the need for a national cadastral fabric. A cadastral fabric is “a continuous surface of connected parcels” as defined by ESRI (2009). What are the benefits? Is it worth the time and money?

While there is no doubt that it is a costly and timely process to establish seamless data the outcome allows for the following:

- Highly accurate cadastral and other spatial data
- Highly efficient and simple maintenance
- Controlled management with little room for error
- Minimises the amount of legal disputes due to the accuracy of the data
- Cost effective once the system is in place

Updating accurate cadastral data used to be a time consuming, manual process. Unfortunately this still is the case in NSW. There are many steps from when a surveyor carries out a field survey to the final step consisting of a manual COGO update in the office by a GIS professional. All in all it is a slow operation. The Netherlands have eliminated most of the manual labour with the implementation of this cadastral fabric. The steps taken to update Holland’s cadastral data are as follows:

1. A surveyor takes a copy of the required survey area from the cadastral database into the field on a field laptop (usually Panasonic Toughbook)
2. The toughbook is connected to the total station or GPS while the survey is carried out therefore instantly loading and automatically updating the data on the spot. This allows a surveyor to be aware of any survey errors they may make and instantly re-survey as required.
3. When the surveyor returns to the office, the newly surveyed data is imported into the national database and an automatic adjustment is carried out accordingly by performing a least squares adjustment on the nationwide fabric.

With advanced GPS technology it is now possible to achieve accuracies of 20cm standard ellipse plus the accuracy of the physical monument in urban areas and 40cm in rural areas.

The use of such technology together with rigorous calculations achieved from least squares, results in sub-metre, reliable cadastral data. M. Elfick (2009) states that using accurate cadastre as a base layer can “serve as the control for GIS data” which is “created and maintained in context with the cadastre”. The most beneficial point to mention is that a shift in the ‘base’ layer will automatically adjust all other dependent GIS data due to established spatial relationships.

Land registration is a system based upon the rights and control of the citizens instead of the involvement of the state. The Netherlands employs a compulsory ‘recording’ system rather than a ‘registration’ overseen by a notary which is part of a private law. Basically private law is the law that regulates the relation between the citizens. Any legal recordings or cadastral updates are made accordingly. A document outlining the full details of the transaction must be recorded at the Land Registry.

## **Germany**

The precision, progression of technology and forward-thinking of the Germans regarding geodesy, surveying and spatial information was undoubtedly remarkable.

Like the Netherlands, Germany has a national cadastral fabric therefore maintaining the data is a similar process. The accuracy however is at a higher standard with a dense, nationwide coverage of about 270 GNSS reference stations approximately 25-60km apart (Jahn, 2008). The German CORS network system is called SAPOS and produces accuracies to +/- 2cm using RTK. This effectively means that cadastral data is also to +/- 2cm accuracy which was the highest level of accuracy found from this research.

Since GPS was so effective, SAPOS was introduced with the cooperation of all 16 states. The main reason to set up this system was for the purpose of improved cadastral surveying. As mentioned the cadastral database can be updated directly from the survey due to the presence of a cadastral fabric. The key to time and cost efficiency in the field was to provide a strong and precise GNSS network for establishing one’s spatial location to tie the local survey into the national framework. SAPOS can produce such required, accurate results within a couple of minutes using both GPS and GLONASS signals.

There is one sole topic which virtually became the focal point of the German sector of research. The topic is the national geodatabase model called AFIS-ALKIS-ATKIS (AAA).

According to AdV, Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany, (2006) the following define the three A’s in the AAA model:

- AFIS - Official Control Station Information System
- ALKIS - Official Real Estate Cadastre Information System
- ATKIS - Official Topographic and Cartographic Information System

In 2000 the ‘AAA project’ commenced to integrate the three systems mentioned above nationwide. Previously all 16 states in Germany had their own database and structure with no apparent national standardisation. The realisation is that the spatial data infrastructure needs to be restructured in order to provide reliable data and allow the opportunity to use it to its full capacity. With the launch of the AAA scheme all systems are being made compatible and therefore allowing for consistent, seamless data nationally. “The AAA basic scheme becomes a core data model that can easily be combined or extended with other data from various administrations in order to build up a spatial data infrastructure in Germany”. (Seifert, 2006)



Historically the foundation of state survey authority was to produce maps for the purpose of war. In the 19<sup>th</sup> century the state began to collect taxes from citizens which lead to the need for a cadastre at the municipality level. This is done in two parts: legal section and cadastral section.

- Legal section – Books held at local county court which states the owner of a certain parcel and any other legal detail. No map or spatial information managed.
- Cadastre section - Geometry and description of the parcel purchased is recorded. This involves updating a cadastre map as well as a cadastre ‘book’. Until the early 80s this was actually a book with hand written parcel descriptions.

The beginning of the digital era allowed for vast improvements in surveying and cadastral management as evident from the discussion above regarding the current update procedure. However, there is still a certain amount of manual work involved to ensure all systems are up to date and correlating. With the implementation of AAA, all systems will be connected.

In basic terms... Corner points are related to the boundaries. Boundaries related to parcels. Parcels related to attributes. A change to one parcel will automatically adjust everything relating to that parcel as well as any changes required to surrounding parcels.

Compared to the tedious, error-prone historical method of cadastral maintenance, it is clear that in the long term the AAA model will prove its worth. Once the system is up and running very little manual labour, time or money will be necessary for the cadastre database. There is no escaping the necessity of a cadastre which can be quite time consuming and repetitious work. However taking on a challenge such as the AAA model or a national cadastral fabric means more resources available in the future to concentrate on further important, advanced systems.

## **Summary**

If there is one thing I have discovered from this Fellowship, it is that despite the fact that the spatial industry can be considered reasonably new compared to others, there is an incredibly vast amount of knowledge available around the world. The speed in which this industry has developed is overwhelming.

Cadastral Management is the key to maintaining land records and providing a platform to all spatial data. As a general statement in terms of cadastral management there is no right or wrong method of management. All in all, it came down to ‘what is appropriate and most effective for each country’. Germany’s system was by far the most advanced and accurate. Their SAPOS system of continuously operating GNSS stations provides a solid network nationwide therefore achieving astonishing levels of accuracy in positioning.

A national cadastral fabric in Germany and the Netherlands allows for efficient and cost effective methods of maintain the cadastral database. A tedious manual coordinate geometry procedure was turned into an on-the-spot updating process.

The spatial management of the cadastre in England is quite unique. The database is based on Ordnance Survey mapping which is unlike any other system I came across. An adoption of general boundaries in the country made this possible. The major difference in the registration system between England and Europe is the property title. A title is in England and Wales is guaranteed by HM Land Registry whereas Europe’s registration system operates on a public law where title is not guaranteed by state.

Further to these differences, the United States of America has title insurance. My understanding is that this is a system solely implemented in America. The state does not guarantee title nor is it a formally recorded agreement between the buyer and seller as is done under the public law therefore title insurance was developed.

Based on the knowledge gained and seeing the functioning systems first hand, it is my opinion that NSW should look to the benefits of an accurate cadastre based upon a single state-wide cadastral fabric similar to that of Germany and the Netherlands. An incredible amount of work is being placed on the NSW GNSS CORS network which is an important and creditable step in the right direction.

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# NSW Vegetation Monitoring using Satellite Imagery



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## ***Introduction:***

*The NSW government has committed in the state plan to monitor the extent and condition of native vegetation. In order to achieve this goal, state-wide routine monitoring must be undertaken. In addition to the ability to monitor current vegetation distribution, analysis of historic vegetation distribution aids in the identification of trends and location of large variations in vegetation through time.*

*The NSW Department of Environment Climate Change and Water has been monitoring vegetation state-wide through the use of Landsat imagery on an annual basis since 2006. Historic analysis has been performed on a biannual NSW Landsat coverage from 1998 to 2006.*

*In addition, high resolution satellite imagery from the SPOT5 satellite has been used on an annual state-wide basis since 2008 to increase the precision of the analysis.*

## **Landsat pre-processing:**

Accurate detection and quantification of vegetation change over time and space requires removal of the confounding effects of geometric distortion; radiometric variability; illumination geometry; and cloud, shadow and water contamination from imagery. These pre-processed Landsat TM and ETM data form the basis of all derived image products.

The Landsat imagery is acquired from Geoscience Australia as Level 5 processed data and rectified to the SPOT 2004/05 image base developed by Geoimage. Development of the SPOT 2004/05 rectified image base is described by Peters (1). The pre-orbit radiometric calibration is used for ETM+ images; the onboard calibration is removed from TM images and an improved time-dependant vicarious calibration (2) is applied. Images are converted to top-of-atmosphere (TOA) reflectance and a three-parameter empirical model (3) applied to further reduce variation due to illumination geometry and bi-directional reflectance distribution function (BRDF).

Images are acquired in the dry season to minimize cloud cover, and maximize the spectral contrast between perennial vegetation and senescing annual grasses, however many Landsat images acquired contain some cloud contamination. Reflectance values are affected by cloud and cloud shadow, topographic shadow, and surface water. The Landsat images are masked using automated and semi-automated Landsat-derived masks for cloud, shadow (4) and water

(5). Areas of deep topographic shadow are masked by simulating illumination at the time of image acquisition using a ray tracing method with the SRTM DEM.

An optional topographic correction can be applied to the radiometrically corrected imagery. This correction is based on the WAK model (6).

#### **Landsat vegetation extent and FPC:**

The metric of vegetation cover adopted in many Australian vegetation classification frameworks is Foliage Projective Cover (FPC). Operational mapping of overstorey FPC requires an efficient and automated method due to the large volume of Landsat data that require processing and interpretation. Regression approaches (17) and other statistical techniques (8) have been used to predict FPC from Landsat imagery.

A multi-temporal rule based approach has been used to map the woody extent and FPC (9). The woody extent and FPC product uses a time series of Landsat images to calculate the best possible prediction of FPC for each pixel within a scene, for a specified time period e.g. 1988–2008.

The FPC products have been validated in Queensland using independent site measurements and airborne LIDAR data (8). It is planned to validate the NSW woody extent mapping using “desktop” validation sites taken from high resolution SPOT imagery. The FPC is currently being validated using sites measured in the field.

#### **Landsat vegetation change mapping:**

The difficulties in consistently and reliably detecting woody change across a wide range of vegetation types over a large geographical area required the development of a change method that combined both the spectral changes from scene to scene and the historical variability in foliage cover. This combination of change detection methodologies was based on combining a modified form of image differencing with a time series model using the FPC time series to detect true change. The method used to map change in woody vegetation was developed in the SLATS program and is described by Scarth et al. (7).

The final classifier sits within the SLATS operational processing framework and is run automatically across the state. However, in order to use this classifier in an operational reporting environment, three levels of classification at the 2%, 5% and 15% omission level are produced which are then further interpreted, edited and checked by an operator. This manual interpretation stage is used to check the output of the classifier, and further improve the accuracy of the final product before it is used to produce the annual SLATS woody change figures and reports.

A sample of the change data is checked through a QA process (16) to ensure a high level of consistency between operators. The analysis and interpretation of the woody change is done on a scene by scene basis. The results are combined to form statewide data sets which are used in a GIS environment to calculate rates of vegetation change, taking into account the different acquisition dates for each Landsat scene.

#### **SPOT 5 pre-processing:**

The calibration coefficients provided with the SPOT imagery is applied to the data to convert the data to radiance. Preliminary validation was performed to confirm that the SPOT calibration was correct and being correctly applied to the imagery.



An atmospheric correction is applied to the SPOT imagery using the 6S code (10). The inputs to this process are based on interpolated meteorological data and climatology data. The Aerosol Optical Depth (AOD) is one of the most sensitive and difficult to obtain parameters. After testing many approaches (11) it was decided to run with a constant AOD of 0.05 as in most cases the atmosphere in NSW is quite clear and all techniques for estimation of AOD were problematic.

Removal of cloud is an important step if automated processing is to be run on the data. A cloud masking method has been developed and being applied (12,13). Further refinement of the method is also being done through a Joint Remote Sensing Research Program (JRSRP) project.

### **SPOT vegetation extent and FPC:**

As the current radiometric correction for SPOT imagery is only an atmospheric correction and doesn't include correction for BRDF effects, significant scene to scene differences exist in some cases. Hence, it was not possible to develop a general FPC model that could be applied statewide to the SPOT imagery. To overcome this problem a cross calibration approach (14) combining atmospherically corrected SPOT 5 imagery and the existing calibrated Landsat woody extent and FPC product is being used to generate SPOT FPC products.

The cross calibration method (14) has been implemented in Pymodeller and is being run to provide FPC data for change mapping. It has been run on the 10m resolution SPOT imagery and in future will be tested on the 2.5m pan-merged products. The development of a multi-temporal SPOT woody extent and FPC product, using an approach similar to that used in the Landsat product will be investigated.

### **SPOT woody vegetation change mapping:**

While it is planned to map vegetation change at the highest possible resolution that SPOT imagery allows, initially only the multi-spectral (10m) SPOT data is being used. A pre-processing method to enable pan-merging of the imagery in a way that is compatible with the radiometric correction method is being tested. This will allow analysis at a 2.5m pixel image resolution across the state.

As the radiometric correction applied to the SPOT imagery is only an interim correction at this stage and does not remote BRDF effects, it was not possible to develop a change mapping method that included automated thresholding of the change index, as is done with Landsat. Thresholding of the woody change index is done manually on a scene by scene basis or multi-scene block, where the image dates are the same. Four possible change class thresholds are set to assist in visual interpretation of the change images.

Similar to Landsat, visual editing is used to check the output of the classifier, and further improve the accuracy of the final product (15). Polygons used in this editing process (Image AOI's) are being kept to enable the re-coding to be repeated with 2.5m change data when available, and are used in the QA stage.

### **Conclusion:**

The NSW Department of Environment Climate Change and Water uses a variety of satellite imagery to monitor vegetation on an annual basis. Historic and trend information has been captured for the period 1988 to 2010. The vegetation monitoring programme has provided systematic and precise information as to the change in woody vegetation throughout continental NSW to better inform natural resource management in NSW.

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# NSW Rural Floodplain Management – A new approach



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## ***Abstract***

*Rural floodplain management plans (FMPs) prepared under the NSW Water Act 1912 are used to assess approvals for flood control works (levees, channels and other earthworks). The plans aim to minimise flood risk to floodplain occupiers and support the needs of the floodplain environment.*

*Accurate topographical surveys and digital mapping, which are used in flood modelling analysis, are a key element of the FMP process.*

*The paper outlines how FMPs have been developed in the past and describes the new Valley-Wide Floodplain Management Planning approach. The paper provide examples of the interaction of flood modelling studies with digital topographical data and highlights the need and importance of associated survey and mapping data to accurately describe river and floodplain surface features to simulate flood behaviour.*

*The paper concludes by describing the techniques that have been used to acquire topographic data from land surveys to aerial data capture using LiDAR.*

## ***1. Introduction and Background***

### **1.1 The origin of the problem**

For the most part, the State (NSW) was originally explored and opened up in pursuit of pastoral land, and in many localities flooding was a welcome and natural process which rejuvenated and maintained large grazing areas. Few attempts were made to control this flooding and as no major problems arose special legislation controlling the utilisation of floodplains did not evolve in our early history.

Initially all irrigation farming developed close to major rivers. In most cases only minor flood protection works were required because the type of crops being irrigated did not warrant the cost of constructing large levees, to ensure full protection from inundation. With this type of development legislation evolved under Part 2 of the Water Act, 1912 which enabled the NSW government to exercise control only over structures in the beds of rivers and along, or in close proximity to river banks.

The situation changed radically with the construction of large storage dams in the 1950s on the headwaters of most western flowing rivers, providing regulated supplies of large volumes of water for irrigation. Consequently, valuable cash crops which were not feasible with an irregular water supply now became a reality. As a result extensive tracts of land kilometres away from the main rivers were developed for irrigation and privately constructed floodplain structures proliferated on the floodplains of inland western NSW. In most cases water was conveyed from the river in elevated supply channels which were often constructed in a line directly across the natural flood paths. Similar development also occurred with the increased use of groundwater for irrigation schemes.

Apart from major flood channels and creeks little attention was paid to providing openings in these irrigation channels to allow flood flows to pass unimpeded. The result was that floodwaters were often constricted and forced onto lands not previously flooded, or the local flood levels were raised above normal heights.

Affected landholders often retaliated by building protective levees, and this had a snowballing effect as opposing levees were then consistently increased in height and extent. This scene was repeated in most major western river valleys. This lack of control over these structures meant that the interests of landholders away from a defined river could not be protected in the same way as those landholders on or close to a river.

### **1.2 The first attempt to address the problem**

As a result of the problem outlined above and following the major floods in the mid 1970's, the NSW government developed some 40 floodplain development guidelines (Guidelines) for rural areas west of the Great Dividing Range. They covered some 31,000 km<sup>2</sup> of the Murray-Darling Basin, providing guidance to landowners on areas to keep open for flood passage and areas of arable land that could be flood protected.

The Guidelines were not statutory documents, and hence their success depended on voluntary compliance by landholders who also funded, implemented and maintained flood protection works.



## ***2. The current practice used to manage NSW Inland Floodplains***

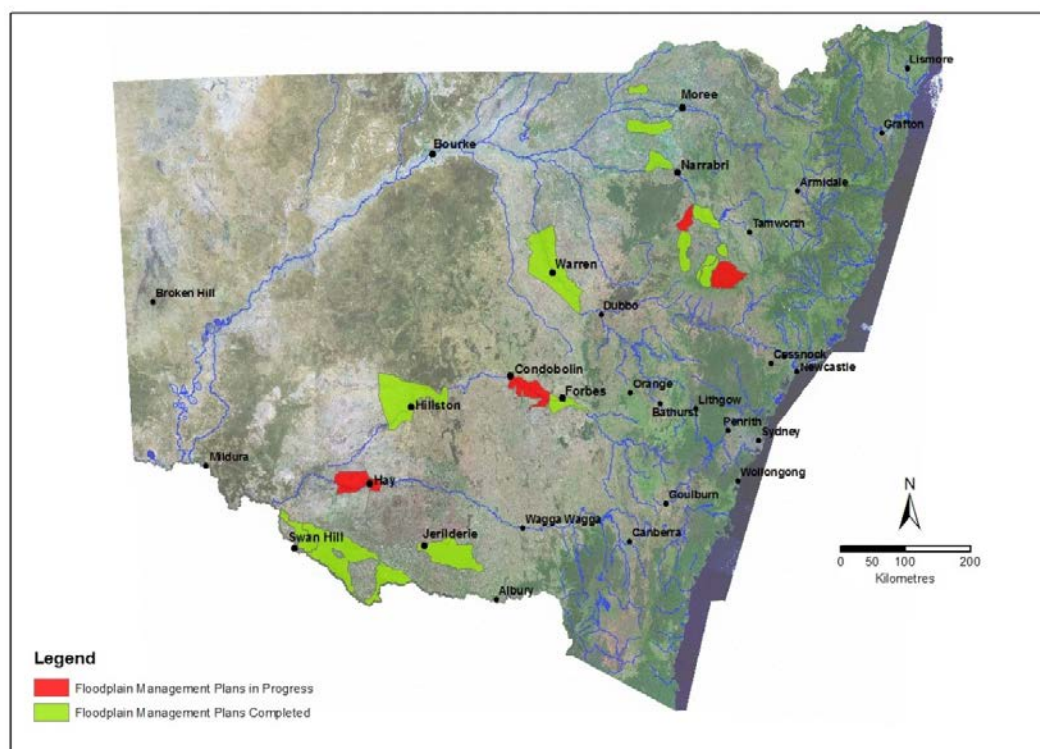
### **2.1 History**

From the 1980s onwards there have been a number of legislative responses to manage structures on rural floodplains in New South Wales. Part 8 of the Water Act, 1912 was enacted in 1984 and amended in 1999 to allow for greater consideration of ecological matters and for the preparation of statutory rural floodplain management plans (FMP's).

Currently, the Department of Environment, Climate Change and Water (DECCW) prepares rural FMP's which represent the principal planning mechanism for managing the distribution of floodwaters in designated floodplains across inland NSW floodplains. Rural FMPs, augment the role of councils in managing land subject to varying degrees of flood risk.

The NSW Office of Water (NOW), a separate office within DECCW, uses the rural FMP's as the basis for determining approvals for flood control works (levees, channels and other earthworks) under Part 8 and for ensuring compliance with approvals.

Since 1999 the DECCW program has included 21 rural FMP's covering 25,000 km<sup>2</sup> of the Murray-Darling Basin – 17 FMP's have been finalized and gazetted and another four are in progress (refer Figure 1). The program has included floodplain areas in the Namoi, Gwydir, Lachlan, Macquarie, Murrumbidgee and Murray River valleys.



**Figure 1 - Rural Floodplain Management Plans in NSW (some sites include multiple Plans)**

### **2.2 Rural Floodplain Management Plans**

Rural FMP's develop a scheme to manage floodwaters by defining corridors or floodway networks that allow the unimpeded passage of floodwaters and maintain floodplain connectivity to flood dependent ecosystems (FDE's) such as wetlands and woodlands as well as protecting fish passage. Typically as part of the development of a rural FMP a design flood standard based on a historic flood event is adopted to determine floodway widths

Subject to approval, floodplain structures such as levees can be built outside floodway networks for the protection of crops and assets. The level of protection achieved against flooding is entirely up to the individual landholder. In other words, levee construction outside or along the boundaries of floodways is purely voluntary (subject to formal approval). Rural FMP's do not specify the design, construction or maintenance standards for levees or other forms of flood control works, aside from the need to comply with approved horizontal alignments and occasionally vertical alignments where levee crest height limitations are required for controlled overtopping for floods greater than the design flood standard.

Rural FMP's also identify specific structures that landholders will need to modify or remove to avoid obstructing floodwaters within the defined floodway networks.

There are no restrictions on agricultural land use within defined floodway networks provided flood conveyance and/or storage is not reduced and FDE's are not compromised. Landholders need to make their own assessment regarding the risk of flood damage to crops or other flood sensitive agricultural activities within these corridors.

### **2.3 Rural Floodplain Management Planning Process**

Under the current DECCW program commencing in 1999, rural FMP's are prepared in accordance with the Floodplain Risk Management Process outlined in the NSW Government's Floodplain Development Manual (NSW Government, 2005). This involves multiple studies completed in stages as follows:

- Flood Study – data collection plus technical assessment of the nature and extent of flooding, usually involving computer hydraulic modeling of flood behaviour.
- Floodplain Risk Management Study – to evaluate various management options for the floodplain giving consideration to hydraulic, environmental, social and economic issues.
- Floodplain Management Plan – outlining adopted strategies and legislative backing to manage flood risk, support the natural floodplain environment and implement recommended works.

### ***3. Valley-wide planning – a new approach***

Rural FMP's have to date, been prepared in response to development pressures in targeted areas, using the staged multiple study format described above. Also, community based committees overseeing the preparation of individual rural FMP's have had to deal with a range of interests and views within the group which has included micro managing solutions for hotspot areas (ie areas where works have a detrimental effect on flood behaviour). This has impacted on the time taken to complete rural FMP's.

As part of a regular review and fine tuning of rural floodplain management in NSW, a new valley-wide approach with enhanced timelines and environmental outcomes is being developed by DECCW. The valley-wide rural FMP's will provide a mechanism for managing flood control works at a broader valley scale using data from existing supporting flood behaviour studies and computer models (filling in knowledge gap areas where required) and by defining detailed assessment criteria to be used to assess work approvals without the need

to determine solutions for specific hotspot areas. Where detailed studies are required for hotspot cluster areas these will be carried out separately using information from the valley wide rural FMP's. An interagency steering panel will engage the community through targeted consultation. More consistent planning outcomes will result, with the planning process considerably fast-tracked with plans expected to be delivered in 2-3 years, compared to 6-10 years previously.

#### ***4. Advancements in hydraulic floodplain analysis and evolving topographic data requirements***

##### **4.1 Some examples of what was used during the 1970's and 1980's**

###### During the 1970's

Assessment of floodplain structures and their impacts on flood behaviour was carried out using open channel hydraulic calculations such as Manning's equation to determine the discharge at selected hydraulic control points:

$$Q = \frac{AR^{2/3} S^{1/2}}{n}$$

where

Q is discharge (m<sup>3</sup>/second)

A = area of cross-section

R= hydraulic radius (A/P) where P is the wetted perimeter of the cross-section

S= flood slope

n = value assigned for channel/overbank hydraulic roughness (roughness co-efficient)

To use the equation, cross-sectional survey data of the river channel and the adjoining floodplain was necessary. Typically traditional survey methods using dumpy levels, theodolites and tape measures were used to survey the topography of channel and floodplain cross-sections at hydraulic control points.

###### During the 1980's and 1990's

The use of one dimensional hydraulic computer modeling to calculate water surface profiles along extended river reaches started to emerge around this time, one example being the HEC-2 model (Hydraulic Engineering Centre [1981]). It was a computer-based application of Bernoulli's theorem utilizing Manning's equation for the friction head loss between cross-sections and adopting the Standard Step Method of calculation. It was widely used in Australia at the time by public authorities and consultants to determine design flood levels for the management of floodplains.

For one dimensional models the floodplain topography is defined by a series of surveyed cross-sections across the channel and floodplain, at right angles to the direction of the flood flow. Values of the hydraulic roughness coefficient are assigned to the main channel and the right and left overbanks, each value being for the reach between successive cross-sections. Calculations start at a known downstream water level and proceed upstream, computing the water level at each successive cross-section.

The requirement for gathering large amounts of topographic information for computer models especially in remote areas where access is an issue resulted in traditional survey methods being supplemented by earlier remote sensing tools such as photogrammetry to map land

contours. The vertical accuracy of survey points as well as the speed at which topographic information was being gathered was becoming an issue.

#### **4.2 Some examples of what is being used at present (post the 1990's)**

Post the 1990's, a number of sophisticated two-dimensional (2D), floodplain models such as MIKEFLOOD, RMA-2, SOBEK, HEC-RAS and TUFLOW became available on the market to accurately model flood behavior and the impact of floodplain development.

The use of these models which solve the hydraulic Saint Venant equations in the X and Y direction provides a realistic representation of flood inundation pathways and extent using digital terrain models.. 2D models are developed by overlaying a 2-dimensional grid over a digital terrain model (DTM's) of the area to be studied.

There has been an industry trend to use remote sensing technology such as high resolution airborne LiDAR (Light Detection And Ranging) mapping to acquire DTM's. The benefits include the capture of large tracts of topographic data accurately and quickly when compared to traditional survey methods.

Further, the contribution and importance of advancements in flood surveillance/monitoring using oblique/vertical flood photography and satellite imagery for calibrating computer models has greatly contribute to improved floodplain management decision making.

### ***5. Conclusion***

The importance of advancement in the various forms of survey data, make it possible to undertake detailed hydraulic modelling of often very complex flood flow analysis in our inland rural floodplains. The ability to do so, results in formulation of accurate and appropriate floodplain management decisions for the community, both now and for future generations.



# An Object-based Approach to Vegetation Mapping in NSW



**Adam Roff**

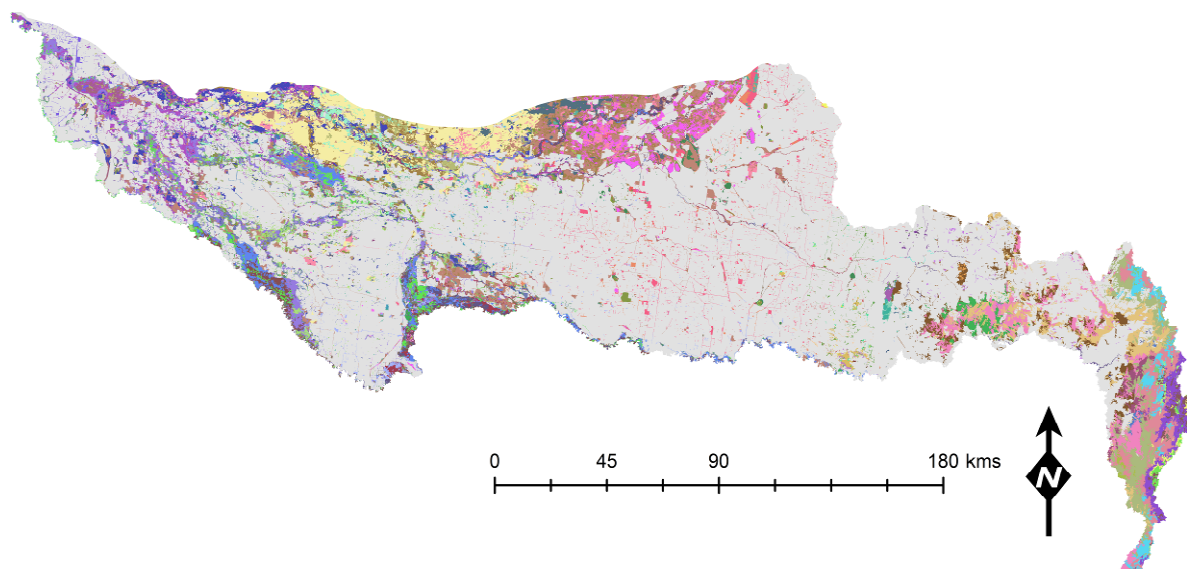
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*This presentation documents the creation of a vegetation map of the Murray Catchment and some work in progress in the Hunter Catchment. In the Murray Catchment, native vegetation was delineated into stands using feature recognition software. A hybrid classification method that combined spatial modelling and visual interpretation was used to combine the features and create a vegetation map.*

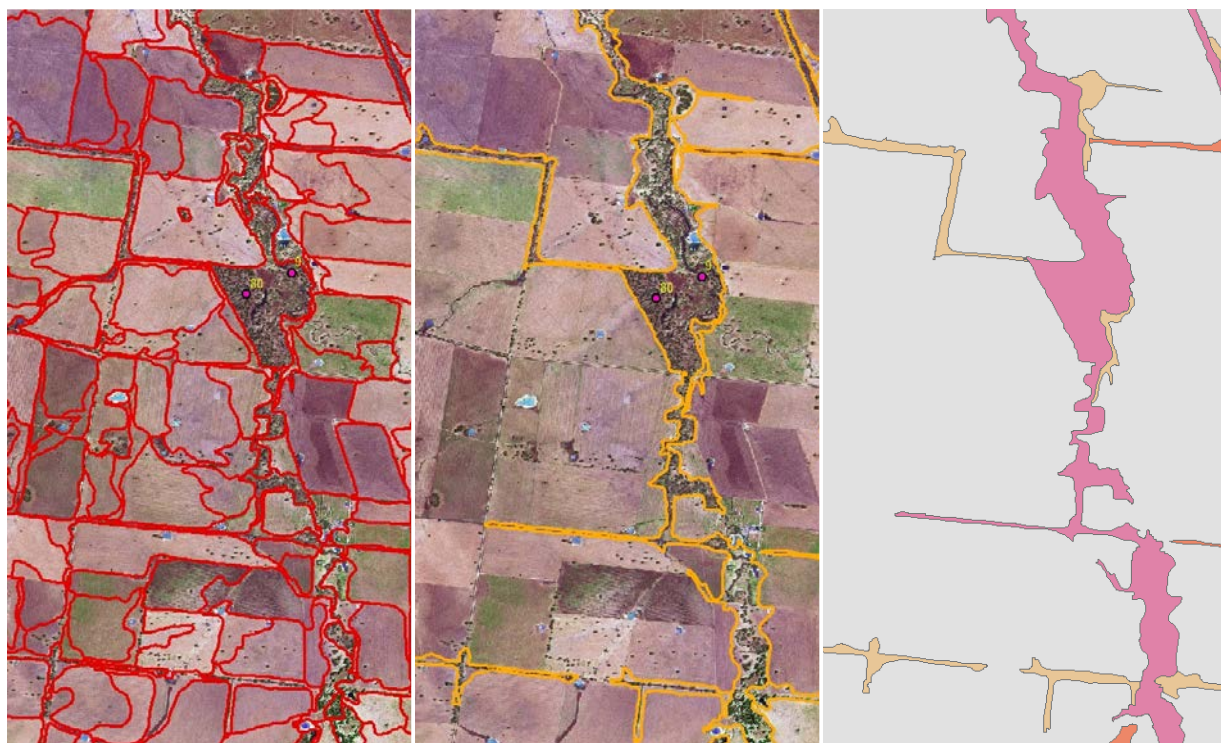


*Vegetation map from the 2010 MCMAA Vegetation Geodatabase Draft 5.0 (see Roff et al., 2010 for detail)*

Spatial layers used in the classification included a Digital Elevation Model (DEM), Landsat reflectance data, radiometric data and soil and climate layers, all of which are available for the entire State. The SPOT 5 satellite imagery was used in the creation of image objects but could not be used in the classification of vegetation type. The spectral response of individual SPOT 5 scenes varied too widely across the catchment. Over 340 new full floristic surveys were commissioned and the results were combined with 900 existing survey records to create training areas for spatial modelling. Each survey site was assigned a New South Wales Vegetation Classification and Assessment (NSWVCA) vegetation type.

The relationship between survey sites and spatial layers was explored by using machine learning software and vegetation type was classified by using an object-based nearest neighbour approach. The catchment was divided into three discrete spatial models with

separate training and validation survey sites. Model performance was assessed on the basis of the number of NSWVCA types mapped correctly in five classes of precision. The percentage of correctly modelled vegetation types ranged between 58% and 68%.



*Segmentation of SPOT 5 at 1: 10 000 scale over pan-sharpened SPOT 5 imagery. The image objects created in segmentation (left) were masked by landcover manually (centre) and then merged based on their classification (right).*

Several vegetation community types were not able to be modelled (e.g. chenopods) or were poorly modelled due to lack of sample data. These communities were added or amended based on the visual interpretation of remotely sensed data. The amended map was assessed against a limited subset of independent survey data. The percentage of correctly modelled vegetation types in five classes of precision ranged between 72% and 78%. The paucity of field data was the limiting factor in the accuracy and the detail of the vegetation mapping.

The use of feature recognition allowed for the rapid delineation of vegetation patterns. It produced a polygon layer that was flexible, enabling re-attribution and spatial edits. The project was constrained by software and hardware limitations in its early phase but was later aided by the grid-computing facilities of eCognition Server. Future projects can now be based on pan-sharpened SPOT 5 multispectral data and other high-resolution remote-sensing data, including lidar, at a catchment-wide scale. Further development is required to optimise the approach when using optical data in areas with high rainfall, in mountainous terrain and in open woodlands.

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# Subsurface Utility Engineering Standards Development



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*In 1991 the RTA formed a Utility Locations Unit in the Surveying Section to address the risk to the Authority in not knowing the precise location of underground public utilities. From that date, underground utilities have been surveyed during the design phase of a road project and again when road construction is about to commence. This enables the Authority to plan and cost the relocation of underground utilities, and also to provide assurance that underground utilities will not be struck during construction. The financial and OHS/WHs risks in this area of operation are very high.*

*In September 1999, the RTA won a NSW Excellence Award for its underground utility work, which was outlined in a submission called “Surveying Down Under”.*

*Acknowledgement both nationally and internationally of the importance of such work has led to a move for the development of an Australian Standard in this area.*

*Mark’s presentation today is on the development of an Australian Standard for the location and mapping of underground utilities, now called SUE – Subsurface Utility Engineering.*

## **The Development of an Australian Standard in Subsurface Utility Engineering (SUE)**

On 23 March 1977, the Institution of Surveyors NSW held a seminar on “The need for common standards in the recording and charting of underground services”. Its key recommendations recognised the need for:

- a central repository of work-as-executed plans,
- all mapping to be on coordinated grid system’
- common symbology
- standardised computer codes.

34 years later, we are about to commence work on these recommendations.

Admittedly, more vigorous action has been taken since a “wake-up call” on September 11, 2001. Asset owners now talk more about infrastructure protection, their vulnerabilities & risk and the value in accurate mapping and recording of their assets.

In 2006, the Surveying & Mapping Industry Council of New South Wales (SMIC) released an issues paper on ‘Underground Services Detection & Data’ (see [www.smicnsw.org.au](http://www.smicnsw.org.au)), recommending common accuracy standards for data capture of new or replaced underground utilities and as-built drawings to be lodged for new or replaced services. Also in 2006, RailCorp NSW supported its 2000 Australian Standard AS4799 *Installation of Underground Utility Services and Pipelines within Railway Boundaries* by publishing a Specification for the Collection of Services Data, specifying survey accurate 3D location for underground utilities.

In the following year, a GITA Workshop in Brisbane concluded that “*a national standard for recording the location of underground services is urgently required*” and “*critical infrastructure protection is a prime driver for recording the location of underground services*”.

In 2009, Main Roads Western Australia published Underground Utility Standard 67-08-121, based on the USA Standard ASCE 38-02. In the same year, the NSW Board of Surveying & Spatial Information (BOSSI) investigated current standards for recording underground services and made key recommendations concerning accuracy, absolute positioning, data capture methods, data quality, symbology and a common data exchange format.

At 9.30 pm on 15 September 2009, a contractor in the Sydney CBD accidentally cut through 10 Telstra fibre optic and copper cables. The final cost of the repair was \$800 million and resulted in an important change in State legislation. The cost of not knowing “where” was significant, and was a catalyst for the current work towards the development of an Australian Standard in the mapping and location of underground utility services.

SUE (Subsurface Utility Engineering) is an engineering process that combines surveying, civil engineering, geophysics and CADD/GIS. It provides more confidence in the reliability of data that defines the positional accuracy of underground public utility services. The SUE process has been incorporated in a USA Standard (known as ASCE 38-02) and a draft Standard in Canada. In the USA, a study sponsored by the US Federal Highway Administration (FHWA) found that approximately \$4.62 was saved in overall project costs for every \$1 spent on SUE.



Internationally, four quality levels have been adopted for the location and mapping of underground services:

- Level D: Document Search (eg Dial Before You Dig)
- Level C: Document Search *plus* investigation of surface features
- Level B: Document search, investigation of surfaces features *plus* using pipe and cable locators
- Level A: Document search, investigation of surfaces features, using pipe and cable locators *plus* confirmation by non-destructive digging (“pot-holing”).

An initial industry meeting was convened by Standards Australia on 10 May 2010, after representations from BOSSI, RTA and the private company Cardno. Some of the current encumbrances that need to be addressed by the proposed Standard are:

- Records of underground assets are incomplete and inconsistent.
- Current information from utility owners is of varying quality and accuracy.
- The position and significance of underground assets vary over time (“asset lifecycle”).
- Utility owners do not take responsibility for the accuracy of the information they provide.
- Not everyone can be accessed through DBYD.
- Lack of Interagency cooperation for infrastructure planning (placement, repair, renewal) – street openings.
- There is no standard approach to records sharing.
- Current locating technologies are not 100% effective.
- Significant variations in practices, approaches, attitudes and emphases.
- Ageing workforce and contracting out means “those who know” are no longer there.
- Some locators only mark services in the field and do not produce drawings.
- Lack of training and no education standards.

Commitments from various parties totalling \$70,000 to fund the development of the Standard have been raised. A Development Committee, comprised of national stakeholders, has been formed and includes representatives from Austroads, ALGA, ANZLIC, Australasian Railway Association, Roads Australia, Dial Before You Dig, Energy Networks Association, WSAA, IPWEA, NULCA, Australian Services Union, GITA, Streets Opening Conference, SSSI, University of New South Wales and the Heads of Workplace Safety Authorities. The committee first met on 21 March 2011, with Mark Gordon as Chair.

The work should take about 18 months to complete. Depending on the level of consensus within the Committee, the process should result in either a Guideline (at the very least) or an Australian Standard. The financial and OHS/WHs benefits of such a Standard are immeasurable.



# Are NSW Surveying Graduates an endangered species?

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## **Abstract**

*The state of New South Wales (NSW) has about 1500 Registered Surveyors of whom around 900 are active. The average age is in the mid-50s. Fryer (2008) identified that there are more Registered Surveyors aged over 60 than under 40. The recent development of BOSSI sponsored workshops has addressed this to a certain extent but the issue remains that not enough graduates are being produced by the two tertiary institutions in NSW to maintain a steady state of Registered Surveyors (Roberts, 2010).*

*A 4-year Bachelor of Engineering in Surveying qualification can be studied at the University of New South Wales (UNSW) in Sydney or at the University of Newcastle (UNewc) in Newcastle. A survey technician qualification can be studied at a Tertiary and Further Education (TAFE) campus in Sydney, Newcastle and Wollongong and can articulate into either of the University courses.*

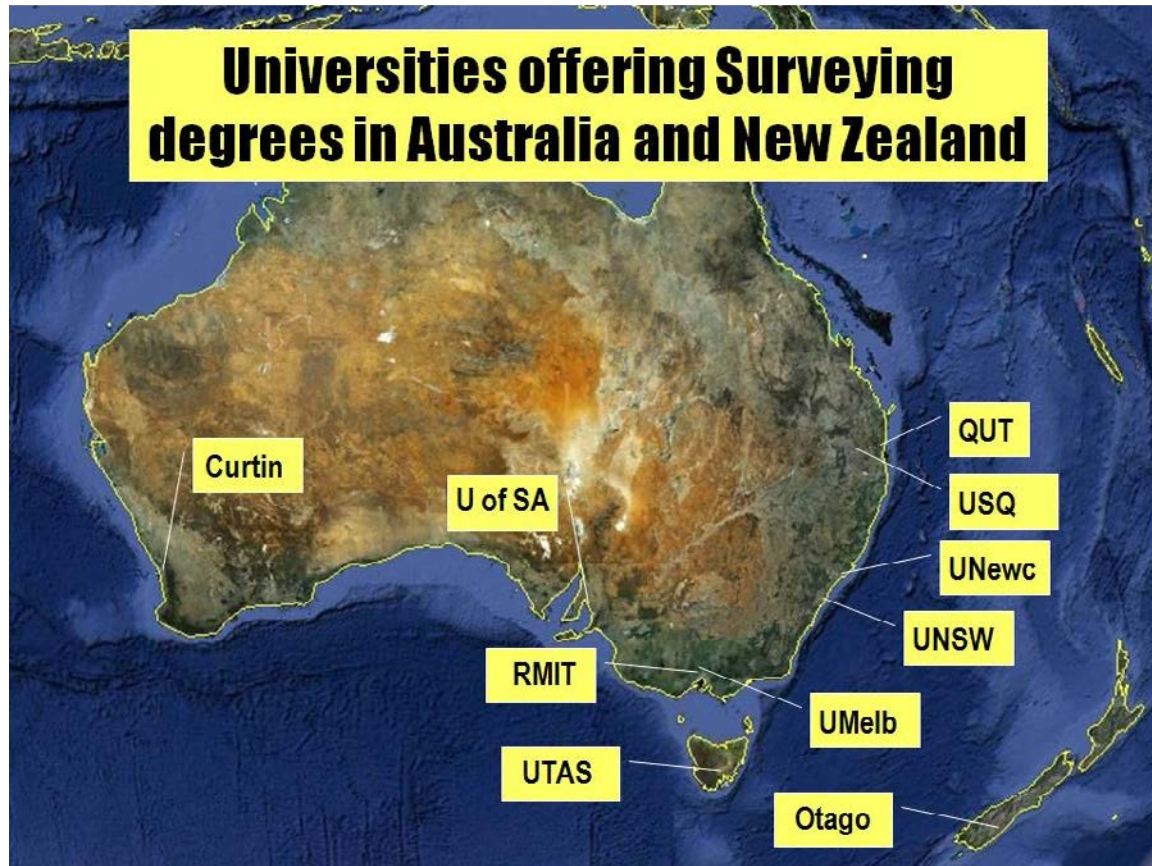
*A closer examination reveals that the TAFE institutions face increasing funding pressures, the UNewc will experience staffing issues in the near future and the declining numbers of undergraduate students at UNSW threatens the future of the school. Coupled with this, only one institution in Australia offers the Surveying degree by distance education and many students and companies are choosing this option despite the very high attrition rate.*

*This paper discusses the institutions that offer Surveying degrees leading to Registration or Licensing in Australia and New Zealand and their different circumstances and then focuses on New South Wales.*

*The author then argues against perceptions that study at UNSW is inaccessible or difficult and presents 10 reasons to encourage the profession to support their only Sydney-based tertiary institution.*

## ***Universities offering Surveying degrees in Australia/ New Zealand***

There are 10 universities offering Surveying education across Australia and New Zealand. Each course offers a specific focus and graduates finish with a range of qualifications such as Bachelor of Engineering (Surveying), Bachelor of Surveying, Bachelor of Applied Science (Surveying) etc.



**Fig 1** – Universities offering Surveying degrees in Australia and New Zealand

Some comments follow about each individual institution. The author has attempted to rank each institution from the most to least healthy. It should be stressed that labels such as healthy, endangered and threatened are terms adopted by the author and are purely anecdotal.

### **University of Otago**

This is the only university in New Zealand offering Surveying education. Students from first year compete to enter second year. Generally there are around 65 commencing students with around 50 graduates per year. This number has been steady for many years. Research is also conducted at Otago and overall the program is very healthy.

### **Curtin University**

Curtin experienced falling enrolments for a number of years but has reversed this situation about 5 yrs ago with a concerted promotional effort with support from industry and government. Nowadays their numbers are steady and they are producing 15+ graduates and this number is expected to rise. The mining boom is possibly a contributing factor. They are an independent school with a strong research culture and good ongoing industry/govt support. Consequently they are a healthy institution.



## **RMIT University**

The Victorian Task Force, made up of the educational institutions, government and industry, have funded a professional marketing company to develop the “Life without limits” campaign. This seems to have had a positive impact on the numbers of new undergraduate students. RMIT is also an active research institution and can also be classified as healthy.

## **University of Southern Queensland**

This is the only University to offer distance education. Indeed USQ have been doing this for over 20 years and do it very well. Distance education offers much greater flexibility for students with full-time employment and/or other commitments, however distance education is a long, lonely road and the number of students completing the degree is significantly less than those enrolled in the degree. There is very little research carried out at USQ, but the high enrolments would classify this as a healthy program.

## **University of Newcastle**

UNewc has experienced growing enrolments in the last few years. This can be partly attributed to a lowering of the entrance mark and perhaps partly due to increased marketing efforts by the ISNSW careers committee and the Hunter Manning group of ISNSW. The program is part of the Civil Engineering school, which is reflected in the emphasis on civil engineering courses in the program offered. However, the staff profile is ageing and there appears to be little succession planning within the University. The School also conducts little research. Despite good support from the profession (in particular the Hunter Manning Group), good undergraduate enrolments and a growing numbers of graduates, UNewc would have to be classified as endangered due to unclear succession planning.

## **University of Tasmania**

UTas has always had small numbers. A recent restructure has been unsettling for the school with some new staffing, but the new structure promises more stability despite the outlook of continued lower numbers of graduates. Universities these days are sensitive to small schools as they require more resources to educate a small student cohort, so for this reason only, UTas is classified as endangered.

## **University of NSW**

UNSW is one of the top four universities in Australia and is research intensive. The Faculty of Engineering is the largest, (and they promote themselves as the *best*) engineering faculty in Australia. For this reason the ATAR (Australian Tertiary Admissions Rank) imposed on the School of Surveying and Spatial Information Systems is the highest of all the schools offering surveying qualifications in the Australia/ New Zealand region. The school has recently also experienced falling enrolments, however the excellent research output of the school has insulated it from dramatic structural changes. It remains an independent school with its own budget. Despite a relatively young staff with diverse experience and good support from the Cumberland Group of Surveyors and ISNSW, it is perceived as “inaccessible” or “elite” and it is believed (no evidence) that students do not attempt to even apply for a place in the program. The low undergraduate numbers classify UNSW as endangered.

## **Queensland University of Technology**

At QUT, various internal structural changes have diluted the Surveying degree. There are few staff and the surveying degree is now offered within a school whose focus lies elsewhere. Nevertheless, the numbers remain small but steady and in recent years the Queensland industry has more strongly supported this program. 2011 enrollments are up. No research is undertaken and QUT is therefore classified as endangered.

## **University of Melbourne**

The Department of Geomatics at UMelb has been merged into the new Dept of Infrastructure Engineering and has, as a result, lost its independence as an autonomous school. UMelb is the only other research intensive university offering surveying education in Australia/New Zealand. In recent years there has been a massive restructure to a 3+2 model which has been imposed across the university. In short, students enrol in a generic degree and after 18 months must choose a major which maybe Geomatics. After 3 years there is an exit point, but it is not possible to progress and become Licensed at this point. A further 2 years (a so-called professional degree) is required (+2) which attracts full fees ie it is not HECS-based. Consequently it is still not clear how many students will enrol in the “+2” professional degree and with RMIT just 1 km away offering a 4 year HECS based program which leads to Licensing, it’s hard to see how UMelb will be able to offer surveying degrees leading to licensing in the future. For this reason it is classified as threatened.

## **University of South Australia**

The UniSA has also moved to a 3+2 model. The initial design offered little maths and physics in the first 3 years which would make the jump to the “+2” very difficult indeed. The local industry have stepped in and re-designed the 3 year offering and are also offering generous cadetships, funded through extra levies on plan lodgements (!), to encourage students to move into the professional degree. However SA is a small state, graduate numbers have always been small and there is no research conducted at all. These are all negative factors against the sustainability of a university program and for these reasons this program is classified as threatened.

## ***Institutions offering Surveying education in New South Wales***

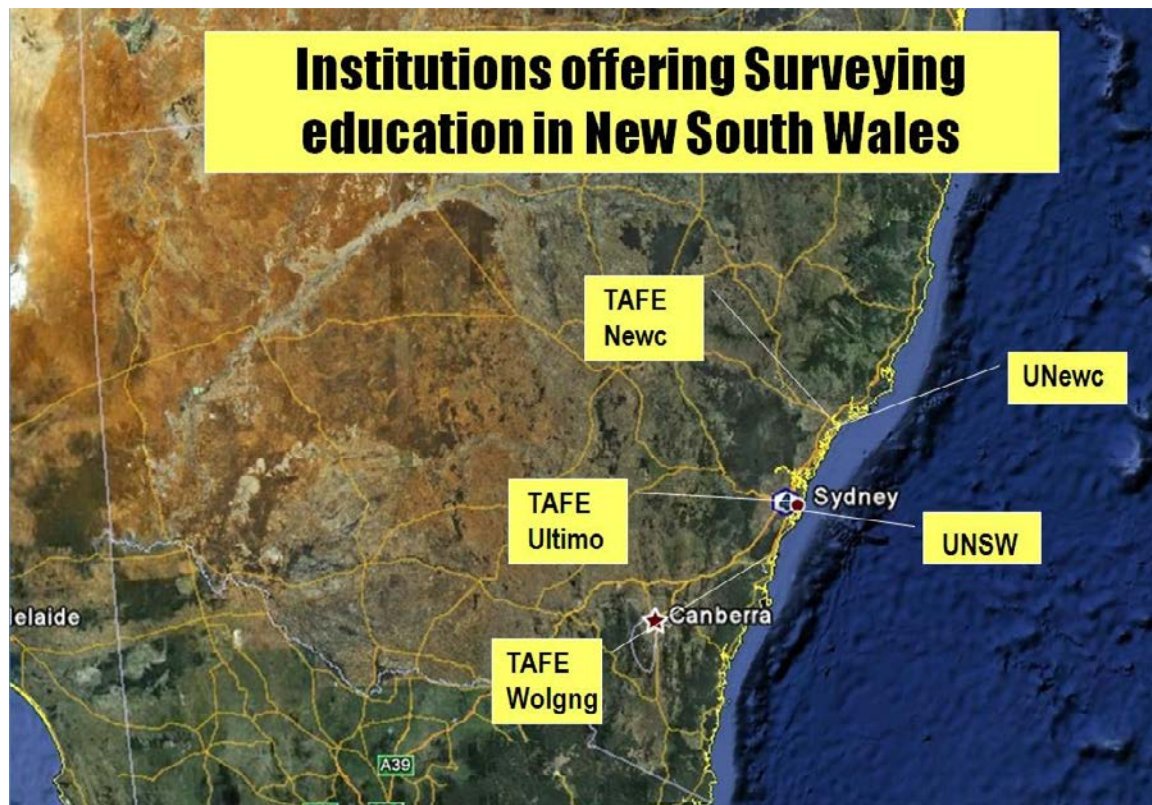
A 4-year Bachelor of Engineering in Surveying qualification can be studied at the University of New South Wales (UNSW) in Sydney or at the University of Newcastle (UNewc) in Newcastle. A survey technician qualification can be studied at a Tertiary and Further Education (TAFE) campus in Sydney, Newcastle and Wollongong and can articulate into both of the University courses.

### **TAFE**

The three TAFE institutions compete with each other for students. They receive funding from either a state-based source or a national source. The state-based funding is more generous and is received when the student enrolls, whereas the new National Traineeships are offered to encourage industry and government to upskill their staff at a registered training organization (RTO) such as TAFE. TAFE will only receive money upon completion of the studies and therefore takes all the risk. The monetary value is also less depending on the number of students and other factors (beyond the scope of this paper). In short the TAFEs in NSW have experienced continual funding cuts over many years which leads to issues such as:

- Old equipment and limited budget for replacement
- Retiring full-time teachers replaced with part-timers
- Tighter budgets
- Loss of young staff
- Sustainability under threat

Despite these tight conditions, the number of TAFE enrolments has actually increased in 2011 and the TAFE institutions have adapted to these tightening conditions. TAFE Wollongong have recently started offering distance education for a Cert III qualification, and are investigating a Cert II in schools to encourage school students to transfer to TAFE surveying. Even a postgrad certificate has been developed for career changers to address the skills shortage in Surveying. TAFE Ultimo have opened two new fulltime positions to replace the previous 4 fulltime positions from retiring teachers. They have also received a grant for new surveying equipment to aid their teaching. So despite the gloomy funding outlook for TAFE funding across NSW, the surveying school at TAFE Ultimo have received some good news in recent weeks. Enrolments are also up at TAFE Newcastle.



**Fig 2 – Institutions offering Surveying degrees in New South Wales**

High performing TAFE students can articulate into the degree programs offered at UNSW and UNewc and progress toward Registration in NSW. However with the pressures on the two universities in NSW to maintain their sustainability and with many NSW-based survey companies encouraging their staff to study by distance instead of locally, the future of the NSW surveying graduate is under threat.

### ***10 reasons to study a degree in Surveying at UNSW***

As stated above, UNSW is sometimes perceived as inaccessible or elite. The following section seeks to address these concerns and present UNSW as a flexible alternative for Surveying education in NSW. 10 Reasons are presented.

#### **Reason 1 – Two new programs**

The restructured Surveying program offers a new Surveying degree which leads to registration and allows more land management, cadastral surveying, town planning, engineering and mining surveying courses to be taken. Our new GeoInformation Systems degree includes about one third of computer science courses, and also focuses on GIS, spatial analysis, satellite imagery and earth observation.

#### **Reason 2 – We welcome TAFE articulators**

Apart from school leavers and “gap year” students, our largest intake is TAFE graduates, who we find to be well trained and committed students. All of our graduates who articulated from TAFE are now Registered Surveyors in NSW or approaching full registration. We offer 20 - 30% exemption from courses in our program and if structured correctly, students can finish



after 3 years of full-time study. We also offer mid-year entry into the programs. More recently we are in negotiation with TAFE to try to encourage those students keen on articulation to university to complete 3 unit maths during their TAFE studies. This is a pre-requisite for entry into the UNSW program and often a stumbling block for TAFE articulators. A clearer path for other exemptions is also being determined as part of this initiative.

### **Reason 3 – Flexible options for studying during session**

We recognise that most of our students work part-time, so we structure our timetable to allow at least one free day per week during the teaching session. Formal teaching comprises 2 x 13 week sessions face-to-face, plus exam periods. This allows at least 20 weeks full-time work per year, plus some part-time work during session. Students can also study part-time if that suits better. Mid-year entry is an option and we do offer some night lectures.

### **Reason 4 – Online resources**

All student notes are online, lecturers email regularly with students, assignments can be submitted by email and enrolment at UNSW gives students access to one of the best library resources in the country, accessible from your own home. Some courses are offered on “Moodle” which is the software used for distance education.

### **Reason 5 – Course material relevant to NSW**

Our Cadastral Surveying and Land Development courses cover material that is specific to the state of NSW, which facilitates easier progression through to Registration.

### **Reason 6 – On campus accommodation**

For students from rural and regional areas, the University now offers 1000+ extra beds on-campus for fully catered student accommodation. This accommodation is not cheap, but there are many rural scholarships available and many are not even used as students simply do not apply for them.

### **Reason 7 – Prestigious University with strong research record**

The Good Universities Guide rates UNSW as the top Faculty of Engineering in Australia and recently we were voted the best University in Australia for Learning and Teaching. Our School has Australia’s strongest research programs in Navigation and Earth Observation. We are engaged in worldclass research in GPS/positioning, InSAR, Earth Observation and have been funded to establish the new Australian Centre for Space Engineering Research. We have an enviable international research reputation. This international connection flows down to our undergraduate education and introduces students to cutting edge ideas which can fuel opportunities for their careers after graduation.

### **Reason 8 – More likely to finish in 4 years of concentrated study**

Undertaking full-time study, even if in a flexible structure where you choose how many courses you will do each session, is arguably the most efficient way of gaining a University education.

### **Reason 9 – Face-to-face learning offers a richer university education**

Distance Education is not offered by our School. We enjoy close links with the Surveying profession in NSW, provide a range of scholarships, and offer students opportunities to network with their peers and future employers. This is the great advantage of face-to-face learning over a Distance Education alternative. Students report that Distance Learning is lonely and requires enormous self-discipline and motivation. As a consequence there is a considerable attrition rate. Close contact of lecturers and fellow students starts friendships and

professional relationships that last a lifetime. Sydney is a world city and the student cohort from all backgrounds, nationalities and religions offers a truly diverse education which is important for the growth of our profession.

### **Reason 10 – Many alternate pathways offered for entry into our programs**

The ATAR entry score is ~ 90 (!), but becoming a great surveyor isn't just about doing well in the HSC exams. There are a number of "pathways" to entry for students with the right aptitude or background for work in these fields. In summary:

- 1) HSC+ gives students who choose 3 unit Maths and Physics "bonus points".
- 2) We interview students to profile their aptitude for Surveying or GIS under the Faculty of Engineering Admission Scheme (FEAS).
- 3) Students who haven't done the right courses, but are keen to enrol in our degrees can apply for entry to the Diploma of Engineering, Science and Technology (DipSET) with an ATAR of 80, and then transfer to our degrees upon its successful completion.
- 4) We typically accept TAFE Diploma graduates with a credit average or above.
- 5) The University also offers pathways for Mature Age entry.

### ***What has research ever done for us?***

UNSW is a research intensive university. However, the benefits of university research is not immediately obvious to industry.

CORS research was first developed at UNSW in the mid 1990s with network RTK algorithm development and combinations of observations from permanent GPS stations. This led to the development of SydNET and now CORSnet-NSW, with unquestioned benefits to the surveying community. Most of the CORSnet-NSW team were educated at UNSW.

Airborne LiDAR and radar remote sensing research conducted at UNSW and in partnership with the Land and Property Management Authority has been underway for almost 10 years. This work has produced deformation maps used by emergency management authorities in China in response to the Sichuan earthquake in 2008. Imagery produced by researchers in the school was also used to assist in efforts during the 2009 Victorian bushfires.

More recently, imagery for flood monitoring has been produced by the School's researchers in response to both the Victorian and Queensland floods. The response time from image acquisition to map production was 6 hours. Based on this success, a temporary ground receiving station will be located in Bathurst to improve data download times from orbiting satellites and, it is anticipated, will produce flood mapping products in under 2 hours.

The continuing work of researchers at Curtin University produced AusGeoid 93, AusGeoid98 and the new AusGeoid09 which will be ready for operational use to give GNSS users AHD heights in real time.

The initialisation algorithm used in Ashtech GPS receivers was developed by a PhD student from UNSW.

AUSPOS v2.0 is almost complete thanks to the efforts of a UNSW graduate. AUSPOS v2.0 will be of great benefit to many GNSS precision users, of which surveyors are the largest group.

The new Asia Pacific Reference Frame is being developed by Geoscience Australia. This is like a regional IGS network and UNSW along with Curtin University is an analysis centre.

This research culture exposes students to cutting edge, international developments in their discipline and pushes them to think beyond their undergraduate lectures, which in turn enhances the profession as these graduates take their places in the workforce. A research active school is of great value to the profession.

### ***Concluding remarks***

The number of institutions offering surveying degrees in Australia is probably too high. The style of graduate produced by the various institutions also differs. Some are practical, some are more theoretical or scientific, some focus on more on civil engineering, whilst others offer more GIS. Perhaps in order to survive, all institutions will need to identify their “niche” and provide graduates accordingly.

In NSW, it is fairly clear that TAFE diploma students are well trained and will become survey technicians, U Newc graduates are practical with skills in civil engineering, whilst graduates from UNSW have a more international degree, strong GNSS skills and given the top 4 status of UNSW, produce the future leaders of the profession.

Are NSW Surveying Graduates an endangered species?

If funding pressures at TAFE continue, if succession planning at U Newc are unresolved and if undergraduate numbers continue to drop at UNSW, then yes. NSW, the most populist state in Australia, with over 900 active Registered Surveyors will not have a local tertiary institution to support the profession.

This paper contends that the UNSW School of Surveying and Spatial Information Systems offers a premium degree with a diverse, highly-skilled and relatively young staff and despite the high ATAR, it is accessible to many school leavers, TAFE articulators and career changers.

It is hoped that members of the profession will encourage new students to apply to the School in an effort to sustain the surveying profession in NSW.

### ***References***

**Fryer (2008)** – Kurri Kurri presentation

**Roberts, C. & Iredale, I. (2010)** Promoting the Surveying Profession in New South Wales, Australia (3852), *FIG2010, Facing the Challenges- Building the capacity*, Sydney, Australia, 11 – 16 April.





# LIST OF ATTENDEES AT 28 MARCH 2011

Surname	First	Organisation	Surname	First	Organisation
Addison	Rob	Eurobodalla Shire Council	Doyle	Greg	Wyong Shire Council
Allen	Mark	Shoalhaven City Council	Draper	Colin	Survey & Instrument Specialists
Anderson	Chris	Dept Industry & Investment	Dubyk	Paul	EnergyAustralia
Athorn	Mick	RailCorp	Dunstall	Stephen	LPMA, LPI
Avery	Mark	EnergyAustralia	Dunstall	Bill	CDE Design Solutions
Baitch	George	LPMA, LPI	Dunstan	Rick	EnergyAustralia
Baker	Tony	LPMA, LPI	Durtanovich	Jim	City of Sydney
Baker	Grant	Blayney Shire Council	Dyce	Lindsay	Pittwater Council
Barnes	Craig	LPMA, CLD	Ellerton	Graeme	RailCorp
Barton	Paul	PHM Survey Equipment	Ellis	Dick	LPMA, LPI
Bartsch	Rayna	The Measurement and Positioning Company	Emmerick	Chris	C R Kennedy - Survey
Bartsch	Stuart	The Measurement and Positioning Company	Evans	John	Port Stephens Council
Begg	Don	Tattersall Surveyors	Evans	Craig	LPMA, LPI
Begg	Lynette	Accompanying Person	Evans	Gavin	ACT Planning and Land Authority
Belbin	Heidi	ACT Planning and Land Authority	Farrington	Roger	Private Surveyor
Bennett	Anthony	Usher & Robson	Fattore	Carlo	RailCorp
Bennett	Neil	Department of Environment, Climate Change and Water	Feeney	Steve	SJ Feeney & Assoc Pty Ltd
Berrisford	Simon	Usher & Robson	Fenwick	Wayne	LPMA, CLD
Birse	Bob	LPMA, CLD	Fielder	Gary	Fielder Instrument Company Pty Ltd
Bowler	Geoffrey	Cowra Shire Council	Filocamo	John	LPMA, CLD
Box	Russell	Ultimate Positioning	Finlay	Leigh	Sinclair Knight Merz
Brady	Alan	UTS	Ford	Andrew	CAD Consulting
Bray	Ed	retired Dept Commerce	Foster	Greg	LPMA, CLD
Brown	David	RailCorp	Friend	Matthew	RailCorp
Bruhn	Norm	RailCorp	Gaggin	Graeme	RailCorp
Burbidge	Brian	Geoscience Australia	Gardner	Les	LPMA, LPI
Burge	Andrew	Whelans Insites Pty Ltd	Gilmour	Ray	RTA
Burgin	Peter	Ultimate Positioning	Glencourse	Stephen	LPMA, LPI
Burke	Martin	Brown Consulting	Gordon	Mark	RTA
Burke	David	RTA	Gore	Troy	EnergyAustralia
Burton	David	Aspect Development and Survey	Grbevski	Kris	DECCW
Butler	Mark	Parsons Brinckerhoff	Griffiths	Bob	Griffiths & Associates
Buttsworth	Mark	Tablelands & Buttsworth Surveyors	Grinter	Thomas	LPMA, LPI
Cadogan	Keith	Retired	Groves	Glendyn	B W Esler & Associates
Cannings	Jarad	NSW Public Works	Hammer	Murray	RailCorp
Carr	Pat	AWT Survey	Hansen	Ross	Parramatta City Council
Carter	Trevor	ADW Johnson	Harcombe	Paul	LPMA, LPI
Carter	Andrew	LPMA, LPI	Hartzenberg	Pierre	Hard & Forester Pty Ltd
Casey	Tom	Casey Surveying and Design Pty Ltd	Harvey	Malcolm	ADW Johnson
Cassidy	John	LPMA, LPI	Higgs	Charlie	TAFE
Catzikiris	Jamie	Upper Hunter Shire Council	Hine	Simon	Voerman & Ratsep
Chia	Liang	Sydney Catchment Authority	Hopson	Matthew	LPMA, LPI
Chidzey	Ross	RailCorp	Horn	Geoff	DECCW
Clarke	Thomas	Retired	Huebner	Thorston	Zenith Surveys
Clifford	Gary	RailCorp	Hurcum	Bert	LPMA, CLD
Commins	Russell	LPMA, LPI	Hurcum	Michele	Accompanying Person
Conway	Christopher	Conway Burrows & Hancock	Hutchison	Chris	C R Hutchison & Co Pty Ltd
Cooper	Barry	B & G Surveying Pty Ltd	Hutchison	Diana	Accompanying Person
Cornish	Peter	Hard & Forester Pty Ltd	Iredale	Ian	Mapsoft
Corry	Paul	City of Sydney	Janssen	Volker	LPMA, LPI
Cox	Glenn	Lockley Land Title Solutions	Job	David	LPMA, LPI
Craig	Marcel	Conway Burrows & Hancock	Johansen	Walter	ACT Planning and Land Authority
Cram	Patrick	TAFE - Ultimo Sydney Institute	Jones	Ian	RailCorp
Dews	Ian	LPMA, LPI	Jones	Glenn	LPMA, LPI
Dickson	Greg	LPMA, LPI	Jung	Steve	Aurecon
Donaldson	Barry	Wagga City Council	Kelahr	Jon	LPMA, LPI
			Kelly	David M	Ballina Shire Council
			Kennedy	Daniel	LPMA, CLD
			Kent	Brian	Kent Gilbert & Associates
			Kilpatrick	Grant	RTA

<b>Surname</b>	<b>First</b>	<b>Organisation</b>	<b>Surname</b>	<b>First</b>	<b>Organisation</b>
Kinlyside	Doug	LPMA, LPI	Rigelsford	Andrew	RailCorp
Kitson	Bill	After Dinner Speaker	Rizos	Chris	UNSW, School of Surveying
Kocoski	Michael	Blue Mountains City Council	Roberts	Craig	"φ -33° 55' 03.7"" λ 151° 13' 53.0"" - UNSW, School of Surveying"
Lahood	Robert	LPMA, LPI	Robson	Daren	Usher & Robson
Lander	Bob	Tattersall Surveyors	Roff	Adam	DECCW
Lang	David	RailCorp	Rolls	John	Meadows Consulting
Leach	Mitchell	LPMA, LPI	Rose	Tony	Tony Rose Surveying Pty Ltd
Leggatt	Geoff	Hornsby Shire Council	Rumble	Dave	Retired ex Pacific Power
Lemon	Richard	Sinclair Knight Merz	Rumble	Sandra	Accompanying Person
Lenton	Geoffrey	RTA	Sadler	Daniel	LPMA, LPI
Lewington	Lou	Private Practice	Saunders	Stephen	NSW Public Works
Lewsam	Darren	Newcastle City Council	Seale	Baxter	LPMA, LPI
Liddell	Mitch	Tweed Shire Council	Sledge	David	Eurobodalla Shire Council
Livingstone	Greg	City of Sydney	Smith	Phillip	Nambucca Shire Council
Lock	Robert	LPMA, LPI	Smith	Matthew	Craven, Elliston & Hayes
London	Michael	LPMA, LPI	Smith	Darryl	AWT Survey
Long	Adam	Transgrid	Smith	Peter	DECCW
Longhurst	Steve	City of Sydney	Songberg	Geoff	LPMA, CLD
Lutton	Col	Tweed Shire Council	Spiteri	Michael	Bathurst Regional Council
Markham	Bob	Transgrid	Stankiewicz	Czeslaw	Parramatta City Council
Martin	Alf	RW Martin & Assocs	Steuart	Phil	Dept Industry & Investment
Masters	John	NSW Public Works	Stewart	Graeme	LPMA, LPI
McAnespie	Andy	LPMA, CLD	Sutton	Stephen	Blacktown City Council
McCulloch	David	JBW Surveyors Pty Ltd	Tesoriero	Peter	LPMA, LPI
McElroy	Simon	LPMA, LPI	Thomas	Warren	LPMA, SPA
McGrath	Peter	LPMA, LPI	Thompson	Kevin	LPMA, CLD
McIlwaine	Greg	Retired from PWD	Thompson	Nathan	C R Kennedy - Survey
Mckenna	Jodie	Accompanying Person	Tooby	Les	Private Surveyor
McNiven	Scott	Scott McNiven & Associates	Tucker	Brian	UTS
Miller	Bill	LPMA, LPI	Turner	David	ADW Johnson
Mitchell	Geoff	Private Surveyor	Usher	Andrew	Usher & Robson
Mocicka	Andrej	Listech Pty Ltd	Veersema	Adam	Usher & Robson
Monk	Greg	Barnson	Vollmer	John	JJ Vollmer
Morrison	Mark	LPMA, LPI	Wadley	Scott	LCPL
Moss	Owen	LPMA, LPI	Wady	Vaughan	EnergyAustralia
Moss	Peter	AWT Survey	Watkins	Dean	LPMA, LPI
Naebkhil	Sam	RailCorp	Waud	Michael	NSW Public Works
Najjar	George	G&R Surveying Services	Wearne	Rodger	Transgrid
Nedelkovski	Peter	LPMA, LPI	Webb	David	Transgrid
Neilson	Ian	Sinclair Knight Merz	Webb	Richard	Private Practice
Nilon	Peter	RailCorp	Wells	Phil	Newcastle City Council
Ogden	Paul	Contech	White	Adrian	LPMA, LPI
O'Kane	Peter	LPMA, LPI	White	Craig	Rutherford Group
Ortiger	David	Voerman & Ratsep	Wilkinson	Paul	RailCorp
Ozdemir	Selin	City of Sydney	Wilkinson	Peter	Gosford City Council
Pâquet	Robert	Dept Industry & Investment	Wood	Keith	KH Wood Surveyor
Paterson	Graeme	Blue Mountains City Council	Wormald	Geoff	LPMA, LPI
Petrow	Alex	ACT Planning and Land Authority	Yan	Thomas	LPMA, LPI
Pettit	Gregory	Usher & Robson	Yates	Kerin	LPMA, LPI
Plokstys	Richard	RailCorp	Coleman	Chris	Private Practice
Poidevin	Michael	Shoalhaven City Council	Gordon	Allan	NSW Maritime
Porter	Neil	State Water	Gilkes	Simon	LPMA, Deputy GM, LPI
Powell	Lisa	LPMA, LPI	Haasdyk	Joel	LPMA, LPI
Pritchard	Rob	EnergyAustralia	Gowen	Brian	Private
Ragen	Peter	LPMA, CLD			
Ratsep	Margus	Voerman & Ratsep			
Ratsep	Melanie	Accompanying Person			
Rawling	Stephen	Sydney Catchment Authority			
Reddington	John	C R Kennedy - Survey			
Reed	David	Shoalhaven City Council			
Rees	David	RailCorp			
Rhynehart	Keith	Land Surveyor			
Riddell	Matthew	EnergyAustralia			