

## Locating the Flag Staff at Bathurst

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### ABSTRACT

*The Bathurst Flag Staff was erected on Friday, 5 May 1815. On Sunday, 7 May 1815, the British Union Jack was ceremoniously raised and the Town of Bathurst proclaimed. 200 years later, Bathurst Regional Council proposes to replicate the Flag Staff as an integral event in its bicentenary. But where was the Flag Staff? Because doubt existed, it was put to surveyors (who else?) to locate where it originally was. The geographical position officially stated in 1815 places the Flag Staff about 4 km east of the actual position. Although relatively precise for its time, this discrepancy led to a fascinating journey of historic and scientific discovery looking at the unchanging certainty of the celestial sphere and the uncertain determination of absolute position on the ground. This paper looks at the advances in the determination of the absolute geographical position of the Bathurst Flag Staff over the last 200 years, with regard also to the position of Sydney upon which the geographical position of Bathurst (and towns elsewhere in New South Wales) was initially based. The Flag Staff was also the official surveyed base point, reference mark or origin for the setting out of the proposed Town of Bathurst and for the exploration and survey of the Central and Western Districts of New South Wales. This paper looks back at original survey plans and retrospectively determines the position of the Flag Staff from these plans and the present occupations of the Town of Bathurst originally set out from the Flag Staff. It finds that an undated, unacknowledged and unsubstantiated rock cairn with a brass plaque purporting to be “the exact location of the Flag Staff” is not where it should be. This paper sets out the surveying methodology used to determine where it should be, with surprising precision.*

**KEYWORDS:** Bathurst, Flag Staff, location, history.

### 1 INTRODUCTION

The Town of Bathurst was proclaimed by Governor Lachlan Macquarie at the Flag Staff on Sunday, 7 May 1815. However, the subsequent purpose of the Flag Staff was to provide a reference mark for aligning the town blocks of Bathurst and for a point of commencement for exploration of the inland of New South Wales (NSW). The Flag Staff was unique, and as a reference mark it predates the 1818 Macquarie Obelisk in Macquarie Place, Sydney, used as the origin for road distances in NSW.

The 2015 Bicentennial Bathurst Flag Staff is to be erected centrally on a concrete slab concourse over an existing rock cairn to commemorate the proclamation of Bathurst. The relocated, unsubstantiated and undated rock cairn and brass plaque purports to be the site of the 1815 Flag Staff. However, the actual re-determined Flag Staff site is about 5.4 m closer to town. This paper contends that this actual position should be acknowledged to commemorate the equally if not more important location and surveying context of the Flag Staff.

## 2 STATED POSITION IN 1815

The dispatch by J.T. Campbell, Governor Macquarie's Secretary, on "Macquarie's First Tour beyond the Blue Mountains 10 June 1815" quotes: *"The site designed for the town of Bathurst, by observation taken at a flag-staff, which was erected on the day of Bathurst receiving the name, is situated at lat. 33°24'30" south, and in long. 149°37'45" east of Greenwich, being also about 27½ miles north of Government House in Sydney, and 94½ west of it bearing west 20°30' north 83 geographic miles, or 95½ statute miles, the measured road distance from Sydney to Bathurst being 140 English miles."*

In this context, the following should be noted:

- Conversion factors: One geographic mile is 1' arc along the earth's equator and 1.8553 km. One nautical mile is 1' arc along a great circle of the earth and 1.852 km. (These were mainly used in sea navigation.) One statute mile, also known as English mile, is 1.609344 km. This is also 1,760 yards, 5,280 feet and 80 chains. As with chains and links (1/100 chain), statute/English miles were commonly used in land measurement.
- Conversion of the stated distances to metric: 27½ miles = 44.257 km, 94½ miles = 152.083 km, 83 geographic miles = 153.99 km, 95½ statute miles = 153.692 km, 140 English miles = 225.3 km.

It is not known why it was necessary to cite geographic, rectangular and polar coordinates as they are mathematically inconsistent and imprecise ( $\pm \frac{1}{4}$  mile or 400 m, see section 5), but it does tend to emphasise the location and position context of the 1815 Bathurst Flag Staff.

## 3 SURVEYING METHODS AND INSTRUMENTS

### 3.1 General

Whitehead (2003, 2004) describes Surveyor General John Oxley's 1817 and 1818 expeditions, providing an excellent account of the surveying methods and instruments of the time. The surveying instruments and methods used differed according to their purpose.

### 3.2 Land Surveying and Dead Reckoning

Compass or circumferentor and Gunther's chain were used in land surveying where the primary task was to dimension grants of portions and allotments as located on the ground. The natural boundaries, pegged corners and blazed lines formed the boundaries and these prevailed over the dimensions that described them. Bearings were referenced to Magnetic North and distances were in chains. Origins and azimuth were connections to existing surveys and the Bathurst Flag Staff was established for this purpose.

Dead reckoning uses land surveying methodology to determine absolute or geographical position for exploration and mapping. A compass/circumferentor and chain traverse was converted to geographical position by the following steps:

1. Summed into latitudes (N+, S-) and departures (E+, W-).
2. The bearing and distance were determined.
3. This was then adjusted for magnetic deviation to True North.
4. The Eastings and Northings were determined.

5. These were then converted to arc (i.e., in this instance, one chain = 1.53'' of latitude and 1.284'' of longitude).
6. Finally, they were added to known geographic coordinates to determine the new position sought.

### **3.3 Astronomical Observations**

A second method used was astronomy, which had its origins in navigation practice where astronomical observations are taken using (then) a sextant, nautical tables and complex mathematics to determine True North, compass deviation from north, and mean solar time, latitude and longitude relative to Greenwich.

The observation used were:

- Amplitude observations (mean between sunrise and sunset).
- Double altitude observations (hour before and after noon).
- Altitude observations of the sun at noon.
- Lunar distances (angles between the moon and the sun or any of nine recorded stars). A Vernier sextant of the time could be read to 0.1' with an experienced observer having a precision of ¼' or 15'' being about 400 m in latitude. Longitude by lunar distances could be anything up to 23 km out.

### **3.4 Astronomical Observation and Chronometer**

The third method used a chronometer. This was used to determine the difference in time between local mean time at the point of observation and Greenwich. It much depended upon the reliability and treatment of the chronometer and its calibration, in this instance, the longitude of the time signal. A difference of 1'' in time is 15'' of arc or about 400 m.

## **4 THE LATITUDE AND LONGITUDE OF SYDNEY**

The story behind the determination of the latitude and longitude of Sydney is one of patronage, unreliability, officialdom, and the improvement of precision over time. When considering the geographical position of the Bathurst Flag Staff, if Sydney's position was imprecise, Bathurst was likely to be also.

### **4.1 The First Fleet and Lieutenant William Dawes**

When the First Fleet arrived in Sydney, one of its first tasks was to determine its latitude and longitude as a reference point for future navigation. The first observatory was set up in July 1788 at Dawes Point (near the southern end of the Sydney Harbour Bridge). Lieutenant William Dawes of the Royal Marines, a competent astronomical observer, undertook the observations. He used instruments provided by the Board of Longitude and the Astronomer Royal, Rev. Nevil Maskelyne, including an astronomical quadrant, two telescopes, a Hadley's sextant by Ramsden, two thermometers and a barometer. Also, importantly, he used a nautical almanac (first published in 1767), an astronomical clock by John Sheldon, and the Kendall No. 1 Marine Timekeeper (K1) made famous by Captain James Cook on his last two voyages.

Even though there were special instructions that the K1 chronometer had to be wound at noon every day, this was forgotten when it was transferred from the *Sirius* to the *Supply* at Cape

Town. It had run down and had to be reset by Dawes. When the First Fleet arrived at Sydney, Dawes had to determine the position of Sydney relative to Greenwich time by (1) Chronometer and by (2) the lunar distance method, a complex method championed by the Astronomer Royal.

#### 4.2 Observations for Longitude from Dawes Point

The following observations were made (Figure 1):

- 1788 Dawes determination (1): The observatory at Dawes Point was then determined at latitude 33°52'30" S and longitude 151°19'30" E (being 10h 05m 18s east of Greenwich). This is 0°06'55" east of the actual location, being about 11 km to the east (and 4 km out to sea off Dover Heights). The magnetic declination was determined at 7°54' E.
- 1788 Captain John Hunter's determination (2): Coincidentally, also in 1788, Captain John Hunter observed Dawes Point at latitude 33°51'50" S and longitude 151°13' E, just east of the present day Government House.
- 1803 Matthew Flinders' determination (3): Flinders observed Dawes Point at latitude 33°51'45.8" S, longitude 151°11'49.5" E (positioned in Darling Harbour). The magnetic declination was found to be 8°51' E.

Hunter's and Flinders' observations are significantly close to the actual position, but who was to say whose longitude was right? Dawes was a protégé of the Astronomer Royal, had instruments and tables provided by him and the Board of Longitude, and, importantly, had the apparent endorsement of both, so his position determination was adopted. (This, it seems, continued to be adopted for many years.)

This is especially relevant as chronometers and Sydney clocks were then set to the time ball and noon gun (and later, the one o'clock gun) at the Dawes Point Battery, based (now seen in hindsight) on Dawes relatively incorrect determination. Also, for convenience, and being the official determination, the noon / one o'clock gun based on Dawes determination probably continued to be used for setting chronometers, even after Karl Runker's precise determinations of latitude and longitude at Governor Brisbane's private observatory in Parramatta Park in 1821.

Sir Thomas Mitchell adopted the Parramatta Park determination for his expeditions and for his 1834 "Map of the Nineteen Counties" and would have noticed the position difference with Dawes when drawing his map. He also commented on his disparity with the Admiralty Chart positions when he reached the Bass Strait on his Third Expedition in 1836.

On 16 December 1824, Captain William Hovell of the Hume and Hovell Expedition believed he reached Western Port, as planned. Two years later the government decided to settle at Western Port but, based on Hovell's longitude, landed at Corio Bay instead, found the land unsuitable and had to abandon the settlement. Hovell's longitude was 80 km out of position.

An additional observation was made in 1840 (Figure 1):

- 1840 Surveyor Charles Tyers determination of the longitude of Fort Macquarie (4): His determination of longitude was 151°15'14" E differing by 0°02'54" and 4.5 km east of actual (151°12'20"). This resulted in part for the 141° E meridian border between Victoria and South Australia being set and marked about 3 km west of the meridian.

It is unknown when Dawes determination was discontinued and was replaced, and with what. The Dawes Point observatory itself had disappeared by 1795. The time ball was relocated to Fort Phillip / Signal Station (at the present-day Observatory site) in 1825, although Fort Macquarie (at the present day Opera House site) was apparently used from 1817 until when the Sydney Observatory was built in 1858. The one o'clock gun was relocated from the Dawes Point Battery to Fort Denison in 1906.

Additional observations were made from Sydney Observatory in later years (Figure 1):

- 1859 longitude (5) was determined at 151°14'59" E, located in the middle of Sydney Harbour, half way to the Heads – even with good equipment, astronomers were having problems 70 years later.
- 1883 (6), when time signals could first be transmitted to Sydney by cable from Greenwich, the determination of Longitude was 151°12'22" E.
- 1903, using both east and west cables from Greenwich, longitude was determined as 151°12'20" E.
- At Station "E" (7), used for trigonometrical surveys, longitude was determined as 151°12'23.1" E.
- In the 1986 edition 1:25,000 AGD66 Parramatta River topographic map, Observatory Hill, Sydney latitude was scaled at 33°51'39.5" S (200 m south of actual), longitude at 151°12'12.1" E (115 m west of actual) and magnetic declination (1980) shown at 12°12' E.
- In the 2002 edition 1:25,000 GDA94 Parramatta River topographic map (8), Observatory Hill, Sydney latitude was scaled at 33°51'34" S, longitude at 151°12'16" E, and magnetic declination (2002) shown at 12°36' E.

Table 1 summarises these geographical positions and their difference from the actual GDA94 position (also see Figure 1). It should be noted that the Greenwich Time Signal (GTS) pips by radio commenced in 1924. The longitude determinations for places like Bathurst were dependent on the Sydney longitude determination and, as mentioned earlier, these varied considerably over time.

Table 1: Determinations of the geographical position of Sydney.

No.	Determination	Method	Latitude (S)	Diff	Longitude (E)	Diff
1	1788 Dawes	Lunar distance	33°52'39"	+1'04" (1.9 km S)	151°19'30"	+7'14" (11.2 km E)
2	1788 Hunter	---	33°51'30"	-0'05" (150 m N)	151°13'	+0'44" (1.1 km E)
3	1803 Flinders	---	33°51'45"	+17.3" (300 m S)	151°11'49.5"	-0'26.5" (675 m W)
4	1840 Tyers	Chronometer	---	---	151°15'14"	+2'58" (4.6 km E)
5	1859	Astronomy	---	---	151°14'58"	+2'42" (4.18 km E)
6	1883	Time signal (cable)	---	---	151°12'22"	+0'06" (155 m E)
7	Station "E"	---	33°51'41.1"	+6.1" (190 m S)	151°12'12.1"	+0'03.9" (115 m E)
8	2002	---	33°51'35"	---	151°12'16"	---





Figure 1: Past determinations of the geographical position of Sydney.

## 5 THE LATITUDE AND LONGITUDE OF THE BATHURST FLAG STAFF

### 5.1 The Present Position of the Bathurst Flag Staff

The position of the Bathurst Flag Staff was re-determined, not from astronomical observations, but by the scaling of its plotted position from early surveys and then its relocation from survey evidence relative to the present layout of the City of Bathurst. The present 2014 re-determined position of the Bathurst Flag Staff was determined by Surveyor Michael Spiteri using Global Positioning System (GPS) technology to be at latitude 33°24'47.176" S and longitude 149°35'08.6526" E (GDA94). This is referred to in this paper as the *actual* geographical coordinate position for the comparison of historic determinations. The magnetic declination was 11°54' E (2009). The actual position of Sydney Government House (Bridge Street) is latitude 33°51'49" S and longitude 151°12'40" E (GDA94), and the bearing and distance between it and Bathurst is 288°17'36" and 158.796 km for actual polar coordinate comparisons.

### 5.2 The 1815 Official Position of the Bathurst Flag Staff

The 1815 official position is contained in a dispatch by J.T. Campbell, Governor Macquarie's Secretary (see section 2). Because the stated geographical coordinates and the stated distances vary significantly in themselves, it is the author's contention that the coordinates may have been viewed "by observation taken at a Flag Staff" by Oxley and that the stated dimensions were calculated from Evans' traverse. Otherwise, why were the differing distances stated? From the precision of the latitude and relative imprecision of longitude, it is assumed that the stated coordinates were based on lunar distance observations. Because the public notice of the Flag Staff event also refers to the road distance, it tends to support the contention that the stated distances were determined from Evans's traverse. Figure 2 illustrates the past determinations of the geographical position of Bathurst, which are discussed in the following sections.

### 5.3 Dead Reckoning Coordinate Dimensions: (1) in Figure 2

The stated Northing (latitude) is 27½ miles being 44.247 km, and the stated Easting (departure) is 94½ west being 152.05 km. The stated origin is Government House, Sydney, being determined at 33°51'49" latitude and 151°12'40" longitude (GDA94). Using Evans' coordinates, the position at Bathurst is latitude 33°27'51" and longitude 149°34'19", being about 5.6 km south of actual and 1.28 km west of actual. The longitude is surprisingly close considering the method used. Bearing and distance is 286°13'31" and 158.357 km, being 2°04'02" and (only) 440 m less than actual (see further comment on difference in magnetic variation below).

George William Evans traversed between Emu Ford and Bathurst from 13 November 1813 to 8 January 1814. Evans was a land surveyor and used a circumferentor and chain. His equipment list did not include a chronometer or a sextant. Evans had (and used) a circumferentor (essentially a compass with sighting vanes to read to the nearest degree) and two Gunther's chains to measure the traverse. All land surveys were on Magnetic North.

In calculating his coordinates, Evans had to adjust his traverse to True North. It is not known what magnetic variation was adopted by Evans, but it probably varied along his traverse at that time (1815) at about, say, 9°47' E at Sydney to 9°05' E at Bathurst. However, compared

to actual, Evans' magnetic variation is a surprising 2°04' less than it should have been; was Dawes' 1788 magnetic variation of 7°54' E adopted?

The connection between Sydney Government House and Emu Ford that is used in the coordinate calculation is also not known. However, the Surveyor General's Office maintained a 'charting map' on which additional survey information, as it became available, was plotted relative to the meridians and True North. Maybe it was scaled from this map.

#### 5.4 Stated (Polar) Bearing and Distance: (2) in Figure 2

This was stated as "bearing west 20°30' north 83 geographic miles, or 95½ statute miles", being 290°30' for 154 km (geographic) or 153.66 km (statute miles) providing ordinates of 53.8 km north and 143.9 km west. This position differs significantly with the before mentioned stated coordinate position (i.e. 9.6 km north-south and 8 2 km east-west) and is 4 km north and 6.9 km east of actual. It is 2°12' more and 5 km less than actual bearing and distance. Its basis, and why it was stated, is not known, and it is not very helpful.

#### 5.5 Stated 1815 Latitude and Longitude: (3) in Figure 2

The stated latitude (33°24'30") is very close to actual (33°24'47.18"), being about 590 m further north. This is indicative of the greater precision in sextant observations for latitude. The stated longitude of 149°37'45" is 4 km east or short of actual (149°35'09"), which, plotted today, is located east of Kelso and towards the Bathurst Aerodrome. Comparatively, Evans Easting is closer (being 1.28 km west), indicating greater precision by dead reckoning. Bearing and distance is 288°57'55" and 155.163 km, being 0°40'17" more and (significantly) 3.633 km shorter than actual.

Unlike Evans, Surveyor General John Oxley was a navy man and had a sextant and an artificial horizon. He requested a "timepiece" or chronometer in March 1815 and may not have received it by 5 May, when the Flag Staff was erected. Irrespective of this, he probably used lunar distances for his longitude determination (hence the imprecision).

Considering the methods used 200 years ago, and using a sextant for latitude determination and dead reckoning for longitude, the results are very close to actual. A major unknown is the difference with his longitude determinations then, and those two years later. Table 2 summarises the polar coordinate comparisons of the stated position of Bathurst.

Table 2: Polar coordinate comparisons of the stated position of Bathurst from Sydney.

No.	Determination	Bearing	Diff	Distance	Diff
1	Dead reckoning	286°13'30"	-2°04'	158.357 km	-440 m
2	Bearing & distance	290°30'	+2°12'	154 km	-5 km
3	Latitude & longitude	288°57'55"	+0°40'20"	155.163 km	-3.633 km
8	Actual	288°17'36"	---	158.796 km	---

#### 5.6 The 1817 Determination by John Oxley: (4) in Figure 2

In 1817, Surveyor General John Oxley located the Flag Staff at latitude 33°24'30" S and longitude 149°30' E. The latitude is the same as the 1815 determination. However, the longitude is significantly west, near Mount Stewart, at a distance of 7.9 km west, and not east, of the actual/present location. This means the distance between the 1815 and 1817 determinations of longitude is over 12 km, a more significant difference. Was this because he



used a chronometer in 1817? Was it set to the noon gun/time ball at Dawes Point and was this set to Dawes' longitude of 151°19'30"?

An interesting theory – see (5) in Figure 2 – is that Oxley's difference between Sydney and Bathurst is 1°41'30", i.e.  $151^{\circ}11'30'' - 149^{\circ}30' = 1^{\circ}41'30''$  according to Whitehead (2004, p. 21), which, when deducted from Dawes' Sydney determination of 151°19'30" gives a revised Bathurst longitude of 149°38'. This is almost the same as the 1815 determination of 149°37'30". Taking this further, 149°30' (see Oxley's 1822 chart) is 0°05'05" west of actual which coincides generally with the average difference of his longitudes (i.e. 0°08'10" west) with actual longitudes on his 1818 journey. Interestingly, Whitehead (2004, p. 58) suggests that he may have changed his Port Macquarie longitude to agree with a later (second) observation used when compiling his 1822 chart. Did he find Dawes' determination was 0°8' out and change Sydney as well?

### **5.7 The 1829 Determination by Mitchell: (6) in Figure 2**

Major (later Sir) Thomas Mitchell, Surveyor General, plotted the position of Bathurst (and, by location, the Flag Staff) on his 'Nineteen Counties Map'. Mitchell used his rapid mapping trigonometrical survey method – he wrote an army manual on the subject (Mitchell, 1827) and used it in the mapping of the 'Nineteen Counties'. He used measured baselines, theodolite triangulation between mountain tops and then, circumferenter and chain infill of detail. His origin of latitude and longitude was latitude 33°48'50.68" S and longitude 151°01'48" E being the centre of the transit at Governor Brisbane's Parramatta Observatory. He did not use Dawes Point or Dawes' values. His baselines were at Botany Bay and Lake George, with lesser bases at Mittagong and elsewhere for local purposes and as checks on adopted distances. His latitudes were based on sextant observations "on Peel River, at Newcastle, Warawolong, Lake George, Jumley (Lumley), and Kurradacbidgee."

Mitchell's Nineteen Counties Map has a constant scale between latitudes and differing scales between lines of meridians to allow for their convergence, thereby maintaining right angles between his parallels of latitudes and his meridians of longitude. From the plotted infill in the map by Surveyor James Richards in 1828-29, the Bathurst Flag Staff position scales at latitude 33°25'40" S and longitude 149°37'30" E. This is 1.6 km south and 3.67 km east of the 2014 and actual location of the Flag Staff.

It should be noted that the 1815 longitude (149°37'30" E), Oxley's 1817 determination, as revised (149°38') and Mitchell's 1829 determination (149°37'30"), using three different methods (lunar distance, chronometer and trigonometrical survey), are virtually the same. Yet they are all about 0°02'40" or 4 km east of actual... Why?

### **5.8 1985 Topographic Map Determination: (7) in Figure 2**

Using the 1:25,000 Bathurst topographic map (AGD66), the Flag Staff position was scaled at 33°24'52.7" S and 149°35'05" E, being 170 m south and 95 m west of actual.

### **5.9 2014 GPS and GDA94 determination: (8) in Figure 2**

Based on position plotted on early survey plans, the Flag Staff, as re-determined, was surveyed by GPS at (actual) latitude 33°24'47.176" S and longitude 149°35'08.6526" E (see section 5.1).

In conjunction with Figure 2, Table 3 summarises the determinations of the geographical position of the Bathurst Flag Staff.

Table 3: Determinations of the geographical position of the Bathurst Flag Staff.

No.	Determination	Method	Latitude (S)	Diff	Longitude (E)	Diff
1	1815 Evans	Dead reckoning	33°27'51"	+3'03" (5.6 km S)	149°34'19"	-0'50" (1.28 km W)
2	1815 -----	Bearing & distance	33°22'40"	-2'06" (3.7 km N)	149°39'39"	+4'31" (6.9 km E)
3	1815 Oxley	Lunar distance	33°24'30"	+17.3" (543 m S)	149°37'45"	+2'36.4" (4.03 km E)
4	1817 Oxley	Chronometer	33°24'30"	+17.3" (543 m S)	149°30'	-5'08.6" (8 km W)
5		(revised)	33°24'30"	+17.3" (543 m S)	149°38'	+2'51.3" (4.43 km E)
6	1829 Mitchell	Trig. survey	33°25'40"	-52.8" (1.63 km N)	149°37'30"	+2'21.4" (3.67 km E)
7	1985 AGD66	Map scaled	33°24'52.7"	+5.5" (170 m S)	149°35'05"	-3.65" (95 m W)
8	2014 GDA94	GPS survey	33°24'47.17"	---	149°35'08.65"	---

## 6 MAP PROJECTIONS, FIGURES OF THE EARTH AND GNSS

Map projections and the figure of the earth have varied with improvements in data, overseas mapping trends and mathematic calculation. Initially, Mitchell adjusted for the convergence of meridians and the maintenance of right angles between meridians and parallels of latitude by varying the scales between each parallel of latitude. In about 1858, the colonies of Australia followed the Ordinance Survey of Great Britain by using Clarke's geocentric 1858 figure of the earth and used Cassini-Soldner and Transverse Mercator projections. During the 1960s to 1990s, Australia adopted the Australian Geodetic Datum (AGD66) to determine the best fit with the continent. In the 1990s, with the advent of GPS, Australia reverted to a geocentric datum, the Geocentric Datum of Australia 1994 (GDA94), for the best fit for Global Navigation Satellite System (GNSS) observations (ICSM, 2009). The mapping projection for GDA94 is the Map Grid of Australia (MGA94), replacing the Australian Map Grid (AMG) but both are standard 6° Universal Transverse Mercator (UTM) projections used by all states and territories across Australia. The Surveyor General of NSW has also endorsed the use of a GDA94 Lambert Conformal Conic projection for state-wide Geographical Information System (GIS) data in NSW.

It should be noted that the GPS location is about 30° and 195 m from the location of the Flag Staff on the Bathurst 1:25,000 topographic map (1985). This is due to the change from AGD66 to GDA94, the latest determination of the figure of the earth so as to be compatible with GNSS technology. The Australian tectonic plate is moving NNE (about 22°30') at a rate of about 60 mm each year. It also rotates (J. Haasdyk, pers. comm.): the west coast (Perth, 70 mm/yr) is moving more than the east coast (Sydney, 57 mm/yr). Since the Bathurst Flag Staff was erected 200 years ago, it (and the Australian tectonic plate) is estimated to have moved about 11.7 m in the NNE direction.

While, in reality, the celestial sphere remains constant and the tectonic plate moves, for practical, legal and continuity reasons its position on the ground, on the Australian tectonic plate and GDA94, is fixed. For the same reasons, measurements and dimensions are ground (level) distance where they are measured and used rather than projection distances on MGA94. Similarly, the already established heights relative to the Australian Height Datum (AHD71 on mainland Australia) and AGD66 are used rather than GNSS ellipsoidal heights. For instance, all heights and contours shown on current GDA94/MGA94 topographic maps are referred to AHD71. In this regard, Bathurst has a geoid-ellipsoid separation of about 25.2 m, i.e. the AHD71 zero surface is located above the ellipsoid (J. Haasdyk, pers. comm.).

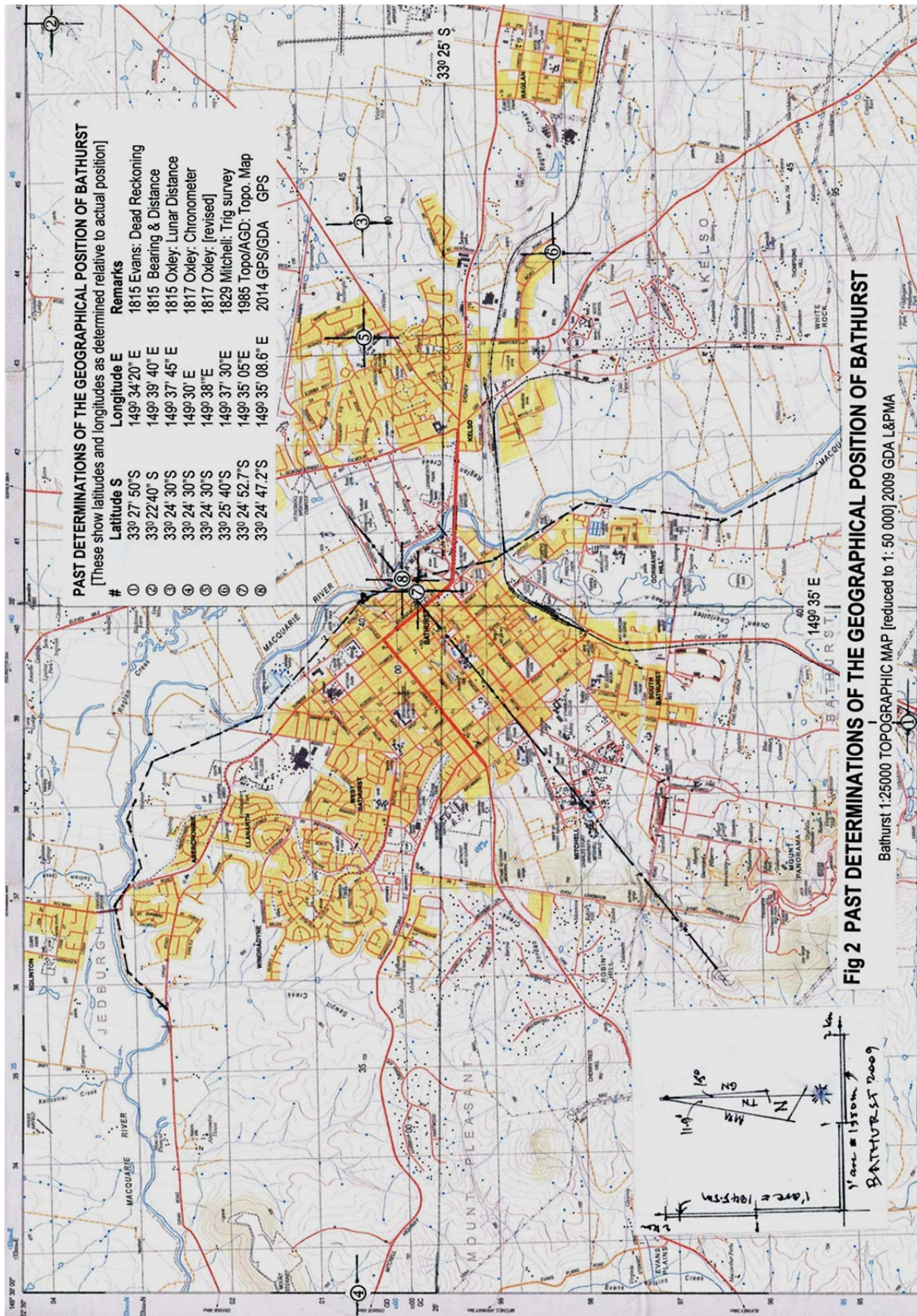


Figure 2: Past determinations of the geographical position of Bathurst.



Global GNSS users utilise a dynamic datum (International Terrestrial Reference Frame, ITRF) with moving tectonic plates, rather than a datum fixed to the tectonic plate such as GDA94. For instance, ITRF positions in Australia have already moved about 1.2 m in relation to GDA94 since 1994. This prompts the possibility of a revised Australian datum in the near future as GNSS precision becomes better and better and more precise data becomes available.

## **7 DETERMINATION OF THE LOCATION OF THE FLAG STAFF AT BATHURST**

There is obviously a disparity in the various Bathurst Flag Staff position determinations, which were obtained in many ways and affected by the evolution or refinement of surveying and geographical coordinate determination generally and in Australia. It is fascinating that, although its apparent purpose was for the determination of absolute geographical position, it is clearly evident that because of past imprecision and uncertainty, these determinations are practically useless in relocating the present-day position of the Bathurst Flag Staff. So, to re-determine its location, we must turn to surveyors and, especially, the forensic aspects of cadastral surveying.

### **7.1 Background**

Cadastral (registered) surveyors look back at past survey documentation, plans and marking in order to determine the present-day boundary position on the ground. In this instance, it certainly helped that the Flag Staff was the origin or reference point for the setting out of the Town of Bathurst. However, in the absence of survey field notes and survey dimensions, the method used to relocate the Bathurst Flag Staff was the correlation, by scale, of its position plotted on copies of the original or early survey plans. Four survey plans with the Flag Staff plotted on them from survey were used (Figure 3):

- SR1293 Evans (possibly 1815).
- Evans (possibly 1818).
- SR1294 Meehan (probably 1821).
- Mitchell (Town Plan 1833).

In the context of Figure 3, the following should be noted:

- Plans (a) and (b) show Governor Macquarie's town layout. Plan (d) shows Governor Darling's (and current) town layout.
- The scales of the plans were determined by the ratio of the town block dimensions, Plan (c) graphical scale, being divided by the actual scaled distance.
- The dimensions to the Flag Staff were determined by multiplying the actual scaled distances by the scale ratio.
- The Flag Staff dimensions were related crosswise to the centreline of the present-day town blocks between George and William Streets. Longitudinally, the distance to the SW side of Stanley Street was determined by deducting 362.1 m (18 chains) from the scaled dimensions to the SW side of Durham Street.

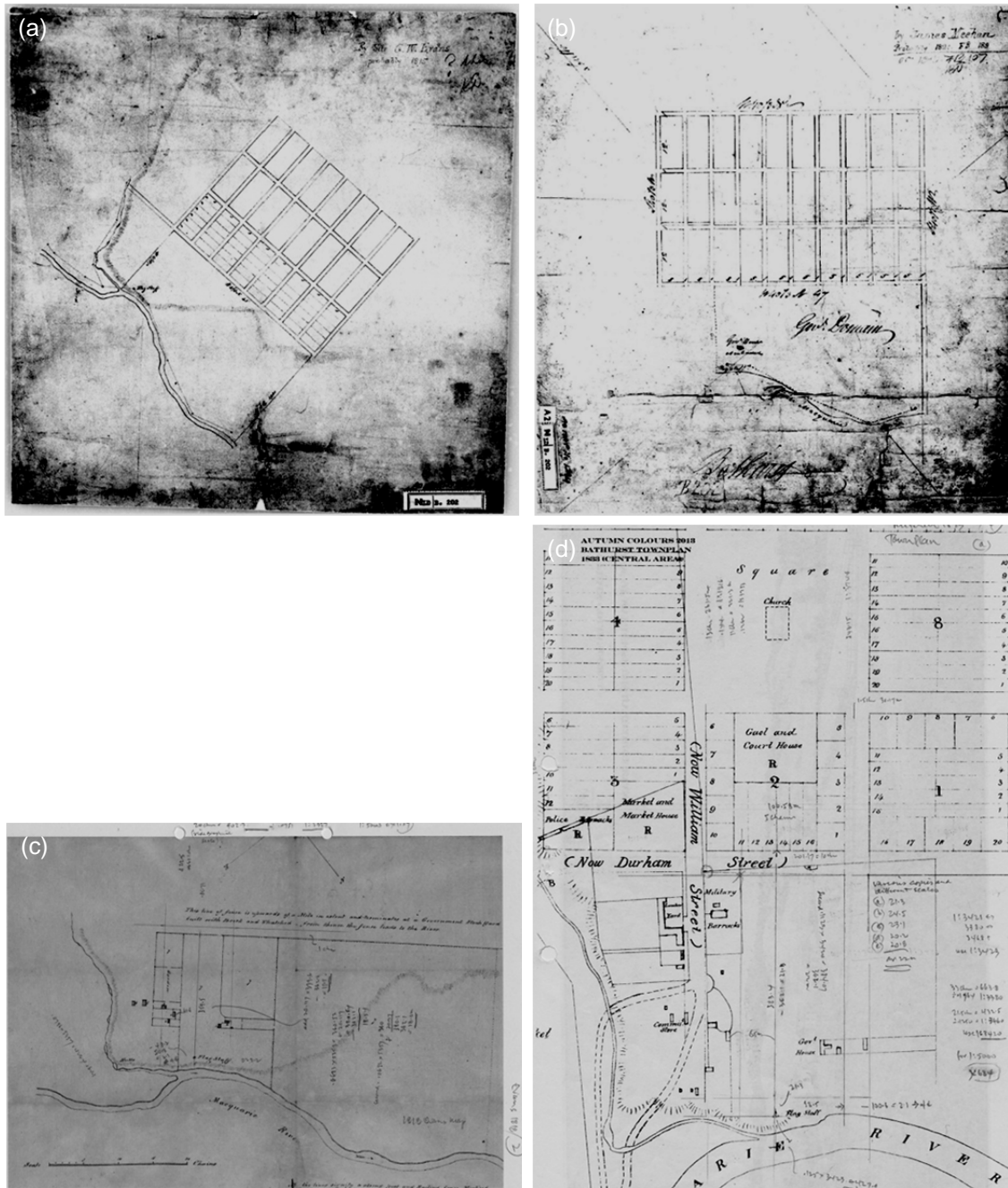


Figure 3: The four survey plans used in determining the original location of the 1815 Bathurst Flag Staff: (a) SR1293 Evans 1815, survey of Government Domain, (b) SR1294 Meehan (possibly 1821), survey of Government Domain, (c) Evans (possibly 1818), and (d) Mitchell 1833.

On 9 December 1813, Surveyor George Evans placed a survey traverse mark remarkably close to, if not on, the site on which the Bathurst Flag Staff was erected 1½ years later, on 5 May 1815. The Flag Staff is clearly shown on the traverse mark in the surveys by Evans and Meehan. This is connected by plot to the ‘Macquarie’ planned layout of Bathurst.

Initially, the Bathurst town layout had half-acre lots with one-chain frontages, 2½ chain depths, and roads one chain wide. This town layout was used by surveyors Meehan and Evans and is shown on their plans. The town blocks were 12 chains by 5 chains with 1 chain wide roads, i.e. 12 by 1 chain wide lots between side streets and 2 x 2½ chain depths, being five chains, between the longitudinal streets. The Surveyor General’s Office and Governor Macquarie had probably approved this town layout.



In Colonial NSW, a 3-step process was usually applied in the designing and surveying of early towns. The practice was:

1. The surveyor to undertake a feature survey of the town site and submit it to the Surveyor General's Office.
2. At the Surveyor General's Office, a town design was prepared.
3. This was sent back to the (or a) surveyor to set out the town.

It seems that this was done initially, as Evans and Meehan both plot the same Bathurst town layout. Subsequently, it is known that Governor Darling regulated a change in town layouts, and this is probably why Mitchell's 10 chain by 10 chain town blocks with 1½ chain wide roads replaced the previous layout. This is the 'Darling' and present Bathurst town layout. In order to compare the four surveys, it was necessary to identify anything common between the two different Bathurst town layouts. In the absence of any other features, the one common feature was the Flag Staff.

The Flag Staff was erected on Friday, 5 May 1815 and at the flag raising on Sunday, 7 May, Governor Lachlan Macquarie proclaimed "the erection of a town at some future period" to be named "Bathurst". However, while the Flag Staff was central to the later Mitchell town layout, the questions are:

- Was it also central (or not) to the initial Evans and Meehan Town Blocks? If so, which ones?
- Was there a common crossroad adopted in both town layouts? If so, which road? Which side? Was it 1 chain or 1½ chain wide from Evans' fence, or is it the centre?

## 7.2 Presumptions

In order to compare the surveys, it is necessary to correlate the initial Evans/Meehan/'Macquarie' town layout with the Mitchell/'Darling'/present town layout. Prompted by field discussions on 09/12/2013, and by the receipt of new copies of the survey plans, the layouts were compared using the common location of the Flag Staff and the centre of the town blocks generally. From this, the following three presumptions were then made.

*Presumption 1: The centreline of the 5 chain wide (initial) and 10 chain wide (present) town blocks between William and George Streets were projected from the Flag Staff.* The presumption is that the town of Bathurst was set out by Mitchell from this centreline. The centreline between Mitchell's 10 by 10 chain town blocks was correlated with the 5 chain wide town block layouts on the Meehan and Evans surveys. It was found that the centreline coincides precisely with the centreline of the third town block on Meehan's plan and the first town block on Evans's plans. Their (Evans, Meehan and Mitchell) location of the Flag Staff is on the extension of the centreline of these town blocks. This is indisputable. In a survey sense, this centreline could be termed an 'azimuth' used in subsequent surveys. Surveyor Michael Spiteri has recently re-determined the centreline of the William and George Street town blocks at the centre of Stanley Street and bearing 51°31' TN from the town.

*Presumption 2: The SW side of Durham Street is common to both town block layouts.* The fence shown on Evans' 1818 survey seems to form the NE boundary of Durham Street. However, this would then put the Flag Staff 1.4 chain (28 m) from the SW boundary of Stanley Street, contrary to all other evidence. Instead, it appears that it conformed with the initial (Macquarie) 1 chain wide road layout that was subsequently widened to the (Darling) 1½ chain wide road layout of Mitchell's plan and the current own layout. Therefore, it is presumed that the SW side of Durham Street must be common to both town layouts.

Presumption 3: *The SW side of Stanley Street was determined at 18 chains (362.1 m) from the SW side of Durham Street.* This was determined by original dimension, being the 16.5 chain town block depth plus the 1½ chain width of Durham Street. This was checked generally with Google Maps, which scaled at 364.5 m at George Street and 358.5 m at William Street, the average being 361.5 m. This confirms generally with the 362.1 m or 18 chains dimension adopted. The SW side of Stanley Street, bearing 141°52'30" TN, as redefined by Surveyor Michael Spiteri, becomes the legal abuttal for the redefined, relocated original site of the Flag Staff.

### 7.3 Scaling of Plotted Positions

The lack of stated survey dimensions from the SW side of Durham Street to the Flag Staff means that precision scaling and mathematical proportion must be applied to copies of the four survey plans by surveyors Evans, Meehan and Mitchell. The method applied is that used to determine and check scale ratios, dimensions and measurements on copies of plans and maps enlarged or reduced by computer and/or photocopying processes.

The probability of determining the most likely position of the Flag Staff is improved or enhanced by:

- Use of the oldest surveys. It should be noted that photocopies were used; scaling from the original survey plans would have given more certainty.
- Averaging the position from four plans of survey and their mutual validation.
- Averaging the position from surveys by the three surveyors.

However, this methodology has the following drawbacks:

- The comparatively small size and scale of the plans used and that one millimetre at 1:5,000 scale ratio (average scale of the plans) represents 5 m on the ground.
- The precision of the initial plot of the surveys.
- The use of copies of the originals and the variable paper and copier shrinkage/enlargement (e.g. the scale ratios of Mitchell's plan are 1:4,742 across and 1:4,785 lengthwise).
- The precision of the scaling in the determination of the plan scale ratios and the scaled distance (a number of scale readings were taken for averaging and as a check).

The method applied involves four steps (Figure 4):

1. Determining the scale ratio of the plan. This was calculated by dividing the stated or known dimensions of the town blocks, or the graphical scale on the plans, by their scaled distance. A 1:100 scale and a magnifying glass were used to read fractions of a mm, e.g. dimension 603.5 m (30 chains) divided by scaled measurement of 0.1433 m (143.3 mm) = 4,211, resulting in 1:4,211 scale ratio. This was repeated lengthwise and crosswise, weighted and averaged to, say, 1:4,220 in this example (SR1293).
2. Next, determining the distances/dimensions to the Flag Staff. The distances scaled from the plans were multiplied by the scale ratio of the plan, e.g. (a) crosswise, scaled distance, 0.0113 m (11.3 mm) multiplied by the scale ratio 4,220 = 47.7 m to Flag Staff, and (b) longitudinally, 0.0903 m (90.3 mm) x 4,220 = 381 m from the SW side of Durham Street to the Flag Staff.
3. Determining distance comparisons and differences. The scaled distances were compared with (crosswise) the dimension to the centreline, and (longitudinally) the dimension between the SW sides of Durham and Stanley Streets, e.g. (a) crosswise, 47.7 m – 50.3 m (2.5 chains) = +2.6 m being right of the centreline, and (b) lengthwise, 381 m – 362.1 m (18 chains) = 18.9 m from the SW side of Stanley Street.

4. Determining average or mean position. The distances from the Flag Staff to the centreline and to the SW side of Stanley Street were averaged to determine the best fit as to where the Flag Staff was originally located.

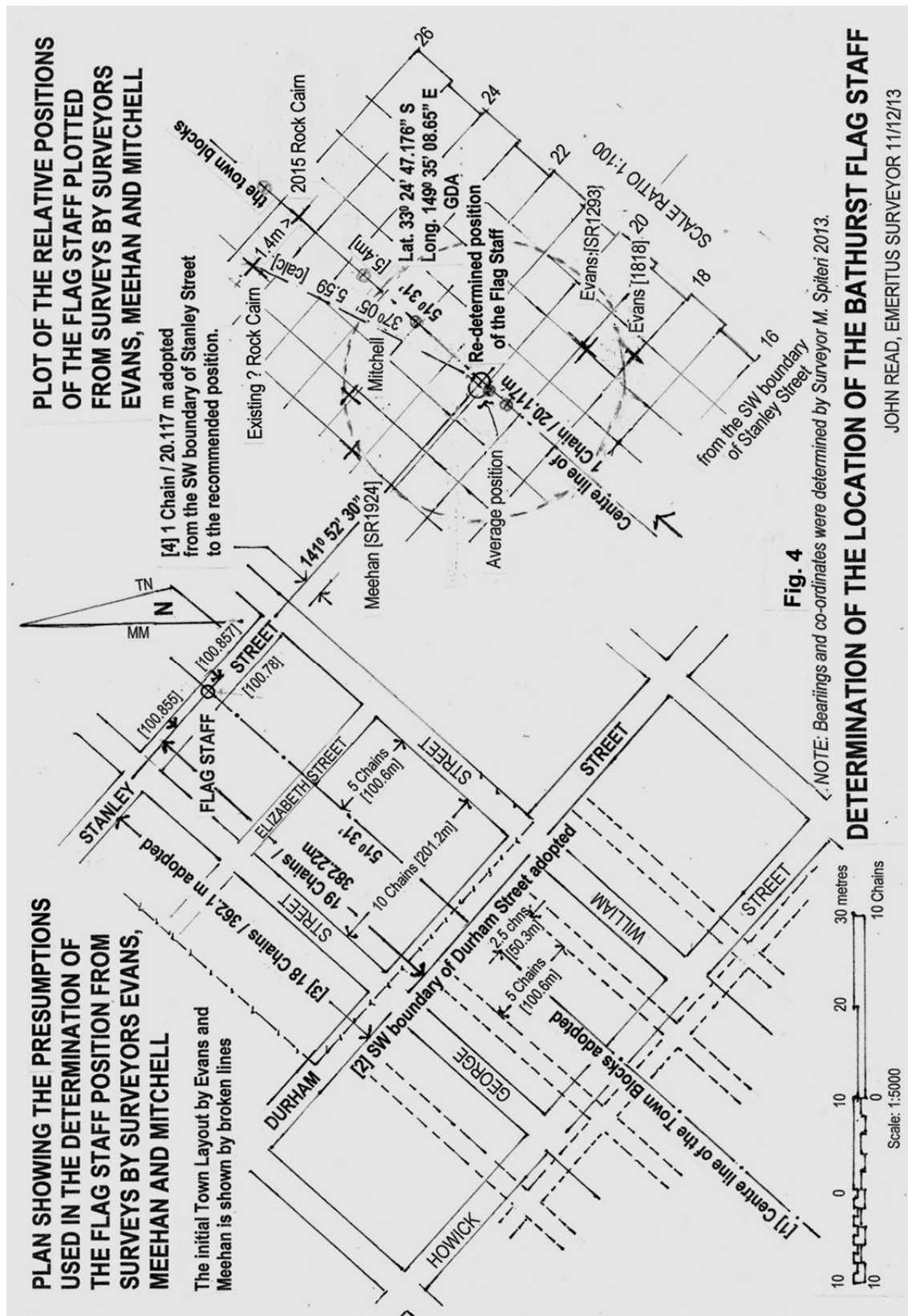


Figure 4: Determination of the location of the Bathurst Flag Staff.

The average position determined from the four survey plans is shown in Table 4. In order to give equal weight to the determination by the three surveyors, the positions on the two Evans plans (i.e. SR1293 and the 1818 Evans plan) were averaged (Table 5).

Table 4: Average position determined from the four survey plans.

No.	Survey Plan	From Centreline	From SW side of Stanley St
1	SR1293 (Evans 1815)	+2.6 m	18.9 m
2	Evans 1818	+2.1 m	18.0 m
3	SR1294 (Meehan 1821)	-3.0 m	21.2 m
4	Mitchell 1833	-2.1 m	22.1 m
	<b>Average Position (1)</b>	-0.1 m	20.1 m

Table 5: Average position as determined independently by surveyors Evans, Meehan and Mitchell.

No.	Surveyor	From Centreline	From SW side of Stanley St
1&2	Evans 1815 & 1818	+2.35 m	18.45 m
3	Meehan 1821	-3.0 m	21.2 m
4	Mitchell 1833	-2.1 m	22.1 m
	<b>Average Position (2)</b>	-0.9 m	20.6 m

## 7.4 Discussion of Results from the Scaling of Plotted Positions

Considering the presumptions, drawbacks and precision of scaling, the results are surprisingly close. The average and re-determined positions are within 3 m and about 0.5 mm by scale of all four plotted positions. All lengthwise determinations come within 4 m on the ground (18.0 m to 22.1 m) and within 1 mm at the ‘average’ plan scale used of 1:5,000, and crosswise within 5.6 m (-3.0 m to +2.6 m of the centreline). This is well within the order of accuracy and precision expected in this method of redetermination.

The average positions crosswise (1) -0.1 m and (2) -0.9 m confirm the assumption of the town block centreline. Average position longitudinally of (1) 20.1 m and (2) 20.6 m across Stanley Street are ‘fortuitously’ and coincidentally close to 20 m and 20.117 m or one chain, and certainly nowhere near the 25.5 m to the existing undated rock cairn (see section 7.4.2).

Back in the 1800s, chains and links (rather than metres) were the official land measurement unit, so ‘rounding off’ to one chain, rather than to 20 m, makes more sense. The average position (1) of the four plans is practically ‘spot on’ both ways. Thinking about this logically, and that the determination of position is already based on three presumptions, a fourth presumption is suggested:

*Presumption 4: The SW boundary of Stanley Street was originally located one chain (20.117 m) from the Flag Staff, and conversely, today, the Flag Staff should be relocated on the centreline at a distance of one chain (20.117 m) NE from the SW side of Stanley Street.*

### 7.4.1 Town Maps

Using the same scaling method, the Flag Staff from the SW side of Stanley Street scales variously on the four town maps as 19.3 m (undated), 19.9 m (undated), 26.4 m (1860) and 23.6 m (1897), i.e. on average 22.3 m. Although 2.2 m longer, it generally confirms the scaled determination of position from the early survey plans. In any dispute between them (i.e. the old surveys and the later town maps), greater regard must be given to the scaling of plots on the oldest surveys rather than those on the later town plans probably derived from them.

### **7.4.2 Existing Rock Cairn Monuments**

Bathurst has two rock cairn monuments:

- The 1930 Proclamation Cairn on the corner of William and Stanley Streets states that “on this spot Governor Lachlan Macquarie proclaimed the Town of Bathurst”, which implies that it was the site of the 1815 Flag Staff and the Proclamation of the Town of Bathurst. This was subsequently proven to not to be the case.
- The undated, unacknowledged and unsubstantiated rock cairn with a bronze plaque on top states that “this plaque marks the exact location of the Flag Staff”. However, again, this has been proven not to be the case. Its position from a survey by Surveyor Michael Spiteri is (TN) 37°05’ and 5.59 m (calc.) from the re-determined Flag Staff site (and 25.5 m from the SW side of Stanley Street).

The origin of the undated rock cairn is obscure and the survey basis for its location is unknown. Hence (especially now that it has been conclusively proven otherwise) any claim that it is the “exact location” of the 1815 Flag Staff lacks any and all credibility. Apparently aware of this, this rock cairn is now to be moved 1.4 m sideways (now being referred to as the 2015 Rock Cairn by this author) to, at least, line up with the centreline of the town block. However, it will *not* be moved 5.4 m towards town to the re-determined site.

On the site (and at great cost) Bathurst Regional Council is constructing its ‘Bicentennial Project and Re-installment of Flag Staff’ proposal consisting of a 500 m<sup>2</sup> suspended concrete slab centred on the relocated 2015 Rock Cairn. This will be viewed through a glass pyramid with the replica of the 1815 Flag Staff erected and floodlit overhead. These will be the focal point of the Bathurst bicentenary celebrations in 2015. Unless corrected, the plaque on the 2015 Rock Cairn will still claim to be the “exact location” of the Flag Staff when clearly it is not, and when the re-determined location is actually 5.4 m closer to town.

On the site (and at great cost) Bathurst Regional Council is constructing its ‘Bicentennial Project and Re-installment of Flag Staff’ proposal consisting of a 500 m<sup>2</sup> suspended concrete slab over an amenities block and centred on the relocated 2015 Rock Cairn. The cairn will be viewed through a glass pyramid with the replica of the 1815 Flag Staff erected and floodlit overhead. These will be the focal point of the Bathurst bicentenary celebrations in 2015. Unless corrected, the plaque on the 2015 Rock Cairn will still claim to be the “exact location” of the Flag Staff when clearly it is not.

## **8 CONCLUDING REMARKS**

The re-determined position of the 1815 Flag Staff is located on the extension of the centreline of the town blocks between William and George Streets and at a distance of one chain (20.117 m) NE from the SW side of Stanley Street. This was rationalised from presumptions made regarding its position relative to the town block layouts, and by the scaling of the plotted Flag Staff position on early plans of survey by surveyors Meehan, Evans and Mitchell. Its position has been determined from the survey by Surveyor Michael Spiteri at latitude 33°24’47.176” S and longitude 149°35’08.65” E in GDA94 and it is located (TN) 231°31’ and 5.415 m towards Bathurst from the proposed 2015 Rock Cairn and replica Flag Staff.

The 1815 Bathurst Flag Staff was placed as a reference point for the survey of the Town of Bathurst and for the exploration and survey of the Central and Western Districts of NSW.



Today, the highlighted 2015 Rock Cairn and the replica Flag Staff are a unique reminder of this function and the importance of surveying monuments to the community generally and to the surveying profession in particular. However, it is a pity that the Rock Cairn, claiming to be at the “exact location” of the Flag Staff, is being relocated to the wrong spot.

## ACKNOWLEDGEMENTS

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