Taming the BEAST: Establishing Street Intersection Corners

Fred de Belin
City of Ryde
fdebelin@ryde.nsw.gov.au

Simon Watt
City of Ryde
simonw@ryde.nsw.gov.au

ABSTRACT

At APAS2015, the first author presented a paper entitled 'Re-Markable Roads: When is a Street Fix Fixed?' In the conclusion, it was proposed to accumulate data at street intersections, including cadastral boundaries and markings by way of a scanning process. The idea was to create a simplified, abridged scan of the built environment at street intersections to house, hold and deliver thousands of points that are useable, stable and accurate enough to define or re-establish a street intersection. As envisaged in a point cloud, an image of the original scanned intersection can be uploaded into a controller, which can then identify, for survey definition or marking purposes, the previously established corners. The loss of actual survey marks at corners, such as pegs, drilled holes or reference marks, can be immediately overcome with reference to the point cloud data image. At City of Ryde, the survey team has investigated this approach, and this paper presents the initial findings. In order to be able to rely on scanned data for cadastral purposes, the scanning procedure must be reliable, repeatable and sub-centimetre accurate. We feel that this is now achievable.

KEYWORDS: *Intersection, road boundary, cadastre, laser scanning, reference points.*

1 INTRODUCTION

Decades after the first land grants in Ryde, which were among the first in the new colony, came the freehold subdivisions of these grants, which effectively changed Ryde from a rural community into a residential urban development. This was the decade of the 1880s, and at a time when modern survey accuracy was being achieved, many new roads were being created and boundary marking was beginning to standardise. However, it would be several more decades before reference marks were required to be placed and shown on plans creating new roads. Alignment posts were being placed along old existing roads in an attempt to rationalise their boundary locations (de Belin, 2014), and many of the early suburban subdivisions tied directly to alignment posts in aligned streets (Figure 1). Here, DP 7997 (1914) is bounded by Blaxlands Road (now Blaxland Road), which has been defined from seven stone alignment posts found. With the arrival of the Local Government Act in 1919 came the requirement to mark newly created streets with solid reference marks, a requirement which has continued to this day. This was 40 years after 1880! In that intervening period, original pegs were removed for first fencing purposes, which led to the situation where the surveyor arrived on site to carry out a survey, only to find no corner marks for a starting point or confirmation of boundary.

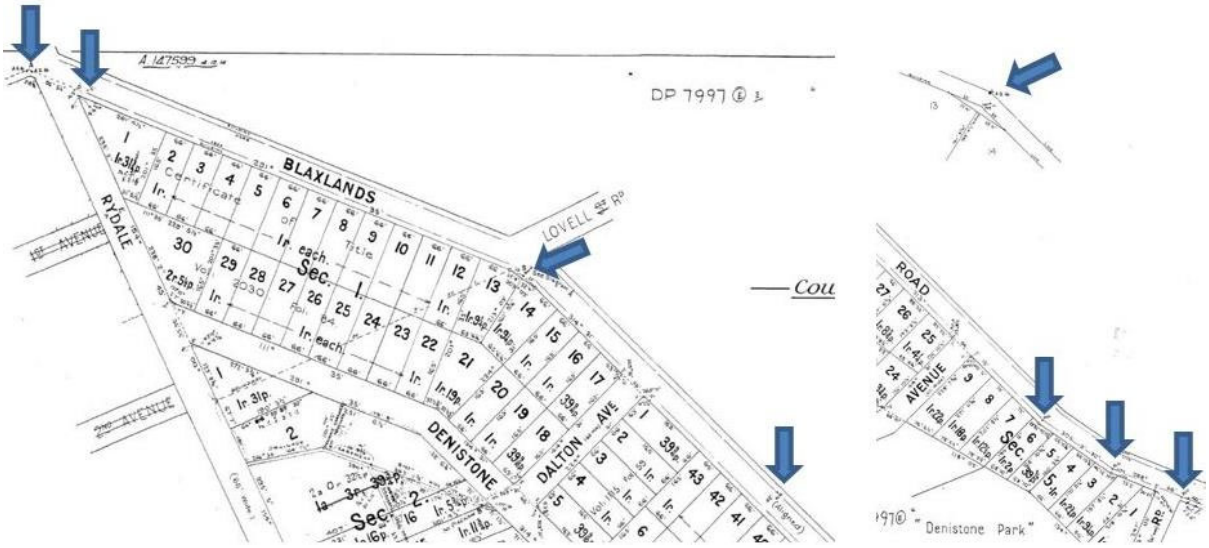

Figure 1: DP 7997 showing alignment definition of Blaxland Road, Eastwood (1914).

DP 7997 created two new streets: Denistone Road and Dalton Avenue. No reference marks were placed, nor required to be placed, as the survey was prior to 1919. What was any following surveyor to do when it came to defining these two streets? A further complication was that many compiled plans of subdivision, which did not require marking, were initiated in this period, based on the initial subdivision and creating a shuffling of boundaries (such as three original lots into five). The surveyor looked to occupations for support and came up with a best estimate for the correct street boundary. This Best Estimate Asserting Survey Truth (BEAST) has hampered, hindered or helped cadastral surveyors in determining street boundaries ever since.

At APAS2015, a paper was presented entitled ‘Re-markable roads: When is a street fix fixed?’ (de Belin, 2015). In its conclusion, it was proposed to accumulate data at street intersections, including cadastral boundaries, marks and buildings by way of a scanning process. The idea was to create a simplified, abridged scan of the street intersection to house, hold and deliver thousands of points that are useable, stable and accurate enough to define or re-establish a street intersection. This data could later be useful in the re-establishment of a street intersection, especially if no original survey marks exist on site.

2 FEEDING THE BEAST

To show how street definition can change over time, let us discuss two examples from the multitudes which exist within the City of Ryde.

2.1 Pittwater Road

Pittwater Road at North Ryde was created in 1882 as a main road, 150 links wide, and extended across Magdala Road (Figure 2). In 1884, Pittwater Road was extended northwards as a straight-line continuation through vacant Crown land (Figure 3). In 1887, this vacant Crown land on either side of Pittwater Road was subdivided into small portions, with Pittwater Road maintained as a straight line (Figure 4). Pittwater Road was aligned in 1885, although only a tracing of the alignment plan remains, catalogued CP 23.2113 (1885).

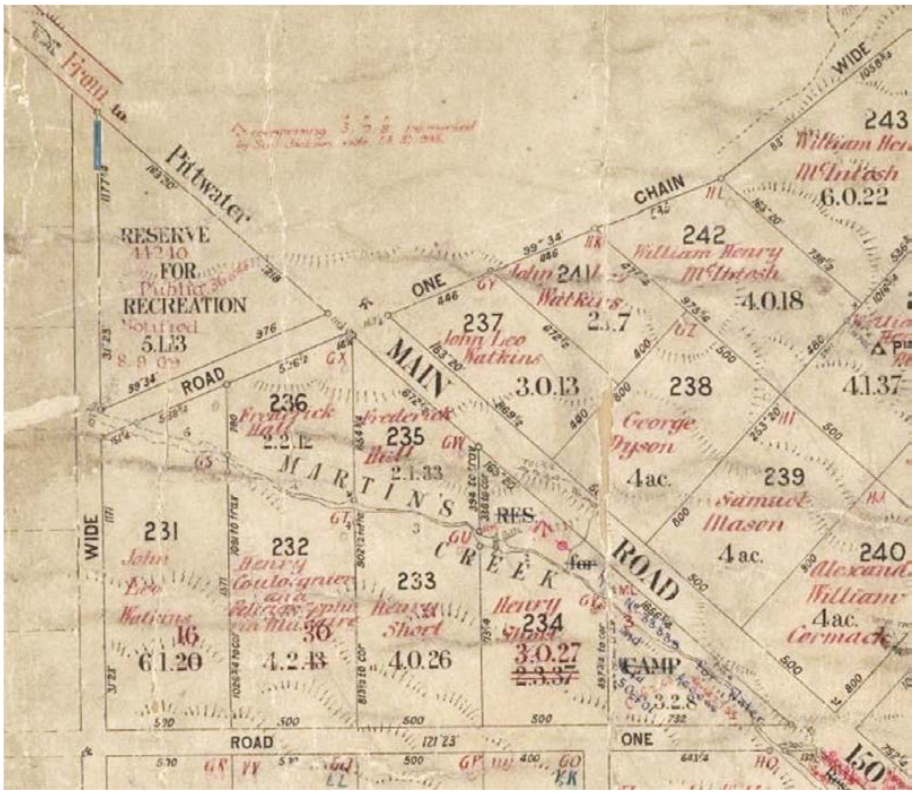

Figure 2: CP 386.2030 showing the creation of Pittwater Road (1882).

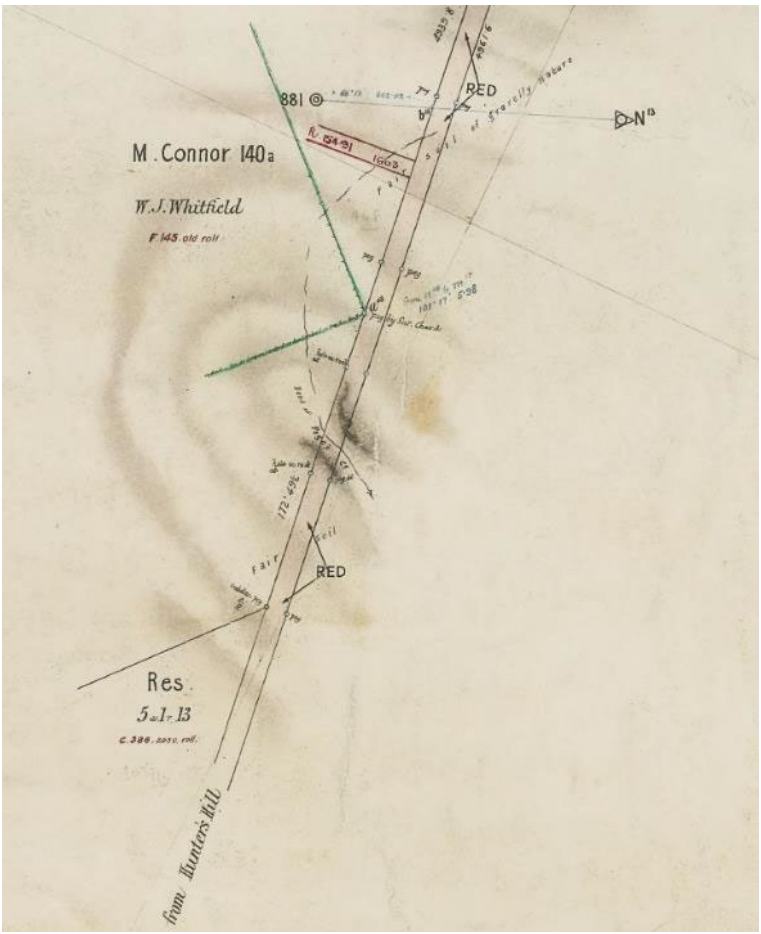

Figure 3: CP 2713.1603 showing the north extension of Pittwater Road in a straight line (1884).

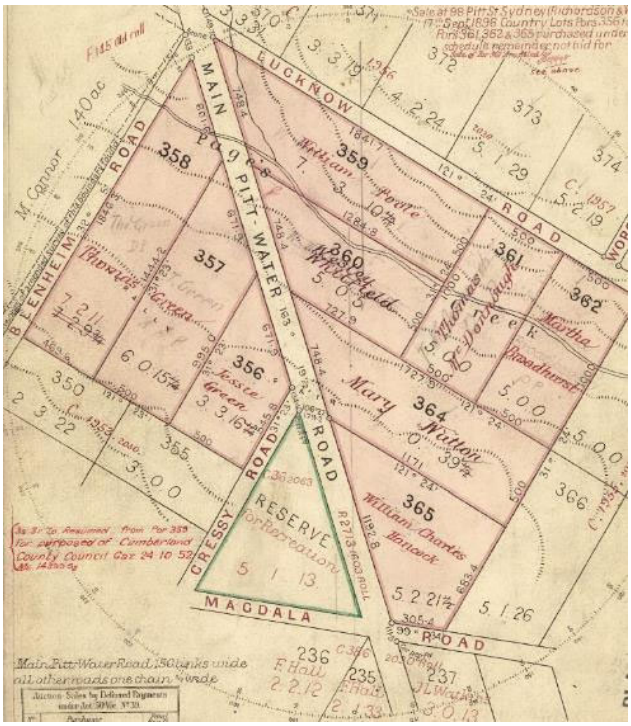

Figure 4: CP 1954.2030 showing Pittwater Road as one straight line (1887).

Pittwater Road, south of Magdala Road, can still today be fixed from surviving big stone alignment posts (de Belin, 2014) and surviving original corner rock marks from 1882 (de Belin, 2017). Pittwater Road, north of Magdala Road, is where the street fix starts to come adrift. Table 1 shows the timeline of survey activity since 1882.

Table 1: Timeline of survey activity in Pittwater Road.

Plan	Date	Survey or Compiled	Reference to Prior Survey
CP 386.2030	1882	Survey	First Portions
CP 2713.1603	1884	Survey	Road
CP 23.2113	1885	Survey	Alignment
CP 1954.2030	1887	Survey	First Portions
DP 8095	1911	Survey	CP 1954.2030
DP 317762	1927	Survey	DP 8095
DP 19636	1941	Survey	CP 386.2030
DP 25524	1953	Survey	CP 1954.2030
DP 27333	1956	Survey	CP 1954.2030
DP 402144	1957	Survey	DP 8095
DP 28139	1957	Survey	CP 1954.2030
DP 404958	1957	Compiled	DP 8095
DP 418768	1960	Survey	DP 8095
DP 879421	1998	Survey	DP 7997 & DP 835760
DP 882160	1998	Survey	DP 8095 & DP 404958 (C)
DP 1016621	2000	Survey	DP 28139
DP 1039302	2001	Survey	DP 8095
DP 1109818	2006	Survey	DP 8095

Fast forward 70 years to 1957. DP 402144 (1957) finds a multitude of alignment posts, fixes Pittwater Road straight and places two reference marks (GI pipe and bolt). DP 418768 (1960) finds the bolt and continues a straight street-line to pegs found over 250 m to the north, then places a reference mark GI pipe midway. Forty years later, DP 879421 (1998) adopts this GI pipe, then continues the straight line for almost 500 m to the north (Figure 5).

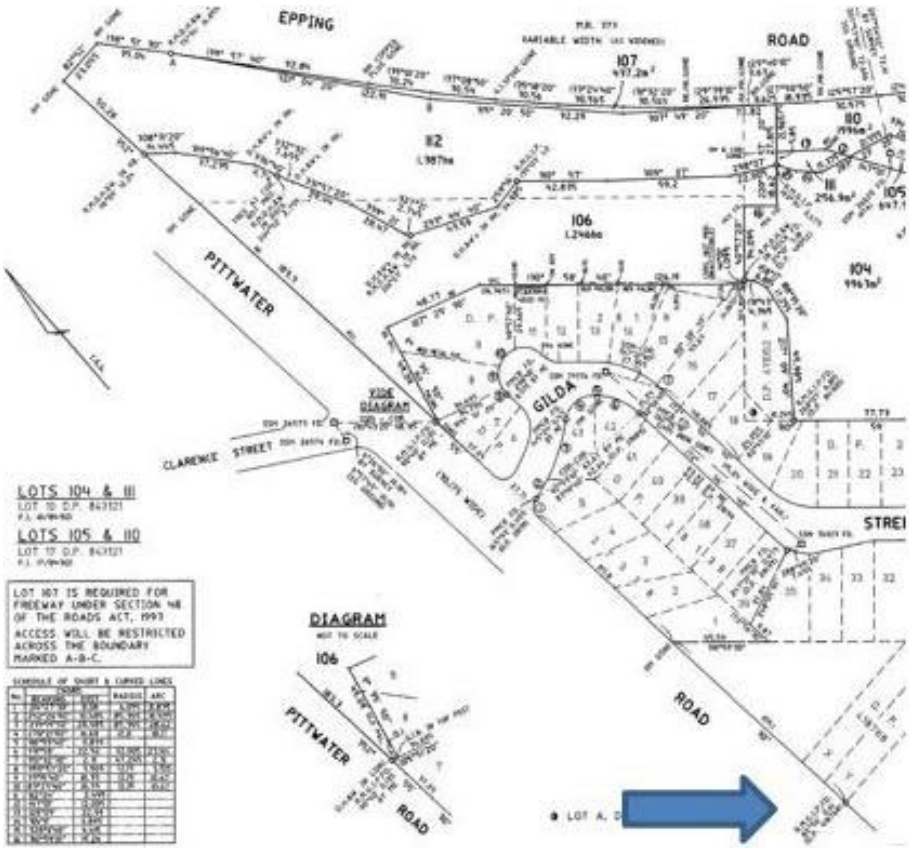

Figure 5: DP 879421 showing Pittwater Road as one straight line (1998).

Then, in 2000, the BEAST arrives! DP 1016621 (2000) creates a drainage easement, and in showing and confirming that enough land is available between the start of the drainage easement and Pittwater Road, the surveyor shows three connecting lines between five reference marks as found in Pittwater Road (Figure 6), which effectively indicates that Pittwater Road now has bends.

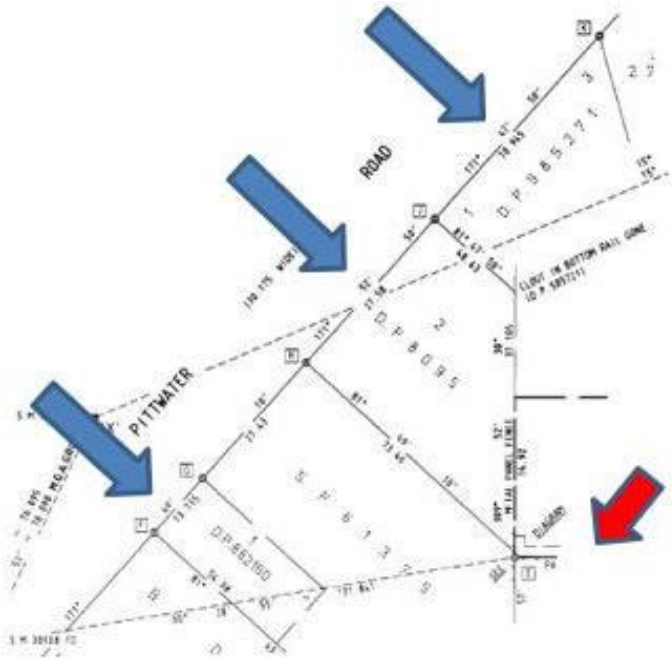

Figure 6: DP 1016621 showing Pittwater Road having bends between adjacent reference marks (2000).

The same surveyor returns in 2001 to subdivide the property, which had the benefit of the drainage easement (Figure 7). This DP 10319302 (2001) shows identical bends in the fix of Pittwater Road.

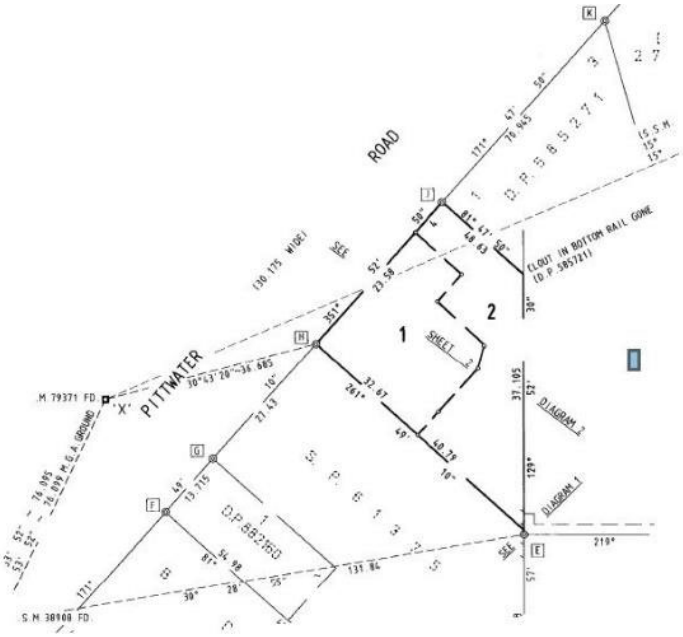

Figure 7: DP 1039302 showing Pittwater Road with the same bends (2001).

Along comes a different surveyor in 2006 who attempts to define the Pittwater Road boundary in a straight line. His DP 1109818 (2006) is requisitioned by Land and Property Information (now DCS Spatial Services) (Figure 8) to re-instate the three bends shown previously in DP 1039302 (2001).

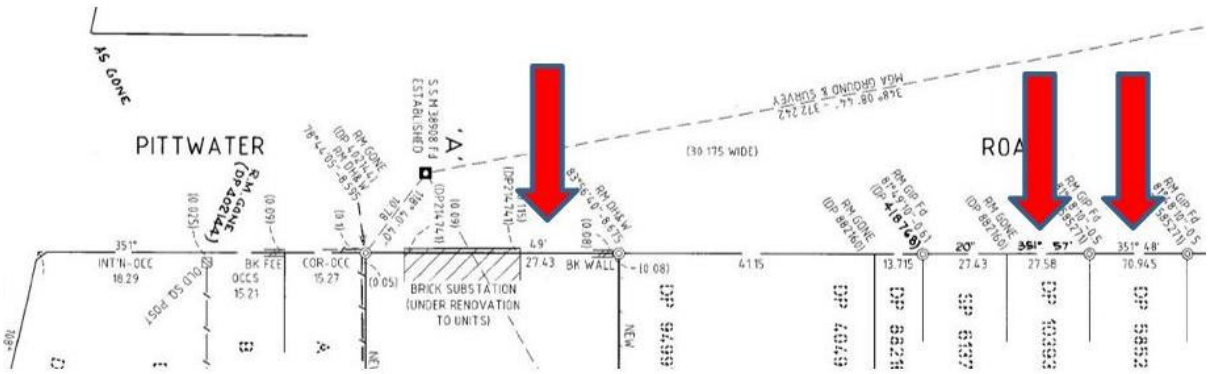

Figure 8: DP 1109818 showing Pittwater Road maintaining the same bends (2006).

A full investigation by the City of Ryde survey team reveals that the original straight-line street fix of Pittwater Road can be validated over its entire length of 1,000 m, with both sides parallel and 30.175 m (150 links) apart. More about this example later.

2.2 Denistone Road & Dalton Avenue

Denistone Road and Dalton Avenue, at Eastwood, were created in 1914 as part of residential subdivision DP 7997 (see Figure 1). The definition of Denistone Road today puts the street in a different position, i.e. about 150 mm south from where it was placed in 1914. This has obvious

ramifications on a lot's depth and rear boundary. The Cadastral Records Enquiry (CRE) shows the current lot subdivision plans over part of DP 7997 (Figure 9).

Figure 9: Cadastral Records Enquiry map showing the current lot subdivision plans over part of DP 7997 (2023).

Table 2 shows the timeline of survey activity since 1914. The first plan of survey was DP 12911 (1923), which adopted a line of pegs found in Denistone Road and a line of pegs found in Ryedale Road. Street angles and lot dimensions completely agreed with DP 7997. The next survey plan, DP 15864 (1927), adopted the pegs placed by DP 12911 in 1923. It is 1940 before the next survey plan appears (Figure 10) and some interesting points are worth noting.

Table 2: Timeline of survey activity in Denistone Road. Note that the flurry of survey activity since 1993 began 80 years after the first subdivision in 1914.

Plan	Date	Survey or Compiled	Reference to Prior Survey
DP 7997	1914	Survey	First Subdivision
DP 952366	1916	Compiled	DP 7997
DP 167865	1921	Compiled	DP 7997
DP 169594	1921	Compiled	DP 7997
DP 12911	1923	Survey	DP 7997
DP 312937	1925	Compiled	DP 7997
DP 15864	1927	Survey	DP 12911
DP 333097	1936	Compiled	DP 7997
DP 336713	1938	Compiled	DP 7997
DP 343691	1940	Survey	DP 15864
DP 19500	1940	Survey	DP 7997 & DP 15864
DP 508494	1962	Compiled	DP 312937 (C)
DP 306621	1963	Compiled	DP 7997
DP 532938	1968	Compiled	DP 7997
DP 537517	1969	Compiled	DP 7997
DP 609259	1980	Compiled	DP 7997
DP 703989	1983	Compiled	DP 7997
DP 717176	1984	Compiled	DP 7997

Plan	Date	Survey or Compiled	Reference to Prior Survey
DP 724091	1987	Compiled	DP 7997
DP 773924	1988	Compiled	DP 7997 & DP 724091 (C)
DP 835760	1993	Survey	DP 7997
DP 837289	1993	Survey	DP 7997 & DP 835760
DP 837290	1993	Survey	DP 7997 & DP 835760
DP 854286	1995	Survey	DP 306621 (C) & DP 7997
DP 869648	1995	Survey	DP 7997
DP 876250	1996	Survey	DP 7997
DP 881658	1997	Survey	DP 7997
Urban Cadastral Project	2022	Survey	DP 7997

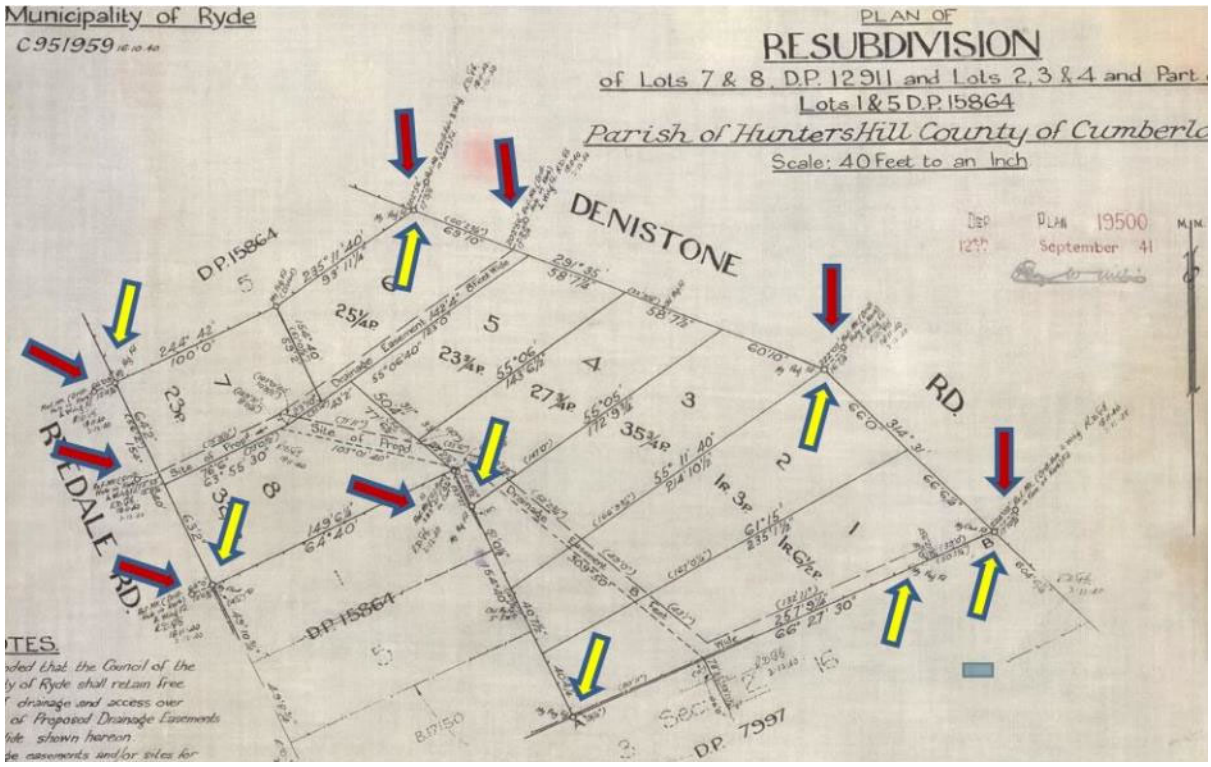

Figure 10: DP 19500 showing at corners “my mark found” and “reference mark found” (1940).

Additions to DP 19500 indicate two rounds of survey requisitions. Adjoining side occupations have been added south along Denistone Road and Ryedale Road, a line in the surveyor’s certificate in regard to the placing of survey reference marks has been struck out (not shown in Figure 10) and each reference mark found shows the evidence of two rounds of requisition (Figure 11).

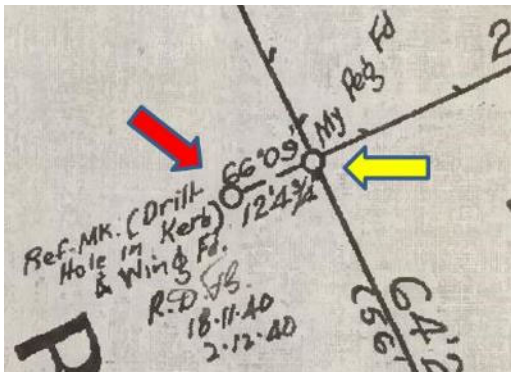

Figure 11: Detail from DP 19500 showing marks found and evidence of requisitions (1940).

There were no reference marks placed by this survey. Obviously, to be found, the reference marks had to have been placed in an prior survey. But which survey? The CRE indicates nothing! However, a title search reveals a transfer dealing C951960 (1940) on Certificate of Title Volume 4213 Folio 2 (Figure 12), which contains a survey plan carried out by the same surveyor and showing the seven reference marks found by DP 19500 (1940).

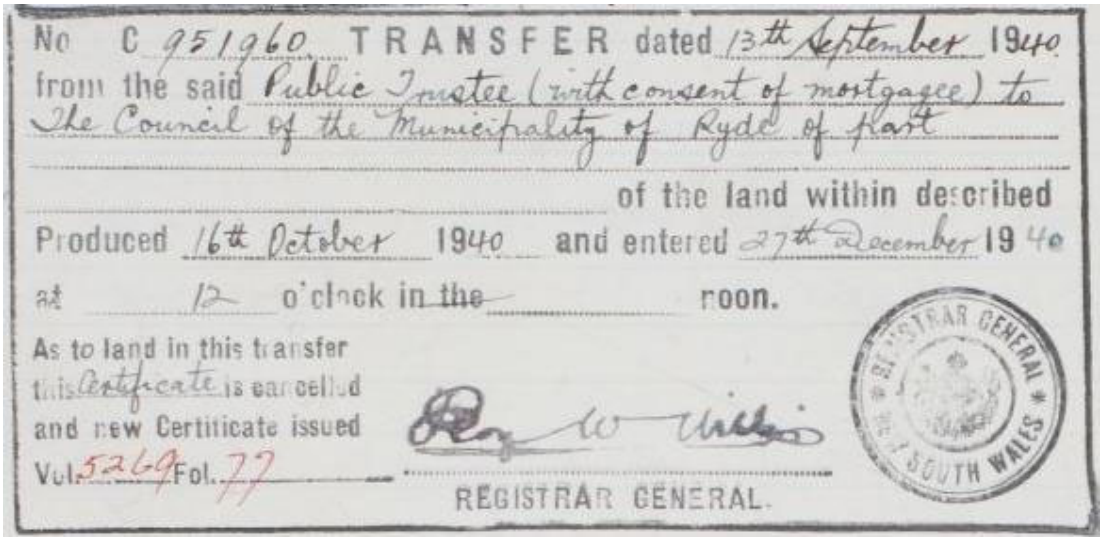
No C 951960 TRANSFER dated 13th September 1940
from the said Public Trustee (with consent of mortgagee) to
The Council of the Municipality of Ryde of part
of the land within described
Produced 16th October 1940 and entered 27th December 1940
at 12 o'clock in the noon.
As to land in this transfer
this Certificate is cancelled
and new Certificate issued
Vol. 5269 Fol. 77
REGISTRAR GENERAL.
REGISTRAR GENERAL NEW SOUTH WALES

Figure 12: Transfer dealing C951960 noted on Certificate of Title Volume 4213 Folio 2 (1940).

The land comprised in Certificate of Title Volume 5269 Folio 77 is all the land in DP 15864 (1927) minus that land being part of lot 5 and edged in blue (Figure 13), as shown on Certificate of Title Volume 5467 Folio 203 (1945).

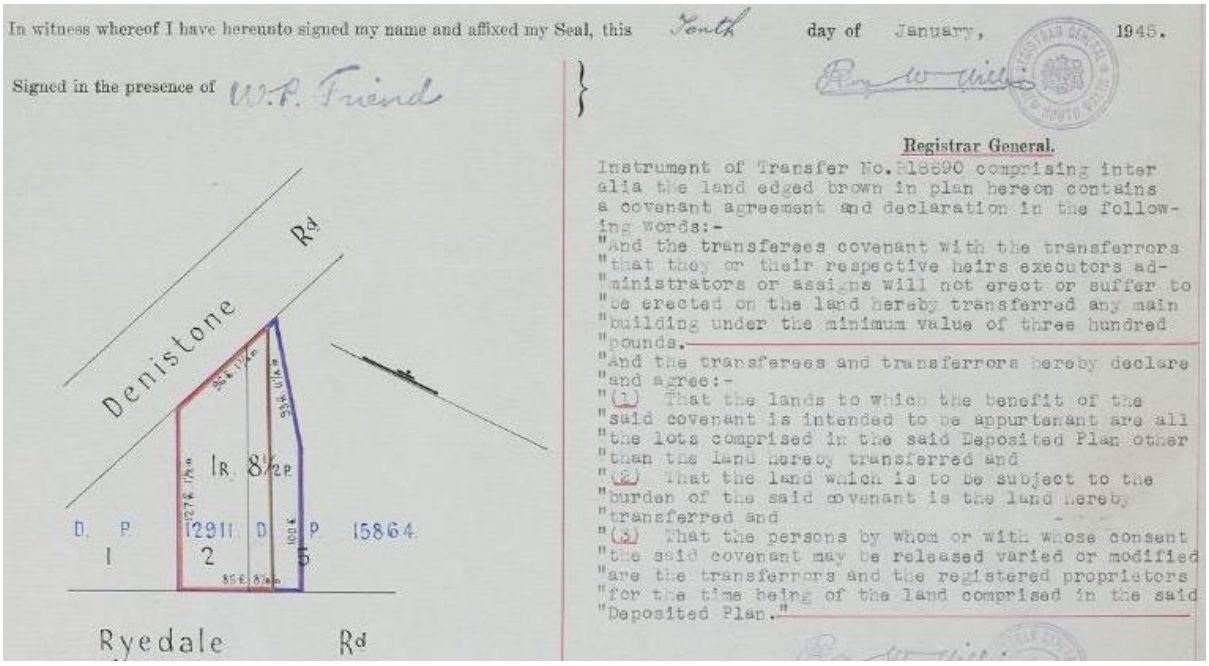
In witness whereof I have hereunto signed my name and affixed my Seal, this Tenth day of January, 1945.
Signed in the presence of W.P. Friend
Registrar General.
Instrument of Transfer No. B18690 comprising inter alia the land edged brown in plan hereon contains a covenant agreement and declaration in the following words:-
"And the transferees covenant with the transferrors "that they or their respective heirs executors ad-"ministrators or assigns will not erect or suffer to "be erected on the land hereby transferred any main "building under the minimum value of three hundred "pounds.
"And the transferees and transferrors hereby declare "and agree:-
"(1) That the lands to which the benefit of the "said covenant is intended to be appurtenant are all "the lots comprised in the said Deposited Plan other "than the land hereby transferred and
"(2) That the land which is to be subject to the "burden of the said covenant is the land hereby "transferred and
"(3) That the persons by whom or with whose consent "the said covenant may be released varied or modified "are the transferrors and the registered proprietors "for the time being of the land comprised in the said "Deposited Plan."
Denistone Rd
1R. 8½P.
D. P. 12911 1
D. P. 15864 5
Ryedale Rd

Figure 13: Title diagram in Volume 5467 Folio 203 showing result of transfer shown in Figure 12 (1945).

The survey plan attached to dealing C951960 is now catalogued as DP 343691 (1940). So, there were four plans of survey plus 15 compiled plans in the first 80 years after DP 7997. All reference marks from DP 343691 (1940), and as found in DP 19500 (1940), are now long gone.

In 1993, there was a modern plan of survey defining Denistone Road, which found recent pegs and adopted street fencing occupations at the bend by balancing and splitting the difference (Figure 14).

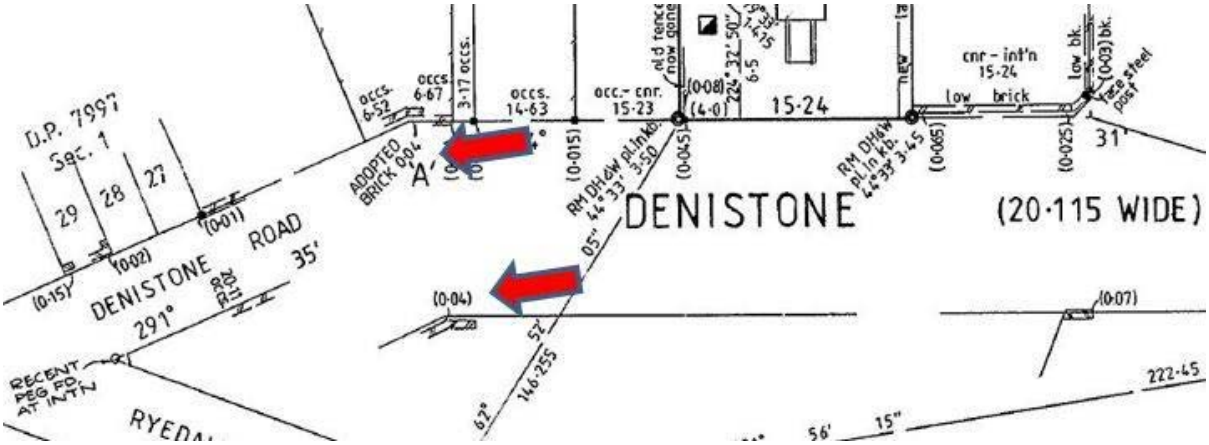

Figure 14: DP 854286 showing the bend in Denistone Road defined by adopting occupations (1995).

This plan of survey showed fencing occupations north towards Blaxland Road (Figure 15) suggestive of a northerly shift.

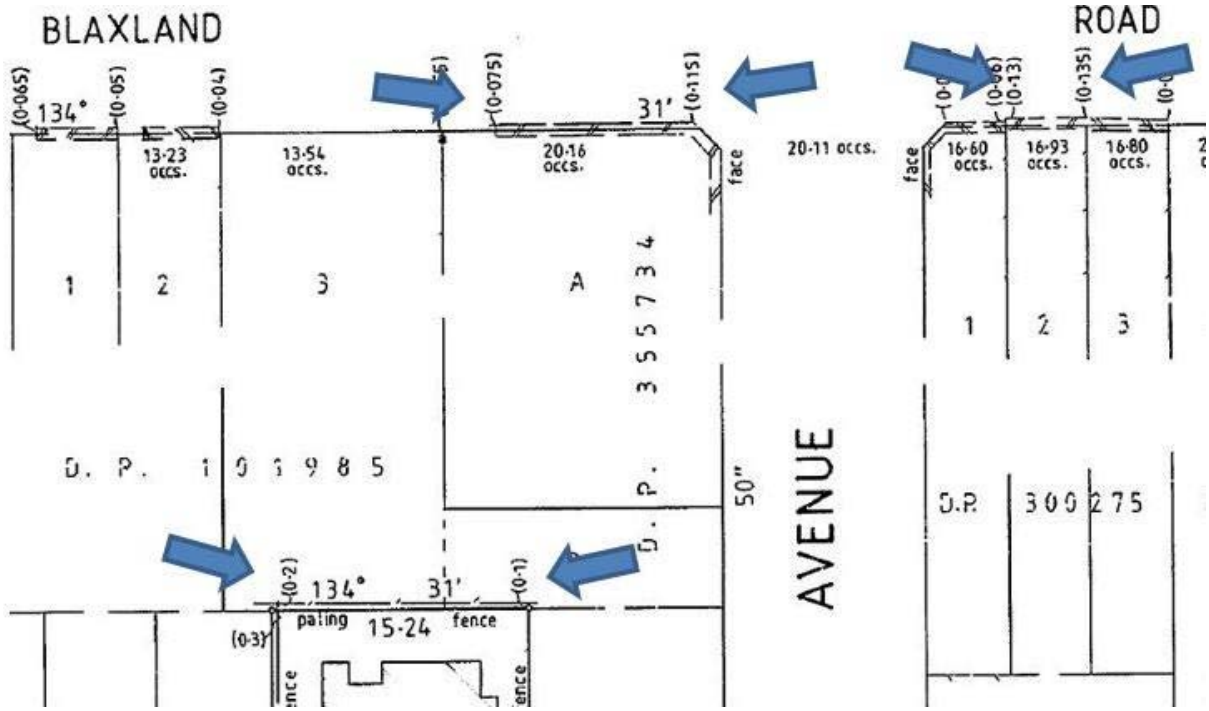

Figure 15: DP 854286 showing occupations northwards to Blaxland Road (1995).

DP 881658 (1997) adopts the same fix of Denistone Road as DP 854286 (1995) and shows some fencing occupations north of the Denistone Road boundary (Figure 16). This DP 881658 (1997) also shows excesses of up to 150 mm between Denistone Road and the definition of Blaxland Road, where an iron alignment post was found, in place of the original stone alignment post.

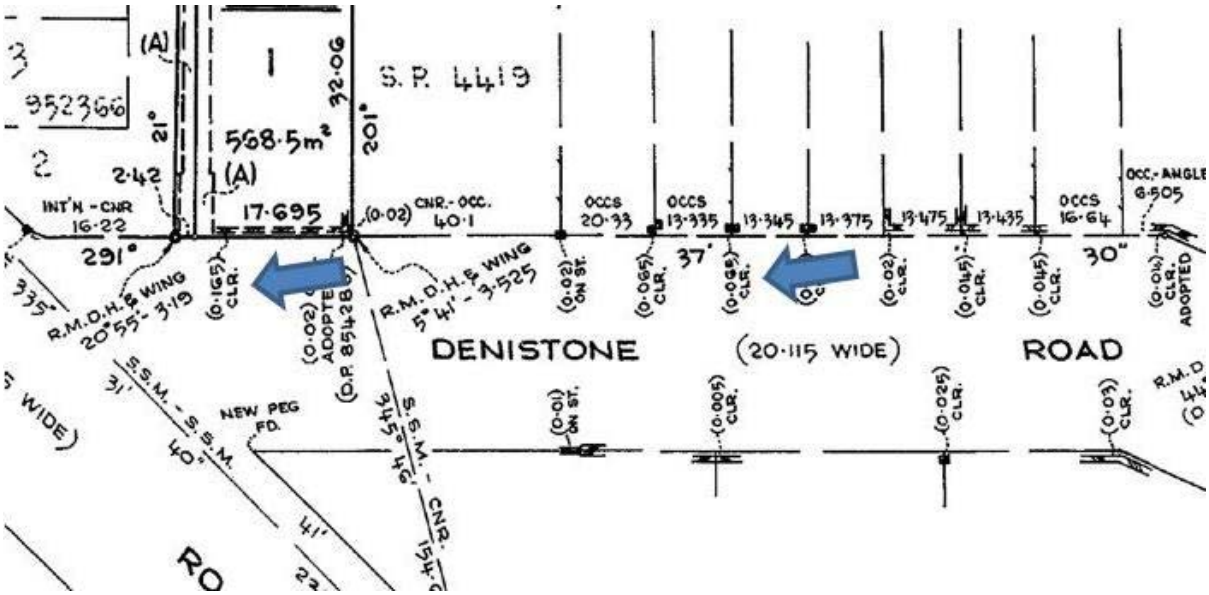

Figure 16: DP 881658 showing same fix of Denistone Road as DP 854286 from 1995 (1997).

A Board of Surveying and Spatial Information (BOSSI) urban cadastral project (2022) re-constructed the old alignment of Blaxland Road (Figures 17 & 18) as it was in DP 7997 (1914), by adopting connections from found reference marks (de Belin, 2018) that were placed at a time when some of the stone alignment posts were still in existence and in position, around 1960. The resultant fix of Blaxland Road was able to maintain original angles between kerb lines with no more than 20 mm difference in distances between the bends. DP 7997 (1914) was then laid out in accordance with original dimensions from the aligned Blaxland Road because the subdivision occurred after the alignment survey. More about this example later.

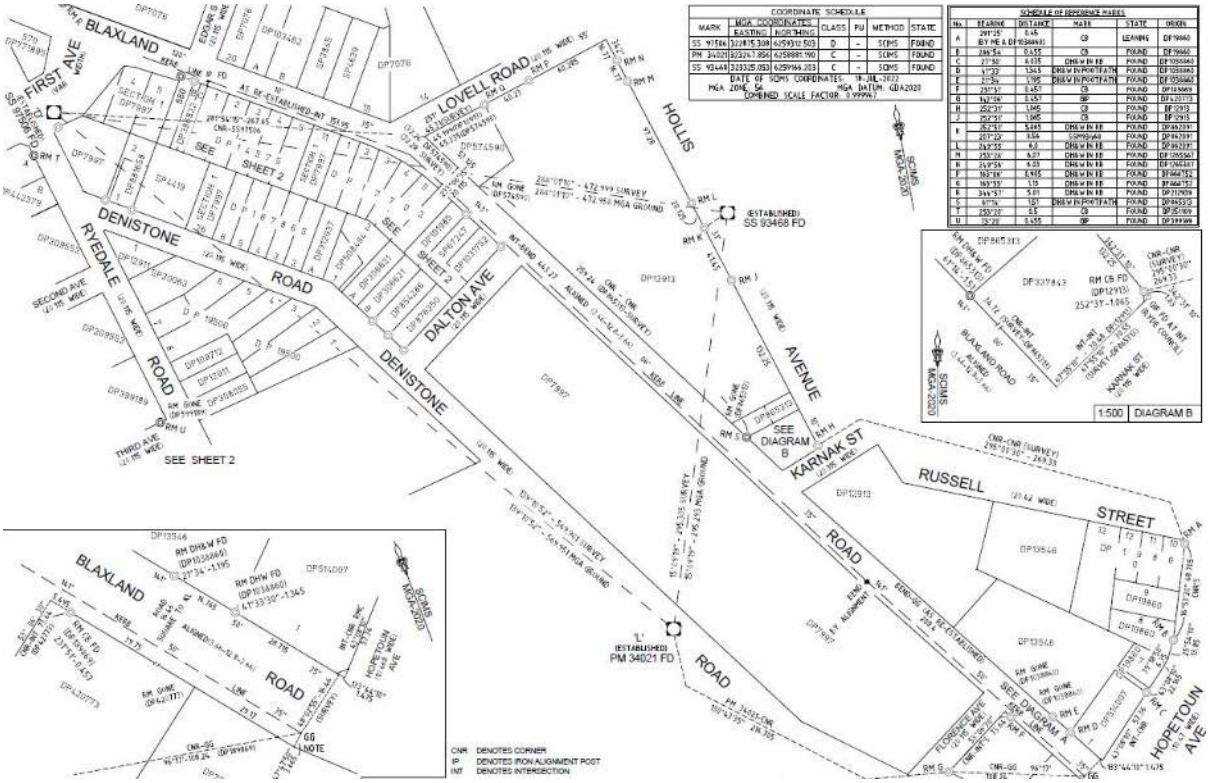

Figure 17: Urban cadastral project showing definition of Blaxland Road as per original (2022).

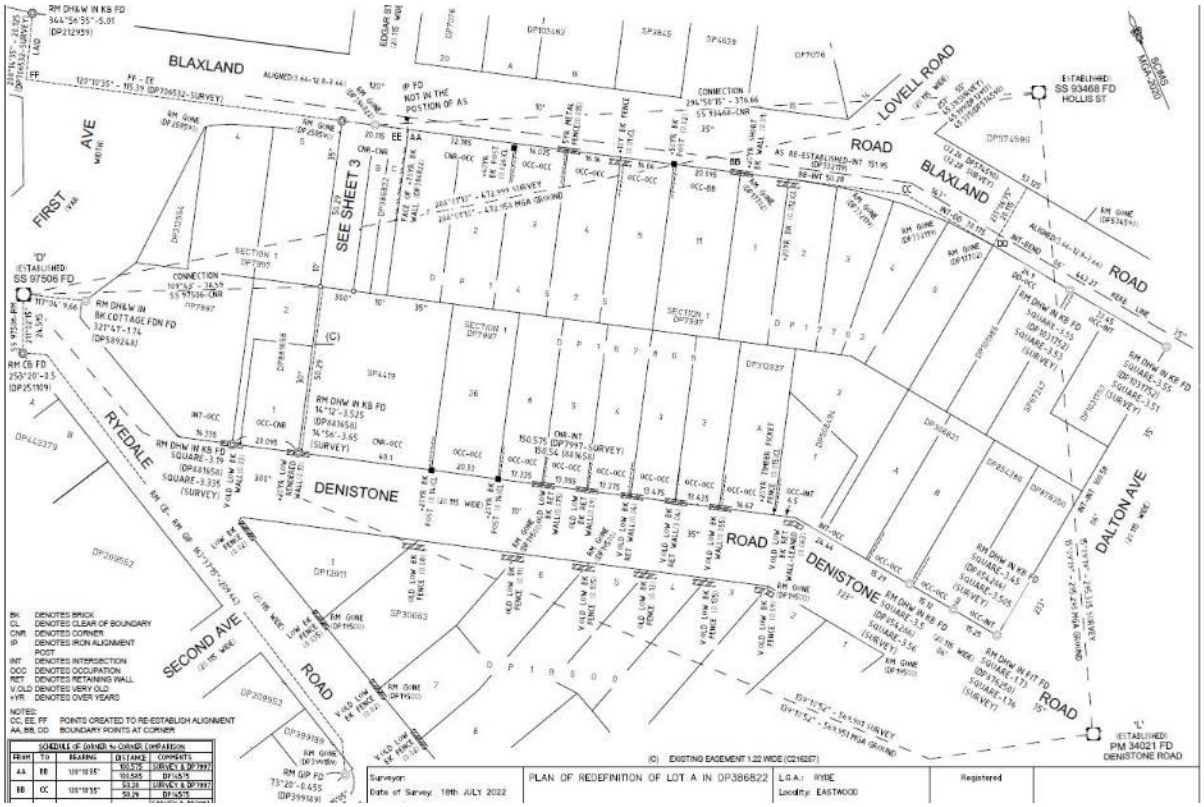

Figure 18: Urban cadastral project showing extents of DP 7997 maintained as per original (2022).

3 TRACKING THE BEAST

Council owns the land, which contains the road reservation after the creation of a new street. Streets are created parallel with a nominal width (Figure 19).

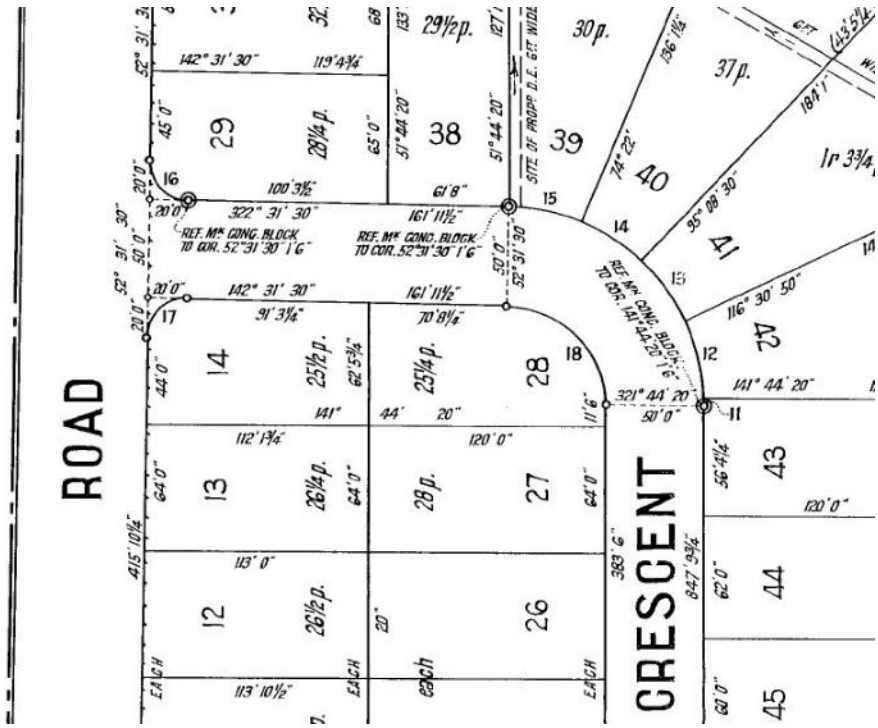

Figure 19: Detail from DP 35226 showing 50 feet width creation of Irene Crescent, Eastwood (1948).

Irene Crescent in Eastwood is reference marked by concrete blocks on one side of the street only. Similarly, Mawarra Crescent in Marsfield is reference marked by pairs of drill hole and wing in kerb on one side of the street only (Figure 20).

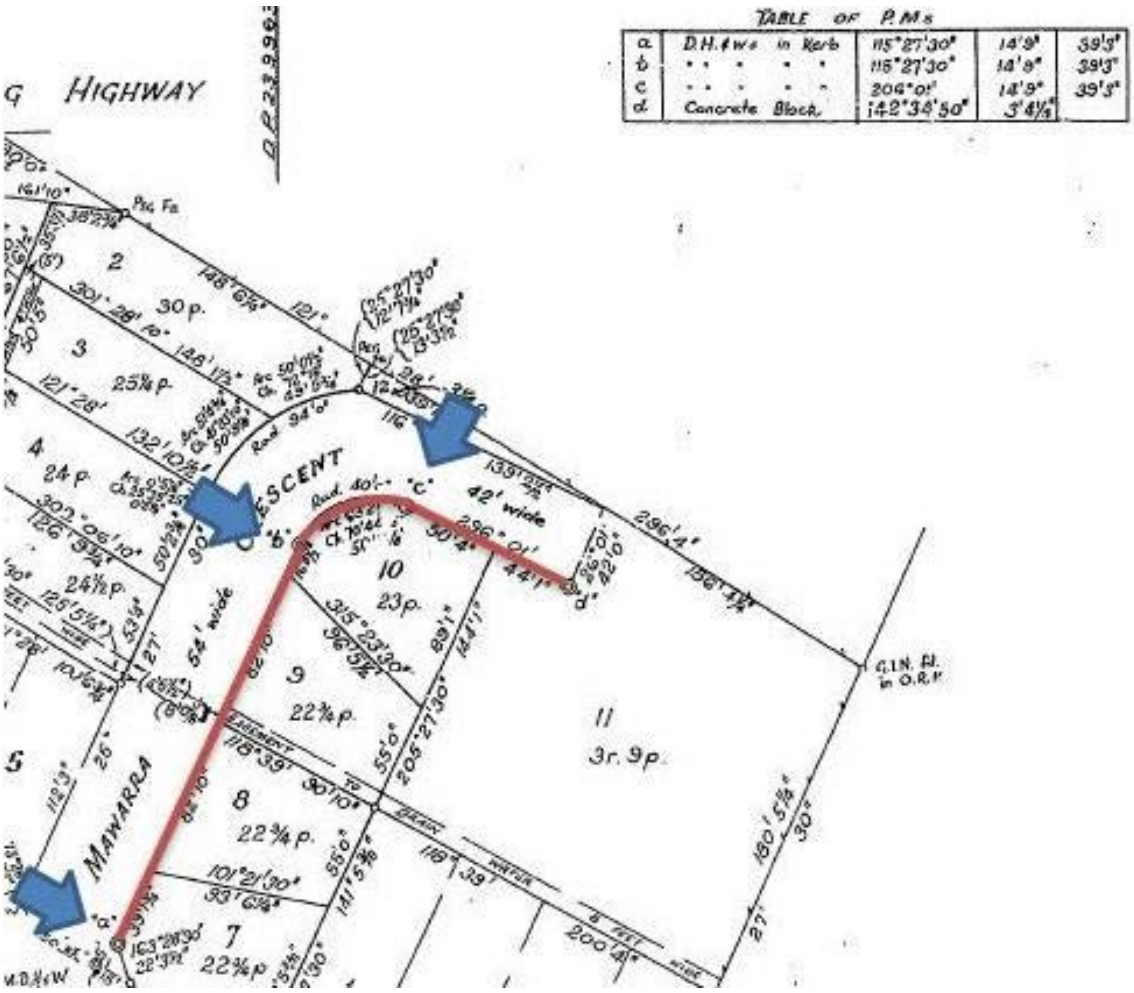

Figure 20: Detail from DP 239963 showing creation of Mawarra Crescent, Marsfield (1970).

Notice that only one side boundary of the created street is tied to reference marks. Therefore, any redefinition of the street requires only the one side of the street to be fixed, then the other side falls in parallel at nominated width. Exclusive of road widening and partial road closure, there is no reason for streets to become variable width!

In saying that, a point of interest is that two streets in the City of Ryde were actually created with a variable width rather than having variability thrust upon them at a later date when the street fix became too difficult or found reference marks suggested a deviation.

Frederick Street in Ryde was created in 1916 abutting the parcel boundary, which contained four bends (Figure 21), so one side of the new Frederick Street contained bends while the opposite side was one straight line.

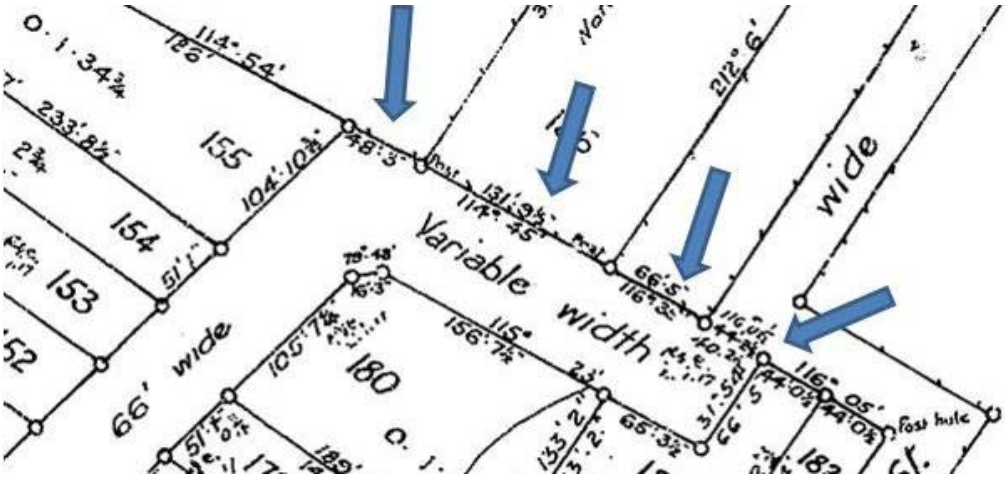

Figure 21: Detail from DP 8721 showing variable width creation of Frederick Street, Ryde (1916).

Goodwin Road at West Ryde was essentially a strip of land between two very first grants. DP 2085 (1887) adopted a straight fenced line as the limitation of its title and as the boundary line between itself and the 146-acre parcel to the north, intimating that this fence formed one side of a road (Figure 22).

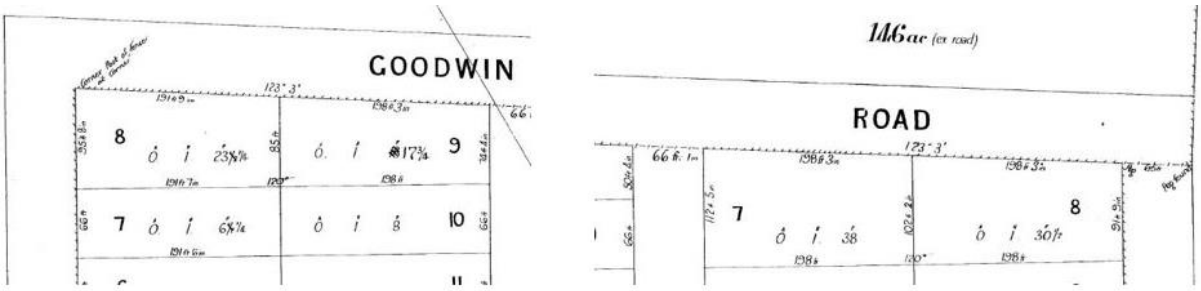

Figure 22: DP 2085 showing definition of one side of Goodwin Road, West Ryde (1887).

Later subdivision on the north also defined Goodwin Road by fencing occupations, with the result that the road boundary on the north has two bends and the street has a width which varies from 66 feet at one end to 47 feet at the other (Figure 23).

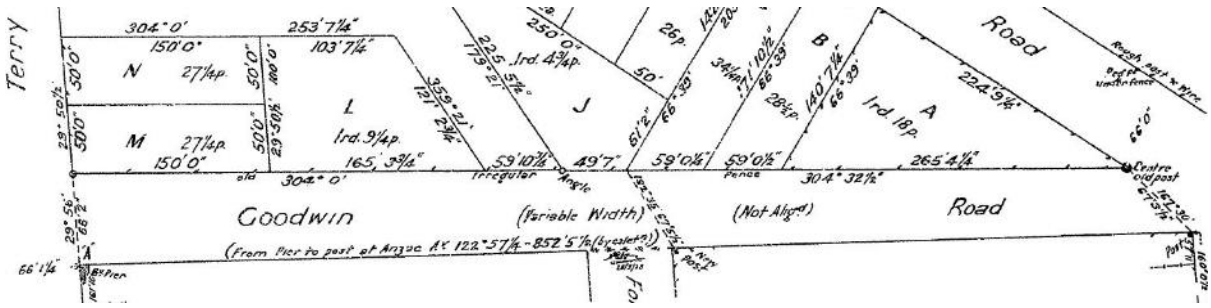

Figure 23: DP 15547 showing variable width definition of Goodwin Road, West Ryde (1928).

Clause 33 of the Surveying and Spatial Information Regulation 2017 (NSW Legislation, 2023) states:

> 33 Procedure if monuments of original survey missing
>
> To the extent that the relevant monuments of an original survey are missing, a surveyor must determine the boundaries and corners of the land surveyed by measurement in correct relation to

(a) adjoining or adjacent parcels of land, and
(b) parcels of land on opposite sides of roads, and
(c) fences, and
(d) such other evidence of correct location as may be found after full investigation and inquiry.

Consequently, when original marking, be it corner mark or reference mark, from the creation of a street is gone, then a pattern of response is activated by the incoming surveyor (de Belin, 2016). The surveyor will rely on old or substantial fencing or building occupations found at street intersections and bends, then place new marks in response to the survey. When old occupations and the new marking are gone, then the surveyor will rely on new occupations and place even newer marks. The cycle repeats itself. The obvious outcome is that the cycle of street fixing may result in a moving of the position of the street boundaries (de Belin, 2015).

At intersections where marking has been lost for decades and best estimates have been the only thing holding the cadastre together, who has the right or obligation to say where a street boundary is sited? Registered surveyors? NSW Land Registry Services (LRS) and the lawyers? Local councils?

Registered surveyors gather up the evidence and offer a best estimate of the boundary based upon what evidence is found. They are continuously attempting to maintain a structurally sound cadastre and call themselves custodians of the cadastre. LRS is interested in the plan purpose and how the new plan fits into its system of the cadastre. LRS calls itself the custodian of the cadastre. Unless it is specifically a street re-definition plan, a local council has no say. That is not to say that local councils are not keenly interested in having street boundaries retained in their original location and original street width.

4 TRAPPING THE BEAST

Binding plans of survey to a national coordinate system was seen as a definitive method which would enable consistent re-establishment of street boundaries. This may work well for newly created streets and carry onwards, but the bulk of the NSW cadastre is not yet tied to the Map Grid of Australia (MGA) and the Geocentric Datum of Australia 2020 (GDA2020). In the City of Ryde, where less than 20% of its land parcels are tied to MGA, there have barely been a dozen new streets created since 1975! This means that over 850 streets were in existence before 1975, and it is from this pool that street definition differences and difficulties will arise. Can these definitions be trapped and controlled before they too are locked onto the MGA?

Returning to the two examples discussed previously, is there a way to establish and hold a street boundary in place? At Denistone Avenue many occupations, houses and structures are visible and usable at its intersections (Figure 24). A street intersection, by its very nature is generally free of vegetation, which therefore provides clear sight lines at an intersection. This setting is ideal for terrestrial laser scanning to enter the scene and collect a wealth of data at intersections and bends (Figure 25). With ongoing construction, as shown in Figure 25, it would be better to defer any scanning at the bend until the new construction is completed and there is a new building in place ready to survive for many decades.

Figure 24: (a) T-intersection of Denistone Road at Ryedale Road (2023), and (b) T-intersection of Denistone Road at Dalton Avenue (2023).

Figure 25: Built and building environment at the bend in Denistone Road (2023).

At the intersection of Pittwater Road and Magdala Road (Figure 26) such a terrestrial laser scan has been undertaken by the City of Ryde.

Figure 26: Intersection of Pittwater Road and Magdala Road (2023).

Detail from the scanned information at this intersection is shown in Figure 27. Data was obtained using a quadrilateral of station set-ups, which enabled data points to be collected to a cadastral accuracy of well under 5 mm. This is considered a suitable technique to validate and confirm data for 20 metres up each road away from the intersection. Connection to Survey Control Information Management System (SCIMS) control marks meant that a full MGA coordination was possible and achieved.

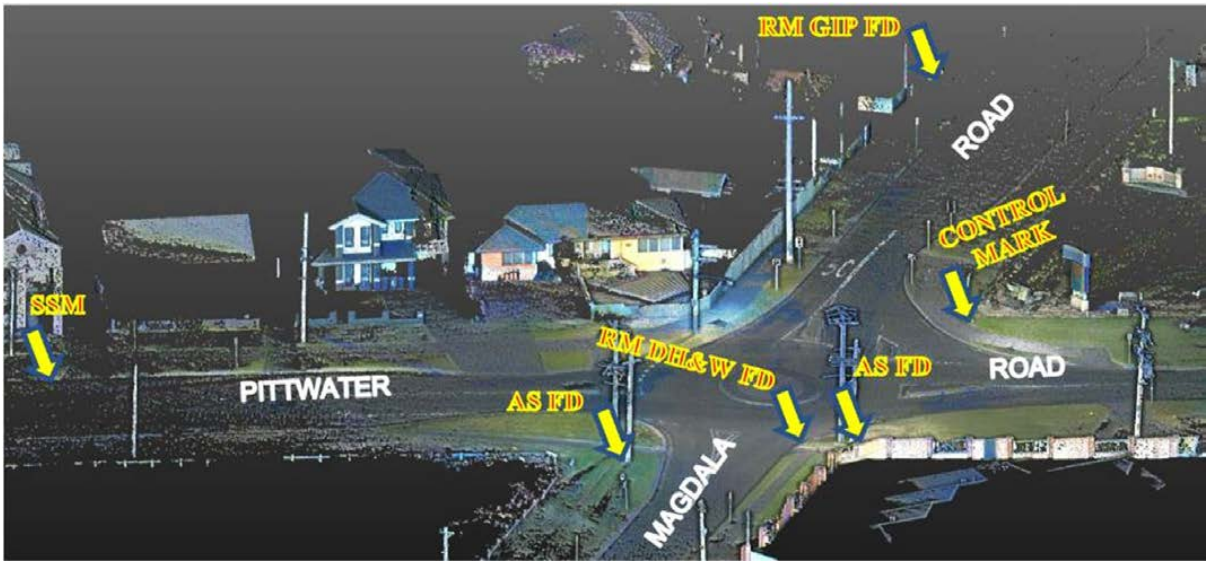

Figure 27: Scanned detail at the intersection of Pittwater Road and Magdala Road (2023 scan).

Figures 28 & 29 show some of the detail obtained from the intersection scan, from the North Ryde RSL signage pillar and its artillery monument to a newly constructed residence, which should remain for decades.

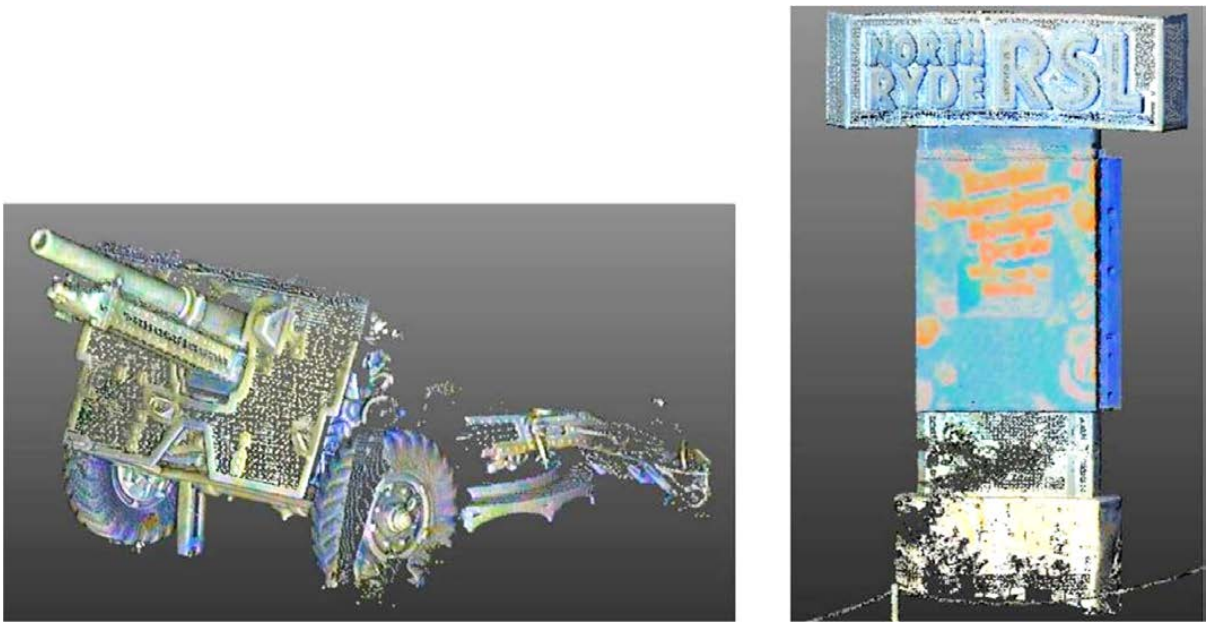

Figure 28: Scanned detail on the North Ryde RSL site (2023 scan).

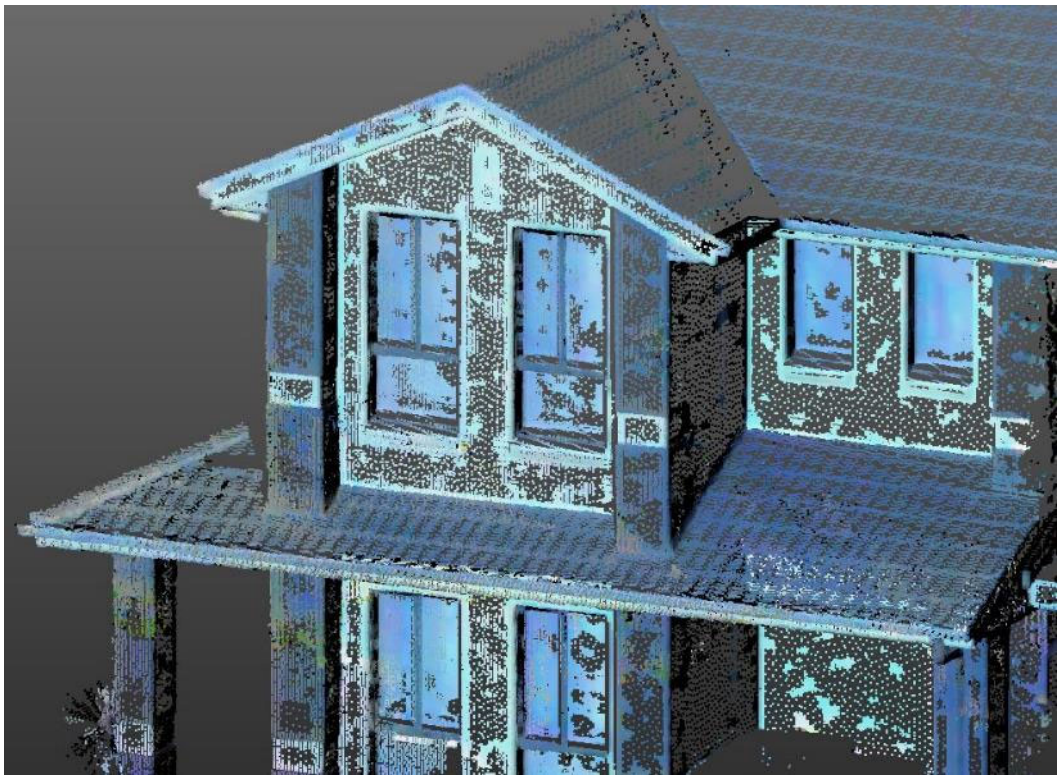

Figure 29: Scanned detail on newly built residence (2023 scan).

Close up detail of the scanned data shows some of the many overall points, which can be used for future reference to establish the road boundary lines (Figures 30 & 31). The step-out in the brick fencing pier enquires at 240 mm from the scanned data and measures 240 mm by tape measure.

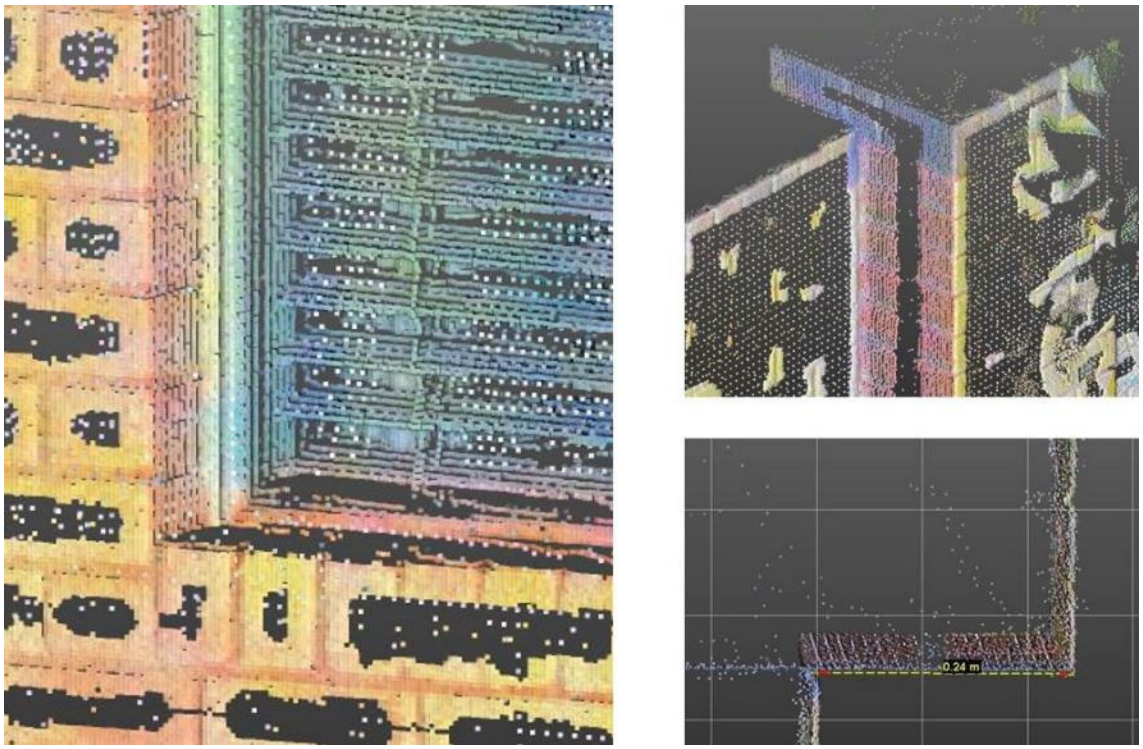

Figure 30: Scanned detail on window frame and edge of brick fencing pier (2023 scan).

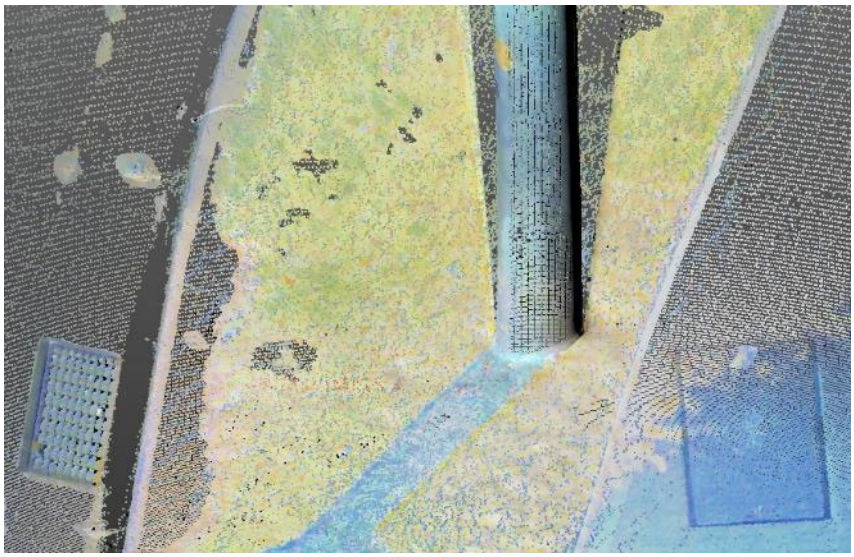

Figure 31: Scanned detail of a metal stormwater grate and a telecommunications pit in the footpath (2023 scan).

5 TAMING THE BEAST

Traverse measurements between several known reference marks and coordinated SCIMS marks are essential to fitting the scanned data to the cadastral framework (Figure 32).

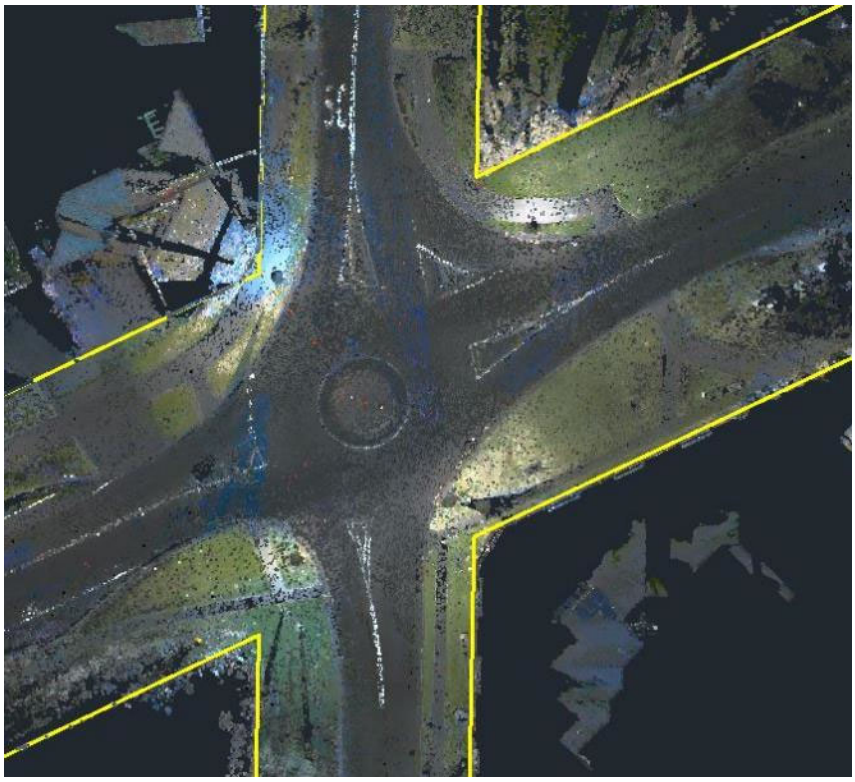

Figure 32: Scanned data fitted to street corner cadastral boundaries (2023).

Where disputes and disagreements about a street fix are unlikely and where the street is still in the position as created, there would appear to be no real urgency in locking down the intersection. In the future, Google Maps and Street View (in whatever form they take) could verify what still exists at an intersection. Check Google Maps and Street View to see the current

state of the street intersection, then upload any relevant points of scanned data to the field controller before using this data to establish a street intersection corner.

Surveyors must be left to make a best estimate of boundary position based on sound and thorough investigation. LRS insisting on complete agreement with a previous already registered plan is not only an easy way out, but is wrong and setting the cadastre up for failure with major zones of conflict.

What is the industry solution and the council solution to a lost intersection? The City of Sydney had this problem in the past. Following first grants, a multitude of constant development and change with rapid loss of survey infrastructure occurred. Occupations became king, a situation which led to the City of Sydney becoming a consent authority, who had the sole power to approve any street boundary determination within its city limits.

What can other councils do?

- Create a plan for a street re-definition showing the most valid fix at a street intersection.
- Maintain a documented history of the relevant DPs, which created their streets in the first place.
- Place a PM at the intersection if a SCIMS mark does not already exist.
- Scan an image of the street intersection for modelling and providing a locality sketch for SCIMS marks placed (there are 85,000 ‘class U’ SCIMS marks which rely on a locality sketch only as a means of finding where they are sited – this is 32% of the marks in the SCIMS database!).

7 CONCLUDING REMARKS & THE BIG EASI

Uncertainty of knowing just what will survive and last, and still be present at a street intersection after several or many decades is the constant problem which needs to be overcome. Time is the enemy. Knowing that things will change, the built environment will become altered and survey marks will be lost and destroyed, gives surveyors a chance to minimise the effect of such changes. Preservation of Survey Infrastructure (POSI) should play a major part in the protection of survey marks, but is POSI really preserving the true corners and boundaries when so many of the survey reference marks are not connecting to a correctly defined street fix or corner?

City of Ryde is not advocating any changes to the current position of side boundaries of lots as determined and fixed by survey. Any side boundary created in relation to an incorrect street fix should remain in its created position, even if the street definition changes and the street boundary line is altered. It is acknowledged that there may be some problems in relation to re-establishing old boundaries which had an angular relationship to the original street boundary.

This is about local councils and surveyors ‘Reclaiming the Streets’ as a solid coordinated network with which to maintain a sound cadastre. In Ryde, not all streets are in their original created position anymore. But for the future, if intersections are scanned now, then the data could be available for decades, because not all of the referenced points and occupations will disappear. This paper has suggested terrestrial laser scanning as a means of protecting and retaining council road assets rather than have them be a dumping ground or repository for past inaccuracies and not fully informed decisions with respect to street boundary fixing. A final point of reference is the big EASI: Just get Everything At Street Intersections!

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