OPTIONS FOR MARKING THE CADASTRE

Lynn Holstein and Ian Williamson

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Land Information Research Group
School of Surveying
University of New South Wales Australia

Report prepared for the Study into a Co-ordinated Cadastre for South Australia being undertaken by the Department of Lands, South Australia.
This article discusses the demarcation and the marking of parcels and boundaries. It only deals with the actual marking of parcels of real estate and the marking of reference marks associated with cadastral surveys.

The article takes a standpoint on the importance of good monumentation. It suggests that monumentation is more important than measurements or the description of the monumentation. Further it discusses and analyses the place of co-ordinates in a cadastral survey system. The article concludes that co-ordinates should not be allowed to override monuments in boundary determinations.

In summary, a number of issues are raised and recommendations made concerning changes to marking the cadastre.
SUMMARY

1. In Common law jurisdictions, monuments over-ride measurements for the determination of boundaries. It is considered that this is in accord with the way society perceives boundaries.

2. No jurisdiction has successfully introduced a system using "legal" co-ordinates to over-ride boundary monuments or long established occupations.

3. Co-ordinates are a fundamental and important component of any modern cadastral system. Their primary role is for administrative purposes to support cadastral mapping and the creation of a DCDB. A secondary role is to assist the redefinition of cadastral boundaries, and to assist the integration of survey and spatial data. Modern technology will simply support these objectives and allow them to be achieved more efficiently.

4. Emphasis should be placed on more permanent boundary marking. Cadastral surveying is labour intensive. It is considered cheaper to mark a boundary permanently" ~ rather than mark it several times in a less permanent manner.

5. Serious consideration should be given to the introduction of more permanent, more direct and simpler reference marking systems. Centre-line marking in suburban areas is recommended. Improved rural marking is recommended in the broadest sense.

6. Co-ordinates should be shown on plans of survey to ~ in boundary definition, however, the main advantage will be for administrative purposes.
7. Recognise the permanent nature of many physical features on or near boundaries. For example houses, fences, buildings etc. can be used to a greater extent.

Consideration should be given to the proposal that boundary occupations should gain legal significance with time. It is suggested that this principle is not in conflict with the concept of a modern cadastre.

8. Wherever possible, boundary marks or reference marks should be placed in rock or other permanent medium when new boundaries are created.

9. The recognition that in time, the cadastral framework, showing all structures on the parcel, will be shown on a large scale map (in digital form). If legal recognition is given to occupations over time the total system will be compatible with the cadastral concept. Co-ordinates, however, are an integral part of such a system.

10. In general, the weakest component of our present cadastral system is boundary marking, whether that marking is point or linear marking.

11. The recognition that cadastral boundaries move over long periods:

12. GPS will assist greatly with the introduction of a modern cadastre into South Australia, but it should not change the way boundaries are perceived or defined or marked.
INTRODUCTION

Courts in Common law countries have long established precedents concerning the weight of evidence when considering boundary disputes. The order of priority is natural boundaries, original monuments, long undisputed old occupations, abuttals, and statements of length and direction (Hallmann, 1973: 176). The importance that courts have placed on boundary marking as compared with measurement is apparent from this order. The overlaying of title registration and associated boundary survey regulations onto Common law have changed the situation very little (see Brown, A, 1980: 156). There is still no such thing as a guaranteed distance in title surveying. The marks and markings a surveyor leaves behind are of paramount importance to his description of them.

It is important to examine marking and its role in boundary demarcation especially with the availability of new technologies that are capable of giving accuracies of five cm at the one sigma level. Today there are now three technologies that allow the potential of 'mass' co-ordination. This has resulted in some surveyors questioning the role of marking in cadastral surveying (Mac Donald Barr, 1983 and Toms, 1978: 249). These technologies are digital photogrammetry, inertial survey systems (155) (Colman et al, 1985) and the global positioning system (GP5). Perhaps GPS, which is on the verge of use in Australia (Lardern and Warhurst, 1985: 13), offers the most potential (certainly by 1990) for providing point co-ordinates with an accuracy useful for cadastral purposes. It is a system which the cadastral surveyor may use independently and is able to afford. Both ISS and digital photogrammetry are both very logistical and systems dependent, and are less suited to ordinary cadastral use. All three systems however only produce co-ordinates. They do not determine property boundaries which are ascertained by inquiry, investigation and
measurement. Boundaries are not primarily determined by or described by "legal" co-ordinates in any jurisdiction known to the authors'. When discussing a proposal to describe parcels by co-ordinates Thigpen (1968: 487) wrote:

..to describe all future parcels of land by specific reference to the plane co-coordinate of each corner is at the outset in direct conflict with long-standing principles of real property law, in a profound argument with logic, in dispute with experience and in a serious quarrel with realities

In effect, co-ordinates would not aid the process that has been occurring in every fixed boundary jurisdiction for hundreds of years. A fixed boundary description is temporal as it describes a mark or marking which again is temporal as it is usually replaced with a physical boundary which may be on or near the described legal boundary. Common law (the accumulated wisdom of the jurisdictions which use it) reflects this in the manner it weights precedents in boundary considerations. Dale's (1976: 23) defacto and dejure boundaries consider this problem. Defacto boundaries arise because of poor description, monument removal, physical boundary development and re-development overtime, until the physical boundary, sometimes long accepted, no longer represents the legal boundary -the dejure boundary. The use of co-ordinates does not stop this process from occurring. Even in New Zealand where all cadastral boundary vertices have a transverse mercator co-coordinate available on a submitted 'traverse' sheet and survey 'deposited plans' are plotted by and show grid lines, they still have the same basic problem as Australia the lack of permanent monuments.

This brief report is simply about boundaries and marking. It is proposing that even though co-ordination devices are available to aid in the boundary description proct*sthey do no aid in the marking process.
The report commences by defining a boundary, discussing classes of boundaries and analysing rural and urban real property boundaries. It includes some discussion about co-ordinates, new technology, and makes appropriate conclusions.

2 BOUNDARIES

Boundaries Defined

Boundaries are lines of demarcation between one parcel or region of land and adjoining lands or parcels. They may be horizontal or vertical in nature. Vertical boundaries are fan shaped and typically may extend from the centre of the Earth, up through a surface mark, to the sky (Hallmann, 1973: 22).

Simpson (1976: 125) states that there are two types of surface indicators of boundaries, the first being an "invisible line" denoting the limit of what is owned, marked on the gound by points on the turning points; and the second being a "physical feature" such as a hedge, wall or bank by which that parcel is bounded or limited.

Boundary descriptions or documentary boundaries are simply representations of the "real" or ground marked boundaries.

Boundary Marking and Boundary Descriptions

There are two distinct considerations when discussing boundaries. The first concerns how the boundary is marked on the ground surface in other words what type of marking is used to show the limits of the parcel. The second consideration is
how these ground markings are described on or in a plan, map, document, deed or title; in other words is the description of the markings verbal (written), graphical or numerical.

It may be stated that if clear boundary marking exists for a parcel and it has a clear reference for identification purposes, then in the short term no boundary description is necessary. Of course clear and permanent boundary marking is rare, and for this and other reasons, such as efficient conveyancing, boundary reinstatement, parcel indexing, land planning, land administration in general, and its use for utility purposes, boundary description is undertaken. Since this report is concerned with boundary marking, boundary description will not be discussed in depth.

3 BOUNDARY MARKING

It is possible to classify boundaries and boundary marking in two different ways. One method is by the material used in the physical objects that mark the boundary, the other is by the function of the marking. The former classification has two classes, natural and artificial boundaries (Halsbury, 1952; Willis 1982), while the latter also has two classes which in this report will be called "point" and "linear marking". The artificial and natural boundary distinction is very useful in discussing natural boundaries but is confusing when analysing artificial features. Simpson (1976: 125) and Dale (1976: 19) both use the concept of function to classify boundaries and marking. Simpson talks of "invisible lines" and "physical features" while Dale divides boundaries into "monumentation by beacons" and

3.1 "monumentation by linear features"
Point marking may be defined as property boundaries that are marked by points at the vertices or turning points of the boundaries. The marking points may be pegs of any material including wood, steel, nylon, aluminum, concrete, rock cairns, marks on rocks and walls, steel pins driven into posts and drill holes in concrete. The marks may be artificial or they maybe marked on natural objects such as rock. An important distinguishing feature is that the boundary line is the line between the marked points at the vertices. It is an invisible line between marks at the corners which are in themselves visible. This boundary line is sometimes "developed" by the erection of a fence line on or near this invisible line. In most jurisdictions this physical feature does not replace the invisible line between the marking points at the corners.

It is this type of marking that is typically associated with Australasia's boundary marking. It is estimated that over 90% of boundaries in Australasia are of this type. In discussing this type of marking Williamson (1983) states "Most of the boundary definition problems within NSW arise because of the loss of all original survey monuments defining the boundaries". This is further compounded by the inadequate description of those monuments to allow adequate replacement. The situation then occurs that the fixed boundary system insists that the boundary is where it was originally marked.

3.2 Linear Marking

Linear marking may be defined as a boundary that is defined by a physical feature along its entire length. The actual boundary is a straight line between terminal points. It just follows the meanderings of the feature. The physical features associated
with such markings include both artificial and natural objects. Natural boundaries here include both riparian and littoral limits and cliff tops and bases, while artificial boundaries include common walls in semi-detached and terrace houses, hedges and ditches, fences, irrigation channels and rice paddy dykes. Linear boundaries are created at the time of survey. Artificial boundaries in this instance would generally have been developed before survey and would be the result of subdivision, the conversion of title systems, settlement before survey, and confirmation surveys as in England.

Linear marking is typically not associated with boundary marking in Australia, however it is very common. It is common with both natural boundaries and artificial boundaries (especially with common walls or party walls and even with rural fencing). An example of the latter is in NSW where the Regulations (Reg 33(b)) allow fences to be defined as "irregular boundaries" in a similar manner to a natural boundary.

Before proceeding to describe rural and urban boundary marking in detail, the term monument is defined, as are the concepts fixed and general boundaries.

A monument in a cadastral surveying context is, according to the Oxford Dictionary, "Any object natural or artificial fixed permanently in the soil and referred to in a document as a means of ascertaining the location of a tract of land or any part of its boundaries."

The NSW Survey Practice Regulations, 1933 state in Regulation 5 that a monument " means a natural or artificial object or point thereon or mark which object, point or mark is used for the purpose of locating or relocating a boundary or a point therein ". It is then any mark, in a point or linear form, that indicates
boundaries and is referred to in a legal document or plan. Ideally a monument should be stable, permanent and built or marked upon materials of a durable nature, but if this is not the case if will not stop a documented mark becoming a monument.


3.4 Fixed and General Boundaries

It has become quite common for publications and practitioners to refer to fixed and general boundary systems when discussing boundary systems. These terms or concepts have not been legally defined either statutorily or judicially in Australia, though in England, and in some African and Caribbean statutes, they are (e.g. Kenya and Cayman Island)

A fixed boundary is a boundary marked by either "point" or "linear markings" with the precise line and turning points surveyed and shown on a plan. The boundaries are actually fixed at the date of survey, which can become important in some natural boundary considerations.

It should be noted that for a fixed boundary to be such it is not necessary that it be described by "metes and bounds", or numerically. It can be described verbally, graphically or numerically. It is a function of definition.

In Australia, fixed boundaries are described by "metes and bounds" and portrayed verbally (in written form) or on a plan. Sometimes the concept of fixed boundaries
A general boundary is a boundary line marked typically by a "linear marking" where
the precise location of the boundary feature on that marking is not determined
They are associated with boundaries that have been developed at the time of survey
and further with the fact that inquiries are not made as to the ownership of the
bounding feature -as to whether the boundary is the centre-line or edge of the
feature for example. To determine the precise boundary of a "general boundary"
enquiries must be made on the ground

Dale (1976: 35) writes

"There are three categories of fixed boundary / namely those defined on the
ground prior to development, those in which the boundary is adjudicated
after development

and those which are defined by surveys to specified standards. Each type
reflects the fact that the precise position of a boundary has been established
through adjudication. There are also three categories of general boundary,
namely that in which the ownership of the boundary feature is not
established, that in which the boundary is the indeterminate edge of a
natural feature and that in which the position of any boundary is regarded as
approximate so that the register may be
kept free from boundary disputes.'
concrete) and only approximate surveys are undertaken to enable the boundary description to be shown graphically on maps of scale 1:4000 or thereabouts.

4. URBAN AND RURAL BOUNDARY MARKING

Boundary marking of parcels will be considered for convenience under the headings of rural and urban boundaries. While there are many similarities there are many emerging differences especially as urban boundaries are usually associated with surveys of a higher precision and the density of boundaries is greater.

4.1 Rural Boundary Marking

In considering rural boundary marking it would appear that in Common law jurisdictions that the greatest use is made of "point marking", especially with the peg being either concrete or wooden. This has grown out of necessity, especially in developing countries because of their lack of cultural features. Therefore it has been necessary to place artificial marks through lack of any other means of defining boundaries. "Linear marking" of rural boundaries, apart from natural boundaries, is rarely used unless the land is already settled, meaning that the parcel is occupied and the proposed boundary developed thus allowing it to become the legal boundary.

4.1.1 Point Marking for Rural Parcels

The use of point marks for rural parcel marking mostly involves the marking of the vertex of a boundary with an artificial mark. It is convenient to split the point marking class into "placed marks" and "engraved marks"
(a) Point Marks

The types of marks placed in rural surveys ranges from the wooden peg to iron pipes set in concrete. These marks are in effect points marking a vertex of a boundary. The type of mark used depends on many factors - the stability of the terrain, the type of soil, the climate, the social conditions of the people in the area, the cost of the marks, the ease of placement of the marks, ease of transport of the marks, the professionalism of the surveyor / the regulations (if any) and the availability of materials out of which the marks are made.

In Australasia, the “traditional” placed mark has been the wooden peg made out of hardwood and recently in some jurisdictions (e.g. NZ) treated softwoods. These marks have had cross-sections of up to 100mm x 100mm and lengths of 550mm for Crown land parcel markings. More common cross-sections are 75 x 75mm and 75 x 35mm. The length is typically 530mm with the last third of the mark tappered to a point. In some jurisdictions, posts of greater dimensions have been used but the difficulty of transport has limited their use. It is widely recognised that it is relatively easy to destroy almost any type of survey mark, especially a wood ern peg. Many countries use more permanent marks, or at least heavier marks. In Switzerland a granite stone” peg” is placed with dimensions of 120mm x 120mm x 100mm with a chiselled “X” marking the boundary vertex (Williamson, 1981). Alternatively a brass plug set in concrete about 35mm in diameter is used. In Thailand numbered circular concrete blocks (100mm diameter, 500mm long) are placed at each corner. In Brazil in the States of Para and Amazonic3 (adjacent to the Amazon River) on land settlement projects, concrete blocks are used as well, although these are 80mm x 80mm and are inscribed with an official mark and a note warning of the mark’s legal importance. In the more remote parts of the jungle the survey labourers have refused “\% carry these heavy marks and consequently aluminium tube marks are
now being used. These are roughly retangular in section -about 80mm x 100mm at
the top widening to about 120mm x 100mm at the bottom and they are about
600mm long -they may be stacked together for ease of carrying

The marks are stamped with an official mark and warning

Another variation on placed marks is the metal mark surrounded by concrete. This
technique is used in the Caribbean, especially on Cayman and St Lucia Islands. Here
concrete is poured on site approximately 200mm in diameter and 300mm deep
about a galvanised metal mark being an iron tube or spike.

In Alberta, Canada, it is common in rural marking to use long steel pipes 1.5m long
driven well into the ground. Apparently such marks have been found to be quite
permanent- in one test over a 4 year period only 1 per cent of the marks had been
destroyed (Dale, 1976: 20). Such marks may be located by magnetic means if they
are difficult to find

Marks that respond to an electronic magnetic locators are quite popular in North
America for boundary marking in non public land surveys. The marks used may be
iron encased in plastic, galvanised tubular pipe or reinforcing steel rods about
600mm long. Some marks are sold with identification caps that can have the
purpose of the survey / the surveyors name and his license number engraved upon
them. Personalised marks such as these are possible in nonpublic land surveys in
some counties, in some States in the USA. In Erie Country in western New York, for
example, there are no "survey regulations" in the Australian sense and boundary
marking is a matter for the client and the professionalism of the surveyor.
(b) **Engraved Marks**

Engraved marks are used when an obstacle inhibits the use of a "placed mark". A mark must be ‘engraved’ upon the obstacle, for example, a drill hole in rock, a blaze in a tree, steel alloy marks ‘fired’ into rock or concrete, spikes placed in posts, and metal marks concreted onto rocks. It must be emphasised that some of these marks are used in preference to II placed marks". In Australia the practice of ‘blazing’ trees on or near boundary vertices and along boundary lines commenced as early as 1811 (Williamson, 1984: 108) and is still used today in Crown land surveys. Regulations in use in 1853 required a broad arrow and numbers of the portion being marked to be cut into the blaze facing the corner. Another set of regulations in NSW in 1864 also required that if rocks which may be upon a boundary line are, wherever the character of the rock will admit of it, to be marked with a pick line; and where at a corner of a portion, with a broad arrow” (Williamson, 1984: 109),

It is apparent that marks in this category have a longer life span than those of the "placed mark" variety. Wooden pegs are subject to movement due to fencing, fire or just the climate and these factors also account for the destruction of blazed trees. Perhaps the most permanent marks are those on substantial rock outcrops especially where the mark is engraved into the rock.

**Terrain and vegetation marks** consist of changing the soil in someway to indicate a boundary line or vertex, or the placing of a tree on the boundary corner. In Australasia the practice of "lockspitting" has been used since at least the 1840's with some success. It consists of a trench dug into the soil radiating along the boundary lines from a boundary vertex; typically 0.3m wide, 1.1 m long and 0.2m deep. They are also used
along boundary lines away from vertices. Current NSW Crown Lands Office Survey Directions (1981: 7) and the NSW Survey Practice Regulations, 1933 require lockspits to be trenches 1 m long, 200mm wide and 150mm deep commencing 300 mm from the peg or may consist of packed stones of similar dimensions.

The placing (planting) of a young tree at boundary vertices has been undertaken in some African countries, notably Malawi and Kenya. A fast growing tree typical to the area is used and the adjacent owners are made responsible for its maintenance. In Zanzibar, during investigations for land registration purposes, concrete marks were found to be unsuitable mainly because of expense and labour difficulties. Such monuments were recommended for use in town areas only. In clove growing areas, clove trees were recommended as well as the planting of bushes and lines of pineapple plants, and in coral areas coral stones were suggested (Larson and Stoimenov, 1983: 26).

Point marking or point monumentation is often said to be the weak link in many cadastral systems. Many prominent writers have made statements that more permanent marks or a change of marking techniques are needed (Dale 1976: 20; Willis, 1971: 11; Williamson, 1983: 195; Simpson, 1976: 128 and 129). If more permanent marks such as steel marks in concrete are used in Australia on a cost criteria alone, costs per mark would increase at least $40 meaning an increase of 100% in mark out costs for an 'average' residential parcel (ISA NSW Div 1985). A better way is not to place the final survey marks in new subdivisions until the services and road works are in place or better still until the fence lines and buildings are in place. This practice involves the placing of temporary boundary marks before development and permanent marking on completion of the constructon. It is of course a costly option.
4.1.2 **Rural Linear Marking**

Rural marking in regard to linear marking includes natural boundaries such as river banks, mean high water line and edges of cliffs. Also included are boundaries that run along man-made features such as walls, fences, rice paddy dykes, irrigation channels railway lines and planted hedge lines. Such boundaries on man-made features tend to come about when land is being brought onto a land register and the boundaries are already developed. This applies in both developed and less developed countries.

**Both artificial and natural boundaries will tend in a fixed boundary system to be** labelled that the boundary is actually the feature and whether the actual line is the centre line or edge. In which case, if that feature moves inperceptively over time then the boundary moves as well. In a general boundary system the position of the boundary on the feature will usually not be stated. The graphical description implies the boundary is on the feature; to ascertain where the boundary is exactly requires inquiries to be made of the abutting owners.

The features of riparian and littoral boundaries have been well described in Brown (1980: 128) and Hallmann (1973) therefore little more will be discussed here. However it must be observed that over the past twenty years in Australasia there has been a trend toward the ‘right-lining’ of natural boundaries in some circumstances. Examples of this are found in New Zealand and in Queensland (OLD Surveyors Regulations, 1978, reg 28 (1)(d) for example. It would appear that the regulation writers (or surveyors) believe that the advantages of being able to **numerically describe a linear boundary outweigh the cost of point marking (albeit temporarily)** a boundary that is already permanently marked lineally.
In Kenya, where linear monuments were in use, the idea of growing a linear boundary was attempted. Hedges were planted along boundaries as agreed between owners, with a view to making photomaps of the subsequent "air visible" boundaries. It transpired that due to drought, white ants and non-planting of hedges, that the programme was not a significant success (Simpson, 1976: 152). It must be observed that such measures for marking boundaries are not in the best interest for developed or less developed countries. A landholder will fence his or her land when economics, privacy / agricultural or other reasons dictate. It is a strange marking system that takes a subsistence farmer away from planting crops to planting boundary hedges.

4.2 Urban Boundary Marking

Urban parcel boundaries are certainly very important as land values in cities are usually high compared to rural areas and because of the density of dwellings. In addition there is always a strong demand for land. Dale (1976) points out that the closer people live together in cities, the more likely it is that they will build fences about their parcels. This process usually will entail the removal of the corner survey monument to construct the fence. Toms (1978: 218) describes the history of the development of urban boundaries.

Monuments in these early urban surveys took the form of wooden posts on the principal corners and pegs on intermediate allotment boundaries. In general, these original marks were not connected to an overall survey-control network and in the course of time the great majority of them have disappeared in urban areas having been replaced with occupations such as fence posts or corners of brick walls. Many have been lost through other causes in the course of urban and suburban development.
It may be observed from this quote that urban monumentation consists of both **point marking and linear marking. While it would appear that in a developed country most marks would be point monuments, it is certain that as city boundaries become more developed and redeveloped, the original marking is disturbed or destroyed. The situation then becomes very much as applies in general boundaries.**

Even in Australia, fencelines become the only visible mark of the physical boundary since the legal boundary is not obvious from an examination of the physical boundary. It may be said that the boundary is on the physical feature while the legal boundary is near the physical feature but in need of further definition. In other words, urban boundaries are becoming linear monuments or markings over time with the precise line left undetermined.

**Urban Point Marking**

New boundary marks are mostly point marks and are predominately marked by

In Australia the wooden peg is most common but in some states other types are allowed. South Australia allows the use of pegs of wood, metal or plastic (SA Survey Regulations, 1976) while Queensland apparently allows any material of a "composition that will resist destruction by fire, natural corrosion or decay ..." (OLD Surveyors Regulations 1978). New South Wales (NSW) requires "a peg, a drill hole in rock, concrete, or other similar material, a chisel mark or nail in fixed timber or otherwise suitably" (NSW Survey Practice Regulations, 1933). In NSW, if a peg is placed it must be wooden.

In Germany some of the States required boundary stones of 'dressed granite' or concrete. The Dimensions to be 12cm x 12cm x 60cm. Many States allow plastic marks (Toms, 1978 : 237) to be used. Toms states when discussing Germany:
“When it is not possible to emplace boundary stones or plastic marks use is made of iron pipes set in the road or footpath surface. Wall monuments such as inset bolts and “stuck on” metal or plastic marks are permitted when corners fall in or on durable structures.

It is interesting to note that in the City-State of Hamburg lot boundaries are marked permanently only on application, the philosophy underlying this approach being that the existence of a dense and well marked survey-control network properly maintained renders permanent monumentation of boundaries superfluous when any corner can be re-instated to an accuracy of 1-2cm from co-ordinates.

When marking established boundaries it is now more accepted to use wall marks, Blachut et al (1979: 72) describes the use of wall marks in Poland and in Canada, not for direct boundary marking but for traverse station purposes and reference points. Special wall marks have been developed to allow the use of such stations as control points. One, a bracket mark, allows a portable centering arm, to be fitted which allows the position of the mark to be used. Another bracket mark allows a small plastic reflector (suitable for EDM purposes) to be fitted.

Urban boundaries in many cases become developed and in many cases the point marks are lost or destroyed. Subsequently on re-definition or perhaps during the conversion process, the now developed boundaries are used for the description of the parcel. In many cases the boundary mark becomes a mark on a fence, a drill hole in brick or the fence itself becomes the boundary. Willis (1974) states that NSW has several kinds of linear marking, namely fences, walls and riparian boundaries.

4.2.2 Linear Urban Marking
Linear marking in an urban environment consists of the actual object being part of the vertical boundary itself. Here the boundary is indicated by a dwelling wall, be the boundary on the edge of the wall or through a party wall, dividing wall or fences. In the case of a separate dwelling wall, the edge of which is indicated as a boundary, the vertical boundary actually will run over the surface of that wall, whether it is vertical or notvertical. This is the type of boundary associated with terrace homes, both single and double storey. Party walls may be one of four types, meaning that the boundary line maybe on the edge or in the centre line of the party wall. In the case where fences are the actual surface marking, this is usually indicated on a plan. In all cases the boundaries are able to move depending on the soil and climate. It should be mentioned that in a fixed boundary system, like in Australia, many boundaries that were originally poorly marked in areas with shortages and excesses, and now have developed boundaries of long acceptance by adjoining owners, this type of boundary is accepted by default. In NSW this is referred to as boundaries defined by occupations (Willis, 1974: 12).

In discussing urban boundaries and marking, several writers have observed that dwelling walls are quite permanent marks and should be used more often as boundary marks, albeit reference marks. Williamson (1981: 452) suggests such an action as does Dale (1976).

To conclude this section on urban boundaries it is observed that authors in six papers in the last ten years in Australia have called for a change in the urban boundary system. The papers are Toms and Lewis (1974), Barrie (1977), Williamson and Holstein (1978), Zwart (1980), Bullock (1980) and Williamson (1983). They have all recommended the introduction of a general boundary system with some modification, in some situations in Australia. They did this after recognising that Australian urban boundaries are now relatively settled and established, and that in reality urban boundaries in many cases are general boundaries already.
5 CADASTRAL REFERENCE MARKS

In Australasia and other countries where similar survey practices are undertaken, such as South Africa, it is usual to place reference marks at corners for boundary corner mark reinstatement or replacement purposes. Typically in Australia each corner mark placed is required to have at least one reference at every corner (e.g. OLD). In NSW the number of reference marks is dependent on the number of lots and on distance. As an example of reference marking, OLD Surveyors Regulations (Reg 25(5)) state that a reference mark is suitably marked tree, fence post or durable mark on a building or other immovable object, or a pin of durable material not less that 15mm x 300mm driven flush into a paved surface or at least 50mm below an unpaved surface.

Therefore reference marks are required to be a steel mark (sometimes buried) marks engraved on rocks, blazed trees if a Crown land survey and under certain circumstances it must be a so-called permanent mark as prescribed by the jurisdiction’s Chief Surveyor. Typically such permanent marks would be an official brass plaque set in concrete poured in-situ.

In some jurisdictions and notably in New Zealand, reference marks are required to be buried at least 150mm below the surface in some circumstances. Certainly some strange unofficial” official marks have been subsequently found in some jurisdictions from the work of of the late 19th century surveyors; for example, stone and glass bottles have often been found. Toms (1978) mentions that in Germany, in some States, a reference mark must be placed vertically below the boundary stone.

The reference marks in some jurisdictions (e.g. Victoria) are actually the traverse marks from which the boundary marks were originally placed, especially when the
survey has not been directly on the boundaries. The importance of reference marks in New Zealand may be gauged by the fact that in a rural cadastral survey carried out by photogrammetric means, two reference marks per boundary corner were required to be placed (Greig, H. W. B. et al 1972). In Western Australia this is a requirement by regulation.

In public land surveys in the USA, reference marks are called corner accessories (Grimes, J. S., 1976: 611) and may be trees, posts, marks on rocks, and rock cairns.

In urban surveys, reference marking is usually by drill holes or plaques in concrete on street furniture of some type, but usually kerbs. With underground wiring and frequent road improvement programmes it is a difficult decision as to where to place reference marks ‘permanently’ A few more successful positions have been on median strips on road centre lines, offset marks on private property and wall marks such as inserted metal or plastic bolts or marks attached by glue (see Blachut, 1979: 2).

6 CO-ORDINATES AS "CADAstral MONUMENTS"

The use of a rectangular co-ordinate as a permanent monument replacement is technologically becoming a distinct possibility as mentioned in the introduction. The use of the co-ordinate in this context would be to take the place of the peg in boundary marking, meaning that each time a boundary was to be determined or redetermined a co-ordinate fix would have to be undertaken based on the assigned co-ordinates for that boundary. If the co-ordinates have legal significance, in as much as that they can over- ride boundary monuments, they are often termed "legal" co-ordinates.
It must be emphasised that co-ordinates have extensive uses in cadastral surveying in general. They are basic to most cadastral survey systems. They are very necessary for cadastral mapping where the maps are to be used for land information system purposes for example, where that data is to be integrated with natural resource data. They are necessary for integrated surveys where engineering, topographic and cadastral surveys use the same major survey control network and accordingly the same co-ordinates. They are virtually essential for reliable cadastral map compilation; they are essential if any form of digital cadastral data base is to be established. Reliable co-ordinates based on the same origin and datum are useful as a starting point for boundary reinstatement (e.g. New Zealand) and finally in new subdivisions they are very useful for setting out boundaries.

Many authors have debated the merits and problems of "legal" co-ordinates for parcels notably Hallmann (1973: 34-39), Bullock (1980), Williamson (1983) and Dale (1976: 166). It must be noted that co-ordinates aid the total system (the construction of the cadastral map and DCDB) more than they aid boundary reinstatement and investigation. As noted in the introduction, property boundaries are determined by inquiry, investigation and measurement. Boundaries, even though fixed at a point in time, can move and as noted above, ultimately can become the position as fenced. This happens even in jurisdictions where there is legislation directly preventing claims of adverse possession for small strips of land occupied by fencing away from the legal boundary (e.g. New Zealand and NSW).

Further it must be stated that many boundaries are very difficult to define by co-ordinates- natural boundaries and non-vertical boundaries if on a dwelling wall. Finally I apart from all the problems of datums of the system of co-ordinates and its parameters, as well as which point one uses as an origin for a particular survey (the matter of accuracy), how does a jurisdiction define legal co-ordinates for all the existing parcels in its jurisdiction under a fixed boundary system. This would mean all boundary corners would have to be investigated and co-ordinates calculated. In
the State of New South Wales this would amount to 2.4 million parcels being
**investigated meaning about 6 million corners.** The authors suggest that legal co-
ordinates are against the Common law used in Australia and against the way in
which people perceive their boundaries.

**It is a fine aim to have co-ordinates derived from maps for all parcels in a jurisdiction**
for utility / administrative and planning reasons. It is another proposal altogether to
have legal co-ordinates defining those parcels.

**While GPS especially gives the opportunity of defining co-ordinates to 0.01 m over**
the area of a city for $500 per point in 1985 and $50 in 1990 (Collins, 1985), it is
considered that this will be most useful for administrative rather than legal
purposes.

**7 COSTS OF BOUNDARY MARKING**

To further stress the importance of good boundary marking, a brief note on costs is
included. The cost of cadastral marking is dependent on many factors including the
cost of labour, the cost of materials, transport, the terrain, whether the terrain is
vegetated or cleared and if the boundaries and the parcel have been developed. An
inspection of the Institution of Surveyors Australia (NSW Division) scale of fees
**schedules reveals that the cost of a city resurvey for an average residential parcel,**
including remarking, would be approximately between $ASO -$A80 per pegged
mark (Instit. of Surv, 1985). This charge includes data gathering, labour and
boundaries on an urban lot and issuing a report is $290 including the cost of five pegs. If those wooden pegs were upgraded to the permanent mark type, the extra charge would be $71 per mark; that is say $284 extra. Effectively the cost of the marking of the lot has doubled. However a mark such as this is not necessary at every corner. The question should be put as to whether it is better to mark a boundary well" once", or to mark that boundary poorly a number of times. Considering the labour intensive nature of cadastral surveying, marking boundaries once must have considerable merit.

Very few studies on cost of cadastral surveys have been undertaken in Australia. Such studies are considered to be long overdue. It is recommended that all aspects of cadastral survey costs should be known and able to be quantified. Rules of thumb are useful, but the costs must be substantiated by studies. Unfortunately such studies are time consuming and demanding in knowledge; nevertheless they are needed.

8. CONCLUSIONS

The marking of cadastral surveys is essential and will continue to be necessary even after GPS is in common usage.

The report defines boundaries and distinctly breaks up the process of boundary surveying into two parts - marking and description. It can be stated that for the most part the use of survey instruments (e.g. tapes, EDM and GPS) is for the description and not the marking of boundaries. Marking or boundary adjudication can be undertaken without measurement, and this becomes an important consideration when discussing legal co-ordinates.
Boundary marking types are discussed for both urban and rural parcels. It is concluded that generally pegs of any type are unstable and liable to removal while drill holes on bed rock and engraved marks on walls and concrete footpaths are quite permanent. Permanent point marking, such as steel marks or plaques in concrete, is expensive and if used for parcel marking will increase survey costs per lot between $50 to $270 depending on the type of mark used. More use should be made of using buildings as monuments.

Linear marking or monuments are discussed and it is suggested that as a community become older, its boundaries become more established and stable. On the other hand, the artificial monuments that originally marked out the parcels typically would have long since disappeared. In effect many city parcels are, by default marked by linear monuments or marking.

**Mention is made of the six papers in Australia over the past 10 years that have argued for a partial change to Australia’s boundary marking system to allow for this fact that its land parcel “fabric” is stabilising**

Those papers have suggested general boundaries or at least in-depth studies of them

Finally the paper discusses the role of legal co-ordinates and concludes that they will not replace cadastral monuments.

**REFERENCES**


Collins, J. 1985. GPS Workshop - discussion session, University of NSW, School of Surveying


