University of Southern Queensland
Faculty of Engineering and Surveying

GIS BASED CADASTRAL PLANNING

A dissertation submitted by

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Abstract

With the proliferation of digital data and the increased availability and functionally of visual based mapping products, the use of a GIS has become the logical base for a cadastral information system, or in terms of this paper a “GIS based cadastral planner”.

The Digital Cadastral Data Base (DCDB) that forms the base layer of the “GIS based cadastral planner”, has been derived from a paper based cadastral reinstatement using existing cadastral surveys and survey control. This DCDB has then been value-added to generate a cadastral information system.

Since the DCDB is presented using a common or defined coordinate system, it has the ability to form a coordinated cadastre that contains all the property corners as well as the reference marks.

This paper outlines the reasons and methods used to develop a GIS based cadastral planner, as well as the benefits of an all in one, visually based system for planing cadastral surveys.

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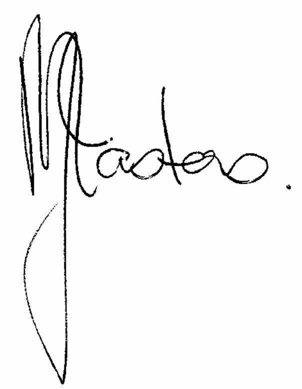

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Terms

AGD – Australian Geodetic Datum

AHD – Australian Height Datum

AHDD – Australian Height Datum Derived.

AMG – Australian Map Grid

Boundaries - Boundaries can be described as the line defined by ground monumentation or by a mathematical description that defines the outermost edge of a parcel. The accuracy of boundaries should reflect factors such as the value of the land, the risk and cost of land disputes and the information needs of the users of the Cadastre (Williamson & Hunter 1996).

Cadastre - A Cadastre as defined by Williamson & Hunter (1996) is a current, parcel based, land information system containing a register of interests in land. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection. The cadastre referred to in the following dissertation pertains to the survey cadastre only, which relates to the land management aspect of the cadastre as part of the legal cadastre.

Coordinated Cadastre - A Coordinated Cadastre is a cadastre where the corners, and possibly reference marks, have been assigned a coordinate value in relation to a defined datum. These assigned coordinates have been calculated from the adjustment of survey records onto the control network. They may be derived from a survey accurate or near survey accurate DCDB. However these coordinates do not represent the legal definition of the corner, merely an approximation.

Coordinate Based Cadastre - A Coordinate Based Cadastre is similar to a coordinated cadastre, as each corner is defined uniquely by a single pair of coordinates. However, in a coordinate based cadastre the coordinates are given legal significance, whereby the coordinates take precedence over physical monuments or boundary corner marks in re-defining boundaries. The coordinates are determined by ground surveys which are used to define, describe and re-define the parcel.

In other words, the established hierarchy of evidence is changed and particularly the Common Law principle of "monuments over measurements" is reversed (Porter 1991).

Coordinated Cadastre (system) - The Coordinated Cadastre (system) as defined above should not be confused with the other interpretation of a Coordinated Cadastre where all the cadastral processes are "coordinated". In other words the emphasis is on a "complete" cadastre where all parcels and interests in land are included in the system. Also, all land transfer, reconfiguration, subdivision, amalgamation consolidation and title conversion processes are integrated or coordinated in one cadastral system (Williams & Hunter 1996). The Coordinated Cadastral System will not be referenced in the remainder of the paper.

CBA – Cost Benefit Analysis.

CC&S – Cottrell Cameron & Steen.

Council – Redland Shire Council.

Covenants – Covenants are associated with the property title requiring that the land be used or not used in specified ways (http://www.dli.wa.gov.au/corporate.nsf/web/Glossary#P).

DBF - dBASE tabular data file and Shapefile attribute table file.

Digital Cadastral Database (DCDB) - A **Digital** Cadastral Database (DCDB) is a complete digital cadastral framework visually depicted where the coordinates of each parcel corner are an approximation of the "true" or surveyed coordinates. The accuracy of the coordinates can vary greatly depending on the requirements of the user. However, in this first case the important considerations are that the cadastral map shows all parcels, the topology is correct and is kept up-to-date (Williamson & Hunter 1996).

Deed Dimension (referred to as **Deed** for this paper) –The bearing (angle) or distance as indicated on the previous registered survey plans, alternately referred to as original angle or original distance.

DSA - Declared Survey Area.

DXF – Drawing Exchange Format.

EDM – Electromagnetic Distance Measurement.

FID – Feature Identification number.

Geodatabases - An ArcMap relational database that contains spatial information. Within the geodatabase the feature classes can also store annotation and dimensions in addition to the normal storage of point lines and polygons. All feature classes in a feature dataset within the geodatabase share the same coordinate system.

GDA – Geocentric Datum of Australia.

GPS – Global Positioning System.

ICSM – Intergovernmental Committee on Surveying and Mapping.

IDAS - Integrated Development Application System.

MGA – Map Grid Australia.

NR&M – Department of Natural Resources and Mines.

Numerical Cadastre - A Numerical Cadastre is a form of DCDB that has been based on the input of bearings and distances for existing survey information in comparison to earlier DCDBs that were based on digitised information.

OP – Original Peg.

PC – Personal Computer.

PRJ - Projections definition file.

Profit a' prendre -An interest in land, enabling the harvesting of that land (for example, trees, sandalwood or wildflowers) as cited from Department of Land Information Government of Western Australia (2003).

PSM – Permanent Survey Mark.

RSC – Redland Shire Council Coordinates.

RTK – Real Time Kinematic.

SBN & SBX- Spatial index for read-write shapefiles.

SCDB – Survey Control Database.

SCS – Survey Control Sketch or Form 6.

Shire – Redland Shire.

SHP - Shapefile (stores feature geometry).

SHX - Shapefile (stores file lookup index).

SP1 – Special publication 1 by the ICSM.

TIFF – Tagged Image File Format.

WGS – World Geodetic System 1984.

Chapter 1

Introduction

"*For every complex question there is a simple answer and it is always wrong*"

Albert Einstein.

There are very few things in life that are simple and although, to most people in the community, surveying is a simple exercise, the cadastre is far from simple.

Over the past four years Redland Shire Council has spent many man-hours, by several Cadastral Surveyors, creating a superb database of cadastral information via a Digital Cadastral Database (DCDB). This database forms the base layer of the Council's mapping system, which gives Redland Shire Council a visual interface for locating and retrieving information about various assets and significant features throughout the shire. However, from this it seems as if Council is using this superb cadastral database for a whole range of tasks, but it is not being implemented to assist in the Council's cadastral survey work.

It was recognised that coordinates could be easily implemented and the cadastral data that was generated in the creation the DCDB could be put to a greater use. This concept has grown to include, not only the coordinated information and the DCDB and associated information, but information about the existing cadastral surveys to form a background on how the cadastre has been formed, which in turn acts as a tool to plan future cadastral surveys.

1.1 Aims

The aim of the project is to produce a GIS that assists Surveyors in assessing existing information when preparing for cadastral surveys.

1.2 Objectives

The primary objective is to allow a representation of the cadastre, enabling the Surveyor to gain an understanding of what marks and reinstatement techniques that may be used in a boundary reconfiguration or an identification survey.

The GIS also assists in construction and design surveys. The approximate coordinates for each boundary corner meets the tolerances for set out of boundary offsets for construction and plotting of the boundary for design plans, as prescribed by Redland Shire Council.

The GIS is to be based on a near survey accurate Digital Cadastral Database (DCDB), which is formed by the amalgamation of the existing and historical survey information. Discrepancies within the survey information are resolved using cadastral principals rather than a least squares adjustment.

1.3 Karragarra Island

Karragarra Island, formally known as Rabbit Island is the smallest of the populated Bay Islands, housing a population of approximately 100 residents.

Karragarra Island is situated on Moreton Bay between Russell Island and Macleay Island, approximately 5 km from Redland Bay. Karragarra Island is serviced by a passenger catamaran and a vehicular barge from Redland Bay.

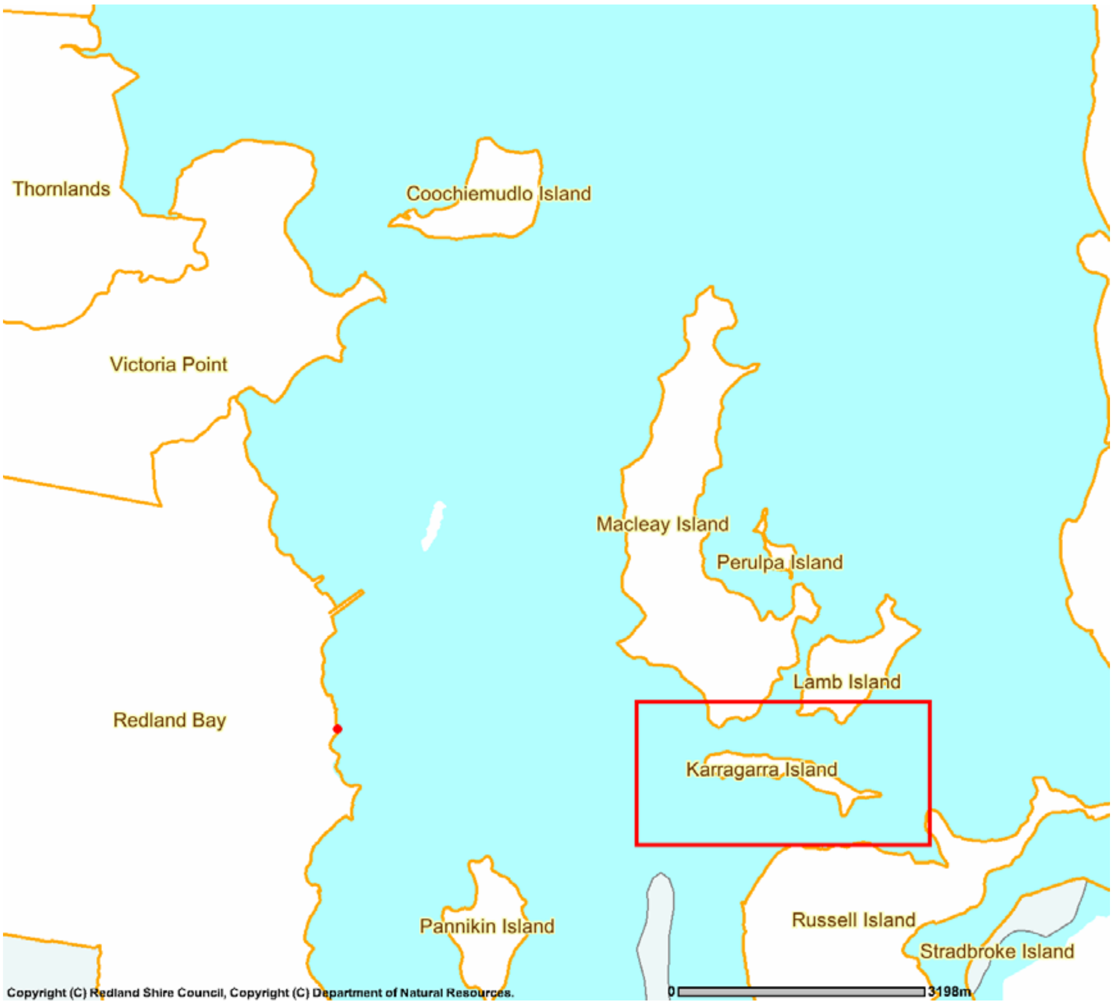

Diagram 1 Karragarra Island

The original survey of Karragarra Island took place in 1889 by E.R. Warren. This survey divided the island into 11 portions, as shown on S312665 in Appendix B.

Karragarra was chosen for the subject site of the project for several reasons.

1. Karragarra Island is isolated from other DCDB areas and would not be influenced by adjoining information.
2. A history of survey, occupation and drainage problems has plagued the Bay Islands.
3. The DCDB had not been completed for Karragarra Island and was scheduled for completion.

4. Karragarra Island is relatively small and easy to control.

5. A range of survey plans (1930 to 1988 as current plans) exist throughout the Island presenting a mix of old and new survey information.

1.4 Project Area Statistics

The project area covers 176 current registered lots, which are on 22 current registered survey plans. Over the project area there has been 66 survey plans deposited with the Department of Natural Resources and Mines (NR&M), 30 of these plans are registered plans, 35 are identification survey plans and one is a deposited plan awaiting registration.

The entire project area including dedicated road is approximately 23.7 hectares. The average lot size is $1203m^2$ and the median lot size being $663m^2$.

From the registered plans, there are 366 current property corners and 90 reference marks have been located within the project area. 18 coordinated control marks are in the project area, 3 of these marks are registered Permanent Survey Marks (PSMs).

1.5 Reasoning for Development

The initial familiarisation with the historical survey, can be a critical component of a cadastral survey. However, for the inexperienced Surveyor this may be a time consuming exercise. Additionally, with many Land Surveyors taking on a project management role, supervising several crews, it may be difficult to give the time required for an appropriate interrogation of the cadastral information.

The GIS based cadastral planner has been developed to aid the Surveyor and the spatial professional in several areas. The following is brief summary of some of the areas that the GIS based cadastral planner may improve productivity.

1.5.1 Reduction in Time Taken to Prepare Cadastral Search

One of the primary objectives of the GIS based Cadastral planner is to decrease the office time pre-survey and increase efficiency. It is anticipated that the time taken to prepare for a cadastral survey can be significantly reduced by creating an information system that;

- combines all the information required to commence a survey into one data base,
- presents the required information in a format that is open, easy to use and interrogate, and
- allows data to be quickly down-loaded to a digital format or printed as required.

1.5.2 Improved Cadastre for Mapping and Engineering Purposes

A DCDB created from survey plans, coordinated control and cadastral principals, presents a more accurate and stable survey cadastre in comparison to its predecessors of digitised survey cadastres and statistically adjusted survey cadastres.

The DCDB forms the base layer of most land based information systems, including Redland Shire Council's. The DCDB is used to align or register subsequent layers, such as the engineering services that are placed at a standard alignment from the boundary. So any error in the DCDB is propagated throughout the GIS on other layers referenced to the DCDB.

1.5.3 Implementation of a Coordinate Based Cadastre

In every journey there must be a first step. If (and that is a big IF) it is decided that the implementation of a coordinated cadastre is a path that Queensland or Australia wishes to take, then the development of a DCDB based on a cadastral reinstatement of the existing cadastral information tied to the control network would be a good starting point. It is proposed that coordinates provided in the GIS would form another tier in the chain of evidence for a corner reinstatement. Although these coordinates currently have no legal significance it could be argued that since the coordinates have been determined by a paper-based reinstatement, rather than a least squares adjustment, they could provide an appropriate solution where other evidence is lacking or provide an alternate check on a corner reinstatement.

Coordinates can then be assigned to each corner as an a-priori value. With subsequent surveys the coordinate values can be refined to generate an accurate value on each corner.

As indicated in the GIS based cadastral planner, a value could be assigned to each corner indicating a reliability factor. Once an assigned reliability factor has been reached the corner may be deemed to have been appropriately fixed. For example, a scale of 1 to 5 may be used with 1 being indicative of an exceptionally well constrained corner and 5 of a very poorly defined corner. A value of 2 may then be set as the value where it is deemed that the corner is sufficiently reliable to be used for future reinstatement. This would be a quick means of determining if the coordinates for a corner can be used, or if further survey is required to verify the corner’s coordinates.

1.5.4 Recognition of Anomalies in the Cadastre Before Survey

The creation of the DCDB and the development of a database of angular and distance based discrepancies enables the Surveyor to recognise anomalies within the cadastre before entering the field. The ability to compare existing plan areas, distances and angles against previous plans and the DCDB highlights areas that may require further investigation. This in turn assists in generating a better cadastre, DCDB and possibly a better coordinated cadastre. The time required in the field is also reduced, as the Surveyor has a greater understanding of the cadastre and can better plan a course of survey to prove the reinstatement of the boundary.

1.5.5 Improved Survey Methodology for Construction

The created GIS allows for an improved ability to find existing reference marks. The Surveyor should be able to set up and obtain a datum from two coordinated PSMs and set out existing reference marks.

Within the Redland Shire most services are constructed to a standard alignment off the property boundary. Having a set of coordinates defined to the deci-metre level for the property boundaries allows for the quick and efficient set out of any offsets to that boundary. From the Council point of view, this would include set out works for sewer, water reticulation and footpath construction. Other services such as Telstra and Energex could also be easily located. However, it should be noted that the coordinates do not define the property boundaries, and that works constructed on the boundary would still require an identification survey to define the boundary.

1.5.6 Storage of Cadastral and Engineering Survey Information

The database as a whole can act not only as a means of retrieval of information but also as a means of storing information. It provides a logical way to store cadastral and engineering survey information. The GIS based cadastral planner could be expanded to cater for topographic and detail survey information or any type of survey information.

1.5.7 Increased Survey Redundancy

The use of predefined coordinates from the GIS based cadastral planner for corners and reference marks acts as a suitable gross error check on field work. This introduces another redundancy in the Surveyors work and is a simple and effective way of finding significant errors.

1.5.8 Allows for Direct Comparison of Surveys

If all surveys are performed on the same datum, such as Redland Shire Council Coordinates (RSC) or Map Gird Australia (MGA), then it would allow for the direct comparison of all future surveys as they would all be on a common azimuth. This would eliminate a possible source of error in converting from one plan datum to another and reduce the time taken for a Surveyor to plan a cadastral job.

1.5.9 Proliferation of Control

Having coordinates placed on all reference marks via the DCDB it increases the number of coordinated marks within the project area by including all cadastrally referenced marks. This allows the Surveyor to have a larger database of coordinated marks to commence an engineering survey.

1.6 Summary

The GIS based cadastral planner is a GIS with refined cadastral attributes that allows for a quick and efficient means of planning a cadastral reinstatement before the field work begins.

This GIS can also be viewed as step towards a coordinated survey cadastre as it provides coordinates for each corner and each reference mark. However, it does not provide a legal coordinated cadastre where each parcel corner is uniquely described by a pair of coordinates.

Other advantages of the proposed GIS are:

- No need to perform radial search.
- Chain of evidence of reference marks can be easily determined.
- Can give a clear picture of how to reinstate corners before entering the field.
- Boundary offsets can be quickly staked for construction purposes.

It should be noted that the DCDB, sets the maximum achievable accuracy of the system, or alternately the more accurate the DCDB the more accurate the GIS. For this reason it is imperative that the DCDB is as accurate as possible, as it affects the functionality of the GIS.

It should be noted that the intention of the GIS based cadastral planner is not an amendment to the current procedure of registering and administering land titles, but it is an aid to the future defining of the survey cadastre.

Chapter 2

Literature Review

2.1 Introduction

To enable a proper understanding of the concepts behind the creation of a DCDB and the development of a coordinated cadastre it is essential to investigate current and past projects, research and literature. The following is a summary of some of the previous work on the coordinated cadastre in its various forms and the development of a suitable DCDB. It should be noted that although many countries have implemented a coordinated cadastre in various forms, the community and cultural requirements and expectations in these areas are very different to the ad hoc creation of the cadastre within most areas of Australia. Also the different legislation between states of Australia creates a range of issues for different states.

2.2 Overview

Over the past two decades there has been much written and discussed on the merits, advantages and disadvantages of various forms of Digital Cadastral Databases and coordinated cadastres.

This has led to the cry from many sectors of the spatial community that cadastral reform is required. However, this is not saying that the current system is antiquated and beyond use. Over the past century the cadastre has provided certainty and security to the nations land markets (Jones, Rowe & Kentish 1999). This is proven by the distinct lack of court cases in relation to boundary disputes (Williamson 1990). However, the low levels of litigation may be related to the high associated costs. At the very minimum, the cadastral systems currently in place could use some minor modifications to improve their efficiency.

Currently the reinstatement of cadastral boundaries in Australia is based on hierarchy of evidence which has evolved from common law and case law. Data, including coordinates, occupy the lower part of the hierarchy, monuments and evidence of intent taking precedence (Jones, Rowe & Kentish 1999). These basic reinstatement principals should not change as coordinates become more prevalent in society, but if existing technology creates a more efficient means of producing the same result it should be investigated.

However, Williamson (1997) argues that:

> "A survey accurate DCDB and coordinated cadastre should not be created without fully understanding the place it holds and the effects it has on the operation of the cadastral system. All reforms to introduce a survey accurate DCDB and an improved cadastral surveying system (collectively a coordinated cadastral system /coordinated cadastre) go hand in hand with reforms to the wider cadastral system including reforms to the title registration system."

2.3 Reform and the Coordinated Cadastre

2.3.1 Reasons for Reform & Advantages of Coordinated Cadastre

Apart from providing a database of cadastral marks and their coordinates as part of a land information system (Smith 1986), there are many and varied reasons for the introduction of a survey accurate DCDB and coordinated cadastre. Some of the major reasons are outlined below.

Technology

- Smith (1986), Williamson (1997) and Jones, Rowe & Kentish (1999), agree that the use of coordinate based GIS, design packages and basically the storage of land objects in computer databases will eventually mean that the move to a coordinate based system is essential. However, Jones, Rowe & Kentish (1999) note that the coordinate based system is conceptually different to the concepts applied in boundary redefinition.

- Nordin *et al* (2004) indicate the use of a coordinated cadastre will open up opportunities in coping with, and accruing benefits for the advances in modern technology in areas such as the compatibility for use with modern survey equipment.

The need for standardisation

- The need to register one form of survey or dataset to another on a standard or defined datum (Smith 1986).

- The need for national large scale land parcel dataset(s).

- Uniformity of scale and orientation of surveys (Smith 1986).

Value for money and efficiency

- Pressures on Government sectors, to give effective land ownership, property boundary system and land information to meet society's requirements will drive efficiency from a public sector point of view (Williamson 1997).

- Maintenance and update will be made easier, especially if digital lodgement of subdivisional and survey plans is accepted.

- A coordinated cadastre will allow for the digital lodgement, including the Surveyor's calculations of the coordinates (Smith 1986) (Williamson 1990) (Coleman 1999). Additionally it will allow the digital distribution of survey information.

- A coordinated cadastre provides unambiguous, unique boundary descriptions in terms of relative and absolute position (Smith 1986).

- A coordinated cadastre will assist field Surveyors in searching and re-establishing marks by giving:
    - Clear identification of the position of a mark or corner.
    - Easier searching of marks without calculation of previous data.

- Simpler and easier calculations for redefinition.
- Assist in closing off and checking work (Smith 1986).

- Assist in establishing a corner when other evidence, such as pegs and reference marks from previous surveys are lost. Any coordinated control mark can be used to re-establish a lost corner (Smith 1986).

Storage and management of information

- Nordin *et al* (2004) state, a coordinate based cadastre will facilitate the integration of cadastral and map based information as well as the use of rapid data acquisition, storage, processing and management techniques.

- The implementation of an accurate DCDB and Coordinated Cadastre provides greater control over the cadastre, reduces error propagation and defines problem areas within the cadastre (Smith 1986).

2.3.2 Issues Related to a Coordinated Cadastre

Legal Issues

- The introduction of a coordinate based cadastre would have great ramifications across the surveying and spatial industries. Not only would it require significant adjustment to the current legislation it would essentially change the way cadastral surveys are performed. If a coordinate based cadastre is to be adopted, a coordinated cadastre should be the initial stepping stone before the introduction of a coordinate based cadastre.

- Davies (1990) states that, the current hierarchy of evidence recognised in common law, places a high value on physical evidence for the reinstatement of boundaries. Any move to a coordinated cadastre will necessitate legislation that raises the level of precedence of coordinates.

Technical Issues

If a coordinated cadastre or a coordinate based cadastre is to be introduced various technical issues will need to be resolved.

- Davies (1990) and Williamson & Hunter (1996) put forward that the accuracy should be relative to the value of the land including environmental and cultural value.

- Data quality and completeness will need to be measured to ensure that production levels are being met, the product is suitable for use, and the product meets the user's needs.

- Other technical issues such as datum, format, software, monumentation etc. will need to be addressed before commencement.

- Holstein & Williamson (1985) note that natural boundaries and non vertical boundaries are very difficult to define by coordinates.

- Datum definition, differences in control and accuracy will cause variations in the allocation of the coordinate's accuracy (Holstein & Williamson 1985).

- Relative movement of control marks via means such as geologic processes including crustal deformation, earthquake deformation, volcanic deformation, and aseismic deformation. These process cause existing marks to physically move and not always in the same direction or the same distance

Financial Issues

- With the tightening of Government budgets it is unlikely that money will be spent on reform unless it can be shown to have significant social and economic benefit (Davies 1990). However, as noted above, the present cadastral system has operated very successfully over the past hundred years and a case to reform may not be easily justified.

Professional Issues

- Issues may arise that Surveyors may feel threatened by the introduction of a coordinate based cadastre, or may not be willing to adapt to new technology. Some may see cadastral surveying changing from a professional art form to a technical discipline (Davies 1990). This can been seen from an alternate viewpoint, in that it will allow technicians to perform the mundane components of cadastral surveying, releasing time for the Surveyors to coordinate, structure and plan the required elements of the cadastre and their business.

As noted by Holstein & Williamson (1985) a coordinated cadastre will contribute essentially to the development of the DCDB, more than it will aid boundary reinstatement and investigation. The process of inquiry, investigation and measurement will still need to continue to determine the boundary location.

2.4 Projects

2.4.1 Northern Territory

The Northern Territory has forged the path and seems as if it will be the first Australian State to able to boast a complete numerically defined cadastre (Fairall 2003/2004).

Menzies (2000) outlines the goals for the Northern Territory are to determine survey accurate coordinates on the GDA-94 datum of all land parcels in the Territory, with the intention that these coordinates will provide the legal definition of the boundaries of parcels in the land titles register.

This meant that:

1. the existing DCDB needed to be upgraded from graphical to survey accuracy; and
2. the regulatory and administrative framework is established to manage the system.

The University of Newcastle, supported by the NSW Land Information Council and the Computer Users Group of the Consulting Surveyors Association, brought to light the initial study. The study was to evaluate techniques to directly create a survey accurate coordinated cadastre. This involved a complete system to convert from metes and bounds to a coordinated cadastre. Menzies (2000) and Elfick (2003/2004) state this system was developed as a three stage process:

1. Entering the bearings and distances of parcel boundaries from survey plans and closing each parcel to detect any gross errors in the plan data or data entry.

2. Joining the parcels together into blocks and carrying out a least squares block adjustment with minimal control to detect errors and anomalies in the block geometry.

3. If block geometry is acceptable an adjustment using dense control is carried out to determine the final coordinates.

This process was performed with the ACS Cadastral Package Software developed by Mimaka.

Menzies (2000) added that new survey practice directions would need to be created and that these directions would be considerably simpler than the previous in the following respects:

1. Searching would be limited to the on-line retrieval of the coordinates as they represent the legal prima facie definition of the boundary.

2. New parcel corners can be pre-calculated and pegged by set out, as the old survey marks will have no status.

2.4.2 Alberta (Canada)

Alberta has mooted the introduction of a coordinate based cadastre, but gives monuments precedence over coordinates.

This was because of the following reasons;

1. The use of monuments was failing due to the high destruction rate in urban areas.

2. Technological change will make serious consideration of a coordinate based cadastre inevitable.

3. No evidence was found that the definition of boundaries by coordinates would not be accepted by the general public. However, it was noted within the surveying profession that the use of coordinates alone would limit the ability of landowners to determine the extents of their land.

4. Coordinate boundary definition potentially offers a more effective, reliable and economic alternative to monumentation in urban areas (Alberta Land Surveyors Association 2002).

The Alberta Land Surveyors Association (2002) noted that the benefits of a coordinated cadastre would rely heavily on the efficient implementation of a suitable legal framework.

2.4.3 Livingstone Shire Council (Queensland)

Livingstone Shire Council has employed Dynamic Satellite Surveys (DSS) for the creation of their DCDB. DSS have used a least squares adjustment program "Spatial Adjustment Engine" (SAE) to adjust the cadastre to the control.

Williams (2003) indicated the initial step of the process was to coordinate existing cadastrally connected points (approximately, 1 coordinated mark per 30 parcels). This was done using both static and RTK GPS. The second step in the process was to enter the registered plan dimensions and create the topology between parcels and coordinated marks. Once this had been completed the least squares adjustment was run.

Williams (2003) stated that all parcel boundaries that vary from deed dimensions by more than 0.1m were highlighted and investigated. If they could not be resolved in the office they were handed back to the local authority (the client) for further investigation, if it was deemed required.

The cost of this process is estimated at about $10 per parcel.

Williams (2003) noted that the DCDB was never intended to have a legal standing, it should be looked at as a spatially accurate dataset that can be used as a base layer for other spatial datasets.

2.4.4 Redcliffs (Victoria)

Williamson & Hunter (1996) indicate that the reasons for adopting a coordinated cadastre by Redcliffs was; the easier location of cadastral boundaries; lower survey costs; quicker resolution of boundary disputes; and the fact that all surveys are placed on a common coordinate datum. However, it was deemed that the use of coordinates in comparison to the original survey marks or occupation was the least desirable means to define parcel corners.

Williamson & Hunter (1996) saw the disadvantages of the coordinated cadastre as:

- Few cadastral marks were input to the adjustment and no side or rear marks were included;
- Not all Surveyors had access to the information and its use was not mandatory;
- Cadastral coordinates were not computed for all property corners.

It was concluded that it is possible and feasible to design, implement and use a working coordinated cadastre, albeit it would be best done in an area with few, if any, cadastral monuments (Williamson & Hunter 1996).

2.4.5 Maryborough (Victoria)

In 1992, the City of Maryborough determined that it would create a digital cadastral map base to overcome deficiencies with its existing imperial, hardcopy plan series. The original intention was to map the city using 1:6,500 photography and manually key in parcel dimensions, which would be adjusted to fit fence corner locations identified from the photography. Analysis of the results indicated that the accuracy had not met the intended standard. The control density was increased and the cadastre readjusted (Williamson & Hunter 1996).

Williamson & Hunter (1996) saw the advantages of this method as:

- In most cases the plan dimensions, connections and relationships are maintained, rather than attempting a global 'best fit' between occupation and title dimensions;
- The DCDB meets Engineering Design requirements for the Shire;
- Good relative accuracy (+/-0.01m) has been attained for points from the same plan, with an absolute accuracy of +/-0.10m;

Disadvantages:

- A Title search was not undertaken, so the database is incomplete.

Williamson & Hunter (1996) concluded:

- The DCDB has been successfully upgraded to near survey accuracy.
- The DCDB is sufficiently accurate to allow for engineering design.

2.4.6 Geelong (Victoria)

Williamson and Hunter (1996) state, Geelong City Council under took a pilot study in conjunction with Geocomp Systems Pty Ltd, on behalf of the Office of Surveyor-General. This was to test computational procedures for deriving a coordinated cadastre, to determine their accuracy and to assess their costs. Existing survey and title information, connected to local control and selected survey reference marks were used to compile a coordinated cadastre.

The project area had extensive pre-existing control and covered 170 lots. Residuals of +/-0.015m between local control and the coordinated marks have indicated that a coordinated cadastre can be created which is survey accurate.

The following issues arising from the study were recognised;

- distribution of excess;
- treatment of discrepancies between general law parcel boundaries and occupation;
- treatment of state land between parcels and whether non-surveyed boundaries should be included on the basis of their dimensions or occupation.

Williamson & Hunter (1996) saw the advantages and disadvantages as follows:

Advantages:

- The methodology is suitable for producing a survey accurate DCDB.
- Cadastral coordinates are suitable for use by utilities and for Surveyors during re-establishment of parcel boundaries.

Disadvantages

- Technical problems need to be overcome relating to treatment of excess land, general law parcels, and non-survey boundaries.
- High cost in comparison to alternate methods.

2.4.7 New South Wales

In the early part of the 1990's it was realised that the digitised DCDB that had formed an integral part of the titling system in NSW was not going to be able to satisfy future requirements due the poor accuracy of various sections. A project was then mooted to upgrade to a numerical cadastre for the entire state.

This project proposed accuracies in the order of 0.04m in new urban areas, 0.15m in new rural areas, 0.1m in old urban areas and 0.3m in old rural areas where the computed coordinated distances are compared to the current survey plans.

It was proposed that the cadastre was built then adjusted to the geodetic control using the adjustment software HAVOC (Cadastral Development Unit NSW Land Information Centre 1992).

The advantages of this method is that it is simple and can be prepared quickly using technicians with little cadastral experience, as it is based on purely data entry from plans and adjustment to the control network.

The recognised disadvantages of the proposed project were:

- It relies on input from private practice to hand in records of cadastral surveys that have not been lodged to enable a more accurate depiction of the cadastre (Cadastral Development Unit NSW Land Information Centre 1992).

- It will need time to evolve to an accurate system with the infill of new areas.
- Accuracies of DCDB may not meet engineering design standards for many shires.
- The undertaking of a DCDB on a state-wide basis is an enormous task.

2.4.8 South Australia

In the Early 1970's the Surveyor General of the day proposed that cadastral boundaries could be coordinated using photogrammetric techniques and a legal cadastre established. The Survey division mounted a number of pilot studies but these showed that the economic benefits originally postulated could not be realised (Williamson 1990).

Smith (1986) states that, the implementation of the coordinated cadastre is seen as a gradual process over the long term, where all new cadastral surveys in the Declared Survey Area (DSA) are connected to the tertiary control network. This is to improve the cadastral framework by adding another layer of information (coordinates) to the boundary identification process.

To facilitate the connection of the new cadastral surveys within the DSA the density of the exiting control network needed to be increased, with a suggested control density of 200m.

Within the South Australia system there would be no changes to the basic redefinition practices apart from using tertiary control marks to determine azimuth. There would be little variation to the presentation of plan, but there would be a need to calculate coordinates for main cadastral corners and marks (Smith 1986). However, Williamson (1990) latter states that removal of the coordinate listing on the survey plan eliminates possible confusion, which could result if the plan coordinates vary from the adjusted coordinates in the database.

Williamson (1990) also recognises that problems arose where minor land divisions were created without survey of the boundaries. This practice does not meet the objectives of a sound title registration and cadastral survey system, as it weakens the state property boundary framework, leaving a legacy of potential boundary uncertainty to be addressed by future land holders or governments. Furthermore, it is in conflict with the overall objectives of a coordinated cadastre, to provide a strong and more reliable cadastral system

Advantages

- The process would be gradual and would be more generally accepted by the surveying profession.
- Cost would be borne through each survey and the usual processing costs. Therefore the costs would be minimal
- The final coordinates would be survey accurate.

Problems

- Discrepancies in surveys where a DSA area meets a non DSA area.
- Confusion may arise with Surveyors working between DSA areas and non DSA areas.
- The process will take decades to complete or may never be completed.

2.4.10 Peninsular Malaysia

Major cadastral reform has been instigated for Peninsular Malaysia. Part of this reform is the coordinated cadastre.

The model proposed for coordinated cadastre is based on a complete DCDB that provides the legal definition of the land parcels resulting in each point being represented by a single set of coordinates. These coordinates are earth centred coordinates based on ground survey, with accuracy relative to land value.

The coordinates implemented are of a dynamic nature and are subject to change over time as further surveys are undertaken.

The implementation of the model is defined by Nordin et. al. (2004) in five steps:

1. Identification of implementation area and establishing the control infrastructure.
2. Gazetting the implementation area.
3. Connection of the selected parcel corners to the cadastral control infrastructure.
4. Adjustment and re-coordination of boundary points in the DCDB.
5. Resurvey of land parcels where required.

It was noted by Nordin et.al (2004) that a number of tasks should be given priority. These included:

- Instigating amendments to existing legislation.
- Completing the required control network.
- Upgrade of the DCDB.
- Resurvey of upgrade areas.
- Development of a new manual of survey practice.
- Undertaking a pilot project.

2.4.11 Other Areas

Hamburg

In comparison to many other areas Hamburg has the luxury of having a dense and well marked survey network. This has allowed coordinates to be calculated to an accuracy of 1-2cm, and used in preference to a network of boundary monuments (Holstein & Williamson 1985).

Singapore

The two main issues concerning the development of a coordinated cadastre in Singapore as indicated by Pong-Chai Goh (1994) were:

- The placement and survey of control. However, Singapore is geographically small and it was deemed viable for a geodetic framework to be established quickly in a once off exercise using GPS.

- The implementation of the legal infrastructure.

The development of coordinated cadastres in areas such as Europe and Asia has been aided by the relatively dense urbanisation (in comparison to Australia) and the availability or the ability to create a dense control network (Porter 1991).

2.4.12 Marine Cadastre Indigenous Rights and Biota

Over recent times there has been a trend to define areas such as Indigenous Rights, Marine cadastre and Biota. It has been suggested that these areas will generate an alternate cadastre each.

The need to address environmental, social and economic issues associated with sustainable development as well as the need to effectively manage and delimitate the costal regions have pushed the issue of a marine cadastre to the fore. This is in conjunction with the need to recognise indigenous rights to both land and sea (Binn et al. 2004)

Many of the cadastral components such as demarcation and legal interests or rights associated with the land based cadastre are also emulated in the marine environment (Binn et al. 2004). It can be seen that the solutions to a marine cadastre could be replicated for systems dealing with biota and indigenous rights. However, currently the development of a system to govern or track information relating to marine, biota and indigenous rights within Australia is in its infancy.

A single datum with defined boundaries will be required to generate a continuous cadastre between land, marine, biota and indigenous rights. It should also be noted that these areas would be difficult, if not impossible to monument, due their vague and dynamic boundaries. This leaves definition by coordinates the obvious solution.

2.4.13 Summary

Most digital cadastres within Australia are the result of digitising cadastral maps, either by scanner or digitising tablet. Both methods have proven to be a cheap and quick method, but it has lead to poor spatial accuracy. Fairall (2003/2004) states that, this has really become an issue in NSW where the cadastre is so inaccurate that 89% of local governments independently update their own datasets. Most local authorities are rapidly realising that the spatial error associated with a digitised cadastre is no longer suiting their needs and change is required.

Williamson & Hunter (1996) summarise that the Redcliffs' project was the State's first working example of the concept, albeit in a rudimentary fashion. The Maryborough project sought to achieve near-survey accuracy of about 0.1m for utility purposes. The Geelong project involved the creation of a survey accurate database in a difficult and long established urban area.

Williamson & Hunter (1996) have drawn the conclusions that:

- The creation and operation of a coordinated cadastre is clearly possible.

- It is feasible to upgrade a digitised DCDB to have an absolute accuracy of approximately +/- 0.1 to 0.3m to meet utility requirements.

Williamson and Hunter (1996) suggest that the proposed vision for a coordinated cadastre for Victoria would have the following attributes:

- The DCDB would form a base layer of the state's datasets enabling integration with other state datasets.

- The DCDB would represent the legal definition of all interests in land, without legal significance. The current hierarchy of evidence would remain in re-establishing parcel boundaries. Monuments and long standing occupation would still have the same status as in the current system. Coordinates would be used as evidence in re-establishing boundaries where all other evidence has been lost.

- The DCDB would represent a continuous digital State title plan.

- All cadastral surveys would be carried out on a geodetic datum.

2.5 Assessment

It is indeed possible to create a cost effective working coordinated cadastre. This will alleviate many of the problems associated with the inaccuracy of the present digitised system of plans. It will also help identify problem areas within the survey cadastre allowing for their rectification.

Queensland has the advantage over many other states in Australia as it has enforced the lodgement of Identification surveys and it has a historical register of all survey plans. This will enable a much strengthened reinstatement from the exiting survey alone without the immediate need for resurvey, in most areas, to properly tie down coordinates on each parcel corner.

In determining the best approach to developing a coordinated cadastre there will always be a trade off between accuracy and cost. The above projects mentioned have used various processes to develop a coordinated cadastre to suit their own needs. The Northern Territory has covered a vast expanse creating a coordinated cadastre with reproducible coordinates that will supply an efficient means of identifying the parcel corners. It is not the most accurate method of defining the survey cadastre, but in areas of relatively low land value it can be seen to have achieved its goal.

The Marybough and Geelong studies have taken the cadastre in its true form and in some way have tried to reinstate the original intention. This is in comparison to areas like the Northern Territory and Livingstone Shire Council where the plan bearings and distance have been entered to a least squares adjustment package. The use of the least squares adjustment does not attempt to reinstate the parcel boundaries, instead it assumes that the errors contained within the cadastre are not random and can be proportioned out.

Livingstone Shire Council and New South Wales, in general have applied the same techniques to produce a base layer for their mapping system. It has been recognised by the Livingstone Shire Council that the coordinates produced from the least squares adjustment are only an approximation of the true corners and do not represent the legal definition of the corner.

Marybough proved that the use of photography, although very cost effective for large areas, produces a product that does not meet the requirements of most Local Authorities. With additional control and adjustment of the cadastre it developed a product that was deemed suitable for their mapping purposes.

Peninsular Malaysia, Alberta and South Australia are incorporating a similar technique to create the coordinated cadastre, where ground surveys are used which is connected to the existing control network. Alberta and South Australia have both opted to remain with current practices of utilising the chain of evidence to reinstate the corner with the calculated coordinates where the corner can not be identified by original monumentation or occupation.

The South Australian approach of surveying each parcel of land in reference to a defined coordinate system should eventually give the most accurate results. This is similar to the Peninsular Malaysia model, but with this model, survey is only performed where an upgrade of the existing information is deemed to be required, otherwise the coordinates from the DCDB are accepted for the coordinated cadastre. However, for both methods it will be a long and time consuming process to bring the entire region or state under a coordinated cadastre.

In relation to the technical aspects of defining the accuracy tolerances for a coordinated cadastre several aspects must be considered, including the value of the land, the significance of the land, the expectations of the community and the practical limitations facing Surveyors (Williamson 1990).

In creating a base for a survey accurate or near survey accurate DCDB the existing survey information should be used to generate a continuous section of cadastre, this should then be compared to the existing ground control. From this comparison it should be assessed if:

1. the problem can be resolved from existing cadastral survey information,
2. field survey is required, or
3. if the section of cadastre falls within tolerance.

This should minimise the need for field survey, whist creating a continuous near survey accurate cadastre, giving a calculated reinstatement of each corner using the existing survey information. This in turn could be used to check a reinstated corner or even reinstate a corner where no other evidence is found, since it is based solely on the existing survey information

2.6 Conclusion

The current DCDB based on digitised information is fast becoming obsolete. This has lead to mapped boundaries meters out of position, with the problem exacerbated in rural areas with coordinates of rural corners being out by tens of meters (Dalrymple, Williamson, Wallace 2003).

The increasing development of coordinated based spatial mapping infrastructure is making it a necessity that the cadastre is represented in an accurate coordinated format. In the coming years a survey accurate DCDB will become increasingly required to support engineering, planning and land administration applications. Jones, Rowe & Kentish (1999) argue that ultimately this could lead to the adoption of coordinates as prima facie evidence of boundary position (a coordinate based cadastre). However, this would require fundamental reforms to current land legislation throughout the county.

The creation of a survey accurate or near survey accurate DCDB will assist in highlighting discrepancies within the cadastre, allowing for problem areas to be rectified. This is partially being done informally through the NR&M and local Councils to improve their own information base.

The accuracy of any database is primarily dependant on the information input into the system, the old adage of garbage in, garbage out, will always hold true. To produce an accurate DCDB which can be used to produce a suitably accurate coordinated cadastre, the principals of cadastral surveying need to be adopted on the survey information. A Surveyor does not use a least squares adjustment to perform a reinstatement, so why should a least squares adjustment be used to calculate the DCDB. In effect the reason is that it is cheaper to have a technician enter plan bearings and distances and adjust to the local control network. This is a suitable solution if the DCDB is only going to be used for mapping, but why not take the extra step in generating a better database and vastly increase its usefulness. The generation of the DCDB could again be improved by using the Surveyors raw information. If the raw data could be submitted in an appropriate digital format, it would allow for a more efficient and accurate generation of the DCDB.

If the DCDB is to be improved, the needs of the current and future Surveyors need to be discussed in implementing the DCDB. This will allow for additional features to be incorporated into or onto the DCDB that will assist future survey work at the time of creation of the DCDB.

Unless a coordinate based cadastre is adopted giving legal precedence to a single pair of coordinates to define a corner, then the process of inquiry, investigation and measurement will still need to continue to determine the boundary location. A system is required that will give approximate coordinates as a starting point for the recovery of existing marks but will also show the history of the reference marks so a reinstatement can be made.

Chapter 3

Planning and Preparation of the GIS Based Cadastral Planner

3.1 Research

As previously indicated in Chapter 2, several previous projects have delivered their own form of a coordinated cadastre. However, they have not delivered an integrated database of coordinated information, cadastral plans, reference marks and historical and ancillary information. The GIS based cadastral planner is a compilation of information providing relatively accurate coordinates for each individual corner. This is supplemented with background information on how that corner has been defined, including information on the existing cadastral reference marks, which will create the basis of the Surveyor's reinstatement.

Previously, coordinated cadastres have concentrated on providing a database solely of the coordinated corners and not giving the advantage of providing additional information for reinstatement. The GIS based cadastral planner gives both coordinated information for reference marks and the historical background of the survey cadastre.

3.2 Resources Available

The following resources have been used to create the GIS based cadastral planner.

- AutoDesk AutoCAD 2004 Map. AutoCAD has been used as a drafting and design package to allow the efficient creation of the DCDB, and associated point, line, polygon and annotation layers.

- ESRI ArcMap v 8.3 – This is the base GIS product used by Council and was the logical choice for use in the GIS based cadastral planner. It is a relatively simple to use package and has good import and export functionality.

- Microsoft Excel 2002 – Excel has been used as a basic spread sheet and text editor for the production of the larger tables. Excel was primarily used due to the operator familiarity and the functionality of dealing with large tables, of both numbers and text. Excel has significant advantages over ArcMAP's table editing functions, although Excel creates a file that must be imported to the GIS rather than creating a file within the GIS.

- GDAy v 2.1 – Is the NR&M's preferred datum transformation program. GDAy has been used in converting AMG coordinates to MGA and vice versa.

- Red-e-map - Redland Shire Councils Mapping Software. Red-e-map has been used as a general information tool in planning and retrieval of information in relation to properties.

The following sources of data have also been referenced in creating the GIS based cadastral planner.

- **SCDB -** The Survey Control Database was obtained from the NR&M. This was of little benefit, as there was minimal survey control on Karragarra Island prior to the commencement of the project.

- **Survey Plans -** A polygon search was performed by the staff at the NR&M Beenleigh office to give a complete listing of all historical plans associated with Karragarra Island. Hard copies of all the plans listed within the search were also supplied. This has been supplemented by the digital images of all plans held by Redland Shire Council.

- **Existing Engineering Survey Control and Connections -** It has been Council’s policy that all engineering surveys performed throughout the shire are to be connected to the cadastre. This is for two reasons, firstly so that the boundaries can be approximately plotted onto the engineering works and secondly to aid in future upgrading of the DCDB.

  A significant road detail survey by Saunders Havill and Associates has connected to several cadastral marks and PSMs. This has covered a significant section of the eastern end of the project area.

- **Approximate DCDB -** The current DCDB held over the Bay Islands including Karragarra Island, is the remnants of the NR&M's DCDB. This DCDB has been generated from bearing and distance input from survey plans and adjusted to the existing control. However, the lack of survey control and other factors has limited its accuracy and usefulness.

- **Field Notes -** The field notes for various plans may significantly assist in preparing the DCDB and subsequently the coordinated cadastre, especially where the boundary is defined by a natural feature. However, for the project area, field notes were not required.

3.3 Permission to Use Data

Permission has been sought and granted from the Department of Natural Resources and Mines, Redland Shire Council and the Australian Copyright Trust. Mr Graham Rush of the NR&M has granted permission to use the SCDB data, historical survey plans and associated data. Redland Shire Council’s cadastral data custodian Mr Peter Benfer has allowed the use of Council’s digital plan database and DCDB. The Australian Copyright Trust via Mr Jack de Lange has granted permission to use all survey plans.

3.4 Consideration of Database Structure

Once permission to use the required information was granted, the structure of the database needed to be contemplated. The overall goal of the project and objectives needed to be considered in determining what data was needed and what information would be required by the end user. This information would then need to be displayed in a suitable format.

To plan for a cadastral survey a Surveyor needs several pieces of information. These include;

- Registered Plans,
- Identification Surveys,
- Control Sketches (Form 6) and
- Reference Marks.

Other desirable features would be;

- Coordinates for corners,
- Coordinates for reference marks,
- Reliability value of a corner,
- Descriptions relating to definition of reference marks and
- Easily accessible background information of survey plans.

A GIS provides a good solution to presenting the cadastral information, as it combines a visual spatial display with tables of background information, allowing the user to seek and find the required information. It also allows for linkages between other packages that allows the display of cadastral plan and survey control sketch images.

The DCDB would provide the only suitable solution to the base layer. The DCDB has been created from a reinstatement of the existing control and survey information.

It would be possible to combine the original plans using only the original bearings and distances without adjustment and reinstatement to create the DCDB. However, the common boundaries on adjoining plans often do not match, creating gaps and overlaps within the cadastre if the boundaries are input as shown on the plans. Without some form of adjustment or reinstatement, the DCDB would not match what is on the ground.

If the DCDB is created with these gaps and overlaps, the associated coordinates of each corner would be of little value.

To produce a suitable GIS, several layers would need to be created. As mentioned above the DCDB would be an essential base layer. The DCDB in association with the determined coordinate system could then give the spatial location required for all the subsequent layers.

The remaining layers should include;

- Registered and Identification Survey Plan Layer,
- Corner Layer,
- Reference Mark Layer and
- Control Layer

Annotation for lots plans and road names would also be required for viewing ease.

This information could be assembled in either an ArcMap project or a personal geodatabase. The geodatabase automatically calculates spatial values for each feature imported, for example, it calculates the area and perimeter values for each polygon imported, or the length of each line imported.

Chapter 4

Creation of the GIS Based Cadastral Planner

4.1 Datum

The datum selection is a fundamental decision that greatly affects the usefulness of the project. There are several issues that need consideration in selecting the appropriate datum, as outlined below.

4.1.1 Geographic Area Covered

The size of the project area will determine if a plane, grid or a geographic is the most appropriate datum. If the area is relatively small, a plane datum may be considered suitable. However, if the area is larger, a grid or geographic datum will need to be used. A grid datum is often preferred as the coordinates can be displayed as an easting and northing, which can be readily interpreted. If the area is significantly large, for example it covers several projection zones, then to allow a consistent datum and coordinate system a geographic datum should be used, requiring the coordinates to be displayed as latitude and longitude.

4.1.2 Project Location

Most states or countries have a standard datum that is used to create consistency. Queensland, like the remainder of Australia uses primarily the Geocentric Datum of Australia (GDA) which is projected as MGA. Redland Shire has a prescribed plane datum that all as-constructed work preformed, as part of an Integrated Development

Application System (IDAS) application or engineering works internal to Council, must be on. These coordinates are commonly referred to within the shire as RSC.

4.1.3 End Users

The end users need a datum or a projection that is easy and simple to use and that can be easily and consistently overlaid with other data from other standard data sources. To be able to do this, the datum must be well defined so it can be readily transformed. For many non-spatial professionals the concept that a measurement within a geographic coordinate system is not the same as what will be measured on the ground is difficult to grasp and often fundamental mistakes are made. If a plane datum is used it will reduce one area where errors may be made.

4.1.4 Input of Data

The majority of information creating the base layers of the GIS based cadastral planner has been gleaned from cadastral plans, which are all based on a plane datum.

To simplify the process of inputting the plans into a suitable digital format, a plane datum has been used. The input information only requires a rotation and a shift of the plan information to bring it onto the common datum rather than a scale, rotation and shift, removing a possible source of error. Also, by using a plane datum it allows for the direct comparison of the final information to the existing.

4.1.5 Datum Defined

A plane datum is the most suitable option as the geographical area covered is relatively small, it allows for a simple comparison between survey plans for the end user, as well as simplifying the input of plan distances. With the adoption of the RSC coordinate system for the GIS based cadastral planner, it maintains consistency between other council surveys within the shire.

Redland Shire Coordinates are based on the Australian Map Grid 1984 (AMG) Zone 56 coordinate system. To minimise errors created from grid convergence, three separate RSC zones have been created within the shire. The three zones are Mainland, Bay Islands and North Stradbroke Island, each separated by expanses of water. Karragarra Island is located within the Bay Island zone and is defined as:

RSC Easting = ((AMG East – 537293.338)/0.9996172)+37293.338
RSC Northing = ((AMG North – 6940203.505)/0.9996172)+40203.505
Origin: PSM130448 Russell Island

	AMG	**RSC**
Origin Easting	537293.338	37293.338
Origin Northing	6940203.505	40203.505
Scale Factor	0.9996172	

This is a simplified formula and there are some minor errors, but the overall errors amount to millimetres within each zone and it is acceptable for all works within the shire at this time.

As an alternative, it would be possible to work in either Australian Map Grid (AMG) or Map Grid Australia (MGA) coordinates. This would involve a conversion from RSC to AMG using the above transformation for AMG. This would be best done in AutoCAD as a shift and scale. The AMG coordinates could then be transformed to MGA using the "Projection Wizard" within ArcMap. This would entail assigning the predefined ArcMap projection of AMG to the original AMG information. ArcMap then recognises that the information is in AMG coordinates and the data can then be transformed to any of the predefined coordinate systems in ArcMap including MGA, or alternately to a user defined coordinate system using the projection wizard. Additional fields would need to be added to include the plane distances and areas, so that direct comparisons could be made with the survey plans.

4.2 Control Definition

4.2.1 Gathering of Data

It was originally anticipated that the creation of the PSM layer would be a relatively simple exercise of manipulating the Survey Control DataBase (SCDB) from the NR&M. The lack of exiting control on Karragarra Island meant that the information contained within the SCDB would not be sufficient to accurately fix the cadastre to the required coordinate system. The coordination of several existing PSMs on the island and coordination of other cadastrally referenced marks was then required. Where a PSM was not connected to the cadastre, a conventional field observation was used to create the required connection. This was done via an identification survey so that it could be appropriately recorded within the NR&M's databases for future use.

To determine the positioning of the new control required, the existing SCDB was imported into ArcMap and overlaid over the existing digital cadastre. This showed that large sections of the project area remained uncontrolled and an increase in the density of cadastrally connected control would be required.

4.2.2 Planning of New Control

Several elements were used to plan the required coordination and connection of survey marks. These included:

1. Historical survey search of the island, including all identification surveys and registered plans as well as deposited plans.

2. SCDB information.

3. Redland Shire Council's mapping package Red-e-map. This has been utilised primarily for the corrected photography. Red-e-map has allowed the display of the cadastre overlaid onto the rectified aerial photography of Karragarra Island. Although the accuracy of the information is limited, it has allowed an indication of where GPS may be suitable for coordination.

4. A separate small planning project was created in ArcMap that has included the approximate DCDB and the existing PSM's. This showed the sections of cadastre that were already fixed to a coordinated datum. It was then possible to concentrate on the areas that were not fixed. This involved identifying critical points on the cadastre so that the minimum amount of coordination and cadastral connections would be required.

The critical or preferred control points that were required to constrain the cadastre were identified from the historical survey search. Existing cadastral marks that would be suitable for coordination were also identified. The positions of these marks were plotted on Red-e-map to show if the marks would be obscured by tree coverage and if they would be suitable for GPS coordination. This process excluded a large number of marks mainly due to the dense tree cover, particularly on the southern side of the Island. The process of identifying appropriate marks was then reiterated until the control was deemed suitable to fix the DCDB.

Although a more suitable control network could have been achieved with an increased density of control, the budget for control work constrained the number of coordinated and connected marks.

4.2.3 Survey Method.

To increase the value for money it was determined to use RTK GPS as the method for coordination. Although it was recognised that an RTK observation produces a less accurate result in comparison to static methods, it is appropriate in consideration of the rural nature of the island and the relatively low value of land. Although, land prices on the Bay Islands are rapidly changing.

Adding to the costs is the inaccessible nature of Karragarra Island, as it is only accessible by water via the Bay Island water taxi and barge services.

4.2.4 Field Work

The overall survey including coordination and cadastral connections was allocated to Cottrell Cameron & Steen (CC&S), a local survey company, which is part of Redland Shire Council's Panel of Providers for Survey Services. They have used RTK methods to coordinate all marks, ensuring repeatability by re-initialising at each mark.

All cadastral connections have been performed conventionally.

4.2.5 Validation of Data

The results in Appendix C show the consistency between coordinates at each point observed. The comparison to existing control gives an indication of the overall quality of the measurements.

In performing checks on the data supplied by CC&S, it was noticed that there was a 4 mm shift in the easting and a 17 mm shift in the northing between converted MGA and AMG coordinates. This comparison is based on the published SCDB values to the observed MGA coordinates converted to AMG using GDAY v 2.01. This difference is consistent across the four (4) existing control marks on Karragarra Island. It was apparent that CC&S had observed in MGA and converted their coordinates to AMG rather than observing in AMG.

Mike Cowie of the NR&M indicated that two separate data sets are kept by the NR&M:

1. GDA (MGA) adjustment.
2. AGD (AMG) adjustment.

The AGD adjustment shows the true AGD coordinates, i.e. the points have been observed in AGD and have not been transformed from GDA. Therefore, for all AMG calculations the AGD SCDB adjustment should be used.

It was also noted that, since GDAY uses a distortion grid the results will not be millimetre accurate for points that lay between nodes of the grid.

4.2.6 Summary

The MGA based information from CC&S has been shifted by 4 mm in the easting and 17mm in the northing to conform to the AGD published values within the SCDB.

Over the project area no new PSMs were placed, two (2) existing PSMs (122200 and 122186) were coordinated and connected to the cadastre, one (1) mark was connected to the cadastre and four (4) marks were coordinated.

The coordinated marks and cadastral connections have been included in Appendix D.

4.3 DCDB

The creation of the DCDB has inadvertently become a major part of the project. The lack of experience in the creation of the DCDB has generated a large and time consuming task that has given rise to many hours of contemplation to give a better solution, which in many cases the difference being only tens of millimetres. This problem has been exacerbated by the ability to zoom to the sub millimetre level, this tends to magnify the importance of very minor inconsistencies within the DCDB.

The reinstatement has followed the general rules or guidelines as set out by Brown (1980).

- Control by Intention.
- Control by lines marked and surveyed.
- Control by natural monuments.
- Control by artificial monuments.
- Control by maps and plans.
- Control by adjoiners.
- Metes and bounds.
- Control by course and distance.

Brown (1980) also indicates that in the absence of evidence of intention that excess or shortage should be proportioned in respect to the boundary length, unless there is evidence that there is a discrepancy within the plan. Brown (1980) continues to add that, where all lots are dimensioned regularly and there remains one lot that is irregular in shape or size, then in these instances it may be appropriate to allocate the discrepancy to this irregular block, where there is no evidence of where the discrepancy actually occurred.

The DCDB has been generated in AutoCAD. As a drafting package AutoCAD has several functions that lends itself to being a useful tool in generating the DCDB, including but not limited to:

- It allows the user to work in coordinates, as well as bearings and distances.
- The transformation (scale rotation and shift) of data can be easily preformed.
- It has a multitude of font styles and line-types that assist in generating annotation.
- It allows for the generation of point, line and polygon features.
- Data is readily transferable between AutoCAD and ArcMap.

4.3.1 Input of Plans

Originally the project area was broken into six (6) subsections A-F. These sections covered areas where a single plan defined a large portion of the area, if not the entire area. All areas, except for area C, could be fixed using control internal to the area. Section C, comprising of only 6 lots, was later combined with Section B to allow both sections to be properly fixed. This also aided in maintaining a straight line along the northern boundary, which appears to be the original intention of the initial survey. Sections E and F were also combined as they formed part of the one survey.

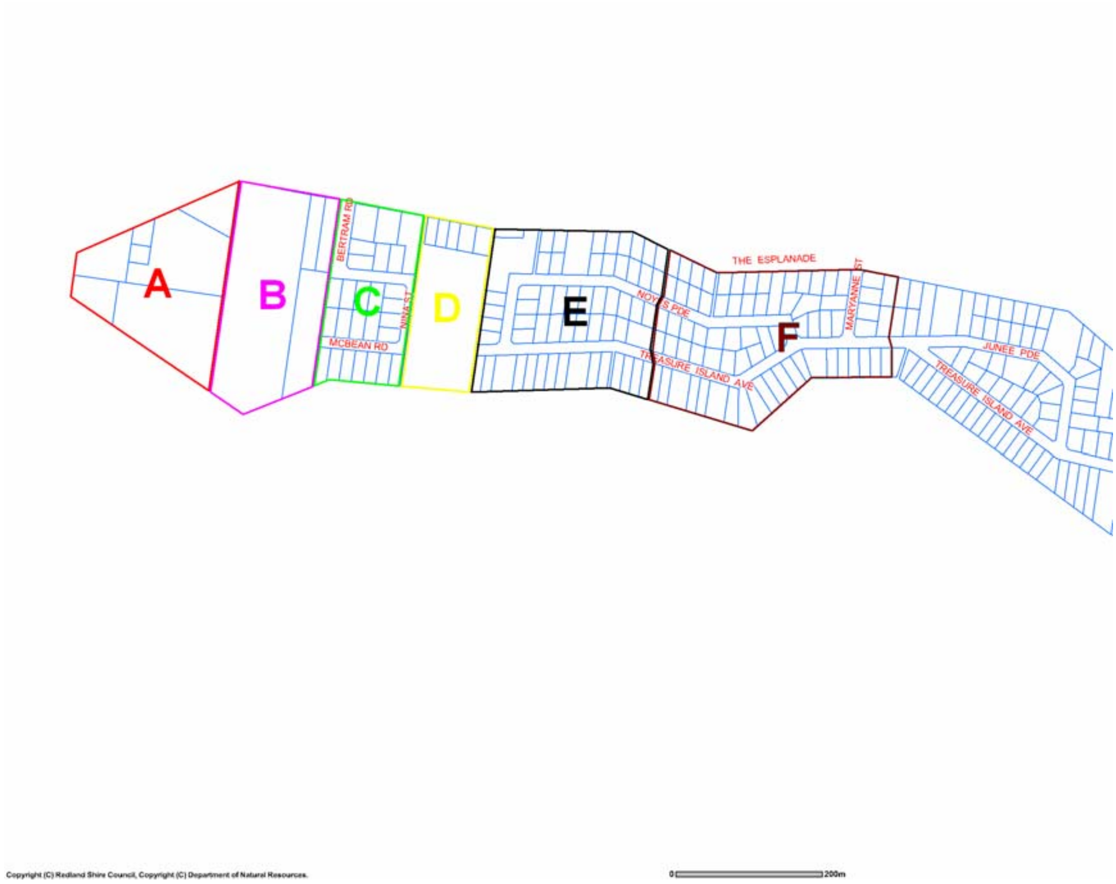

Diagram 2 DCDB Sections A-F

The DCDB has been broken into four (4) sections A, BC, D and EF. A surround of each section was drawn in AutoCAD and the misclose checked. If the misclose of the complete surround was deemed outside tolerances (40mm), the source of the misclose was determined from the existing survey plans within the section. Once an acceptable close had been made, the road sections were added. Connections to control marks or corresponding reference marks that would aid in aligning the section to the adjoining section, were also added. This created a skeleton of the section with all coordinated marks, reference marks and the lot frontages shown.

The four (4) surround sections then needed to be linked to the adjoining sections. Although there was usually agreement within each plan or each section, the comparison between sections was not as suitable. Between sections A and B, 87 mm needed to be redistributed, between sections B and C (RP178377 and RP139475), there arose a 120mm difference. In comparison of cadastral information, between sections C and D a difference of 92mm arose between RP100121 and RP139475.

The surrounds were then aligned (shifted and rotated) to the control, holding one point fixed. A direct comparison could then be made on how the cadastre fitted with the control, or alternately, the control could be used to aid in allocating excess or shortage within the section and resolving discrepancies between plans.

Each control point was given an arbitrary error factor of 30 mm, this was based on the accuracy of the RTK measurements. Anything that fell within 30mm of the point was deemed to give agreement.

4.3.2 DCDB at a Closer Look

Once the surrounds had been created, the infill of each area was required. This has brought to the fore the primary principals of cadastral reinstatement.

Certain errors always exist within any measurement. However, to have an accurate DCDB the gross errors need to be resolved. A solution found on best evidence, based on the principals of reinstatement has been interpreted from the available information.

Each individual lot has been recreated within the surround previously created. Where possible, deed or original plan angles and distances have been used in the creation of the DCDB. However, the distances have rarely reflected original distances. Where possible these have been proportioned along the entire line. The original angles have been maintained in most cases along the road frontages. No new bends have been added to the cadastre but angles at some critical points have been adjusted to better fit the existing control and cadastral information.

The primary objective of the reinstatement was to conform to the intention of the original Surveyor.

It has been noted that in most areas that there has been an excess of land available in comparison to the distances indicated on the original plans. There has been few significant differences between the survey plans and preceding survey plans. Some identification surveys show a proportionment of excess, usually only 1-2mm per lot. However, there are several angular discrepancies that have needed to be attended to. The larger discrepancies included:

- Lot 2 on RP178377 has indicated a misclose in the order or 220mm in the balance area.

- IS12574 indicates a large discrepancy in the order of 450 mm in the boundary between lots 2 and 4 on RP90863.

- IS174765 has noted differences in the north/south boundaries of lot 3 on RP90863.

- IS175836 has shown differences of approximately 30 mm in the north south boundaries of both lots 24 and 61 in RP130218.

A solution for these discrepancies has needed to be found using a combination of the existing survey plans, survey control and applying the above mentioned principals by Brown.

4.4 Creation of Shapefiles

Once the DCDB is generated and placed on the required coordinates, it forms the base of all the subsequent layers. These layers need to be registered to the DCDB to create one spatial reference system. The following shapefiles have been generated via AutoCAD:

- **Corner**. At each corner of the DCDB, points have been created to form the spatial attributes associated with the corner table.

- **Control**. A point for each control station has been created to form the spatial component of the control table.

- **Reference mark**. A point at each reference mark has been generated to form the spatial component of the reference mark table.

- **Boundary**. A line has been generated for each boundary line for the spatial component to be associated with the boundary table.

- **Lot**. A polygon has been generated around each individual lot to create the spatial attribute associated with the lot table.

- **Registered Plan**. A polygon has been generated for each registered plan to create the spatial attribute associated with the registered plan table.

- **Identification Plan**. A polygon has been generated for each identification survey to create the spatial attribute associated with identification plan table.

Each feature has been generated in a separate AutoCAD file, this has simplified the administration of the data and the checking of each layer. Once each layer is completed it is checked for spatial accuracy and completeness. The line and polygon features are checked for continuity ensuring that all corners meet and there are no overlaps or gaps between features.

Each of these points, lines and polygons have been exported using the AutoCAD Map function of "Export to Shapefile". Within the "Export to Shapefile" function, the export feature class is selected from point, line, polygon or text. The export features can be visually selected, or selected via a filter based on the layers or feature classes. Alternately, the AutoCAD files could have been directly imported into ArcMap using the "Add Layer" function in ArcMap.

4.5 Creation of Tables

The creation of the tables has been via two distinctly different methods.

Tables Generated in Excel

The larger tables associated with the lots, registered plans, identification surveys and corners have been generated in Excel, as it has greater text and number manipulation features which has aided in generating the tables. Once created, these tables have been exported as a comma delimited text file (*.CSV), alternately a text file (*.TXT) could have been used, both files are readily imported into ArcMap.

Tables Generated in ArcMap

After the point shapefile has been imported from AutoCAD, a base table is automatically created within ArcMap. The relative fields have then been added to this base table, using the "Add Field" function, for the point features, these fields have then subsequently been populated.

The smaller control table and the reference mark table have been generated within ArcMap. This method has been used for the reference marks table for two main reasons, firstly as an experiment to find out if it was an appropriate alternative to generating the tables in Excel, and secondly, as most of the GIS had been completed, it was possible to use the other layers to gather some of the information required to populate the reference mark table.

Fields have also been added to several of the Excel generated tables in ArcMAP. These fields, including the easting and northing fields for the reference marks, corners and control tables have been calculated within ArcMap. This has allowed for the coordinates to be automatically generated using the spatial location of the relative feature. This has been done by using the "Calculate Values" function after generating an easting and northing field. The calculation of the values are based on a pre-logic VBA script code in the advanced calculate values box.

With every table generated in ArcMap, two fields are automatically created, the FID and Shape fields. The FID, Feature Identification Number, is a unique number associated to each feature so that it can be readily identified. The Shape field describes if the attribute associated with the FID is a point, line or polygon.

4.5.1 Survey Control

The source of survey control data has been from the existing SCDB, engineering survey control that has been connected to the cadastre and a specific control survey associated with the DCDB, as outlined above in section 4.2 Control Definition.

Although the SCDB information has been supplied in a digital format, this has not provided a suitable starting point for the PSM tables. The small amount of existing SCDB information has been cut and pasted into the control table to prevent typographical errors. The remainder of the table has then been populated within ArcMap.

FIELD HEADER	Description of Field
FID	ArcMap Feature Identifier.
Shape	Feature Shape – Point.
Desc_	Mark description such as PSM 122200 or if it is a cadastral mark the station and plan number.
Type	Type of mark such as brass plaque or OIP.
Date_plcd	The recorded date of placement.
Surveyor	The Surveyor who placed the mark.
Class	The NR&M prescribed class of the mark as per the Intergovernmental Committee on Survey and Mapping (ICSM) Special Publication 1 (SP1).
Order_	The NR&M prescribed order of the mark as per the ICSM SP1.
Cad_Con	A description of whether or not a mark has a cadastral connection (Y or N).
Plan	The cadastral plan that the mark appears on.
Easting	RSC Easting of the point.
Northing	RSC Northing of the point.
Height	The registered height of the mark, if available.
LINK_PSM	Hyper-link to the Form 6 tiff image.

Table 1 Control Table

The “Desc_” or mark description contains a description of the mark showing if it is; a registered mark with the NR&M, being displayed as a PSM number; a Redland Shire control mark, being displayed as a RSC number; a cadastral mark, being displayed as a description of the mark, as well as the plan and station number so it can be found; or an engineering survey mark. This allows a search on a PSM number, a RSC number or a plan number, to see if there is any control marks associated with a specific plan.

The “Class” and “Order” fields have been included to allow the Surveyor to judge the accuracy of the control, enabling an informed decision of what control station to adopt or connect to.

A Height field has been included to aid in future engineering surveys within the area.

The “Cad_con” and “Plan” fields show if an existing control mark has already been connected to the cadastre and what plan it is connected via. These points provide a good starting point for a survey, as the marks have both a cadastral connection and a coordinate, allowing the Surveyor to be on either plan datum or the RSC coordinate datum once two cadastrally connected survey marks are observed.

The “Easting” and “Northing” fields give the RSC coordinates for each control mark. These can be selected either via the map or the table. The selection can then be exported via the table to a DBF file that is read into a text editor or Excel. This can be printed or edited for upload into a total station.

It should be noted that, only stable marks have been allocated coordinates. Marks such as dumpy pegs that have been coordinated, have not been entered into the project due to their instable nature.

4.5.2 Plan Layer

The plan layer is associated with two tables, firstly the registered plan table, and secondly the identification survey plan table.

The majority of this information has been gleaned from the “Survey Search Report” from the NR&M and registered and identification plans. Unfortunately the NR&M has been unable to supply the survey search report in a digital format. This would have saved considerable time in manually inputting the information into the tables and reduced a possible source of error.

FIELD HEADER	Description of Field
FID	ArcMap Feature Identifier.
Shape	Polygon covering all subject parcels.
Plan_No	Registered plan number.
Signed	Date the survey plan was signed.
Surveyor	The Cadastral Surveyor who has completed the survey.
Status	Status of the survey i.e. if it has been lodged or registered.
Cmp	Y or N if the plan has been compiled.
Field_Note	Y or N if field notes have been lodged with the survey.
Imaged	The date the plan was imaged.
Lots	A listing of the lots created.
Original_P	The original plan(s) the plan has been created from.
Cancelling	The cancelling statement of the plan.
Plan_Desc	Description of the actions associated with the plan.
Marks_Plcd to Mark_Plc24	A listing of all the reference marks placed.
Orig_Mark to Orig_Mark7	A listing of the original marks shown on the face of the plan indicating from which corners the reinstatement has taken place.
Link	A hyper-link to the tiff image of the plan.

Table 2 Registered Plan Table

Many Cadastral Surveyors work in a small geographic area, this allows each Surveyor to build a knowledge of the reputation and consistency of the work of previous and current Surveyors that have produced plans over the same area. The "Surveyor" field in the tables enables a quick reference to what Surveyors have produced plans specific to a certain area.

The "Marks_Plcd" fields show any new mark that has been placed on a plan. This allows the origin of all new marks to be determined.

The "Orig_Mark" fields show all the original marks connected to on a survey. This provides information to assist in determining the reliability of the survey, the reliability of the marks placed and the corners reinstated. This enables searches for a specific mark to determine information such as what plans the mark has been connected on.

FIELD HEADER	**Description of Field**
FID	ArcMap Feature Identifier.
Shape	Polygon covering all subject parcels.
Plan_no	Plan number.
Signed	Date the survey was signed.
Surveyor	The Cadastral Surveyor who signed the plan.
Status	Status of the survey plan.
Field_Note	Y or N if field notes have been lodged with the survey.
Imaged	The date the plan was imaged by the NR&M.
Desc	Description of the action associated with the plan.
Orig_Mark to Orig_Mark9	A listing of the original marks shown on the face of the plan.
Mark_Plcd to Mark_Plcd5	A listing of all the reference marks placed.
Link	A hyperlink to the tiff image of the plan.

Table 3 Identification Plan Table

In relation to the registered plan and identification survey plan tables, the following points should be noted.

- Where the identification surveys have only identified part of a lot the associated polygon has selected the entire lot.

- With the original marks and the marks placed, the fields show plan stations where possible, otherwise a lot number is shown. These can be distinguished as all stations are preceded by Stn.

- The deposited plans have been included with the identification surveys, as they are considered to be for information only and have not been examined as a registered plan. As such, the status field is still required in the identification plan table.

4.5.3 Lot Layer

This information contained in the lot table has been gleaned from the survey plans and Council’s property database.

FIELD HEADER	Description of Field
FID	ArcMap Feature Identifier.
Shape	Polygon covering the associated lot.
LOT	Lot number.
PLAN	Registered plan number.
HOUSE	House number.
STREET	Street name.
EASEMENT	This field indicates if an easement exists, it is either be B – Benefited or E – Encumbered or N – No an easement does not exist. (However, there are currently no easements within the project area).
PLAN_AREA	The lot area, as shown on the face of the plan.
AREA_m	The area shown on the face of the plan converted to square metres.
LOT_PLAN	Lot/Plan number (This field was initially added as a unique identifier for the lot, so that it would be possible to join tables associated with the lot based on this field).
ASSOCIATED to ASS_7	Survey plans that are associated with the subject lot.
Link	A Hyperlink to the registered plan for the lot.
Shape_Area	A field calculated from the DCDB area of the lot.
Lot_diff	A field calculated from the difference between AREA_m and Shape_Area. This shows the difference between deed area and DCDB area.
Covenant	This field indicates Yes or No (Y or N) if a covenant exists on the lot.
Profit-a	This field indicates Yes or No (Y or N) if a profit a’ prendre is associated with the lot.

Table 4 Lot Table

The “House” and “Street” fields allow a parcel to be found using the address in comparison to the lot and plan description. This is useful as most residents will know their street address but will not know their lot and plan description off hand.

The “Associated” fields allow the Surveyor to see every plan that has referenced the subject lot. Using the “Select by Attributes” it is possible to build a query to return all the lots associated with a certain plan.

The “Shape_Area” has been generated to allow a comparison of the registered plan area and DCDB area. An additional column has been calculated to show the difference between the DCDB and the registered plan areas.

The shapefiles for the lots and boundaries have been alternately imported into a personal geodatabase. This has automatically populated fields for area and perimeter for the lot polygons and length for the boundaries. These values have been exported from the personal geodatabase and added to the appropriate tables in Excel. It was then possible to add a field in ArcMap (Lot_diff) and calculate values for the difference between the registered plan area (AREA_m) and DCDB area (Shape_Area) using the “Calculate Values” function. This gives an indication of how much the DCDB has changed in comparison to the registered plan and may indicate if there are some discrepancies within the survey cadastre.

4.5.4 Corner Layer

The data contained within the corner table has been generated from investigation of the cadastral plans. The easting and northing fields have been automatically generated within ArcMap from the DCDB information.

The “Plan” field could be divided into two separate fields being a “Created” field and a “Reinstated” field. The created field would show on what plan a corner was created and the reinstated field would show the plans on which the corner has been subsequently reinstated. However, the lot table already shows each plan that an individual corner is reinstated on.

FIELD HEADER	Description of Field
FID	ArcMap Feature Identifier.
Shape	Feature Shape – Point.
Plan	Associated registered plan, where two plans define the same corner the most recent reinstatement has been shown.
Lot	The adjoining lots.
Variance	The greatest difference in angle shown at the corner by associated plans.
Reliability	A number 1 to 4 indicating the reliability of the corner, with 1 being the greatest.
Easting	RSC Easting.
Northing	RSC Northing.

Table 5 Corner Table

The variance at each corner has been determined by investigating each plan that shows the particular corner. If there is an angular difference in the corner, it was noted on the face of the plan, and later input into the database. If there was more than one angular difference at a particular corner, the greater value was assigned as the variance. This value is not designed to form the basis of any calculations and has been entered as a text field. It is purely an indicator that a discrepancy exists at this corner between survey plans.

The corner attributes, like the control marks, can be selected and displayed via the map, using either the “Identify” or the “Select Features” tool. The “Select Features” tool allows a selection of multiple corners that are viewed via the table. The selection within the table can then be exported via the table to a DBF. The DBF file can be read into a text editor or Excel to be either printed or edited into a suitable format for upload into the total station or data recorder.

The reliability factor associated with the corner table is a subjective value intended to give an indication of how well the corner is fixed. This reliability factor has been assigned a value from 1 to 4, with 1 being an indication of a very reliable corner and 4 indicating a very poorly defined corner. The reliability has been considered to be a factor of four separate elements, these being:

1. Agreement between; a) previous survey plans,
   b) DCDB.

2. How the corner has been defined. This has taken into account what reference marks have originally been used to place the corner and if there have been any discrepancies shown between marks.

3. Marks remaining from the original reinstatement. If there are no marks remaining from the original reinstatement it could be very difficult to reliably reinstate the corner where the original Surveyor intended.

4. Age of the original plan/survey. This has taken into consideration that measuring technology has improved over the years and an older survey will be more likely to have discrepancies in distance, especially pre EDM.

Each corner has been assigned a value (1 to 4) for each criterion. The lowest value has then been adopted for each corner, as the reliability may be poor if it scores lowly in any one of the criteria. The reliability values have been assigned to each corner via assessing each current plan.

4.5.5 Reference Mark Layer

The fields for the reference mark table have been populated by close inspection and consultation of the survey plans. This has been a manual process of highlighting all the original marks on the plans with one colour and the marks placed in a separate colour. This has allowed a description of how each new mark has been defined from the original marks.

FIELD HEADER	Description of Field
FID	Feature Identification Number.
Shape	Point.
Mark Type	Description of mark type such as, pin, nail, screw, PSM.
Easting	RSC easting of the point.
Northing	RSC northing of the point.
Comments	Comments associated with the point including, if the mark has been noted as gone, disturbed, leaning, or if there has been a new reference to the mark.
Plcd_from	A list of the original reference marks that the new reference mark was placed from.
Orig_plan	The plan where the reference mark first appears.
Adjoin_lot	The adjoining lot(s) to the reference mark.
Associated to Ass9	Plan(s) that the mark subsequently appears on.

Table 6 Reference Mark Table

The RSC easting and northing of each reference mark can be exported and edited by the same method as the control and the corners.

The “Orig_plan”, “Placd_from” and the “Associated” fields show the history of the mark, enabling an indication of the reliability of the mark. From inspection of the “Comments” field the Surveyor can see any discrepancies that may have arisen with the reference mark or problems associated with the mark.

4.5.6 Boundary Layer

The boundary layer has been generated by importing a shapefile of all the boundary lines into a personal geodatabase. This has been created to give a comparison between the DCDB distances and the on plan deed distances.

FIELD HEADER	Description of Field
FID	ArcMap Feature Identifier
Shape	Feature Shape -- Line
Shape_Leng	The boundary length in metres

Table 7 Boundary Table

This table could be improved to note all the distances for a particular line, so when selected in the GIS it would not only show the DCDB distance for the line, but each distance for the boundary line for each plan, as well as a difference in distance.

4.5.7 Validation

There have been several methods of validation used to ensure the data is complete and correct. These have included:

- Each table has been manually checked via visually inspecting each field and information queries.
- Each hyperlink has been checked to show that it is associated with the correct tiff image.
- By joining each Excel based table to the shape file, it generated a check that all features had been created.
- The overlay of the various layers has ensured that spatial information is correct.
- The final registered plan tables and identification plan tables have been checked against the original radial search information.
- The redundant measurements within the survey data have acted as a check on each survey and between surveys.
- A comparison of the DCDB lot areas to the deed areas has indicated no gross errors exist within the lot sizes.

- General use of the GIS for testing and comparison to alternate methods has indicated consistency within the GIS.

Other methods of possible comparison may include:

- Some of the control table could be directly compared against the SCDB within either ArcMap, by importing a CSV file of the SCDB and calculating differences between the SCDB and the Control table. Alternately this could be done in Excel by exporting the control table to a DBF file and importing it into Excel and again calculating the differences between the two sets of data. However, in the project area only one mark is in both the SCDB and the control table, in other areas where the SCDB is more complete this process would be of more use.

- As like most Local Authorities, Redland Shire Council maintains a rates database. This database contains information in relation to street addresses as well as lot and plan descriptions. It would be possible to compare the two databases via the same means as the control table and the SCDB have been compared.

Implementation and the direct comparison to the observed coordinates would be the ultimate test for the DCDB generated coordinates from the GIS based cadastral planner.

4.6 Joining of Shapefiles to Tables.

The tables created within Excel needed to be imported into ArcMap and joined to the appropriate shapefile. The Excel file has been generated with a column labelled FID, this column corresponds to the FID field within the base table associated with the shapefile. The Excel spreadsheet has then been exported to a comma delimited text file (CSV). Once both the shapefile and the CSV file have been imported into ArcMap, a join can be performed using the common FID column in both the shapefile and the CSV file, to create one table showing the required information.

4.7 Allocation of Symbols and Colours.

The symbology and colours greatly affects the visual appeal of the project as well as usability. The following colours and symbols have been assigned:

- The PSM's have been represented by a standard PSM symbol of a circle with a dot in the middle. This symbol could be further delineated to show a different hue for a different class or order.
- Each corner has been represented by a small white square replicating a corner peg.
- The reference marks have been shown by a small blackened circle, this replicates the symbol for an iron pin, as shown on many older survey plans.
- The lot layer has been shown in a light green to represent the land.
- The identification surveys have been shown in a red outline.
- The registered plans have been shown as a grey fill colour.

Annotation has been added from AutoCAD Drawing Exchange Format (DXF) files. This has included annotation for the road names and the lot and plan descriptor.

Chapter 5

Implementation Considerations

The following looks at the needs, requirements and problems associated with the implementation of a GIS based cadastral planner. Implementation will need to be considered on a local government level and a regional level in particular.

5.1 User Training

With any new system, user training must be implemented. If the user has a basic knowledge of ArcMap or the ESRI product suite, then the GIS based cadastral planner should be simple to use. However, there are several areas that should be addressed in relation to basic GIS user knowledge and ethical responsibility.

5.1.1 GIS Knowledge

For the GIS based cadastral planner to be a useful tool the user will need to be trained in the basic operation of a GIS. The user will need to know aspects such as:

- Adding/removing layers.
- Turning layers on and off.
- Changing the display order.
- Setting selectable layers.
- Table structure.
- Adding and calculating fields within tables.
- Basic queries.
- Advanced queries including SQL queries.
- Creating new layers from queries.

The functionality of the GIS based cadastral planner will be largely dependant on the GIS skills of the user. The better the GIS skills of the user, the more information the user will be able to retrieve from the GIS based cadastral planner.

For end users, a training manual could be quickly devised indicating the tables and what information is contained within each table. As many Surveyors have GIS skills, then a background in what information the GIS contains maybe all that is required for the Surveyor to start using the GIS based cadastral planner. However, the use of the GIS based cadastral planner may not be limited to Surveyors, as it is a useful tool to obtain cadastral survey information for any purpose, including, design or planning.

5.1.2 Ethical Responsibility

The production of the GIS allows the ability for approximate coordinates for a property corners to be downloaded and set out. This raises two problems, firstly the temptation may arise that a Surveyor, for whatever reason, may neglect to do a proper reinstatement using the appropriate chain of evidence, secondly an engineering Surveyor staking an offset to the boundary may find it easier to stake the approximate corner rather than the offset, which is a practice not condoned within Queensland. To avoid such instances the end user’s of the GIS would need to be made aware of the limitations of the data contained within the GIS and of their moral and legal responsibilities

5.2 Datum

As previously discussed in 4.1, the datum greatly affects the GIS based cadastral planner. Using the GIS based cadastral planner over a larger area would force the project to be displayed in MGA coordinates. However, an MGA datum will still provide problems for local authorities that span a zone boundary.

In using MGA coordinates for the base coordinate system, the GIS based cadastral planner would then need to incorporate additional fields so that coordinates on a plane datum could be shown as well as fields that calculate plane distances from the MGA distances.

The conversion to MGA can be implemented using the “Projection Wizard” tool within ArcMap. The projection allows the direct conversion from one defined projection to another.

5.3 Responsibility Including Maintenance and Update

The GIS based cadastral planner, or similar variations, need a custodian to take responsibility for the creation, maintenance and upgrade of the GIS. If the GIS is to remain a local tool for Redland Shire Council it could be maintained and upgraded as a Council based project. However, it would be appropriate for the NR&M to take custodianship of the GIS as they are the custodians of the DCDB and the cadastral plans that form the basis of the GIS based cadastral planner. Like the DCDB and SCDB the NR&M could on sell the GIS based cadastral planner to the local authorities or service providers as they see fit. Alternately, a web based mapper could be produced allowing the information to be downloaded over the internet.

5.4 System Limitations

The users of the GIS based cadastral planner need to be made aware of the limitations of the data they are using and also the limitations of any survey equipment they may be using, particularly GPS.

The users also need to know that the coordinates supplied via the DCDB for the property corners are of limited accuracy and they should not be assumed to be millimetre accurate.

With current GPS products a user may expect, if they are on the correct datum, that they may get a point position of 2 to 10m in most instances from their hand held GPS. This may cause problems where the non survey trained user expects the coordinates being produced by the GPS to be millimetre accurate in comparison to the approximate boundary coordinates

5.5 Distribution of Information.

If delivering to a large scale audience the GIS based cadastral planner would be best distributed over the internet on a web based mapper, using a package such as ArcIMS by ESRI. However, this may limit the functionality of the product. The mapper would allow the user to view the information within the system and would be able to retrieve information from existing fields, but the mapper would not allow the user to build quires or calculate values from the database. The alternative would be that all users would need an ArcMap licence or similar product to view, access and use the GIS based cadastral planner to its full potential. This may be an appropriate option where there are a limited number of users, but it would quickly become cost prohibitive where larger numbers of users are concerned.

5.6 Time & Budget

The time and budget allowed for the implementation of the GIS based cadastral planner will greatly affect the functionality of the end product. With limited time and budget an investigation of the essential components of the GIS based cadastral planner for the specific end users would need to be determined. The non essential elements for operation may then need to be discarded. As an example it may be deemed that coordinates are not required, then an accurate DCDB is not essential, but in loosing the accurate DCDB, a comparison between plan areas and distances and the accurate DCDB is also lost. This comparison is a possible means of highlighting problem areas. Without an accurate DCDB the GIS based cadastral planner looses some of its functionality. However, it retains the ability to quickly search survey information for details that would assist in planning.

Many of the fields such as the hyperlink fields can be quickly populated. However, the fields that require investigation of the survey plans will still require significant number of hours to create. Some of the fields tend to overlap in different tables, such as reference mark information which can be obtained in the plan tables (identification and registered plan tables) and the reference mark table. The need for this overlap may be overcome by using the functionality of the GIS to build queries associated with the tables. It may be possible to eliminate this overlap and reduce the time required to create the GIS.

To maximise speed and efficiency, a Cadastral Surveyor should create the DCDB and possibly have the GIS based cadastral planner implemented by a person more experienced in GIS.

5.7 Cost and Cost Benefit Analysis

5.7.1 Project Costs

The following is an approximation of the time and cost involved in generating the project. The costs and times are based on the methods used in generating this project, with the field component being completed by an external provider and the generation of the DCDB and GIS based cadastral planner completed in-house. There will be significant variations in the costs if the entire process is performed in-house or alternately if it is completed by an external provider.

The following times have not included the planing and consultation times required in determining the specification of the project. It has been assumed for the following calculations the cost of an in-house Surveyor is $35 per hour.

The cost of producing the GIS based cadastral planner, as per table 8, has been $12 345, including the preparation of the DCDB. This gives an average of $70 per lot to produce the GIS based cadastral planner. However, if we look at only the creation of the GIS based cadastral planner alone with out the DCDB then the cost is reduced to $4025, averaging to $23 per lot.

It is expected costs will be reduced for both the DCDB and the GIS based cadastral planner with larger project areas, and with additional experience, particularly in generating the DCDB.

Task	Hours	Cost	Totals
DCDB			
Preparation of Data – Ordering Search Colation of Plans Control and Connection	16 hrs	$560	
Coordination and Cadastral Connection (External provider)		$6 500	
Generation of DCDB	36 hrs	$1 260	**$8 320**
GIS Based Cadastral Planner			
Table Preparation	30 hrs	$1 050	
Creation of Spatial Features	21 hrs	$735	
Checking of Spatial Data and Tables	16 hrs	$560	
ArcMap Import of data and Joining of Tables	10 hrs	$350	
Presentation of ArcMap Data	4 hrs	$140	
Testing and Correction	18 hrs	$630	
Documentation of Process	16 hrs	$560	**$4 025**
TOTAL	**167 hrs**	**$12 345**	**$12 345**

Table 8 Cost Table

5.7.2 Cost Benefit Analysis

Prior to implementation, an in depth Cost Benefit Analysis (CBA) will need to be performed. The CBA needs to take into account both the tangible and intangible benefits and costs associated with the GIS based cadastral planner. In general, the CBA will show the financial value associated with the increased productivity versus the implementation costs.

5.8 Implementation at the PC Level

At the computer level, implementation is a matter of having available the required hardware, software and data files.

The minimum software required to operate the GIS based cadastral planner would be ArcMap. However, to enable update and maintenance, AutoCAD Map would be required as well as Excel.

To operate ArcMap 8.3 the recommended PC requirements are:

- CPU speed of 800 MHz or higher
- RAM is greater than 256MB, and
- Disk space greater than 605 Mb.

The operating platforms for ArcMap are: Windows 2000, Windows NT and Windows XP.

The implementation onto any PC or network will require the original data files including the ArcMap shapefile (SHX), projection file (PRJ), database file (DBF), index file (SHX), spatial index files (SBN and SBX) and the CSV information tables. The tiff images of the cadastral plans and the survey control sketches would also be required. This will require negotiation with the NR&M.

5.9 Maintenance and Update

The continual process of maintenance and update needs to be considered before implementation. The maintenance and update of the attribute or table information can be easily done within ArcMap or using Excel and importing the relevant files. The spatial data can be edited in ArcMap, although AutoCAD would be preferable due to the inbuilt functionality and the ability to accurately manipulate points, lines and polygons.

If subsequent or future plans uncover or highlight significant discrepancies within the allocation of boundaries within the DCDB, large sections of readjustment and recalculation of a new DCDB may be required. Minor discrepancies may be able to be dealt with by reapportioning the discrepancy over a relatively small area.

Chapter 6

Problems Encountered

The following chapter is a brief description of the more significant problems or unexpected delays in completing the GIS based cadastral planner.

6.1 Problems Encountered in Planning and Creation of the GIS based Cadastral Planner

Through thorough planning and careful creation and implementation the problems directly associated with the project have been minimised. External forces have increased the workload in relation to the project but this has not affected the overall outcomes of the project.

6.1.1 Preparation

The limited availably of literature on the successful elements of existing coordinated cadastres has not allowed the project to draw on the success of previous attempts to create a coordinated cadastre.

Delays in receiving permission to use copyright material were of little hindrance as it was assumed it was forthcoming and progress proceeded on alternate areas of the GIS until permission was granted.

The contemplation of areas that could be used as a project was an area of minor discussion. In hind-sight it would have been better to use an area of existing DCDB. This would have allowed the project to concentrate on building a cadastral database and implementing a more interactive GIS rather than creating a DCDB. However, in stating this, the background knowledge obtained of the cadastre in generating the DCDB has been invaluable.

6.1.2 Layers

There have been several minor problems in generating the individual layers in ArcMap, however, all have been overcome in some form or another.

The importing of annotation provided a small delay, as ArcMap has problems interpreting data within an AutoCAD 2004 file format. This was resolved simply by converting the file format to an AutoCAD 2000 DXF file and reattempting the importing of the annotation.

As discussed in section 5.2.5 Validation of Data, there was minor differences encountered in the control values used depending on the transformation.

When importing the CSV files for the lots and corners into ArcMap some unusual errors were encountered. The lot table fields ASS_2 and ASS_3, were imported as double precision numbers, this caused either the letters to be stripped off the front of the plan number or a null value to appear in the field. The format of these columns was checked in Excel and they were shown as text columns. It was then attempted to bring these files in as a text file and the same result of conversion to double precision occurred. The CSV file was directly checked and the data values were plan numbers, which should have been imported as text. ESRI Australia Pty Ltd, was then consulted, but could offer no reason or solution for the occurrence. To circumvent the problem the original CSV file was imported and joined to the spatial attribute table, two additional text fields ASS_2a and ASS_3a were added and populated with the required information. A similar problem was encountered with the corner table where the variance was imported as a long integer instead of a text field. The same solution was applied to the corner table.

The generation of the layer tables has been a somewhat arduous task. The creation of the tables has involved close scrutiny of the survey plans and many hours of data entry. A high level of concentration has needed to be maintained over extended periods of time to ensure the correctness of the tables.

With the initial importing of information into the project, it was noted that a layer with an associated projection was required to be imported into the project first, otherwise the units on the coordinates were not shown as metres. For example, if one of the CSV files such as the lot_table.csv was imported into ArcMap as the first layer then the units shown within ArcMAP are unknown.

6.1.3 DCDB

As noted previously, the DCDB has unintentionally become a large part of the project. Although, each section of the DCDB presents its own problems, this section of Karragarra Island showed nothing that could be considered unusual. An identification survey should be performed to better fix the western end of the island. This was not deemed necessary for the GIS based cadastral planner and the land values will be later scrutinised to investigate if it is required for the final version of the DCDB.

6.1.4 Time and Size

The size of the project and time required to produce the GIS based cadastral planner has been greater than first anticipated. However, in gaining the experience in an experimental situation it would enable future sections of a GIS based cadastral planner to be produced in a far more efficient manner.

6.1.5 Testing

No simple or automated way of testing the entire integrity of the system has been devised. This has instigated manual testing and viewing of files to ensure they are complete and accurate. Any system that is based on human judgement will always be susceptible to error. Although all the minor errors found in checking and testing were been corrected, it can not be assumed that the GIS is 100% error free.

6.1.6 Implementation

The problems with implementation have previously been discussed within chapter 6. However, these are largely theoretical as the GIS based cadastral planner in currently a personal project.

The survey control sketches and survey plans were originally numbered in the NR&M convention of the number of the plan or sketch followed by a ";" then a numerical descriptor of the version. For example the original sketch for PSM 123456 is SCS123456;0 and the first revision is SCS123456;1 and so on. This has caused a problem when copying the files to CD as the copying software fails to recognise files with ";" as a valid file name and will not copy. This has meant that the survey plan and survey control sketch files have needed to be renamed and the links to these files recreated.

Chapter 7

Comparison to Conventional Methods

A random selection of lots has been made to perform three surveys, two identification surveys and one reconfiguration survey. Lot 6 on RP100121 was chosen for the reconfiguration survey, as it remains a large parcel of land with smaller lots on the northern, eastern and western boundaries. For the identification survey, an older lot and a newer lot have been chosen to try and show a range of information.

7.1 Conventional Method Summary

The following is a brief indication of the steps required to conventionally prepare for a cadastral survey.

1. Order radial search from NR&M or service provider such as CITEC.
2. Wait for response.
3. Collect radial search.
4. Search existing database of plans and retrieve required plans and order the plans not available in the database.
5. Run close on plan (This is still required and has not been automated within the GIS based cadastral planner at this stage)
6. Search for reference marks that define the subject boundaries.
7. Collect at least two PSMs within vicinity (Not required for identification survey).
8. Sketch existing boundaries and reference marks for field connection.
9. Note any differences between plans.

7.2. Overview of GIS Cadastral Planner Method

The GIS based cadastral planner compares two sources of information. Firstly, a comparison has been made between the existing plan data, for example, the corner table contains the "Variance" field which is a comparison of the angle variation at a particular corner, as shown on the existing plans. Secondly, the GIS based cadastral planner has enabled comparison between the existing plan data and the DCDB, for example, the lot table has shown the difference between the plan area and the DCDB area of each lot.

7.2.1 Compilation of Required Paper Plans.

The GIS based cadastral planner has greatly simplified the process of compiling the required plans. Each plan is hyper-linked to each associated lot. To retrieve the plans for a particular lot, it is a matter of clicking the lot with the hyper-link tool. If there is only one plan associated with a lot, then that plan is displayed, if there are several plans, then a list of the plans will appear and double clicking on the required plan will bring it to the screen. This enables the plans associated with a lot to be retrieved within seconds. The process for displaying the plans for the subject lot is then repeated for the adjoining lots.

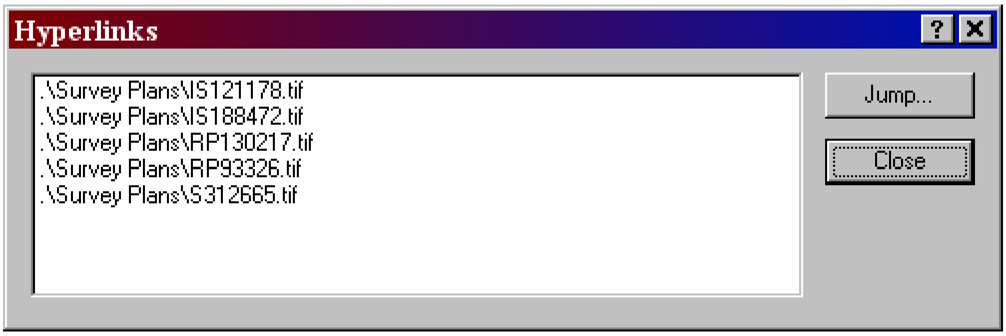

Diagram 3 – Plan selection using hyper-link tool

An alternate means to determine the plans required, is to use the "Select Features" tool to select an area. It is then possible to view all the associated plan numbers by viewing the identification plan table and the registered plan table.

7.2.2 Investigation of Corner Information

The database tables can be queried by two methods, individually using the "Identify" tool or via a selection of multiple corners using the "Select Features" tool. The "Identify" tool retrieves information directly for a single feature. However, since there are usually several corners involved in each survey, a selection of the corners can be made using the "Select Features" tool. The results of the selection can be viewed in the corner table.

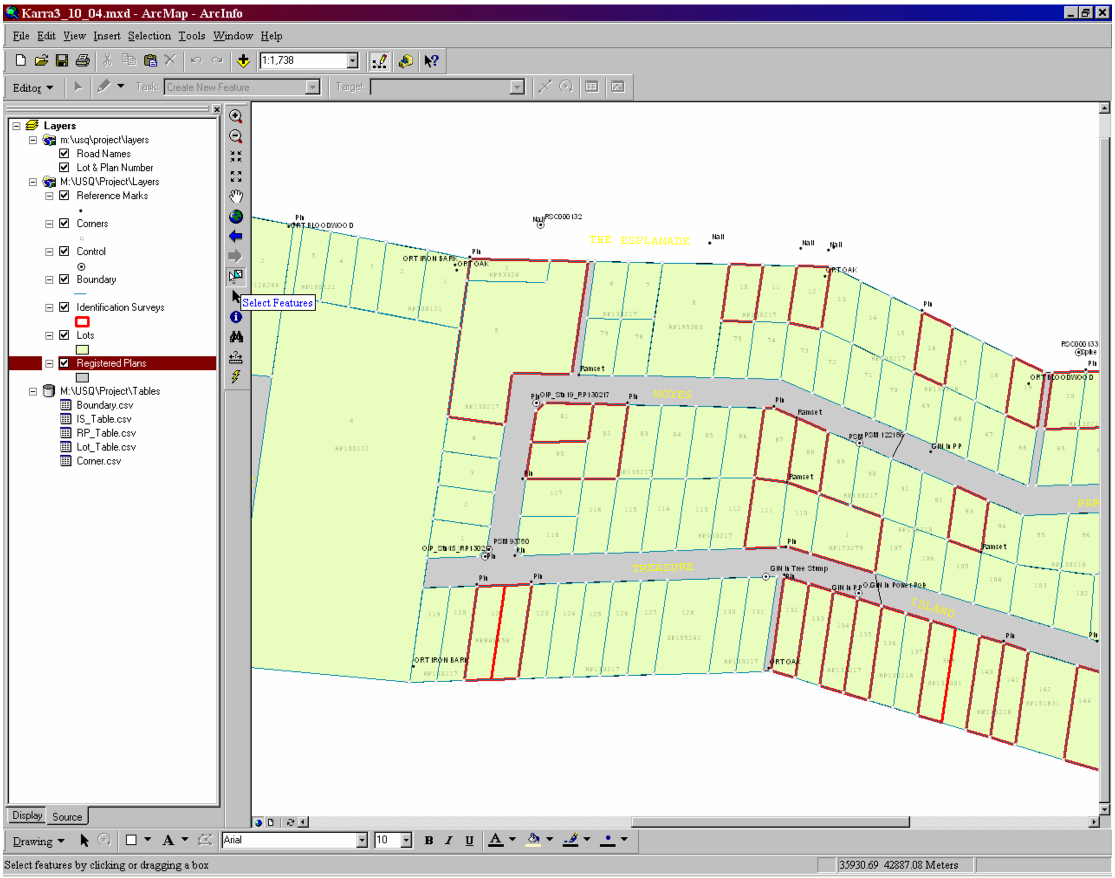

Diagram 4 – "Select Features" Tool

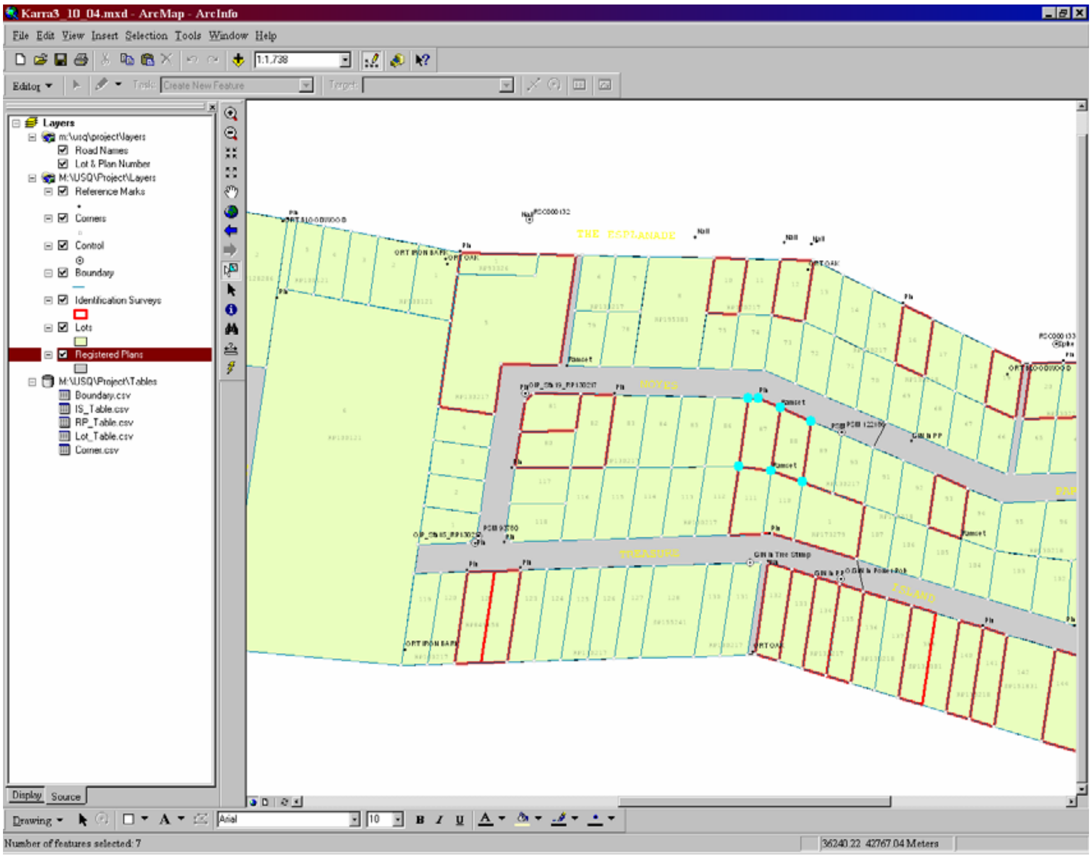

Diagram 5 – Selected corner features

Selected Attributes of Corners

Corners.FID	Corners.Shape	Plan	Lot	Corners.Variance	Reliability	Corners.Easting	Corners.Northing
6	Point	RP130217	87/88	0	2	36220.014	42809.715
49	Point	RP130217	87/88/110/111	0	2	36215.07	42775.567
125	Point	RP130217	1/88/89/110	0	2	36231.883	42769.574
127	Point	RP130217	86/87	0	2	36202.623	42815.029
128	Point	RP130217	86/87/111/112	0	2	36197.253	42777.944
260	Point	RP130217	88/89	0	2	36236.665	42802.602
261	Point	RP130217	87	50"	3	36207.845	42814.914

Record: 1 Show: All Selected Records (7 out of 366 Selected.) Options

Diagram 6 - Results from selected corner features

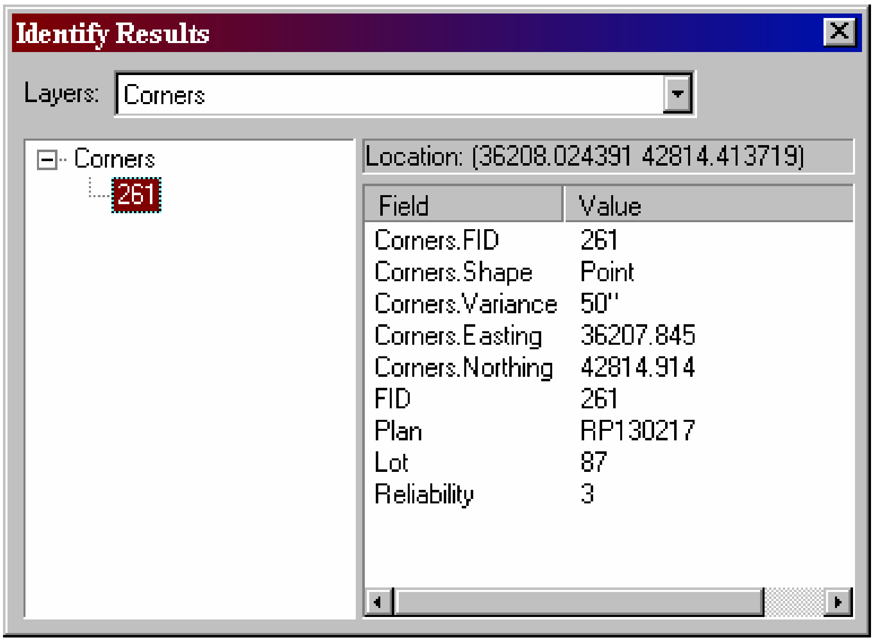

Diagram 7 – Display of corner information from "Identify Tool"

7.2.3 Investigation of Reference Marks

The reference marks can be quickly selected to give a listing of associated coordinates derived from the DCDB, as well as a brief history of how the mark has been placed and which plans it has subsequently been shown on. In addition to this, the "Comments" field indicates if the mark has been designated as destroyed, not found, disturbed, leaning, new reference or any other comments that may be applicable to the mark, as shown on previous plans. A selection, for example, of the marks that are "Gone", can be made using the comments field and the "Select by Attributes" function, using a selection statement similar to:

SELECT *FROM Ref_Mark WHERE: "Comments" LIKE '%Gone%'

Equation 1

This returns all the marks that have been noted as gone.

This enables a quick reference to the history and the noted condition of the reference marks that will form the basis of future reinstatement.

7.2.4 Investigation of Control

As with the survey plans the Form 6 Survey Control Sketches (SCS) are hyper-linked to the relevant tagged image file format (tiff) image. This allows quick retrieval and printing of the relevant Form 6. This table also contains marks that have been coordinated through previous engineering surveys. A listing is provided in the control table for the coordinates of each mark, this allows easy printing or upload into the instrument.

7.2.5 Boundary Lines

This table has been added to the project as it provides the ability to compare the length of a boundary line in the DCDB to the existing plans. This is a manual process of comparing the value within the table to the registered plan or identification survey plan, but it can provide an indication of any problems with excess or shortage within a line.

7.2.6 Registered Plan & Identification Survey Investigation

The registered plan and identification survey plan tables provide a general background to any plan that may appear over a lot. Both the registered plans and the identification survey plans can be viewed via the hyper-link.

7.2.7 Lot Investigation

A direct query on the lot layer retrieves general information, such as, house address, plan lot area in both, metres as well as acres, roods and perches, if the plan was produced before the introduction of the metric system.

A field has been added to calculate the difference between the on plan deed area and the area calculated from the creation of the DCDB. This gives a general comparison of how much alteration has been required to the plan bearings and distances to create the DCDB. Although, it should be noted, that there may be significant rounding in the plan area, and the rounding will be affected by the size of the lot and if the area is calculated or a balance area.

7.3 Identification survey of Lot 1 on RP54520

This lot was originally surveyed by J.E.G. Stevenson in 1937. There have been no subsequent identification surveys to define the boundaries as per this plan. However, Cottrell Cameron & Steen surveyed a portion of the adjoining lot as an identification survey to connect PSM 122191 to the cadastre. This survey has defined part of Lot 2 on RP178377 and consequently the northern corner of Lot 1 on RP54520. A selection of the results and tables from the investigation into the identification survey of Lot 1 on RP54520 can be found in Appendix E.

To prepare the search for the identification survey of Lot 1 on RP54520, including printing the plans for the subject lot, the adjoining lots and the PSMs, as well as exporting the reference marks and corner marks to a DBF file, has taken 11 minutes. The analysis of the search prepared to derive the following summary has taken approximately a further 10 minutes.

The lot table has indicated that there is only a 1m difference in area between the DCDB and the original plan, which is originally in acres. This can probably be accounted for by rounding alone.

The boundary table in comparison to the plan distances as shown on RP54520, indicates that the DCDB has allocated an extra 47mm to the line 1-2, an extra 20 mm to the line 1-3, with the line 2-3 approximating the plan distance.

The reference mark table has no indication of any of the reference marks being lost, although it is unlikely that the Original Reference Tree (ORT) remains. However, all marks are able to be set out from the listed coordinates.

The corner table shows that all corners have a poor reliability factor. There has also been a 30 second variance noted at the northern corner. Considering the age of the previous surveys this is to be expected.

From the analysis of the information given in the GIS, it could be expected to find that the plan distances are shorter than the distances on the ground. There may be minor differences in the deed angles particularly at the northern corner. This will be confirmed by connection to the available reference marks.

7.4 Identification Survey of Lot 87 on RP130217

Lot 87 on RP130217 is one of the more recently defined lots on the island. It was surveyed by J.T. Bowers in 1971. From the creation of the DCDB it was apparent that there is conflicting information from the survey plans that defined this lot and the DCDB may contain a moderate amount of error in relation to what is physically represented on the ground. A selection of the results and tables from the investigation to the identification survey of Lot 87 on RP130217 can be found in Appendix F.

Again to prepare the search for the identification survey of Lot 87 on RP130217, including printing the plans for the subject lot, the adjoining lots and the PSMs, as well as exporting the reference marks and corner marks to a DBF file, has taken 11 minutes. The analysis of the search prepared to derive the following summary has taken approximately a further 15 minutes

Directly associated with Lot 87 on RP130217 are five (5) plans, three (3) registered plans, and two (2) identification surveys, all of which can be retrieved via the hyper-link.

There has been a variance noted at the northern-most corner of lot 87, but at all other corners no variance has been indicated. This shows agreement between the identification survey and the original plan. The reliability factors indicate that the corners should be reasonably dependable, giving reliability factors of 2 and 3.

The lot table indicates a difference between the DCDB area and the plan area of $2m^2$. Although this area is not of great significance, it should be noted that there could be some minor discrepancy.

The DCDB based boundary table in comparison to the plan distances indicates the plan distances along the frontage of 87 are shorter, due to the geometry of the lot, the side boundaries are also shorter. However, the southern boundary shows plan distance.

The reference mark table indicates that there are a number of reference marks available. None of these marks have been noted as gone or not found and should provide a sound basis for the identification survey.

It is expected that the identification survey will show a close reflection of the registered plan bearings and distances. There will be, most likely, a difference in the angle at the northern most corner of lot 87 and depending on the reference marks used, there may be some minor differences in the distances. With a greater number of reference marks connected it could be expected to see a greater shortage shown on the identification survey plan.

7.5 Boundary Reconfiguration of Lot 6 on RP100121.

This lot stands out as one of the few remaining lots on Karragarra that would support subdivision. The reconfiguration itself holds little importance, more the fact that the boundaries will need to be fully reinstated and connections will need to be made to at least two (2) PSM's with the final survey plan being lodged and registered with the NR&M.

To prepare the search for the reconfiguration survey of Lot 6 on RP100121, including printing the plans for the subject lot, the adjoining lots and the PSMs, as well as exporting the reference marks and corner marks to a DBF file, has taken 14 minutes. A brief analysis of the search prepared to derive the following summary has taken approximately a further 15 minutes. The analysis of this information could be as long or as short as the Surveyor feels compelled to do, but as a minimum, to obtain a grasp on the survey cadastre, it is anticipated that 15 minutes is required.

Three (3) original plans cover Lot 6 on RP100121, with no identification surveys defining the original boundaries. As noted before, the plans associated with the lot can be quickly retrieved using the hyper-link. The lot table indicates that the plan area converted to meters is 18540 m^2 this is in comparison to the DCDB area of 18559 m^2 giving a difference of 19 m^2.

The boundary table shows some excess in comparison to the plan distances, particularly along the longer, north south boundaries. The line from station 3 (RP100121) to the south west corner has an excess of 17mm, the line from stations 5-6 (RP100121) has an excess of 31mm and the line from stations 5-7 (RP100121) has a 5 mm excess. Both Cottrell Cameron & Steen and Ian Davis Surveys have recently identified the northern boundary of lot 24 on RP139475, which abuts the subject lot. Although both Surveyors show agreement in distance for this boundary, CC&S shows that the north east corner of lot 24 is in a different location to Ian Davis.

The reliability factor in the corner table shows that there could be some problems in reinstatement. However, there are no marks that achieve the worst rating of a 4, with all the corners showing a 2 or 3.

The GIS indicates that there has been angle differences noted between subsequent plans within Lot 6 on RP100121. Angle differences have been noted at the north west corner of the subject lot and there has been differences noted where Treasure Island Avenue meets lot 6. However, these discrepancies should be resolved especially if the Iron Bark ORT at the south east corner of lot 6 can be found. The reference mark table shows that there are several marks that are gone or missing. However, if the two ORT's remain at the southern section of the lot there should be more than sufficient marks at the northern end of the lot to reinstate the original boundaries.

7.6 Comparison of Methods

The GIS has distinct advantages over current practices of researching a cadastral survey, including the following:

1. Data is contained in one place and PSM and plan data is contained in one system.

2. Data is stored on site and there is no need to run searches through an external provider.

3. The GIS shows differences in angles between existing plans.

4. The GIS facilitates a comparison of plan distance to DCDB distance and plan area to DCDB area of all boundaries and lots.

5. The reliability factor contained in the corner table allows an indication of the value of a corner in relation to the reinstatement.

6. Allows the printing of the boundaries and reference marks providing the basis for a field sketch.

The search is quicker to compile, as all the associated plans can be selected through the identification and registered plan tables or through the hyperlink.

The information contained in the GIS allows for a quick guide to show previous discrepancies between surveys and also between the previous survey and the DCDB. The Surveyor will still need to analyse the existing information to produce a proper reinstatement. However, much of the information has been reduced to a more suitable format that is easier to read, such as the variance field within the corner table.

Chapter 8

Critical Analysis and Further Work

8.1 Critical Analysis

There are several areas that the GIS based cadastral planner has improved on current practices, although there are still some functions of the GIS based cadastral planner that could be improved.

8.1.1 Eliminates Need for Radial Search

The GIS based cadastral planner eliminates the need for a radial search as it contains a lot plan history for each lot. The plans can be easily displayed by clicking on the required lot with the hyperlink tool. This process is instantaneous in comparison to either, personally visiting the NR&M search counter or alternately ordering the radial search, waiting for a fax reply, selecting the plans required, ordering the plans and waiting for the plans to be delivered.

8.1.2 Additional Check on Survey

The GIS based cadastral planner provides an additional check on cadastral work in several forms.

1. The GIS gives approximate coordinates of corners acting as a gross error check when placing pegs.

2. It ensures the Surveyor is aware of any discrepancies that have occurred between previous plans and the DCDB, which the Surveyor may have missed on the face of the plans.

3. It allows a check on the Surveyors control to alternate reference marks.

4. In creating the DCDB the overall cadastre is given a health check, many minor errors are adjusted in the DCDB and the creation of the DCDB highlights areas that require further investigation or survey.

8.1.3 Ease of Updating Tables and Attribute Information

The updating of the attribute data is relatively simple. This can either be done by the same methods used to create the GIS, by updating the spatial information in AutoCAD and the tables in Excel. This may be the preferred method if there are significant updates to be made. However, usually there would only need to be minor updates made and this could be simply done within ArcMap using the required editor function.

8.1.4 Efficient Determination of Background for Cadastral Survey

The GIS based cadastral planner allows the Surveyor to quickly obtain the historical search for each future cadastral survey. In addition to providing the previous plans it also has;

- pre-calculated values showing the reliability of each corner,
- a noting of any changes in angle at each corner,
- a noting of the difference between plan area and DCDB area, and
- the DCDB distance for each boundary line allowing a comparison to plan distance.

This is in addition to the tables showing the history of all the reference marks. All of these features allow the Surveyor to note if there is a possible discrepancy within the cadastre and start to plan the best means to resolve this discrepancy before field work commences.

8.1.5 Difficult to Maintain DCDB

The DCDB is a critical component of the GIS. If future surveys indicate that there are significant errors within the DCDB or errors at critical points within the DCDB this may proliferate through large sections of the DCDB and require a significant re-evaluation on how the plans and control come together to form one continuous layer. To avoid problems such as this, if discrepancies exist within the surrounds that can not be easily resolved by existing survey, then it would be of great benefit to perform an identification survey to ensure the individual sections within an area of the DCDB are well defined.

If there are minor discrepancies within new survey plans there should be little problem in massaging the DCDB to find a more appropriate solution.

8.1.6 Difficult to Implement Over a Large Area

As discussed in Chapter 7, there become significant problems in producing the GIS over a larger area. This arises due to aspects such as, different needs, different time-lines, different stages of advancement of mapping products and technology, different products in use, who has custodianship, funds available, coordinate systems to be used and general communication between the participants.

If the GIS based cadastral planner is limited to a single local authority such as Redland Shire Council, many of these issues can be quickly resolved as the consultation and planning process can be done quickly and efficiently within the organisation. The GIS based cadastral planner can then be implemented on a shire wide basis.

The implementation of the GIS based cadastral planner should be viewed as another step in creating the DCDB. Once the DCDB is created, the additional work required to produce the GIS based cadastral planner would be outweighed by the efficiency produced by its utilisation.

8.1.7 Automation of Comparison

It was hoped in generating the GIS that the end product would be more automated and that the Surveyor would virtually be in a position that they would not need to look at the survey plans. With more effort the GIS based cadastral planner should be able to become more automated by calculating angles within the DCDB from line elements giving comparison of DCDB angle to plan angle. In addition, the input of plan distances would enable direct query of line to give discrepancies rather than needing to open the plan. A misclose field should also be added to the lot table to show the misclose within an individual lot.

8.1.8 Time and Cost

It is anticipated that the time and cost to implement will be considerably offset by future savings. The GIS based cadastral planner will provide time savings in preparing the search for each survey. However, it is anticipated that there will be also significant time savings in relation to field surveys for both cadastral and engineering surveys, as field calculations will be minimised, if not eliminated, as all reference marks are on a common coordinate system. The uploaded file from the GIS based cadastral planner to the total station or possibly GPS, will allow all reference marks to be set out and found, minimising time spent in the field searching and calculating positions of reference marks.

8.1.9 Ease of Export of Digital Data

As much of the cadastral data is now contained in a digital format it makes it readily available for export and import into other software packages. This allows for greater communication of the data via e-mail and the use of the spatial information in other mapping packages or the import of the table information into survey and design packages such as CivilCad and 12D.

The ability to export and print also allows for a plot to be quickly created showing the boundaries and all the relevant reference marks. This plot could form the basis of the field notes or field sketch as used by most Surveyors to record the field observations.

8.1.10 Accuracy of the GIS Based Cadastral Planner

Without field testing the accuracy of the GIS based cadastral planner can not be confirmed. However from the construction of the DCDB it is anticipated that most corners have an absolute accuracy of less than 50 mm. Some of the older corners at the north-west of the island and the corners at the southern end of lot 2 on RP178377 may exceed this estimate.

8.2 Further Work

As with any product the GIS based cadastral planner can be improved and several suggestions are made below to improve the functionality of the GIS.

8.2.1 Comparison of Distances between Existing Plans

The comparison of distances between existing plans could be done via two methods. Firstly, by inputting each distance from each plan in the boundary table so that calculation between fields can be made to show the differences in distances within each boundary. Secondly, by interrogating the survey plans and generating a value like the variance, which shows the greatest discrepancy in one field. The second method would be a quicker solution and would succeed in highlighting distance discrepancies within the existing plans.

8.2.2 Misclose of Each Lot

Within the lot table a field can be added to show the calculated misclose for each lot. This could be broken into two sections over three fields, one showing a bearing and distance misclose field and the other showing the misclose ratio.

8.2.3 Automatic Comparison of DCDB Distances to Plan Distances

The GIS based cadastral planner currently shows DCDB distances in the boundary table, this allows for a manual comparison to the plans. However, if the plan distances are entered into the boundary table as a new field, the difference could be automatically generated in a separate field.

8.2.4 Comparison of DCDB Angles to Plan Angles

The comparison of the DCDB angles to the plan angles could be performed in a method similar to the automatic comparison of the distances. However, unless this process could be automated it would be a very time consuming task and the resources may be better allocated elsewhere.

8.2.5 Automatic Updating of Tables via Generated Form

The update and maintenance could be simplified by generating specific forms that relate to each table or a form that relates to several tables. The user would use this form as a template and once completed the tables could be automatically updated.

8.2.6 Export to Total Station

It would be advantageous to be able to automatically export the coordinates of selected features to various formats that can be directly uploaded into selected total stations.

8.2.7 Orthophotgraph Backdrop

Work has been done to display the rectified aerial photography as a backdrop. Problems were encountered in manipulating the DBF file to position the image on the RSC coordinates. This problem has not been resolved and the aerial photography has not been utilised.

8.2.8 Cost Benefit Analysis

A CBA should be performed to indicate the actual benefit associated with the GIS Based cadastral planner.

Chapter 9

Conclusion

9.1 Completed GIS Based Cadastral Planner

The aim of the GIS based cadastral planner was to produce a GIS that assists a Surveyor in assessing existing information when preparing for cadastral surveys. A GIS based product has been formed that improves the efficiency of planning not only for cadastral surveys but also engineering surveys within the project area of west Karragarra Island.

The geographic area covered in the project has given an indication of the time taken to generate the database as well and the size of the database generated. The project has also shown the problems that arise in generating the DCDB.

The GIS has been successful in generating a visual database that will decrease the time taken to prepare for a cadastral survey. The primary advantage of the GIS is that it contains all the information required to prepare for the survey at the click of a button on one computer.

The generation of a plan based DCDB derived from a paper based reinstatement has generated a more acceptable solution in cadastral terms, in comparison to the previous DCDBs based on a least squares adjustment of the plan bearings and distances to existing survey control. This provides a better base for all future mapping applications and enables a more accurate spatial representation of subsequent layers that are spatially registered to the cadastre. This will also enable more accurate calculations associated with these features for planning, maintenance and financial purposes.

As a by-product of the cadastral planner, planning for engineering surveys is also enhanced. The GIS provides a visual display of existing control and associated control sketches as well as coordinates for these marks. The coordinates on the DCDB enable Council Surveyors to set out any required services that are located at an offset to the boundary. The DCDB can also be imported into the final engineering survey drawings to show an approximate location of the property boundaries, which is currently required for most engineering surveys performed within Redland Shire.

For the project area, the maintenance and update is expected to be minimal. Most of the new survey plans related to Karragarra Island are compiled plans which are amalgamating existing lots. However, in most of the mainland sections of the south-east Queensland, a higher degree of maintenance and update would be required to keep pace with the changing cadastre. The update and maintenance of the GIS based cadastral planner is a straight forward process of updating the required tables and shapefiles on an as needs basis. The maintenance and update of the DCDB may cause problems if significant errors are found in the existing DCDB.

The GIS based cadastral planner has the ability to improve the versatility and usefulness of the survey cadastre. The digital cadastre from the GIS based cadastral planner can be easily imported into various packages for various survey and mapping purposes.

Discrepancies within the survey cadastre are easily recognised from the GIS based cadastral planner. These discrepancies can be marked for investigation and resolved, resulting in an improved survey cadastre.

The coordinates from the GIS based cadastral planner gives the field Surveyor another means to check cadastral surveys and peg placement. This aids in reducing errors in cadastral surveys.

9.2 Further Work

As outlined in section 8.2, there are several areas that could be improved upon. Some of the suggestions may not prove to be feasible, as the end result does not warrant the resources required for their creation. The areas of future work that could be given priority are:

- Misclose of each lot.
- Export to total station.
- Orthophotgraph backdrop.
- Cost Benefit Analysis.

As Theodore Roosevelt said:

> "*Do what you can, with what you have, where you are.*"

The GIS based cadastral planner will be dependant on the resources that are available to the organisation that decides to implement the GIS. It has the ability to provide a better system of searching cadastral information and acts as means to improve field survey efficiency.

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Appendix A

Project Specification

University of Southern Queensland
FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/4112 Research Project
PROJECT SPECIFICATION

FOR	**Jason Scott Masters 0031210918**
TOPIC	**GIS Based Cadastral Survey Planning**
SUPERVISORS	Glenn Campbell Yan ~~Lui~~ Liu
ENROLMENT	ENG4111 – S1, External 2004 ENG4112 – S1, External 2004
PROJECT AIM:	The aim of the project is to produce a GIS that will assist surveyors in assessing existing information when preparing for cadastral surveys.
SPONSORSHIP:	Redland Shire Council

Programme: **Issue A, 17 April 2004**

1. Application to Department of Natural Resources Mines and Energy and Redland Shire Council for permission to use copyright constrained information for study and research purposes.

2. Research background information relating to
   a. Alternate means of Cadastral Survey Planning
   b. Design requirements of GIS
   c. Historical Cadastral Reinstatement
   d. SCDB and PSM's
   e. Creation of scripts and efficient data input into GIS
   f. Historical and current survey plans.

3. Creation of DCDB base layer as both line and polygon features (Possibly including coordination and reinstatement field component).
4. Generation of corner point features and appropriate tables.
5. Input of PSM & SCDB information.
6. Generation of Historical Plan database.
7. Testing and debugging of GIS.
8. Testing of performance of GIS in comparison to Alternate means.
9. Analysis of cadastre including areas of excess, shortage and possible reinstatement problem areas.
10. Evaluation and critical analysis of GIS.

As time permits:

11. Design of scripts for update and maintenance of database.
12. Design of scripts for download of corner information to Leica TCR 1103.

AGREED:

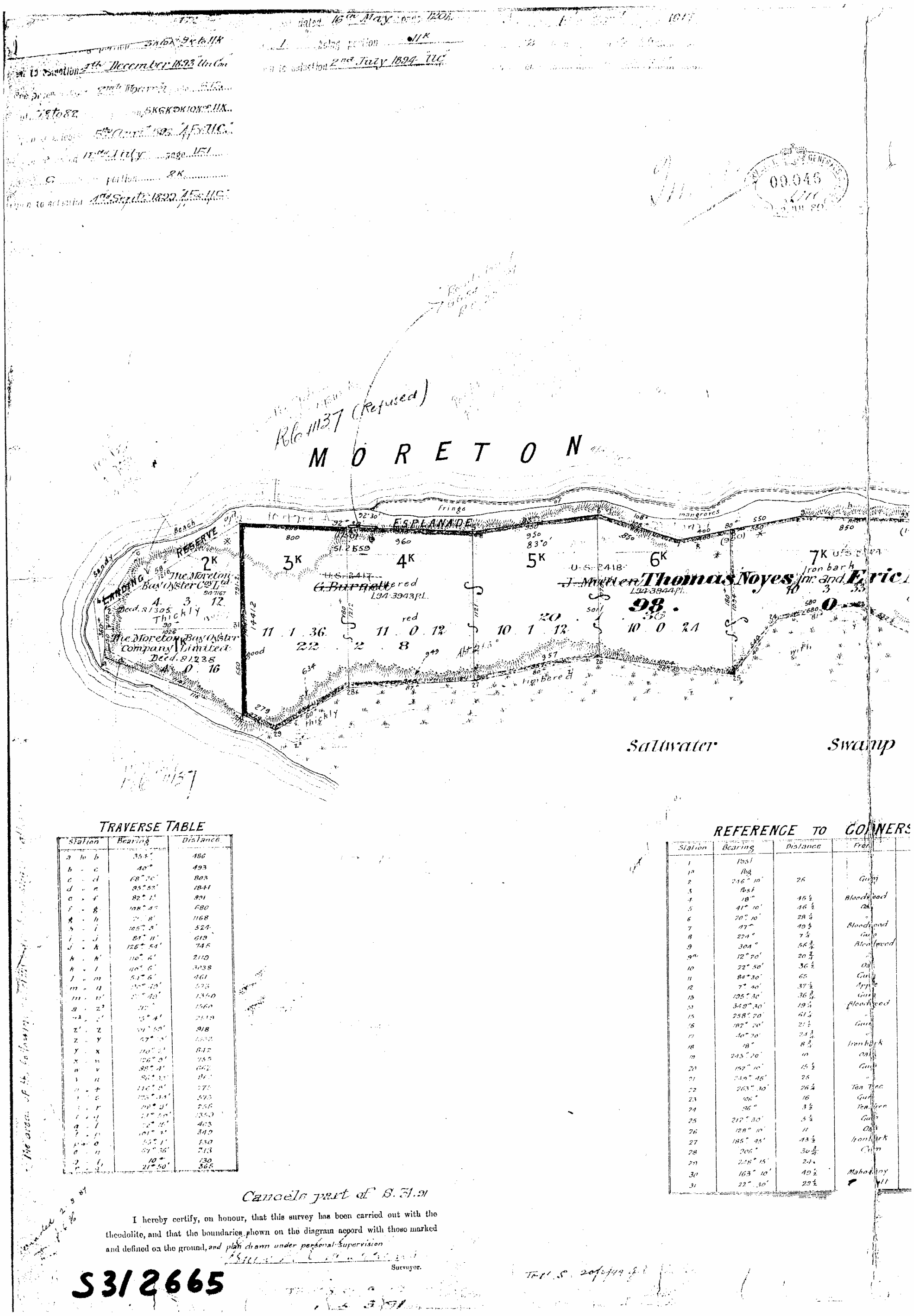
________ (Student) ________, ________ (Supervisors)

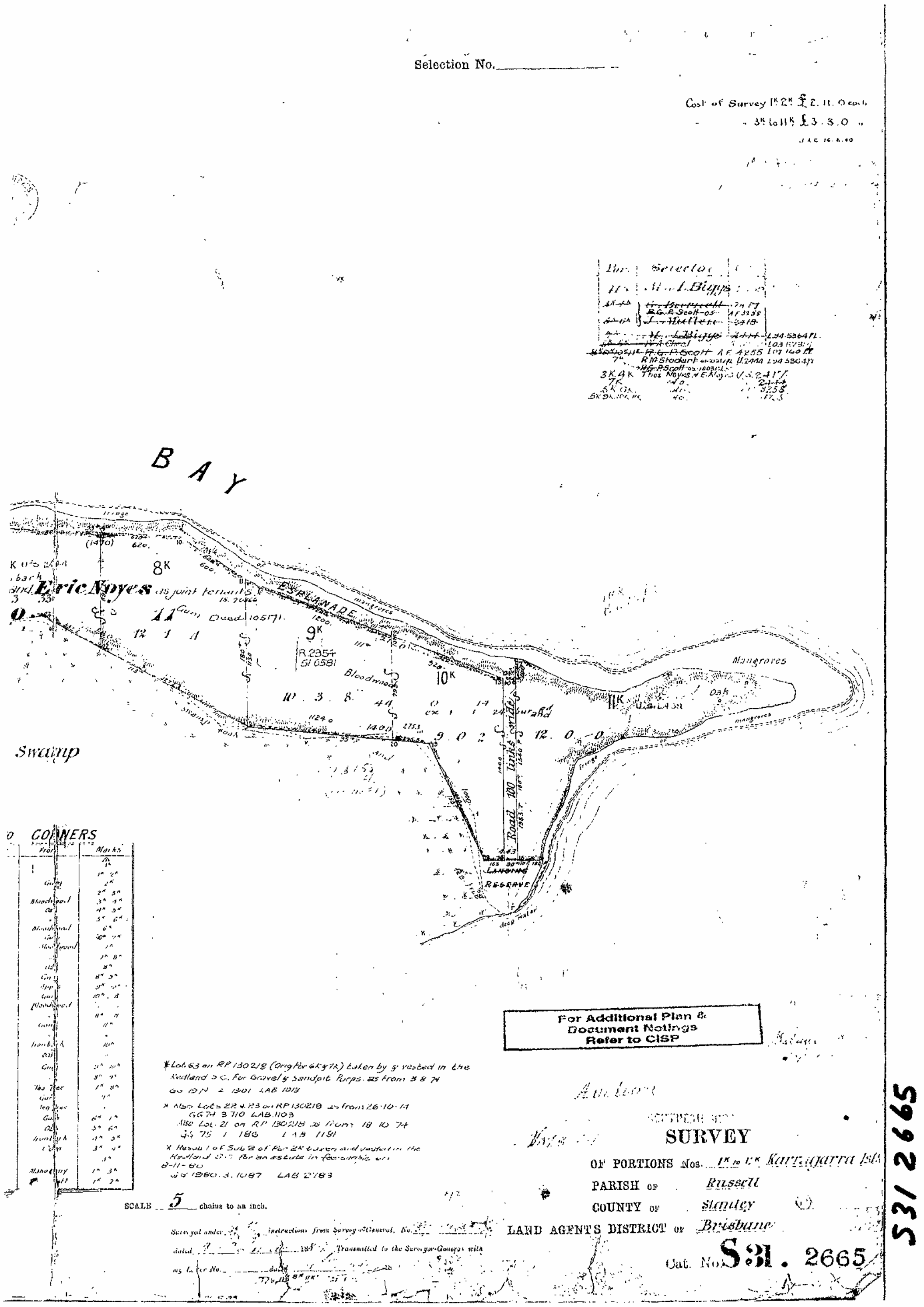
18/3/2004 23/3/2004 24/3/2004

Appendix B

Original Survey Plan S312665

Jason Masters
0031210918




Selection No.
BAY
ESPLANADE
Mangroves
Swamp
CORNERS
Road 100 links wide
LANDING RESERVE
For Additional Plan & Document Notings Refer to CISP
SURVEY
OF PORTIONS Nos.
PARISH OF Russell
COUNTY OF Stanley
LAND AGENTS DISTRICT OF Brisbane
SCALE 5 chains to an inch.
Cat. No. S31. 2665
S31 2665

Appendix C

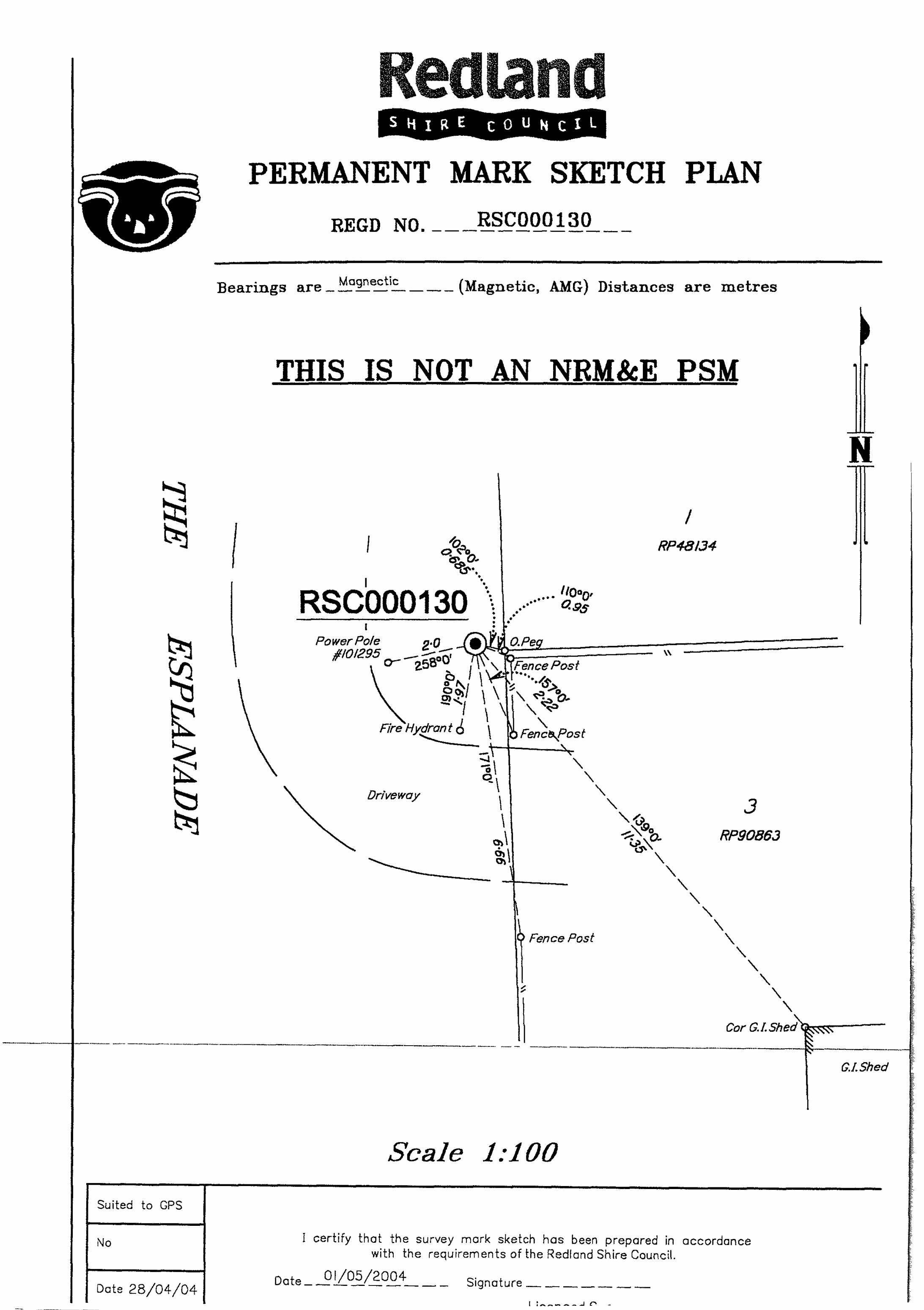
Cottrell Cameron and Steen Coordinated Marks and Cadastral Connections

Karragarra Island						
GPS(RTK) Survey 29/04/04						
Origin of Coordinates PM122182, MGA, GDA/94, 536748.400mE,6943039.510mN, 1.43m AHD						
	MGA	**MGA**	**AHD**		**AMG**	**AMG**
Mark	Easting	Northing	RL (AHD)	Std Dev	Easting	Northing
PM122482	**536748.4003**	**6943039.511**	**1.429975**	**0.01785**	**536643.221**	**6942852.107**
PM122186	**536359.1978**	**6942983.021**	**7.610725**	**0.01385**	**536254.017**	**6942795.617**
PM122191	**535813.4313**	**6943157.918**	**1.564225**	**0.014475**	**535708.247**	**6942970.515**
PM122193	**537013.5866**	**6942745.923**	**7.75365**	**0.022475**	**536908.409**	**6942558.517**
PM122200	**535980.9017**	**6942927.027**	**8.650625**	**0.018225**	**535875.719**	**6942739.622**
PM130446	**537377.8689**	**6942406.368**	**3.175325**	**0.025625**	**537272.694**	**6942218.960**
RSC000131	**535953.3412**	**6943046.664**	**7.7664**	**0.017625**	**535848.158**	**6942859.260**
RSC000132	**536189.8469**	**6943097.751**	**2.896625**	**0.0209**	**536084.665**	**6942910.347**
RSC000133	**536475.6481**	**6943030.565**	**2.381875**	**0.022575**	**536370.468**	**6942843.161**
501	**535569.8496**	**6943020.257**	**1.492225**	**0.03005**	**535464.665**	**6942832.853**
502	**535570.191**	**6942967.256**	**1.210675**	**0.025875**	**535465.006**	**6942779.851**
503	**536796.495**	**6942999.97**	**2.88935**	**0.0302**	**536691.316**	**6942812.566**
504	**536938.4791**	**6942968.876**	**5.9671**	**0.016**	**536833.3**	**6942781.47**
505	**536417.2193**	**6942961.395**	**5.559875**	**0.026425**	**536312.039**	**6942773.991**
506	**536324.2393**	**6943002.833**	**8.330325**	**0.019075**	**536219.058**	**6942815.429**
507	**536185.4522**	**6943013.129**	**11.39203**	**0.030625**	**536080.270**	**6942825.725**
508	**536834.4422**	**6942911.566**	**7.161975**	**0.016775**	**536729.264**	**6942724.16**
509	**536747.8119**	**6942933.991**	**4.7128**	**0.024875**	**536642.633**	**6942746.586**
OIP, 510	**537010.3377**	**6942761.664**	**7.93225**	**0.030475**	**536905.160**	**6942574.258**
OIP, 511	**537184.496**	**6942705.644**	**5.069733**	**0.0345**	**537079.32**	**6942518.24**
Dpy 512	**537272.0148**	**6942715.739**	**4.617175**	**0.028375**	**537166.84**	**6942528.33**
PM93773	**537387.9339**	**6942612.889**	**5.115825**	**0.025125**	**537282.76**	**6942425.48**
BASE	**536012.5599**	**6942987.914**	**10.1361**		**535907.38**	**6942800.51**
RSC000130	**535578.848**	**6943018.269**	**N/A**		**535473.66**	**6942830.87**
RSC000134	**537276.753**	**6942749.170**	**N/A**		**537171.58**	**6942561.76**
PM39926	**536845.432**	**6942924.368**	**N/A**		**536740.25**	**6942736.96**

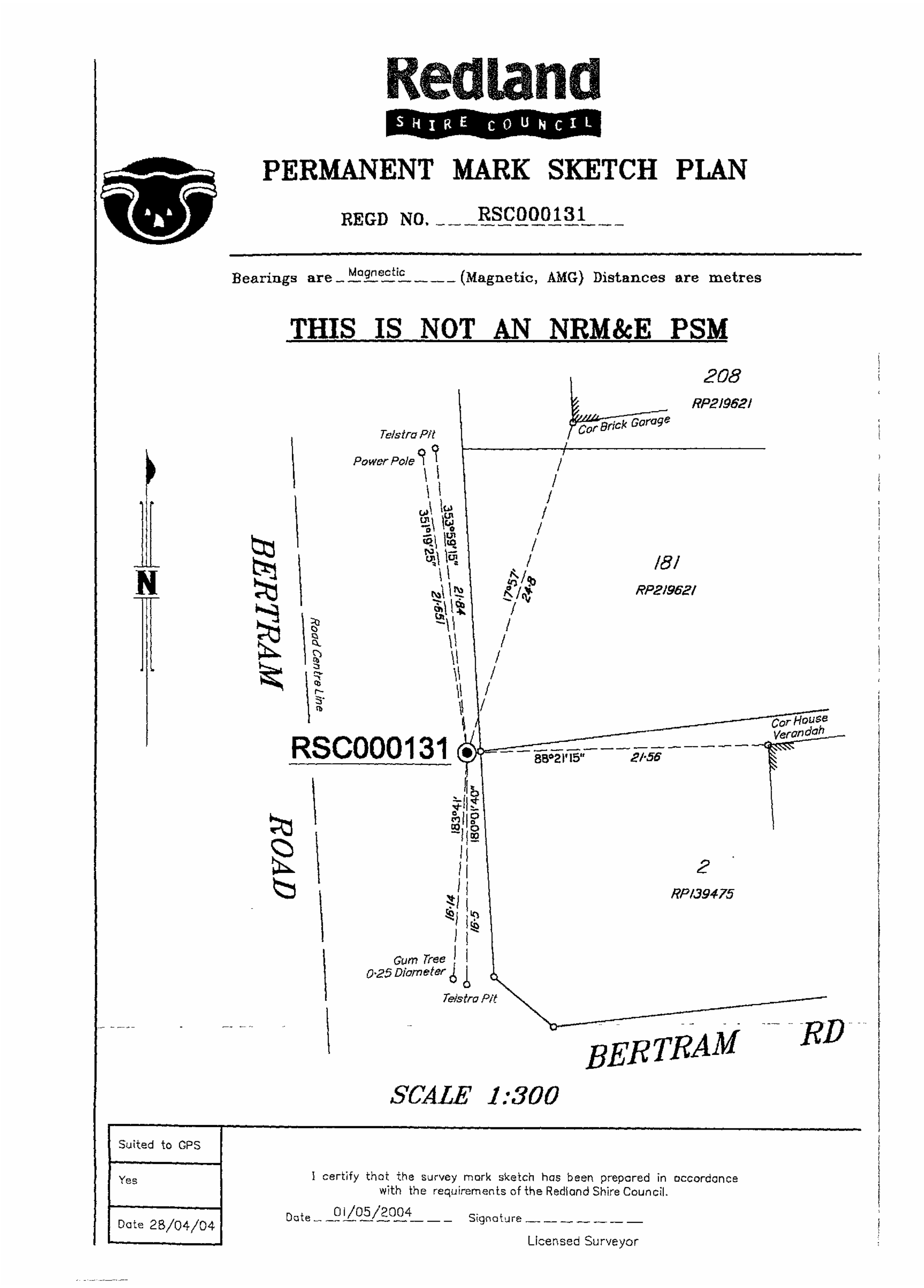
Table of New Control Marks

Appendix D

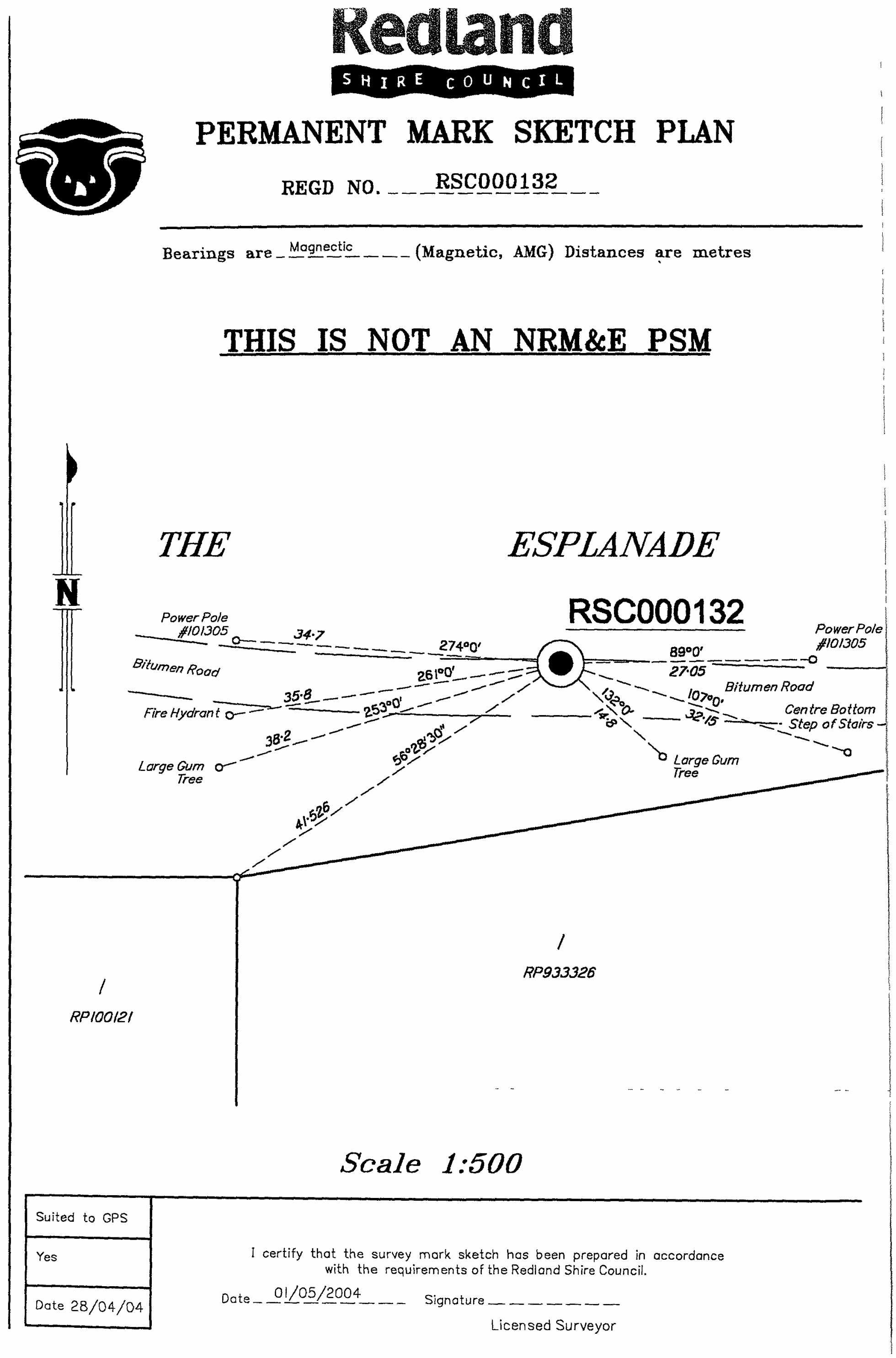
Cottrell Cameron and Steen Control Sketches and Identification Surveys



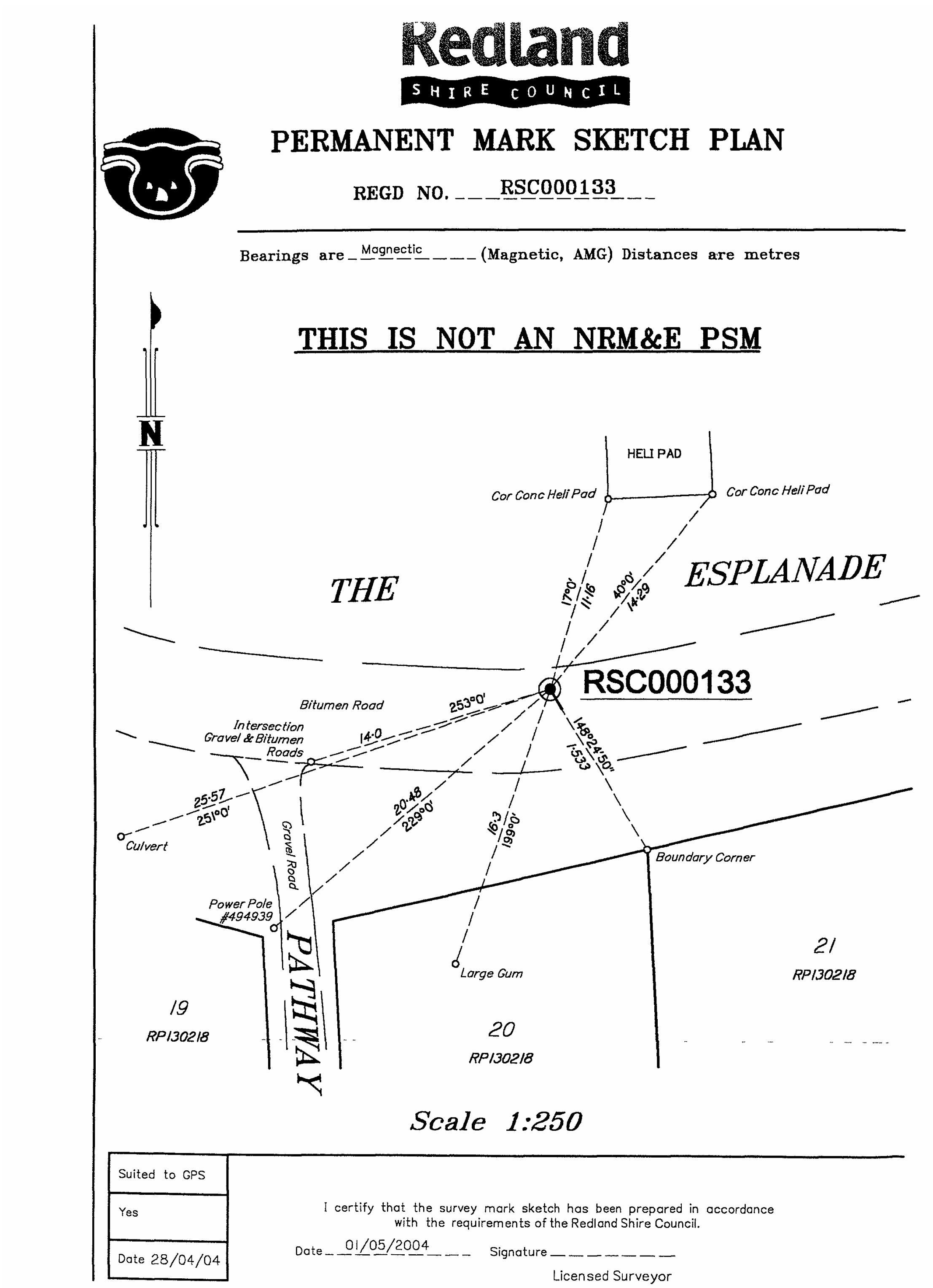
Survey Control Sketch for RSC000130



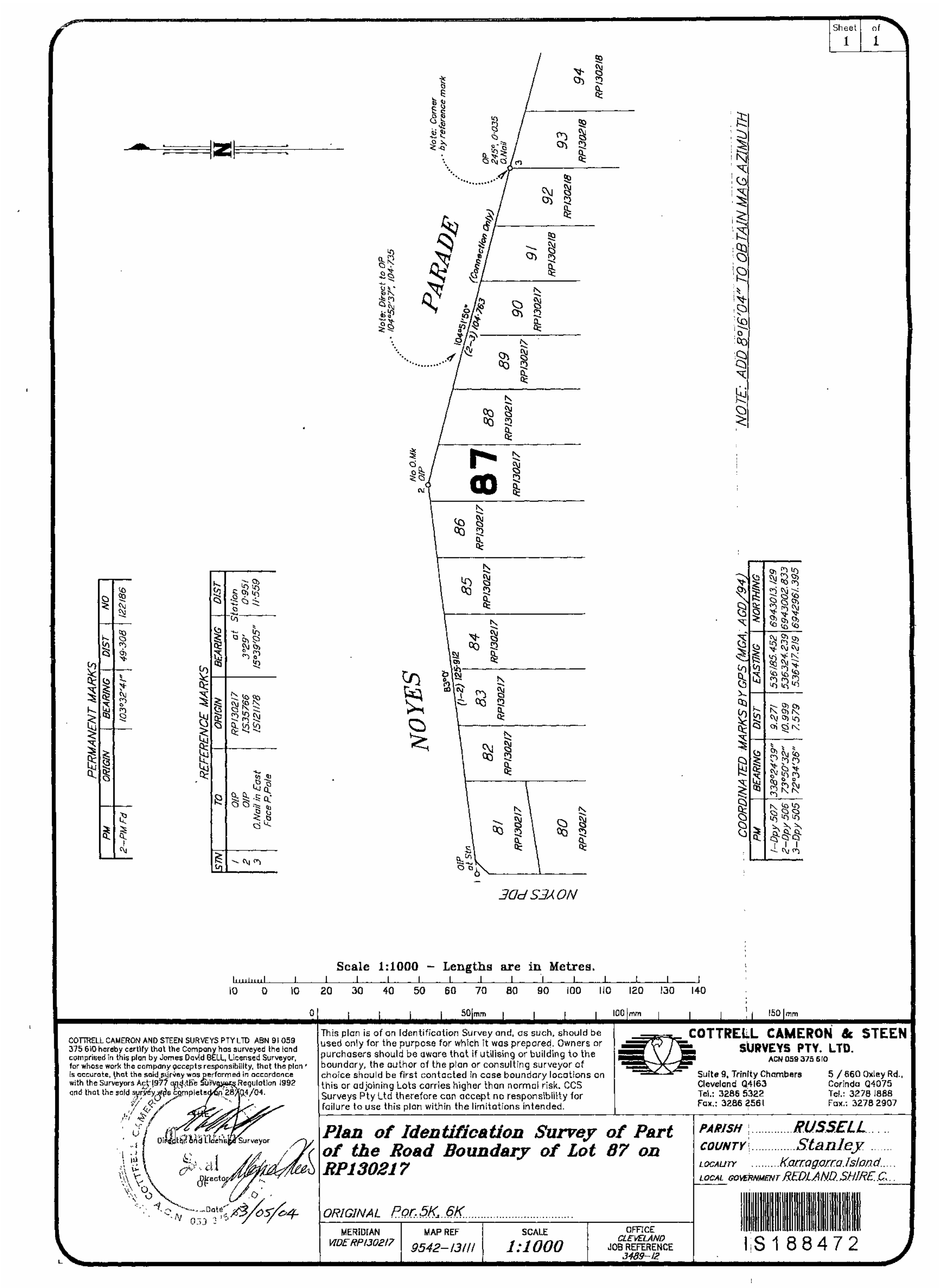
Survey Control Sketch for RSC000131



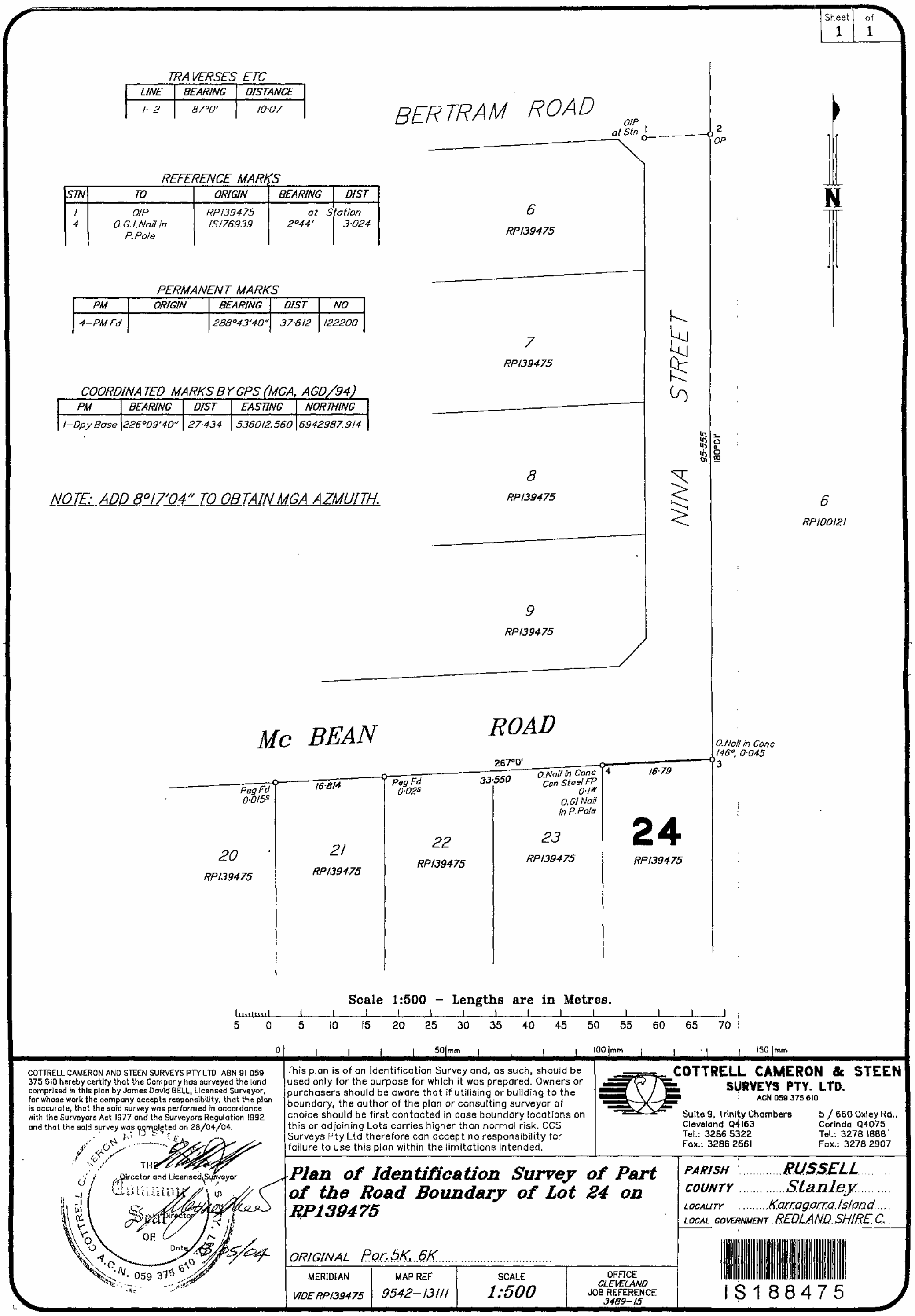
Survey Control Sketch for RSC000132



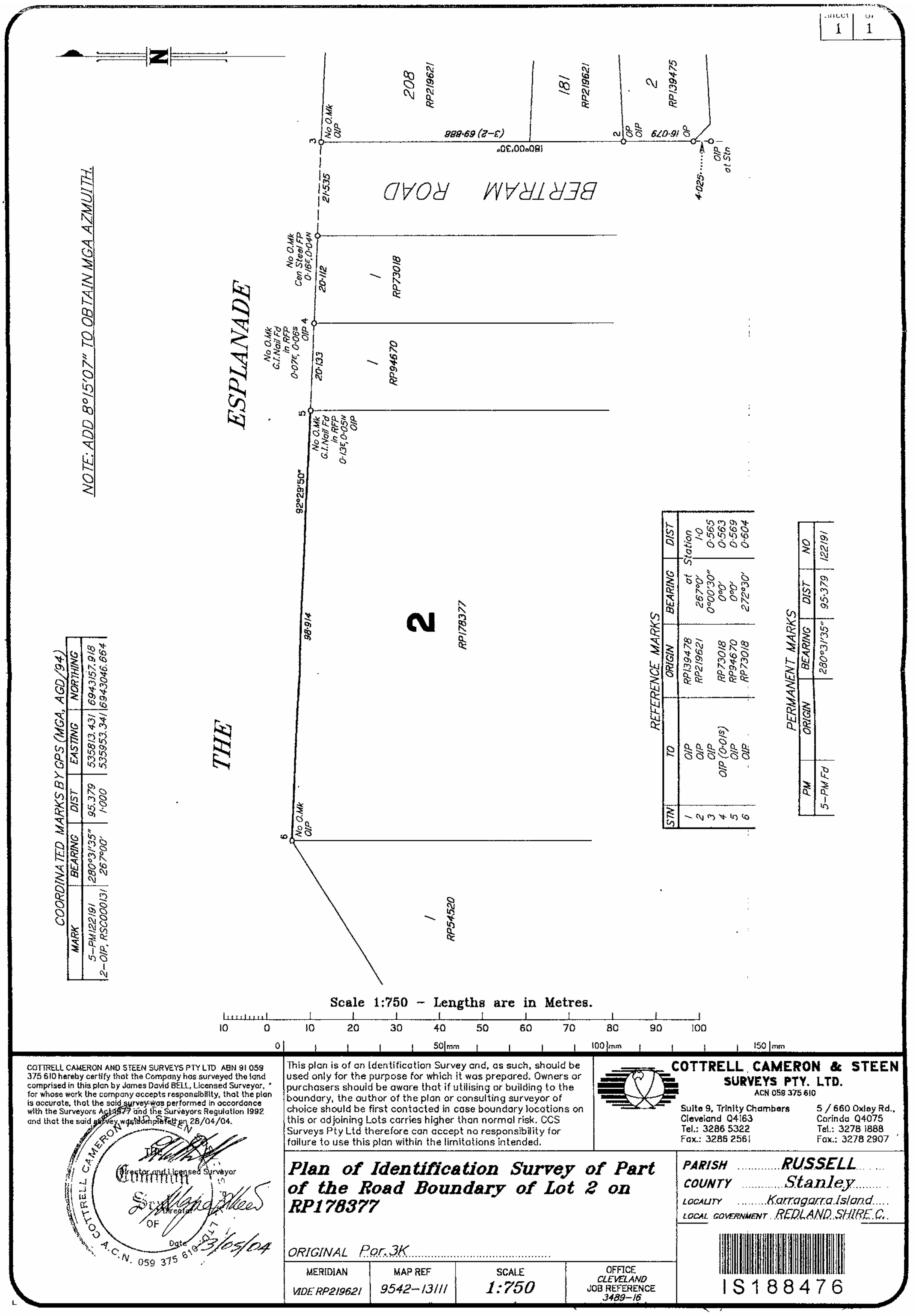
Survey Control Sketch for RSC000133



Identification Survey Plan IS188472



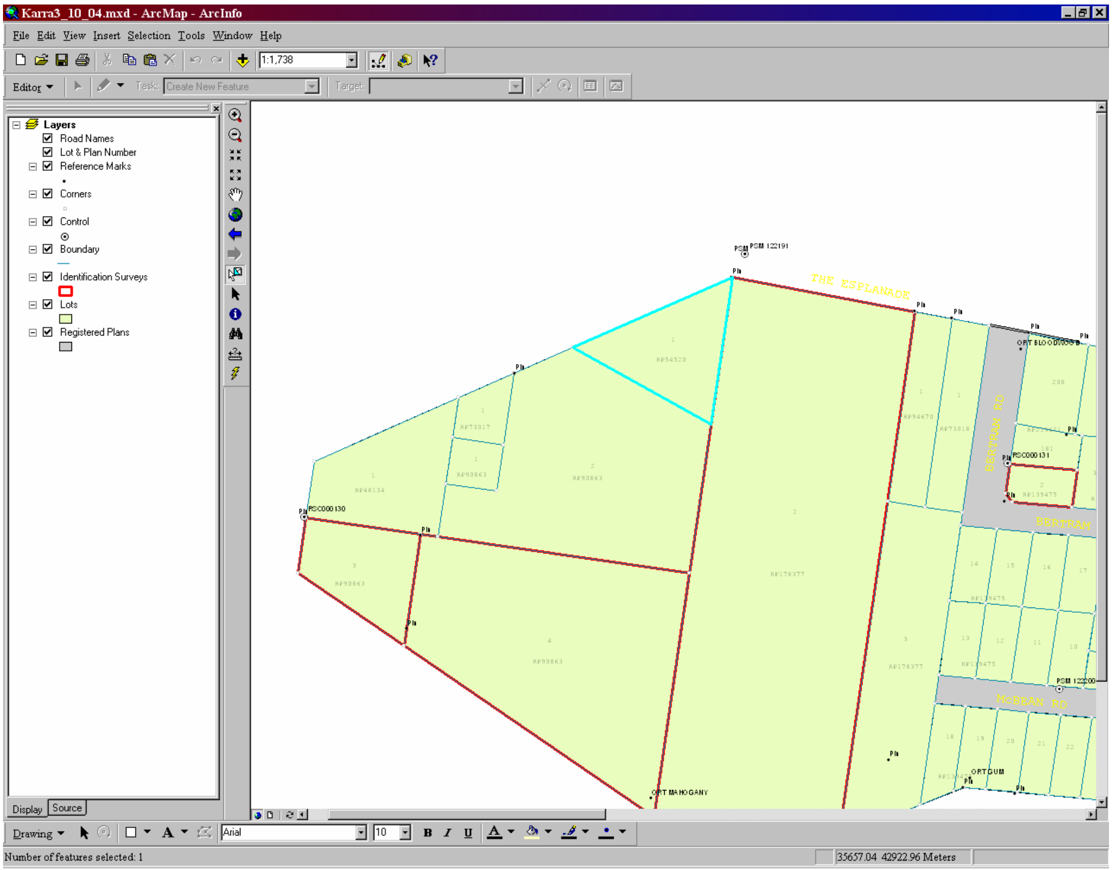
Identification Survey Plan IS188475



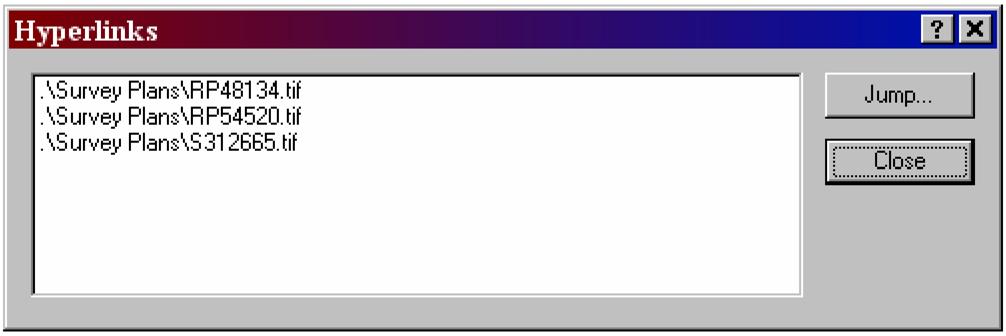
Identification Survey Plan IS188476

Appendix E

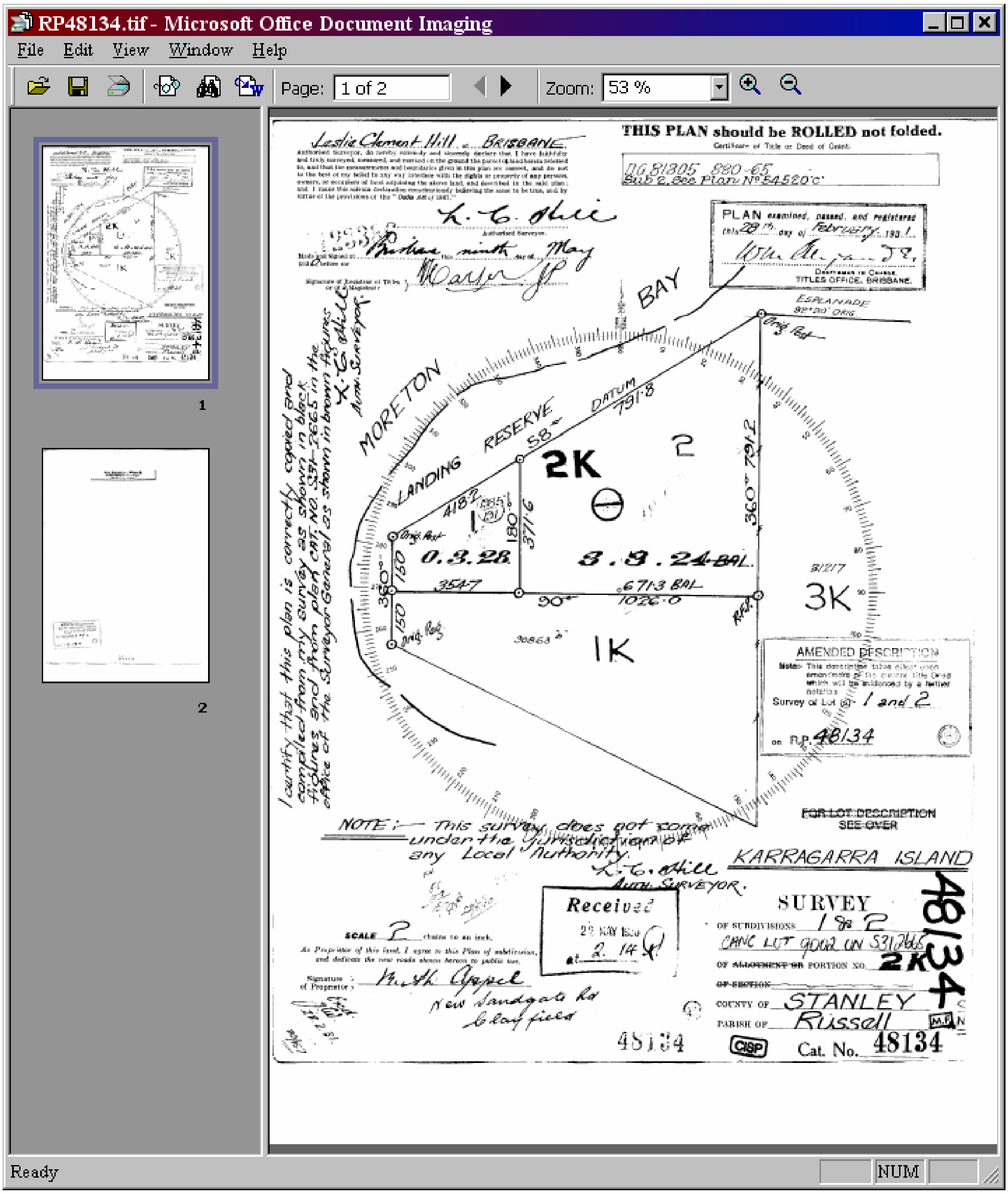
Identification Survey of Lot 1 on RP54520 Results



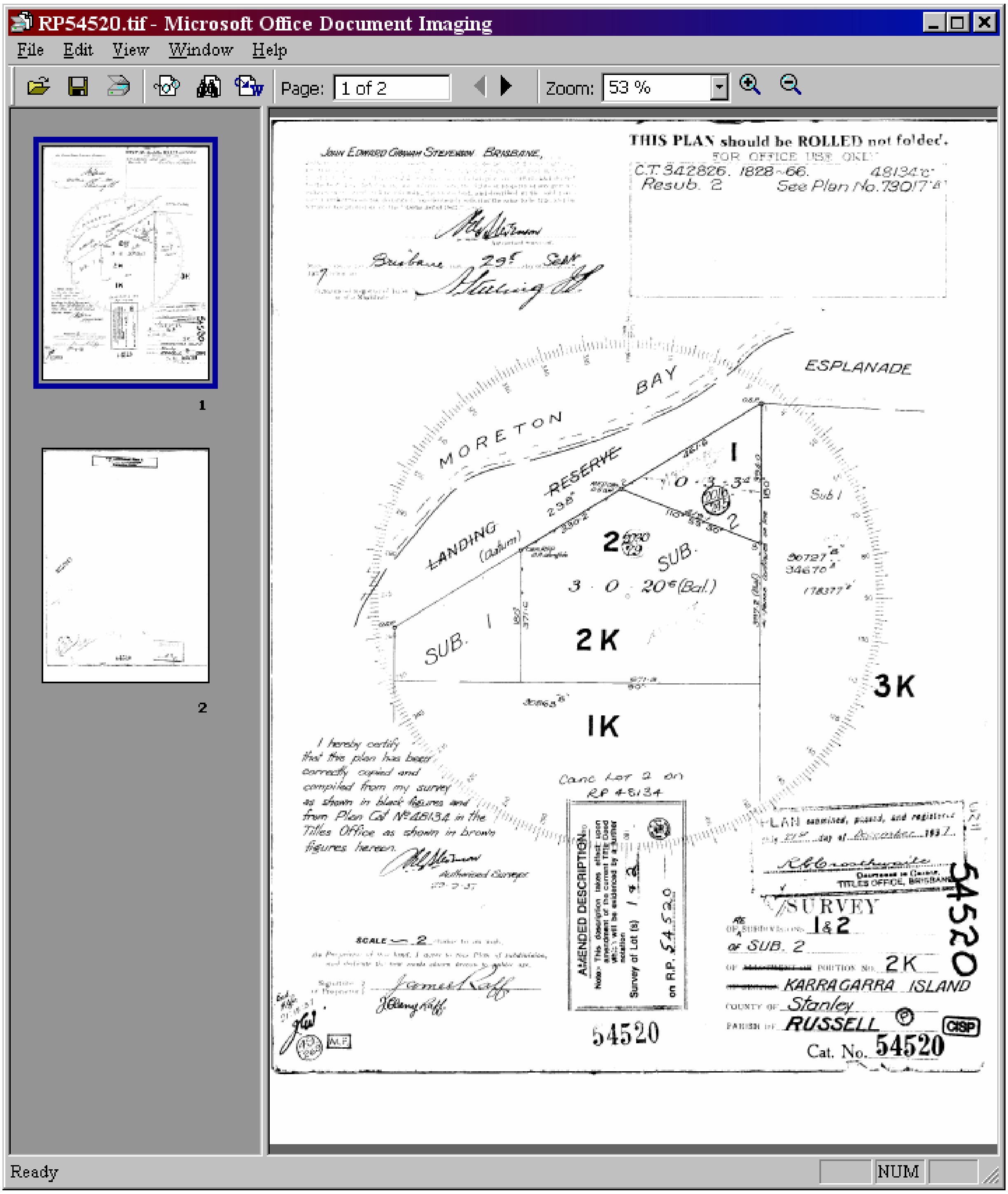
Location of Lot 1 on RP54520



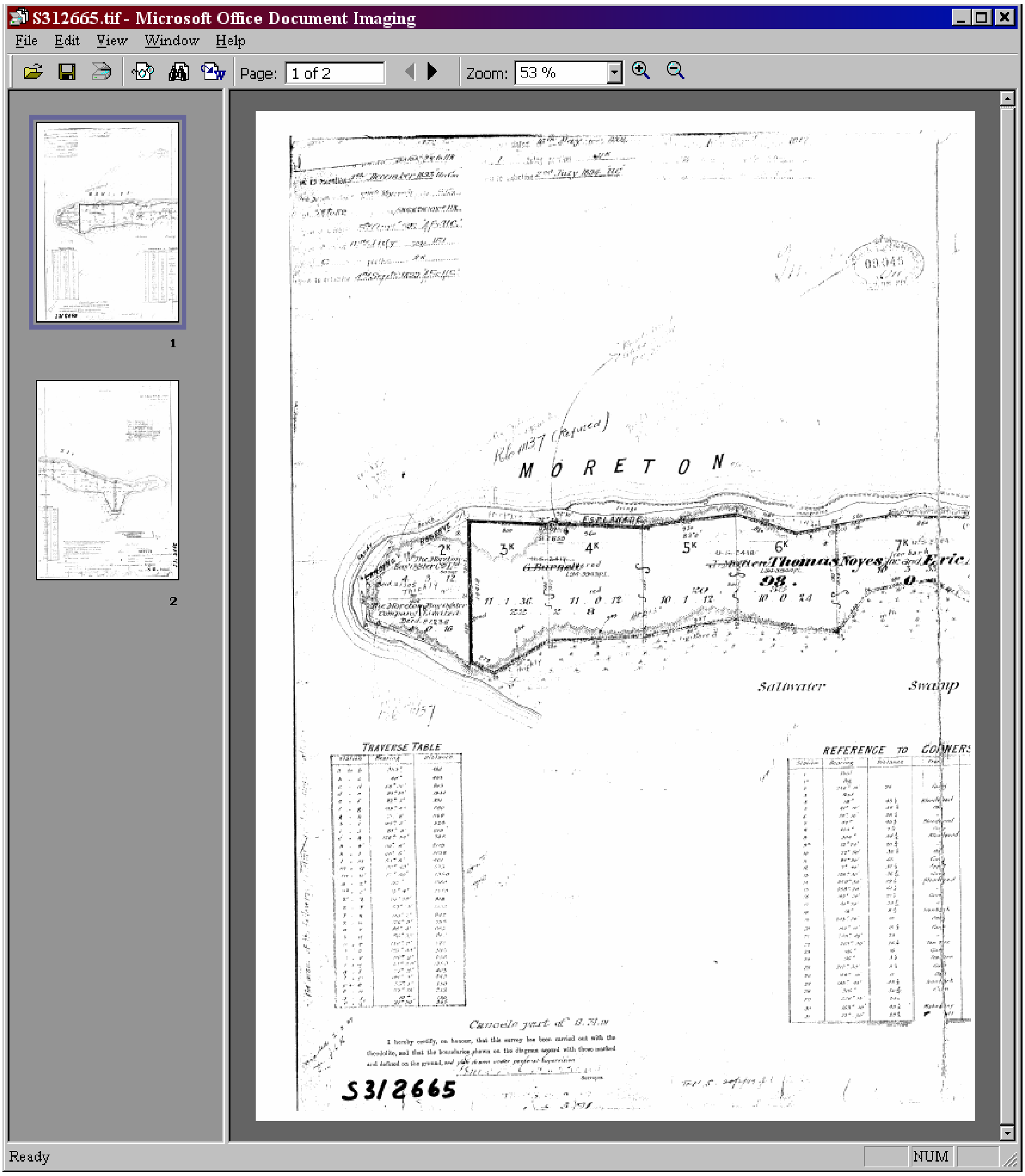
Results from Hyper-link



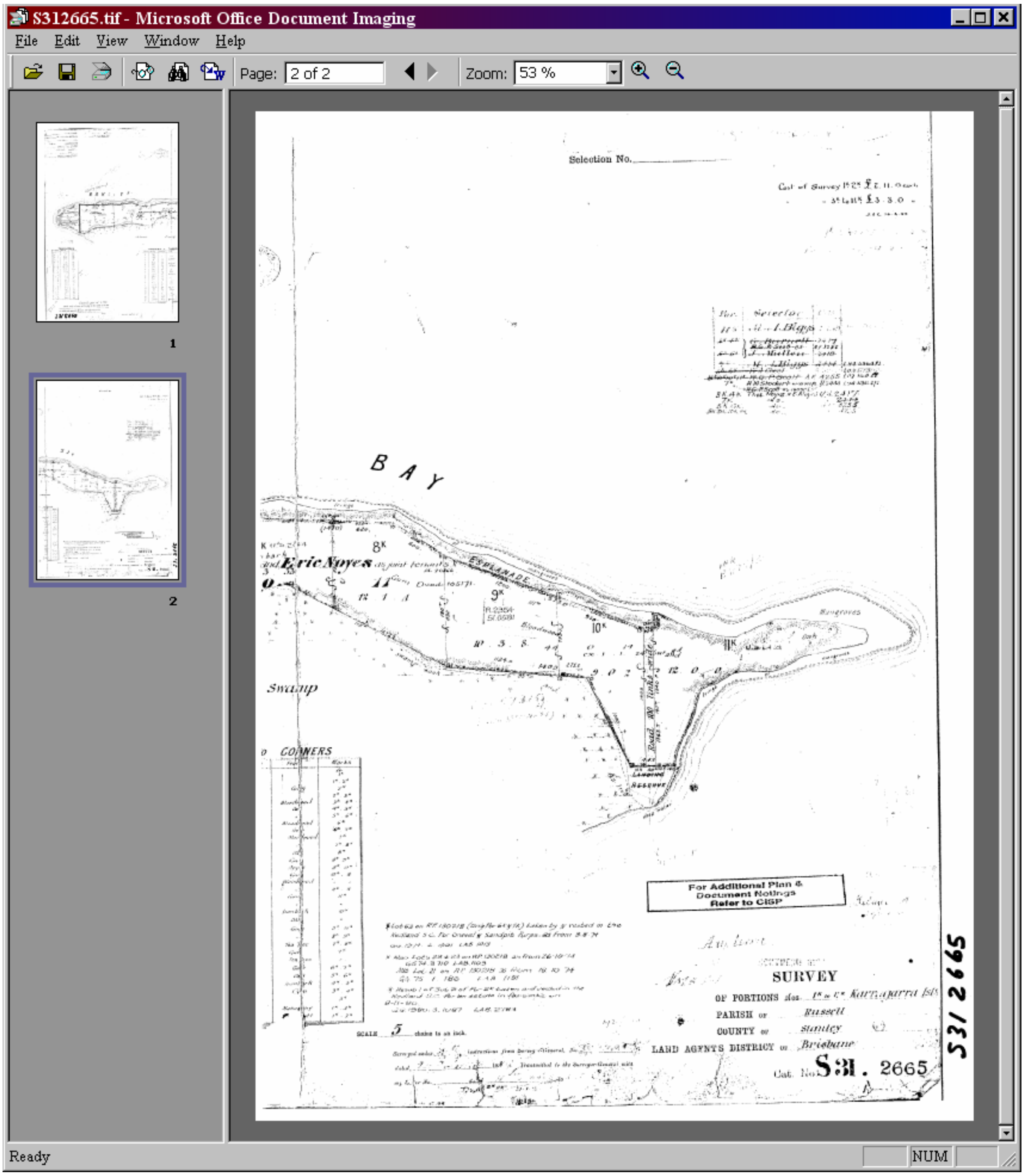
Hyper-link to RP 48134



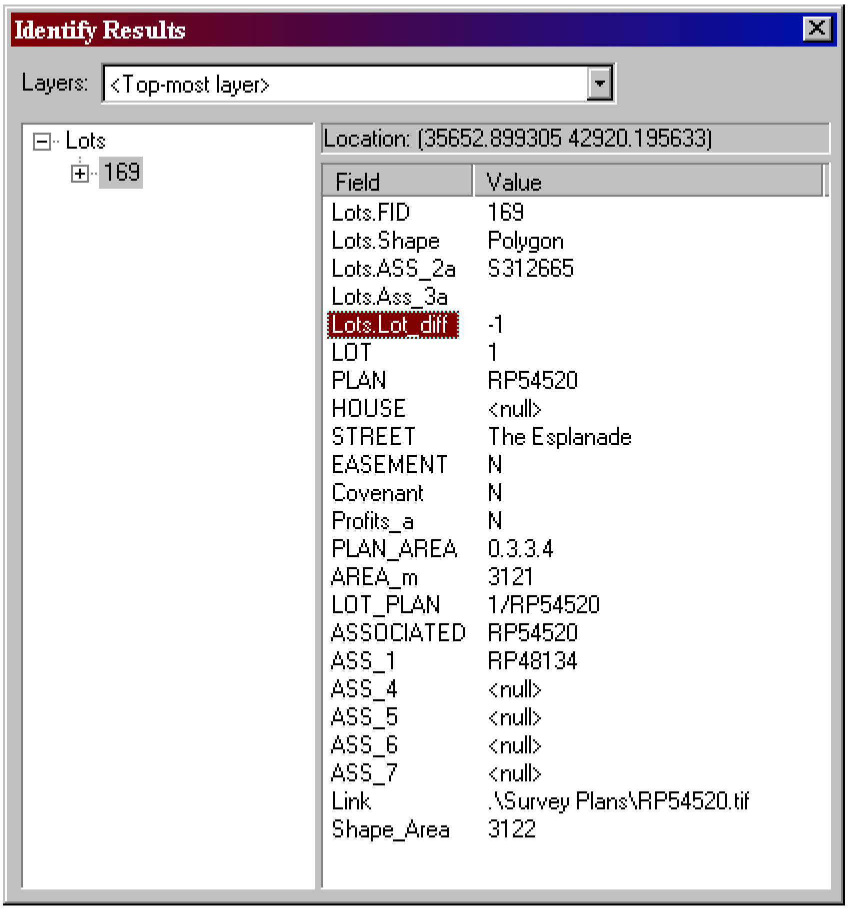
Hyperlink to RP54520



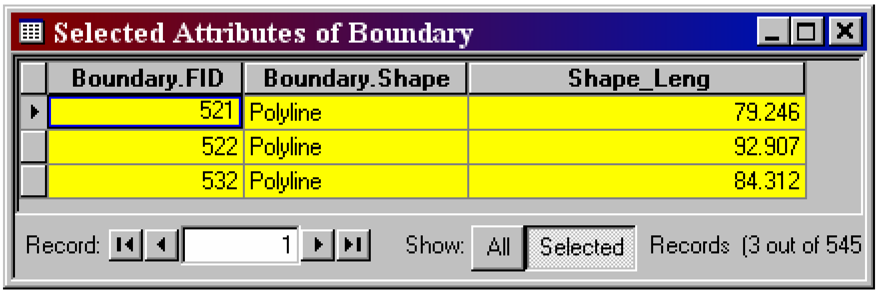
Hyper-link to S312665 page 1



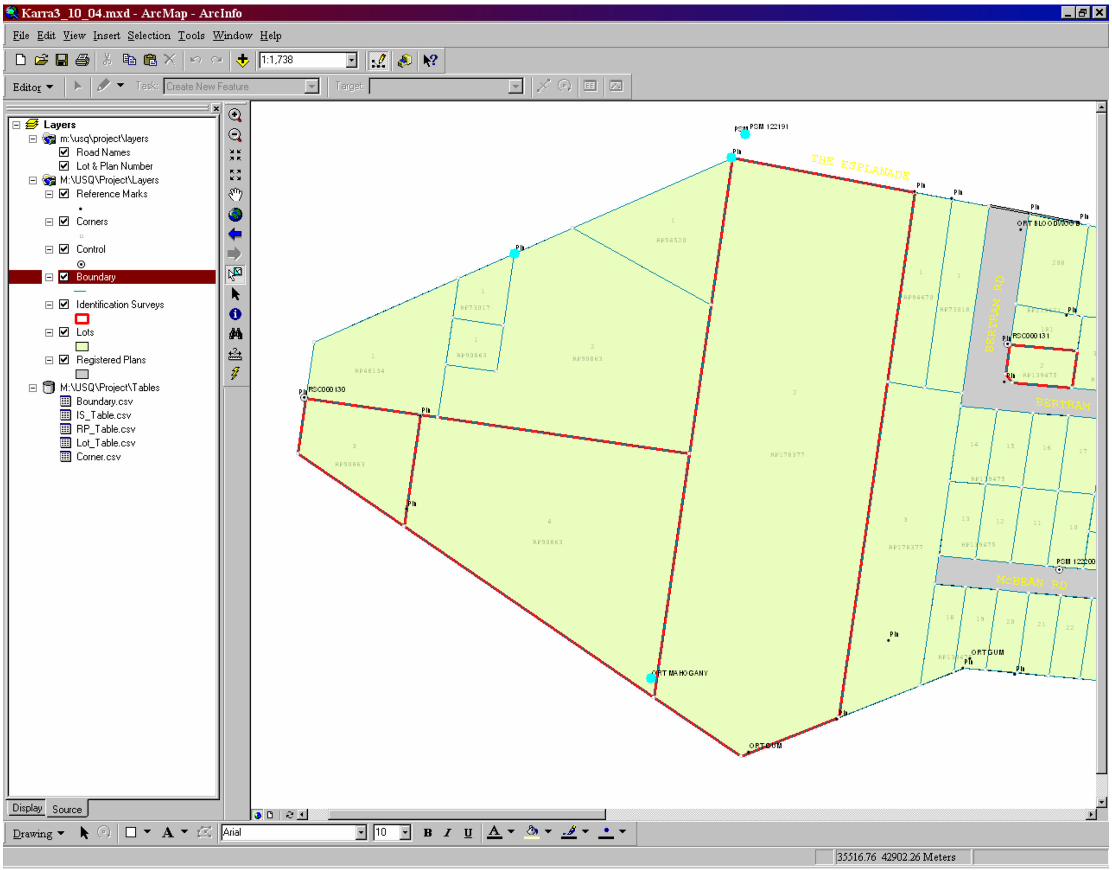
Hyper-link to S312665 page 2



Lot Table and Difference between Plan and DCDB Area.



Boundary Table Selection



Reference Mark Selection

Selected Attributes of Reference Marks

FID	Sha	Mark_Type	Easting	Northing	Comment	Plcd_from	Orig_plan	Adjoin	Associated	Ass2	Ass3	Ass4	Ass5	Ass6
56	Point	ORT MAHOGANY	35657.476	42682.351			S312665	2/4						
63	Point	Pin	35700.174	42959.422		OSP STN 3 S312665/OSP STN 2 S312665	RP73017	1/2	RP73018	SL2559	RP76597	RP84609	RP94670	RP109798
64	Point	Pin	35584.752	42908.367		OSP STN 3 S312665/OSP STN 2 S312665	RP73017	1/1	RP90863					
89	Point	PSM	35707.644	42971.558		OIP STN 2 RP94670/OIP STN 2 RP73018/OIP STN 1 RP73017	IS188476	1/2						

Record: 1 Show: All Selected Records (4 out of 90 Selected.) Options

Results from Reference Mark Selection

Selected Attributes of Corners

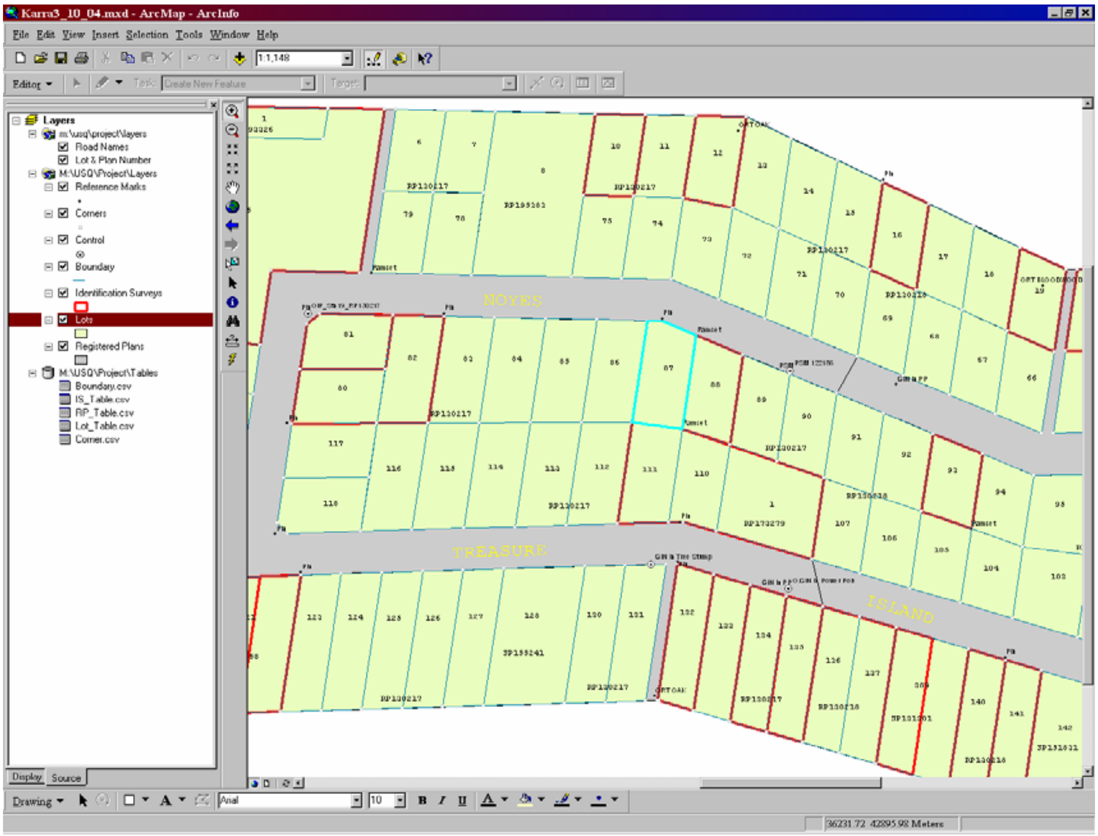
Corners.FID	Corners.Shape	Plan	Lot	Corners.Variance	Reliability	Corners.Easting	Corners.Northing
79	Point	RP178377	1/2	30"	4	35700.767	42959.309
312	Point	RP178377	1/2/2	0	4	35689.335	42880.891
355	Point	RP90863	1/2	0	3	35615.7	42921.956

Record: 1 Show: All Selected Records (3 out of 366 Selected.) Options

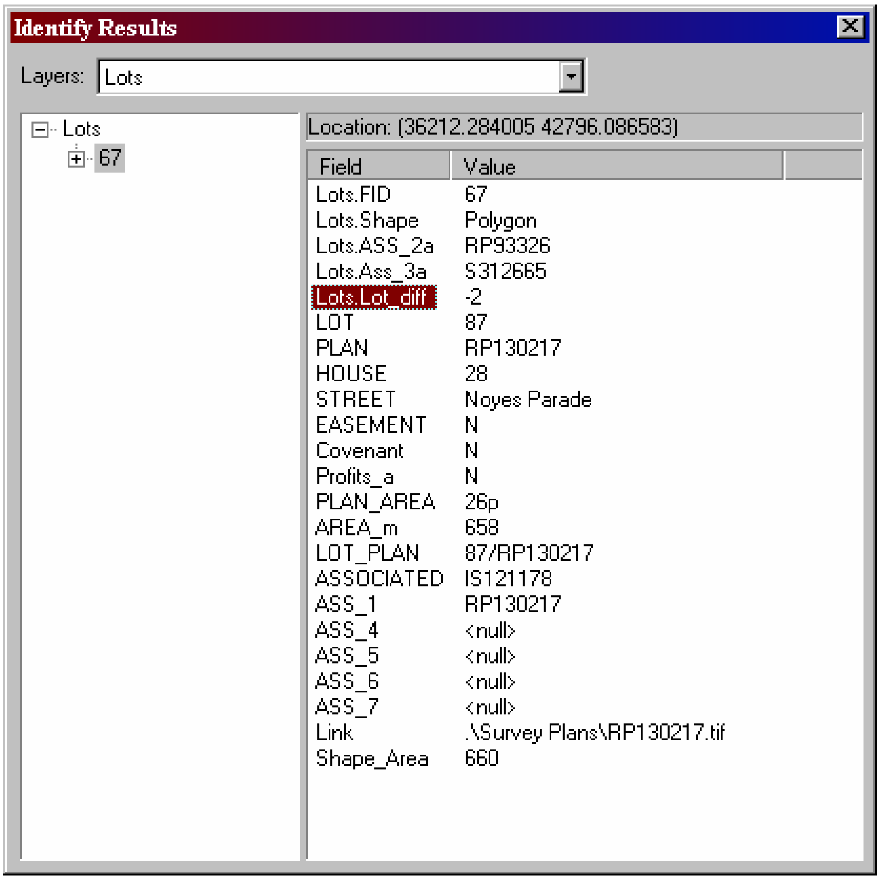
Results from Corner Selection

Appendix F

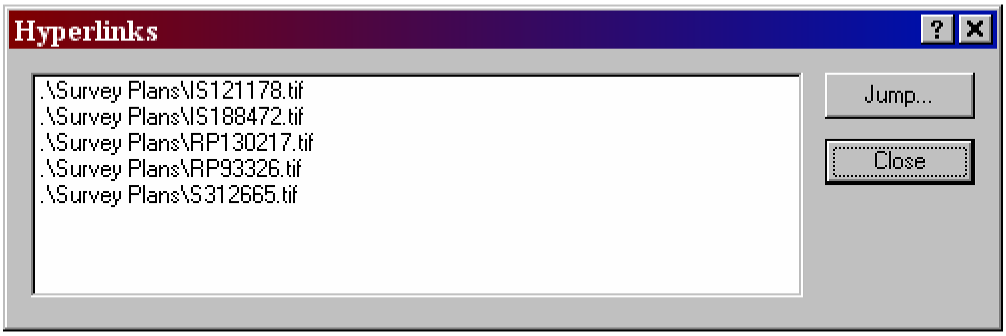
Appendix F – Results -Identification Survey of Lot 87 on RP130217



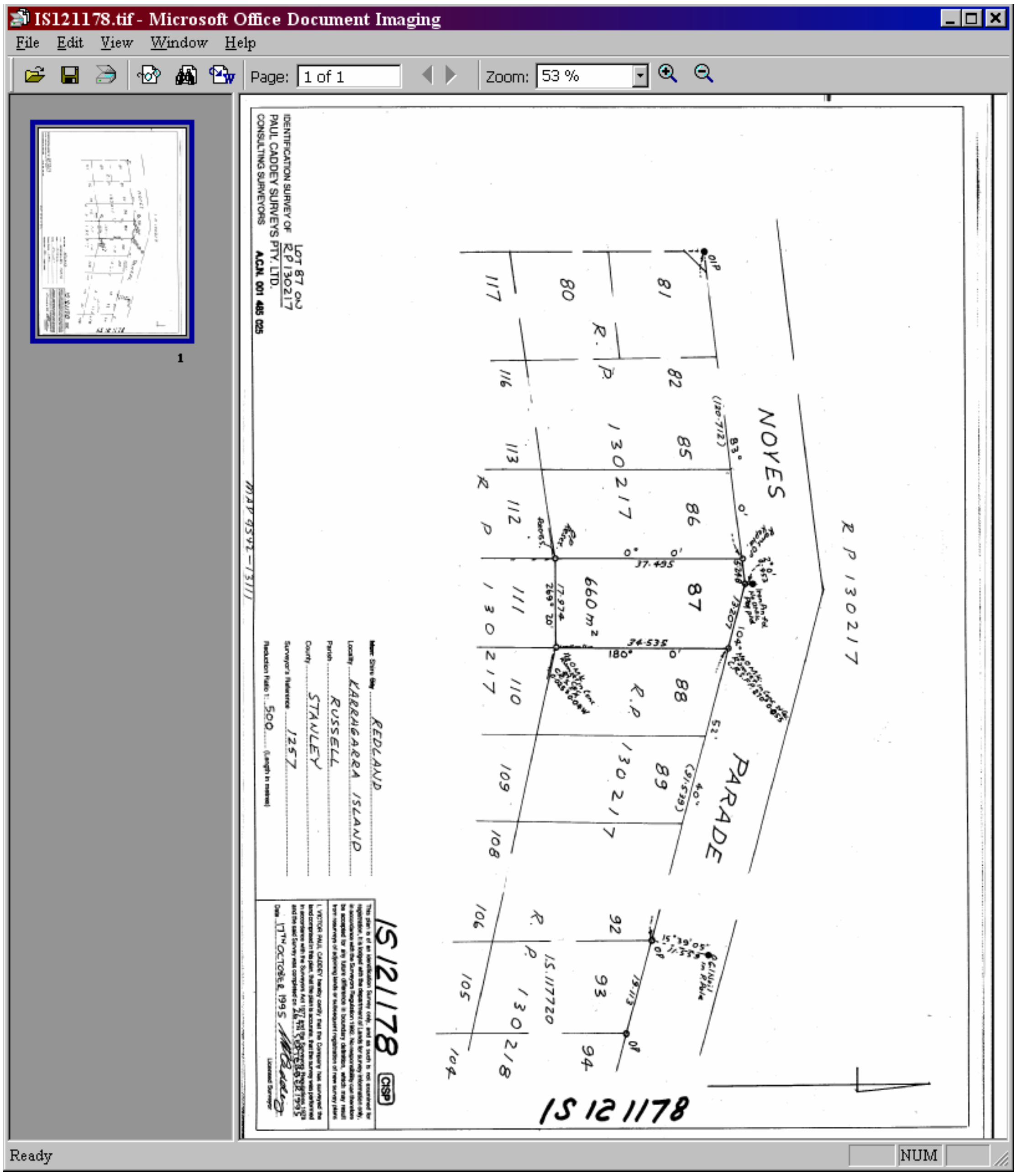
Location of Lot 87 on RP130217



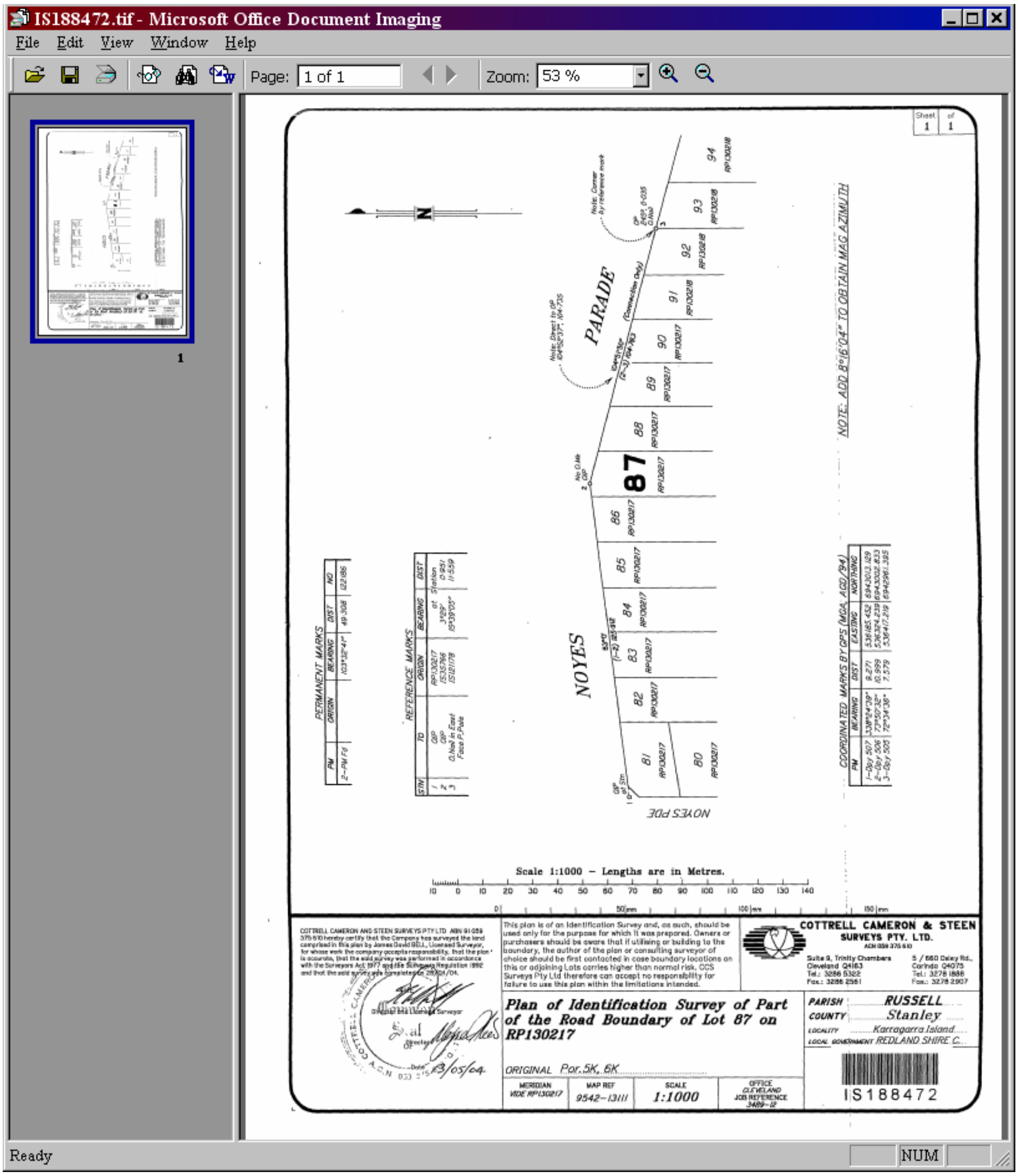
Lot Details



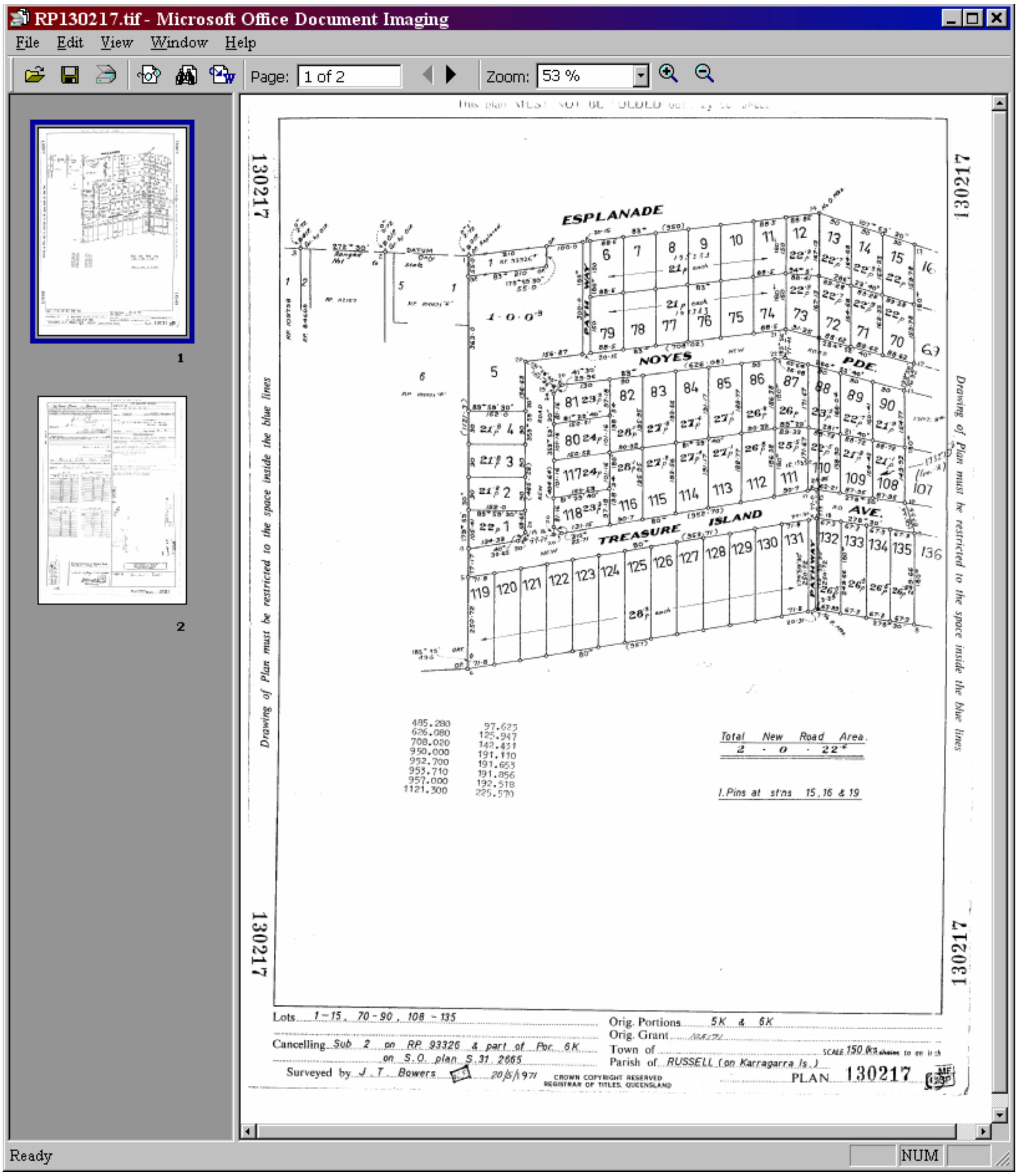
Results from Hyper- link to Plans Associated with Lot 87



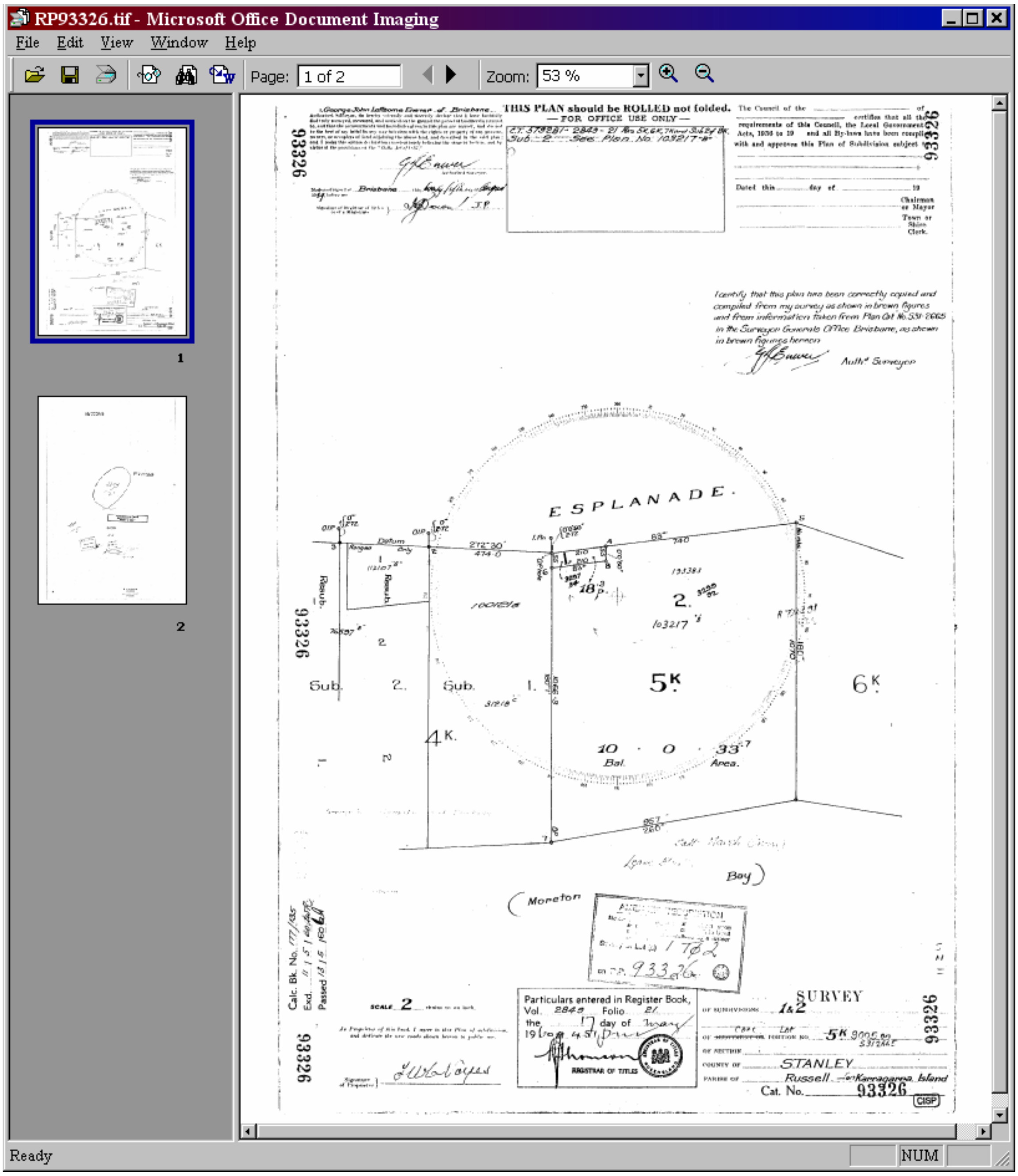
Hyperlinked Plan IS121178



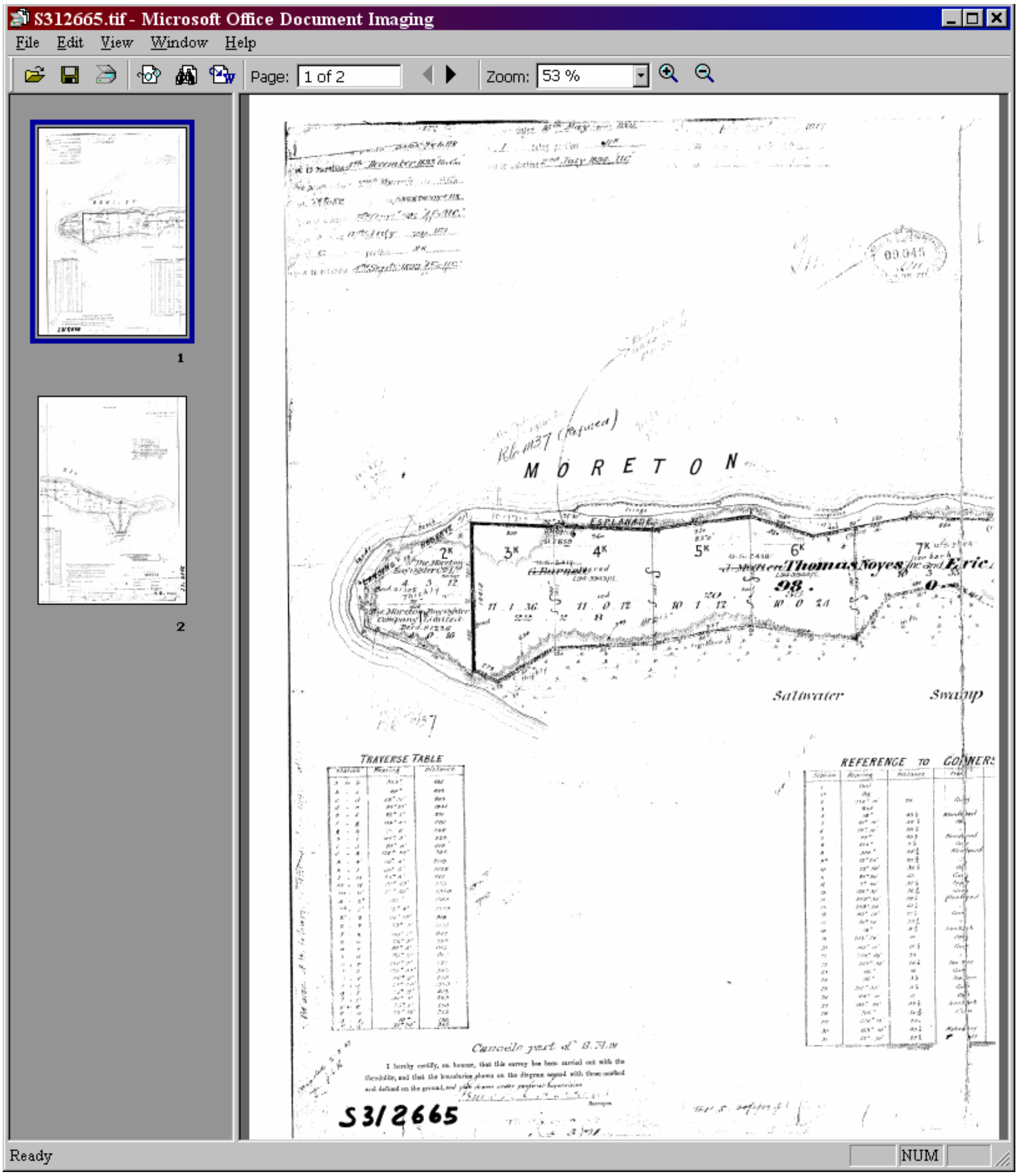
Hyper-linked Plan IS188472



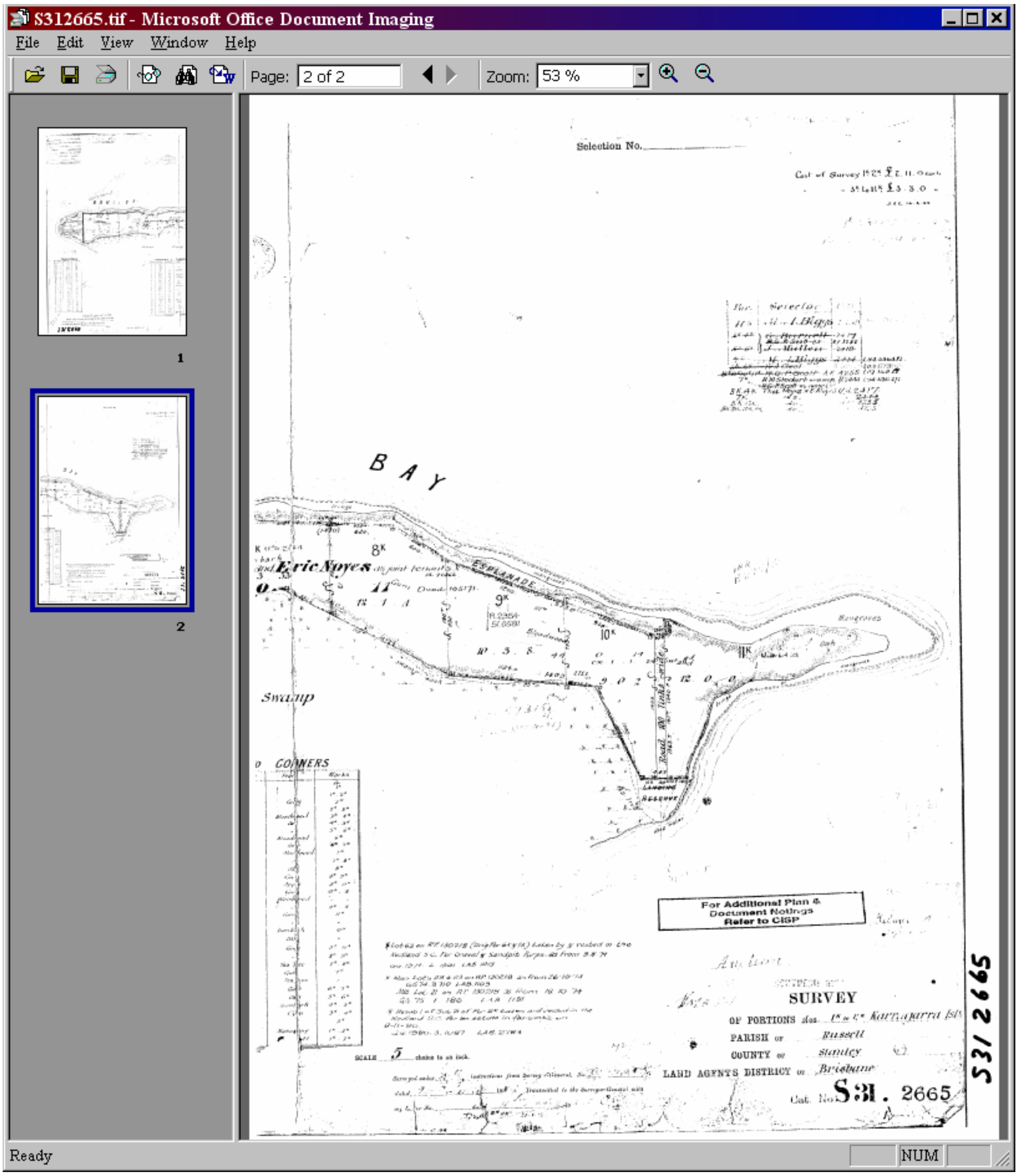
Hyper-lined Plan RP130217



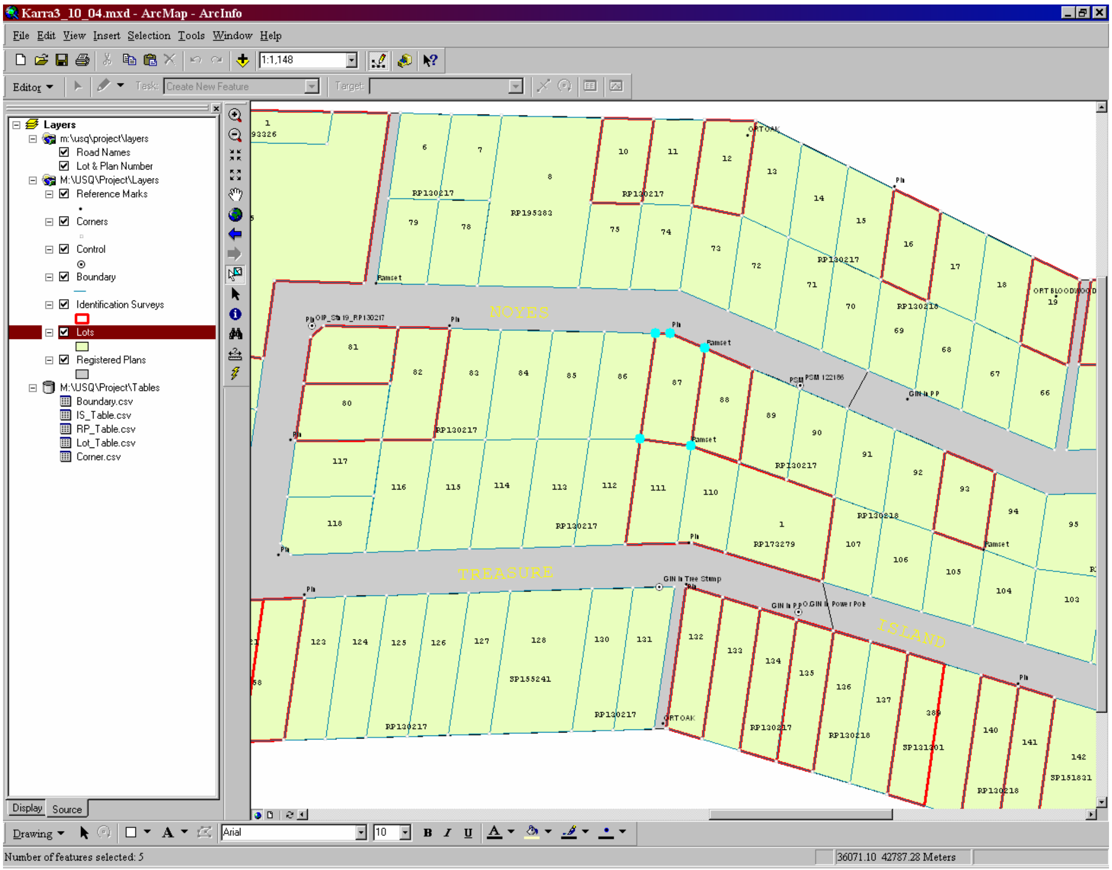
Hyperlinked Plan RP93326



Hyper-linked Plan S312662



Hyper-linked Plan S312662 page 2



Selected Corners

Selected Attributes of Corners

Corners.FID	Corners.Shape	Plan	Lot	Corners.Variance	Reliability	Corners.Easting	Corners.Northing
6	Point	RP130217	87/88	0	2	36220.014	42809.715
49	Point	RP130217	87/88/110/111	0	2	36215.07	42775.567
127	Point	RP130217	86/87	0	2	36202.623	42815.029
128	Point	RP130217	86/87/111/112	0	2	36197.253	42777.944
261	Point	RP130217	87	50"	3	36207.845	42814.914

Record: 1 Show: All Selected Records (5 out of 366 Selected.) Options

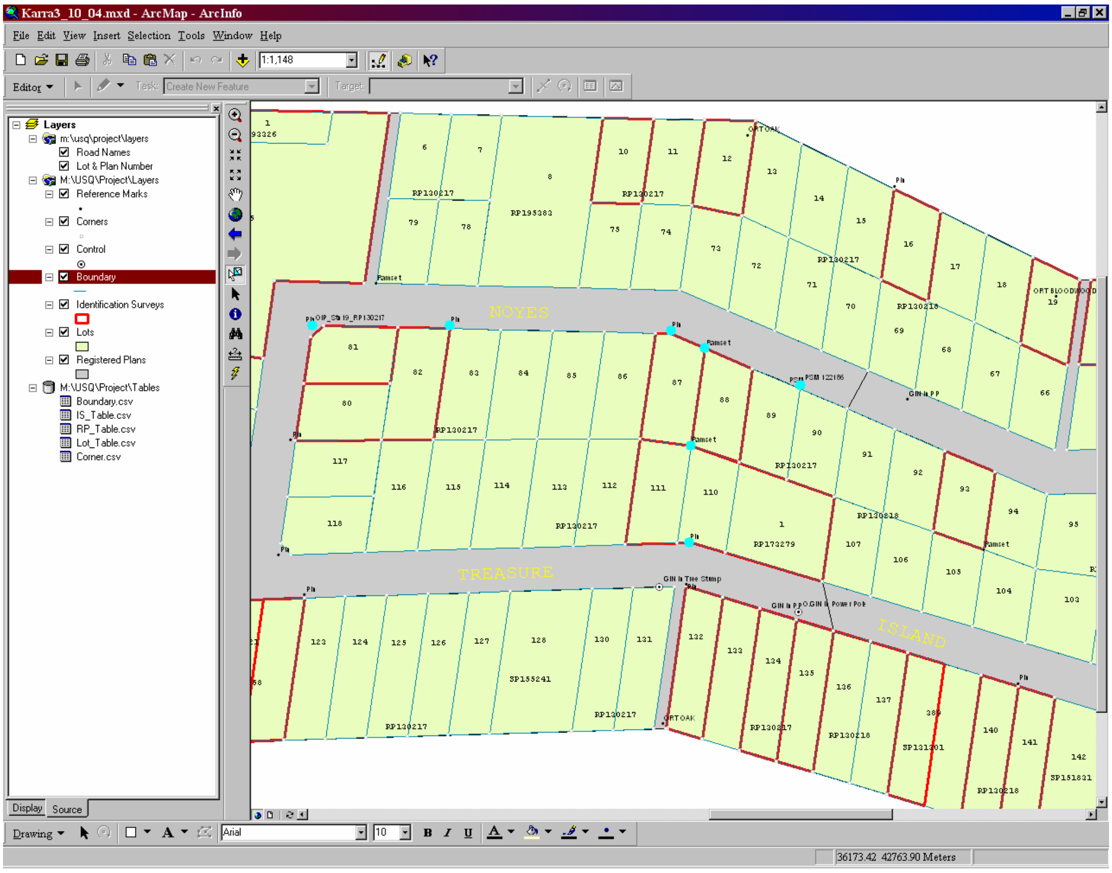
Results from Selected Corners

Selected Attributes of Boundary

Boundary.FID	Boundary.Shape	Shape_Leng
154	Polyline	34.504
155	Polyline	37.472
201	Polyline	5.224
202	Polyline	13.233
233	Polyline	17.975

Record: 1 Show: All Selected Records (5 out of 545

Results from Boundary Table



Selected Reference Marks

Selected Attributes of Reference Marks

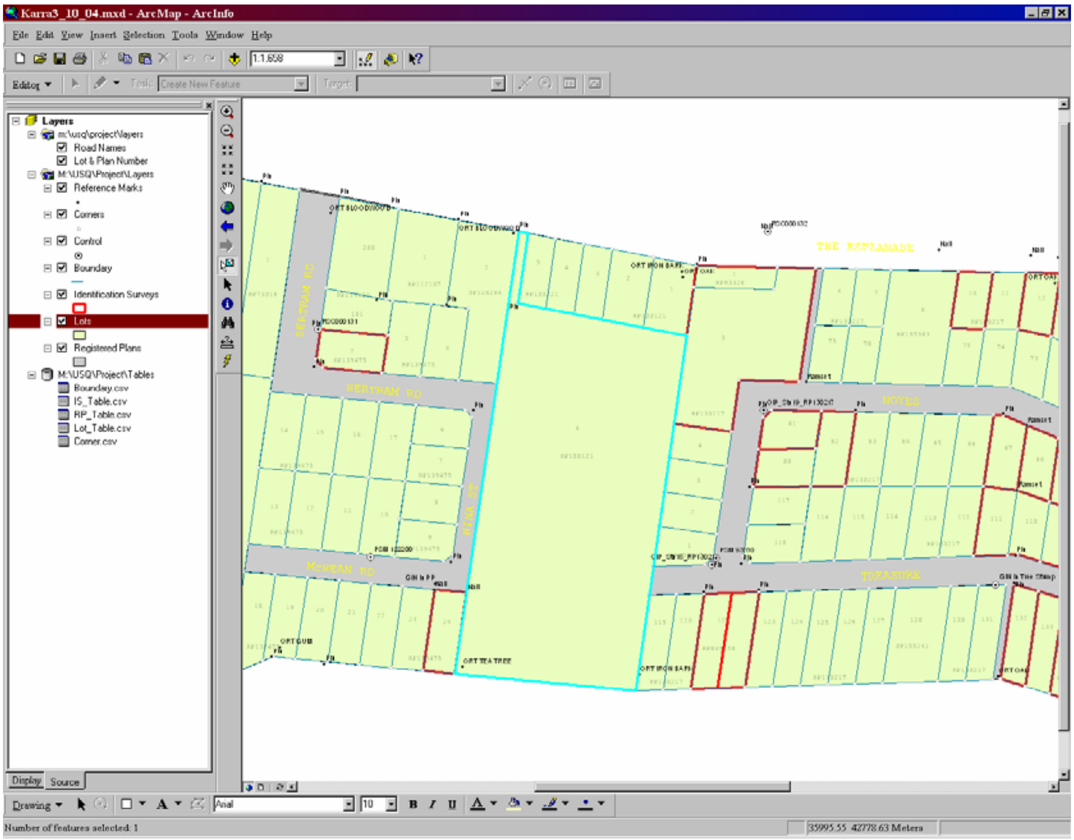
FID	Shap	Mark_Ty	Easting	Northing	Comment	Plcd_from	Orig_plan	Adjoin_lol	Associated	Ass2	Ass3	Ass4	Ass5	Ass6	Ass7	Ass8	Ass9
19	Point	Ramset	36215.07	42775.567		GIN 92/93 IS117720/OIP STN 19 RP130217	IS121178	87/88/110									
20	Point	Ramset	36220.014	42809.715		GIN 92/93 IS117720/OIP STN 19 RP130217	IS121178	87/88									
22	Point	Pin	36130.269	42817.763		OIP 16 RP130217/OIP STN 19 RP130217/OIP 87 IS35766	IS107559	82/83									
24	Point	Pin	36214.324	42741.548		OIP 16 RP130217/OIP STN 19 RP130217	IS15350	110									
32	Point	Pin	36208.039	42815.845		OIP STN 19 RP130217/OP 73/74	IS35766	87	IS107559	IS12117	IS188472						
69	Point	PSM	36253.623	42796.593		OIP STN 19 RP130217/OIP 87 IS35766/O GI Nail 92/93 IS121178	IS188472	87									
79	Point	Pin	36081.934	42817.698		OIP STN 1 RP93326/OIP STN 4 RP84609/OIP STN 4 RP76597/OR	RP130217	81	IS15350	IS20777	IS35766	IS82269	IS107559	IS108618	IS117720	IS121178	IS188472

Record: 1 Show: All Selected Records (7 out of 90 Selected.) Options

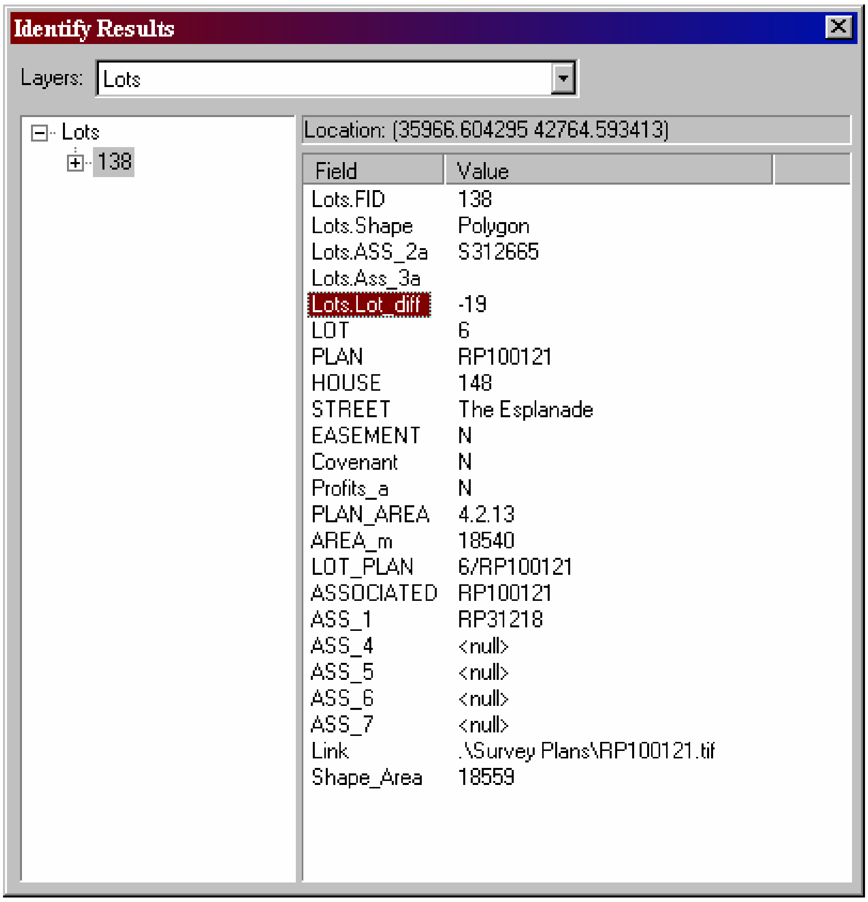
Results from Selected Reference Marks

Appendix G

Results-Boundary reconfiguration of Lot 6 on RP100121

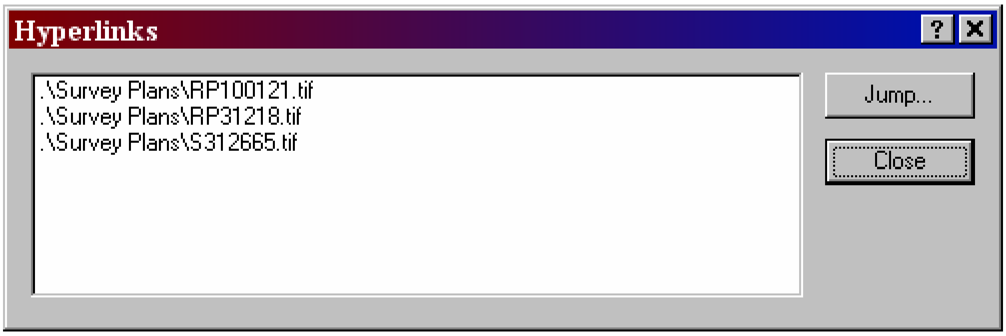


Location of Lot 6 on RP100121

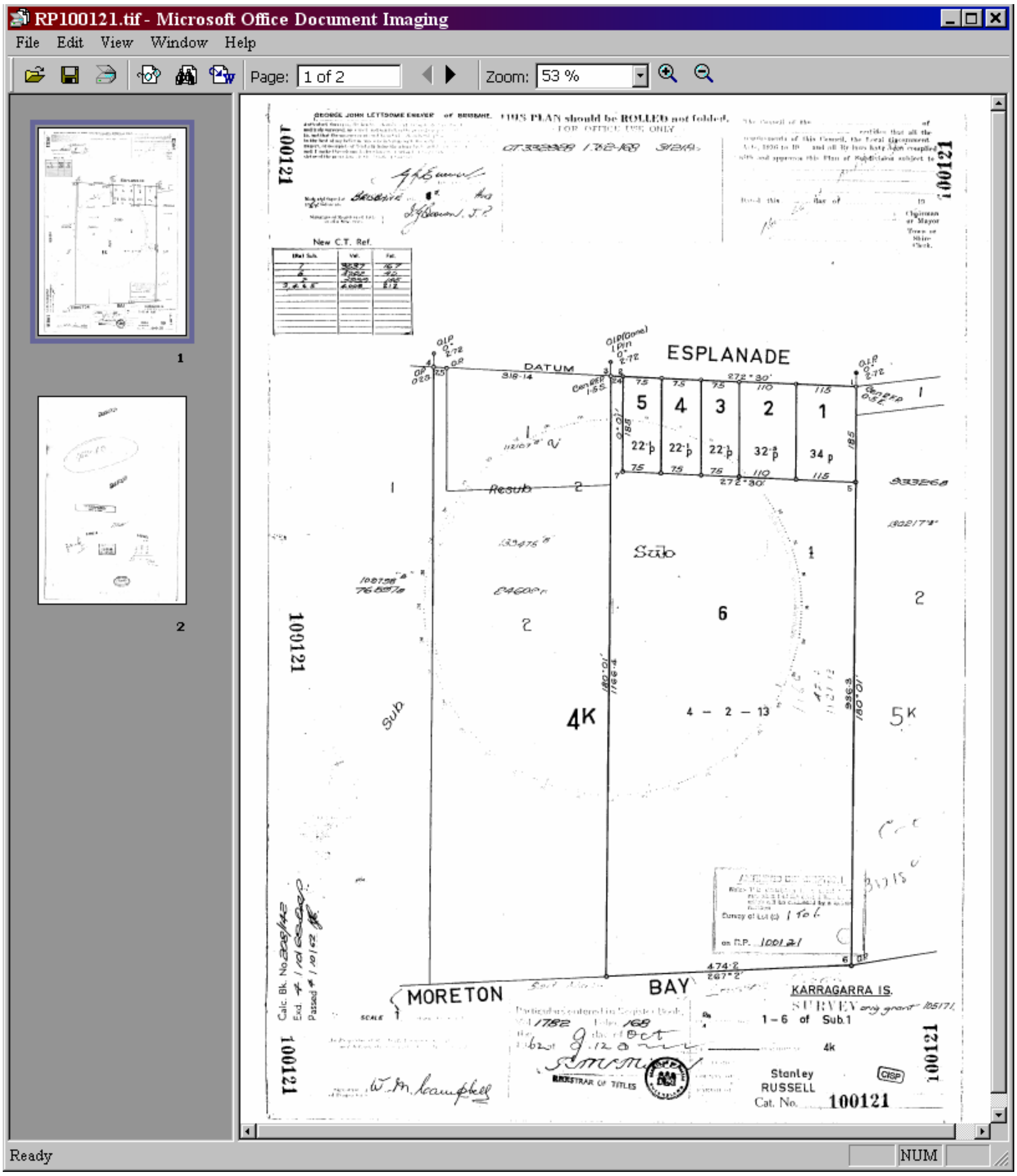


Field	Value
Lots.FID	138
Lots.Shape	Polygon
Lots.ASS_2a	S312665
Lots.Ass_3a	
Lots.Lot_diff	-19
LOT	6
PLAN	RP100121
HOUSE	148
STREET	The Esplanade
EASEMENT	N
Covenant	N
Profits_a	N
PLAN_AREA	4.2.13
AREA_m	18540
LOT_PLAN	6/RP100121
ASSOCIATED	RP100121
ASS_1	RP31218
ASS_4	<null>
ASS_5	<null>
ASS_6	<null>
ASS_7	<null>
Link	.\Survey Plans\RP100121.tif
Shape_Area	18559

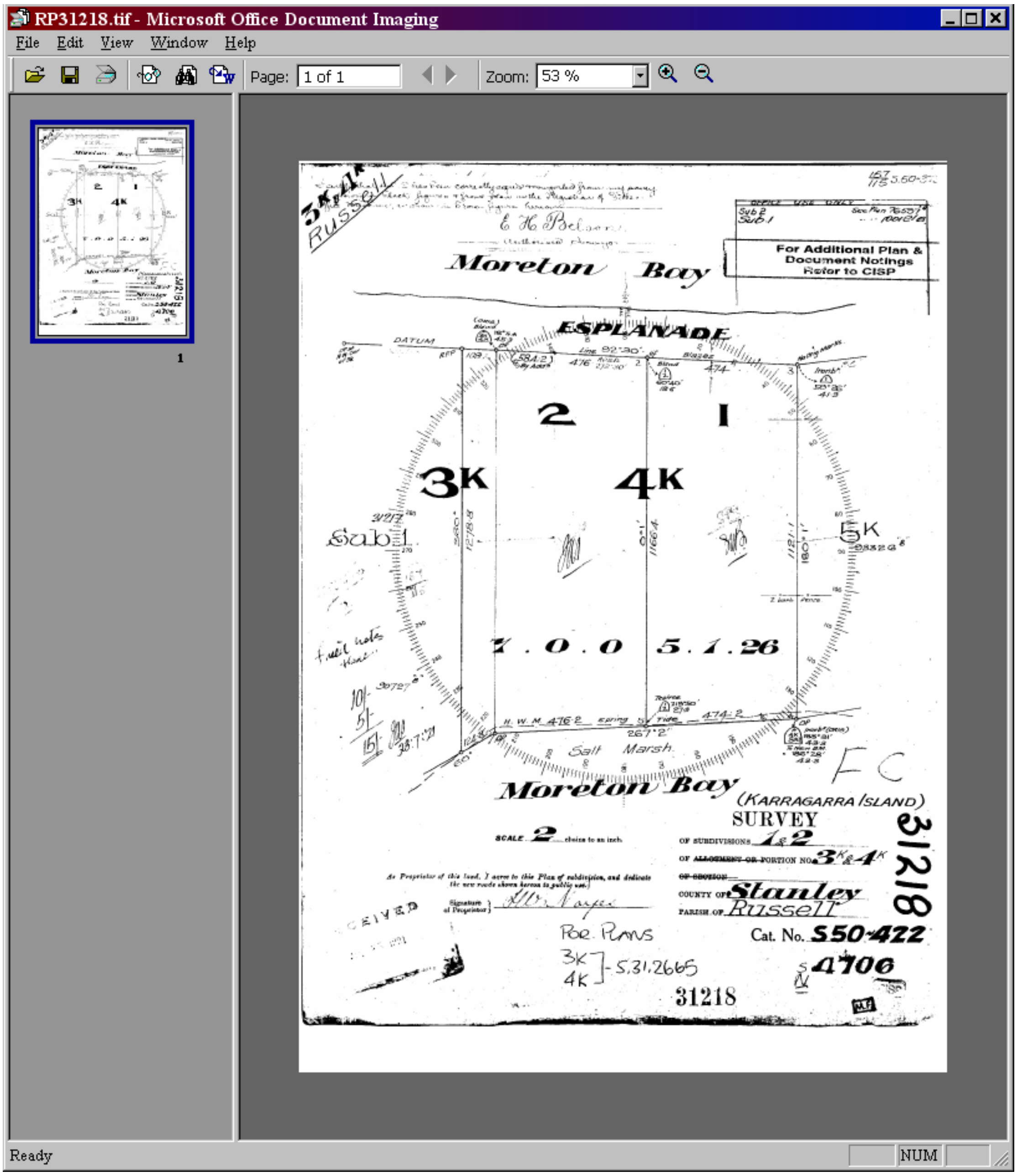
Lot Information



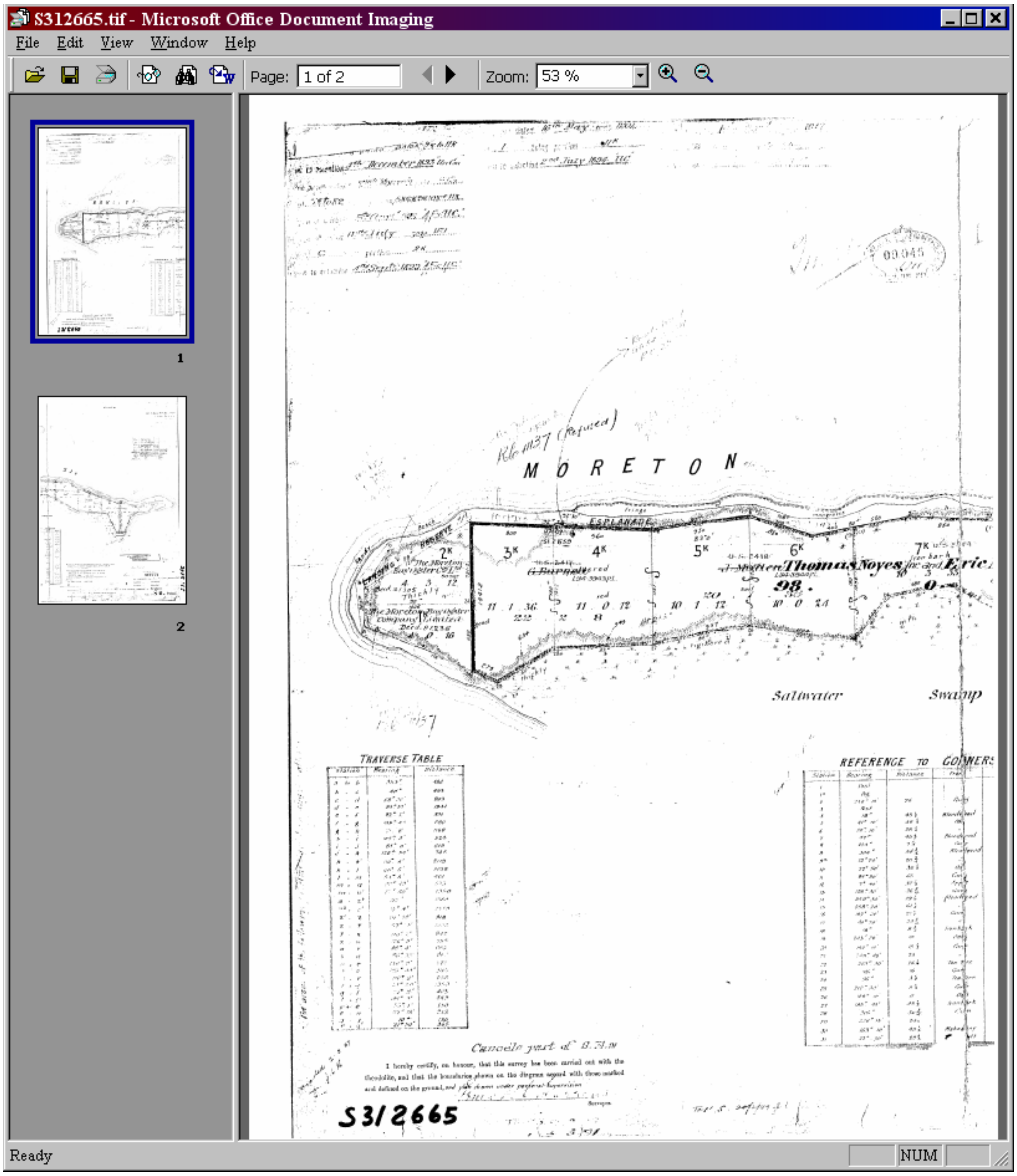
Results from hyper-link associated with Lot 6 on RP100121



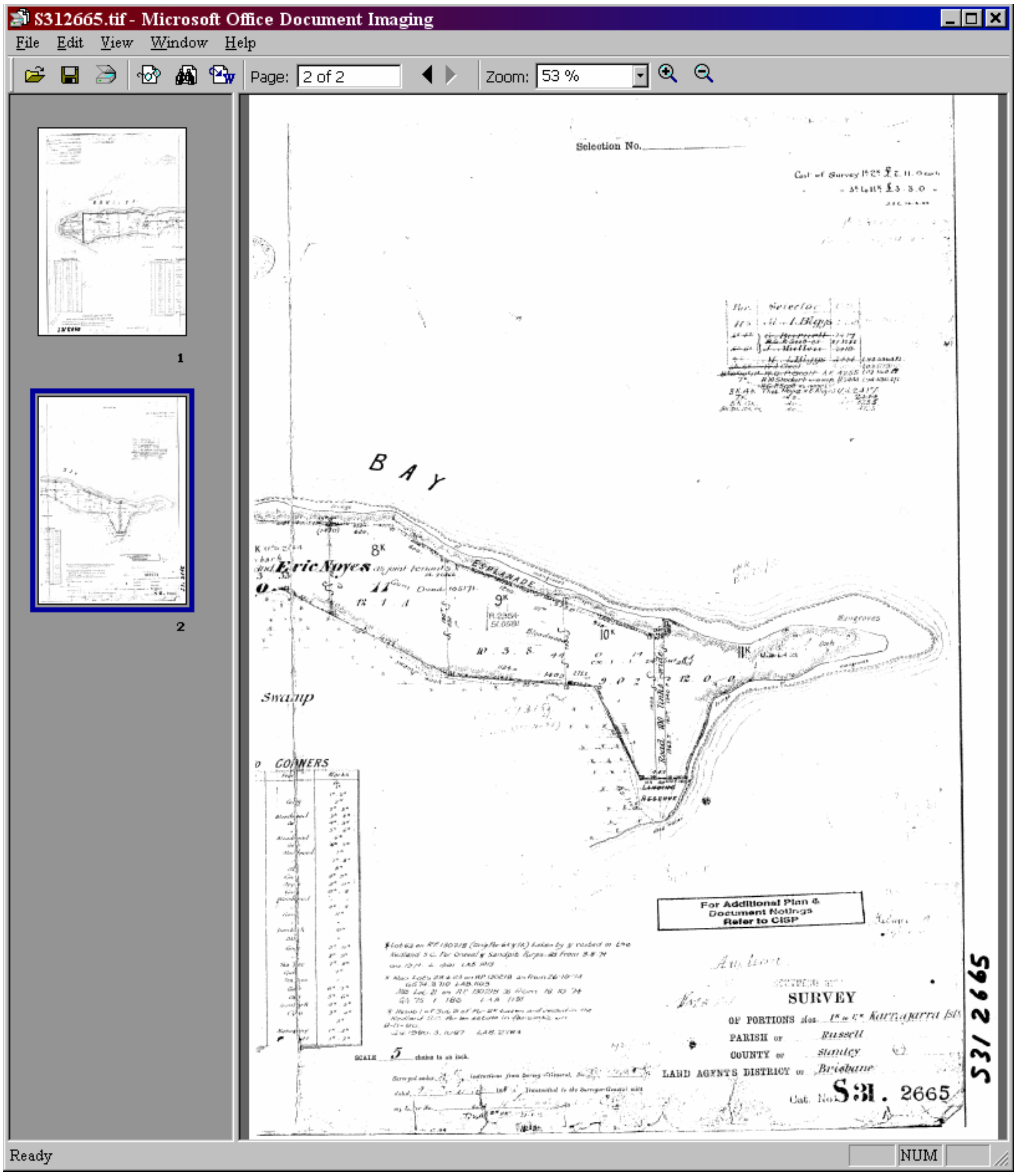
Hyper – linked Plan RP100121



Hyper – linked Plan RP31218



Hyper – linked Plan S312665



Hyper – linked plan S312665 page 2

Selected Attributes of Boundary

Boundary.FID	Boundary.Shape	Shape_Leng
413	Polyline	23.135
442	Polyline	95.397
443	Polyline	188.385
444	Polyline	90.531
446	Polyline	4.829
447	Polyline	234.659

Record: 0 Show: All Selected Records (6 out of 545

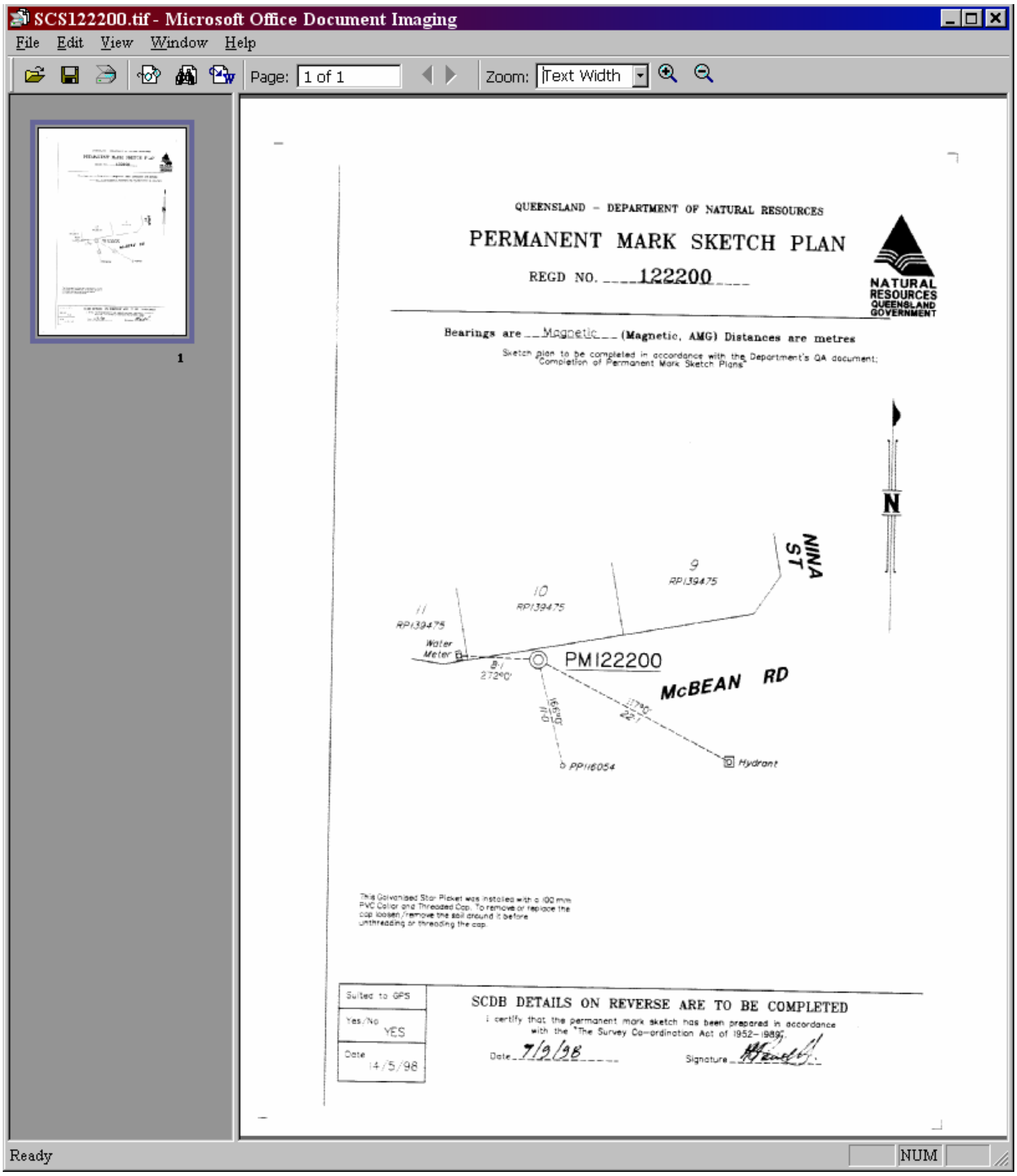
Boundary Table

Selected Attributes of Control

FID	Shape*	CONT	DESC_	TYPE	Date_Plcd	Surveyor	Class	Order	Cad_	Plan	Easting	Northing	Height	LINK_PSM
12	Point	0	PSM 93780	Brass Plaque	01/01/1986	DMS	4	D	N		36056.761	42740.238	10.803	.\Survey~1\SCS093780.tif
14	Point	0	PSM 122200	Star Pkt	14/05/1998	Paul Powell	No	No	Y	IS188475	35875.18	42740.576	8.651	.\Survey~1\SCS122200.tif

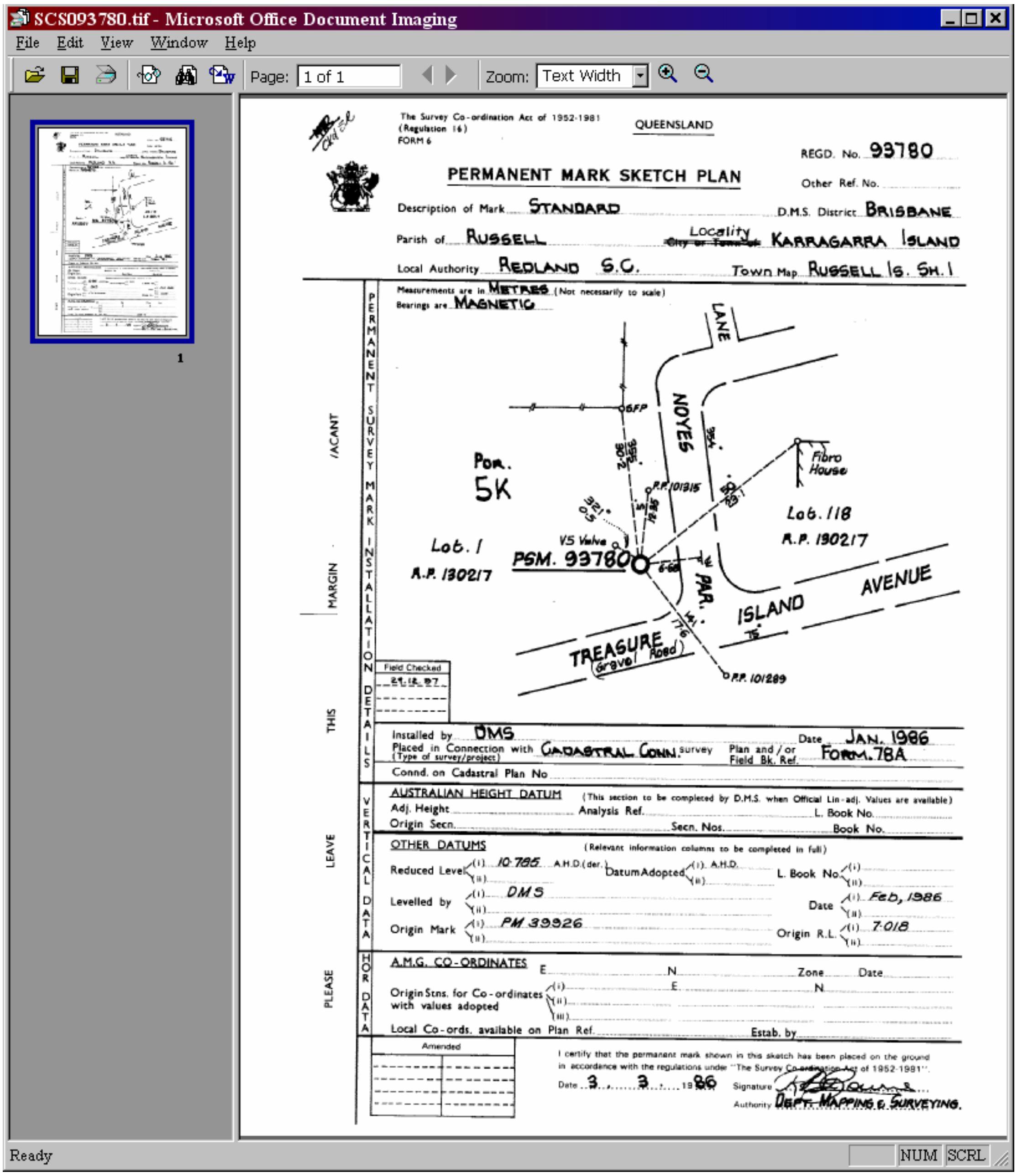
Record: 1 Show: All Selected Records (2 out of 18 Selected.) Options

PSM Selection



Survey Control Sketch for PSM122200

Jason Masters
0031210918



Survey Control Sketch for PSM93780

Selected Attributes of Corners

Corners.FID	Corners.Shape	Plan	Lot	Corners.Variance	Reliability	Corners.Easting	Corners.Northing
65	Point	RP130217	4/5/6	0	2	36034.568	42810.447
66	Point	RP130217	3/4/6	0	2	36031.969	42792.525
67	Point	RP130217	2/3/6	0	2	36029.37	42774.602
68	Point	RP130217	1/2/6	0	2	36026.772	42756.679
70	Point	RP139475	24/6	0	2	35925.474	42721.98
71	Point	RP139475	24/6	0	2	35919.274	42679.225
73	Point	RP112107	2/6	0	3	35952.947	42911.455
149	Point	RP130217	6/119	0	2	36021.5	42720.322
150	Point	RP130217	6/1	20"	2	36023.728	42735.686
154	Point	RP130217	6/119	2'	2	36014.263	42670.411
287	Point	RP100121	1/5/6	0	3	36041.295	42856.846
288	Point	RP100121	1/2/6	0	3	36018.566	42861.159
291	Point	RP100121	2/3/6	0	3	35996.825	42865.285
292	Point	RP100121	3/4/6	0	3	35982	42868.098
295	Point	RP100121	4/5/6	0	3	35967.176	42870.911
296	Point	RP100121	5/6	0	3	35952.351	42873.724
297	Point	RP100121	5/6	0	3	35957.692	42910.555
298	Point	RP139475	2/6	0	2	35941.356	42831.514

Record: 1 Show: All Selected Records (18 out of 366 Selected.) Options

Corner Table

Selected Attributes of Reference Marks

FID	Shap	Mark_Ty	Easting	Northing	Comment	Plcd_from	Orig_plan	Adjoin_lot	Associated	Ass2	Ass3	Ass4	Ass5	Ass6	Ass7	Ass8	Ass
35	Point	Nail	35925.474	42721.98	at Corner	OIP 6 RP139475/OP 24/6	IS176939	24/6	IS188475								
40	Point	Pin	35947.43	42869.203	missing RP	OSP STN 3 S312665/OIP STN1 RP73017/OIP STN 4 RP76597/OIP	RP84609	2/6									
41	Point	Pin	35953.025	42911.999	Replaced	OSP STN 3 S312665/OIP STN1 RP73017/OIP STN 4 RP76597/OIP	RP84609	2/6	RP109798	RP1302	RP139475						
45	Point	ORT OAK	36039.508	42887.619	Gone SL2		S312665	1									
46	Point	ORT BLO	35950.394	42910.472	Gone RP7	ORT STN 4 S312665/ORT STN 27 S312665	RP31218	2/6									
47	Point	ORT TEA	35923.452	42682.973		ORT STN 4 S312665/ORT STN 27 S312665	RP31218	24/6	RP76597	RP8460							
48	Point	ORT IRON	36016.479	42678.835	New BM O	ORT STN 4 S312665/ORT STN 27 S312665	S31218	6/119	RP76597								
49	Point	ORT IRON	36038.837	42890.479	Gone RP7	ORT STN 4 S312665/ORT STN 27 S312665	RP31218	1/1									
65	Point	Pin	36046.714	42894.218		OIP STN 4 RP84609/OIP STN 4 RP76597	RP93326	1/1	RP100121	RP1302	DP167338						

Record: 1 Show: All Selected Records (9 out of 90 Selected.) Options

Reference Mark Table

Appendix H

GIS Based Cadastral Planner